Thesis - Darragh Hammel

by DARRAGH HAMMEL

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Title Page

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THE NATIONAL UNIVERSITY OF IRELAND MAYNOOTH

Froebel Department of Primary and Early Childhood Education

M.Ed. (Research in Practice) 2024 – 2025

Remember The "Why"

Teaching for Conceptual Understanding in a Primary School Classroom.

Darragh Hammel

A Research Dissertation submitted to the Froebel Department of Primary and Early Childhood Education, Maynooth University, in fulfilment of the requirements for the degree of Master of Education (Research in Practice)

Date:

Supervised by: Eddie Costello

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I would first like to thank my supervisor, Eddie Costello. Eddie, thank you for always showing an interest when I spoke my Maths ideas and observations. Our conversations were not only enlightening but also a genuine pleasure. I never felt out of place sharing my enthusiasm for the subject. Thank you for your guidance throughout the research and with writing this thesis. I have learned so much. Perhaps we are only getting started.

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Finally, a special thanks to the camogie team I coached over 2024/2025. You kept me busy. You kept me on my toes. You were the best distraction I could have asked for. The silverware was just the cherry on top. Girls, thank you.

Abstract

This Action Research study investigated the impact that teaching mathematics for conceptual understanding may have on students' engagement, confidence, and developing Mathematical Identities. The research was conducted in a mixed-ability Sixth Class (11-12 years old) in a DEIS Band 2 Irish primary school, over two cycles with a single class group. The central research question asked: *What impact can teaching with the aim of achieving conceptual understanding have on my students' engagement, confidence and developing Mathematical Identities?*

A targeted teaching intervention was designed, moving away from procedural instruction toward approaches prioritising meaning, reasoning and relevance. It incorporated three key strategies: embedding mathematical concepts in meaningful real-life contexts, explicitly addressing common misconceptions and integrating student Maths Journals as reflective tools. Data were collected through student journals, classroom discussion notes, the researcher's reflective teaching journal, and pre- and post-intervention administration of the adapted Abbreviated Maths Anxiety Scale (AMAS). Qualitative data were analysed using Braun and Clarke's (2006) six-phase thematic analysis framework, while quantitative AMAS results provided supporting context.

Findings revealed three overarching themes: (1) meaningful contexts enhanced student engagement, (2) conceptual understanding builds confidence, and (3) conceptual teaching requires significant preparation and strong Mathematical Knowledge for Teaching. The intervention fostered more positive Maths Identities, with students increasingly viewing mathematics as understandable, relevant, and discussable. Common Misconception strategies helped reduce Maths Anxiety by normalising error and reframing struggles as part of the learning process. AMAS results showed a general trend toward reduced anxiety, though some persistent discomfort with unpredictable testing remained.

The study concludes that teaching for conceptual understanding can positively transform how students engage with and perceive mathematics. To strengthen this impact, the study recommends sustained professional development, greater emphasis on Mathematical Knowledge for Teaching in teacher training, and deliberate strategies such as using real-life contexts and addressing misconceptions directly.

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List of Acronyms

AMAS: Abbreviated Maths Anxiety Scale

AR: Action Research

CCK: Common Content Knowledge

CPD: Curriculum Professional Development

CU: Conceptual Understanding

DEIS: Delivering Equality of Opportunity in Schools

EAR: Educational Action Research

HCK: Horizon Content Knowledge

KC: Knowledge of Curriculum

KCS: Knowledge of Content and Students

KCT: Knowledge of Content and Teaching

MA: Maths Anxiety

MCK: Mathematical Content Knowledge

MKT: Mathematical Knowledge for Teaching

NCCA: National Council for Curriculum and Assessment

SCK: Specialised Content Knowledge

STEM: Science, Technology, Engineering, and Mathematics

Chapter 1: Introduction

1.1 Background

Mathematics plays a central role in the Irish primary school curriculum, yet for many children it is a source of anxiety, disengagement, and low self-efficacy (Boaler, 2016; Dowker et al., 2019). In the Irish context, research by Smyth et al. (2006) highlights the difficulties students face during the transition from primary to secondary education, noting a decline in mathematical performance despite high levels of engagement and self-belief. Such findings suggest that fragile conceptual understanding developed in the later years of primary school may contribute to these difficulties. This issue is particularly pressing in senior primary classes, where students begin to encounter more abstract and complex concepts that often expose the fragility of their mathematical understanding and the limitations of procedural fluency alone (Kilpatrick et al., 2001). In my own sixth-class practice, I have consistently observed how these difficulties manifest in the classroom: a reluctance to attempt new tasks, visible emotional responses to challenge, and an entrenched belief among some students that success in Mathematics is reserved for those who are *naturally good at it.*

One incident early in the school year captured this concern vividly. A student who regularly receives learning support was handed a worksheet. Without glancing at the content, she pushed it aside and said, “I can’t do that, it’s too hard.” This refusal even to attempt the task reflected not only a lack of confidence but also an entrenched disposition towards Mathematics as something inaccessible and threatening. This interaction underscored the realisation that my students’ challenges were not limited to the procedural gaps but were deeply connected to their identities as learners and their emotional relationship with the subject.

I began questioning whether my teaching may have unintentionally contributed to negative feelings and attitudes towards mathematics. Reading the work of Skemp (1976) and Boaler (2016) deepened this reflection, as they highlight the importance of prioritising conceptual engagement over procedural instruction. Their research prompted me to reconsider whether I had been offering students sufficient opportunities to explore the “why” behind mathematical ideas. This literature suggests that teaching for conceptual understanding – emphasising meaning, connections, and reasoning – can play a transformative role in improving both mathematical proficiency and students’ relationships with the subject (NCCA, 2023;

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etc

Kilpatrick et al., 2001). This is consistent with the position that developing conceptual understanding is not only a cognitive goal but a socio-emotional one, reshaping how students view themselves as capable mathematical thinkers (Boaler, 2016).

This research emerges from a recognition of the need to move beyond surface-level procedural competence towards an approach that prioritises conceptual understanding as a means to reshape students' experiences of Mathematics. By situating this inquiry within an Action Research (AR) paradigm, I aim to explore the impact of a deliberately designed intervention that fosters conceptual learning in a classroom environment that is emotionally safe, dialogical, and inclusive. The central research question guiding this study is:

What impact can teaching with the aim of achieving Conceptual Understanding have on my students' engagement, confidence and developing Mathematical Identities?

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In the sections that follow, I outline the stylistic conventions adopted in this dissertation (1.2), describe the reconnaissance work that informed the development of this research (1.3), provide a rationale for initiating the study (1.4), and detail my pre-intervention teaching practice (1.5). These sections establish the context, purpose, and direction of the inquiry, grounding it in both my evolving classroom practice and the wider literature on Mathematics Education and Identity.

1.2 Conventions Used

Before expanding on the research area, it is important to clarify some of the conventions that will be used throughout this dissertation. Because this study employs an AR approach, reflection is central to its design and analysis. To capture the complexity of classroom life and the development of my practice, vignettes will be used at key points. These provide snapshots of significant classroom moments that informed my thinking, captured student attitudes, and shaped the direction of the intervention. To distinguish them from the main academic text, these vignettes and reflective passages will be italicised.

In the interest of protecting the anonymity of those involved, all participating students are referred to using pseudonyms. Where it is necessary to refer to specific individuals or the school context, identifying details have been altered or omitted to ensure confidentiality.

Throughout this dissertation, the term *students* will be used when referring to the children in my class. This reflects both my professional context and the language of the Primary Mathematics Curriculum (NCCA, 2023). When discussing the curriculum, I refer to the most recent 2023 iteration unless otherwise noted.

Finally, I will frequently use the phrase *teaching for conceptual understanding.* In the context of this research, this refers to the deliberate pedagogical approach that prioritises making the underlying meaning of mathematical ideas explicit, helping students to make connections between concepts, and situating mathematics within meaningful, real-world contexts. This emphasis reflects recommendations from the National Council for Curriculum and Assessment [NCCA] (2023) that mathematics in Irish classrooms should promote reasoning, problem-solving, and connection-making. This definition also aligns with Skemp's (1976) distinction between relational and instrumental understanding which is elaborated further in Section 2.3 of the Literature Review.

1.3 Reconnaissance Phase

The starting point for this study emerged not only from my current role as a Sixth-Class teacher but from years of observing students engage with Mathematics. Now in my fifth year of teaching, I have worked in a range of roles – including as a learning support teacher (Year 1), a 4th/5th Class teacher (Year 2) and a 5th/6th Class teacher (Years 3 and 4). Across these roles, I have repeatedly encountered the same pattern: many students approach Mathematics with visible apprehension, low confidence, and an ingrained belief that success in the subject is reserved for those who are "naturally good at it." These attitudes are well-documented in the literature (Boaler & Greeno, 2000; Dowker et al., 2019).

It was during my third year of teaching, when I first took on a 5th/6th Class, that I began to notice the depth of the conceptual gaps in students' understanding. By my fourth year, I had started to intentionally zone in on this issue, paying closer attention to how often students were able to perform procedures without understanding why they worked. This pattern revealed that many students experienced Mathematics as arbitrary rules rather than a sense-making discipline, limiting engagement.

While these issues initially appeared to manifest as a lack of procedural fluency or reluctance to engage with tasks, further reflection suggested that students' difficulties may have been related to their beliefs about themselves as mathematical learners. Evidence from my classroom experiences supported this, as even students who could successfully apply procedures often displayed anxiety when asked to explain their reasoning or approach unfamiliar problems. Philipp (2007) argues that students' affective domains – including their

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This recognition prompted me to conduct a reconnaissance phase, which took place from Monday 2 September until Friday 11 October. During this six-week period, I engaged in a process of systematic reflection and informal inquiry to clarify the nature of the problem. I began by observing student responses during Mathematics lessons, documenting instances of disengagement, challenge-avoidance, and frustration. I also reflected critically on my own practice, questioning whether my approach – which often relied on procedural instruction – inadvertently reinforced these negative attitudes. Conversations with colleagues further contextualised these observations, revealing that similar issues were common in other senior primary classrooms. This collegial dialogue reinforced the notion that the challenge was not confined to my classroom but part of a broader systemic issue in how Mathematics is taught at the senior primary level. Although I cannot definitively diagnose individual students with Mathematics Anxiety (MA), I observed patterns of behaviour consistent with avoidance, apprehension, and low confidence, which echoed what the literature describes as common indicators of MA. These observations further shaped my motivation to design an intervention centred on conceptual understanding.

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Through this phase, it became clear that students were accustomed to a procedural model of Mathematics learning, one that prioritised memorisation and speed over reasoning, exploration and sense-making. This approach, while effective for producing correct answers in the short term, offered little opportunity for students to develop deep conceptual understanding (Skemp, 1976). It also limited their ability to view Mathematics as meaningful or personally relevant, echoing Boaler's (2016) findings that procedural teaching often diminishes student engagement and reinforces fixed-ability beliefs.

This reconnaissance process served two critical functions. First, it sharpened my awareness of the complex interplay between pedagogy, student identity, and engagement. The issue was not solely about content knowledge but also about how Mathematics was experienced by students – as a subject that often felt alienating or inaccessible. Second, it clarified the need for an intervention designed to challenge these entrenched beliefs and practices. Specifically, one that would centre conceptual understanding, provide emotional safety, and actively reshape students’ relationships with Mathematics.

These insights laid the groundwork for the design of the intervention, detailed in Chapter Three, and informed the formulation of the research question: *What impact can teaching with the aim of achieving conceptual understanding have on my students’ engagement, confidence and developing Mathematical Identities?*

1.4 Initiating the Research

Building on the insights gained during the reconnaissance phase, it appeared the issues I observed in my students’ engagement with Mathematics were not merely superficial nor temporary. Instead, they seemed to point towards a systemic problem: students may have been socialised into viewing Mathematics as a rigid, procedural subject. This mindset appeared to limit their achievement and shape their Maths Identities, making them reluctant to engage with challenge or explore new ideas (Boaler & Greeno, 2000).

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By my fourth and fifth years of teaching, I recognised that these problems could not be solved through minor adjustments as my procedural approaches produced only short-term gains without fostering relational understanding (Skemp, 1976). They demanded a deeper transformation in how Mathematics was taught and experienced in my classroom. Furthermore, my observations confirmed what the literature repeatedly emphasises, which is that students’ beliefs about Mathematics and their self-perceptions as learners are inseparable from their cognitive engagement with the subject (Philipp, 2007; Boaler, 2016).

In response, I sought to reframe my teaching practice. I aimed to create a Mathematics classroom where conceptual understanding - the *why* behind mathematical ideas - was prioritised over memorisation and rote application of rules. This shift required not only instructional changes but also a cultural one: cultivating an environment where mistakes were normalised, curiosity encouraged, and every student could see themselves as a capable mathematical thinker. This cultural shift was central to fostering growth mindsets (Dweck, 2006), essential for challenging fixed-ability beliefs. This aligns with the principles of the Primary Mathematical Curriculum (NCCA, 2023), which advocates for meaningful, connected learning experiences.

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This reflection also revealed what Whitehead (1993) describes as a “living contradiction”: my values as an educator - to make learning inclusive, empowering, and meaningful – were misaligned with elements of my practice, which at times defaulted to procedural teaching that reinforced the very attitudes I aimed to change. Confronting this contradiction became a central motivator for this study.

Action Research (AR) provided an appropriate methodological framework for this inquiry. As a cyclical process of planning, acting, observing, and reflecting (McNiff & Whitehead, 2010), AR allowed me to investigate my own practice in real time, co-construct knowledge with my students, and iteratively refine my approach. It also aligned with my epistemological belief in knowledge as something constructed collaboratively and my ontological commitment to education as a democratic, values-driven practice (Glenn, Curtis & Naughton, 2023). This alignment between my values and chosen methodology reflects what Carr and Kemmis (1986) identify as the emancipatory potential of AR.

The research aim that emerged from this process was therefore both practical and values-based: to explore how teaching for conceptual understanding could influence students' engagement, confidence, and Maths Identities.

The following sections outline the baseline of my current practice (1.5) and my educational values (1.6) providing the foundation for the intervention described in Chapter Three.

1.5 My Current Practice: Teaching Mathematics Before the Intervention

Prior to this study, my approach to teaching Mathematics, though well-intentioned, largely reflected the procedural paradigm that has been critiqued in the literature on Irish mathematics education. Prendergast and Roche (2017) highlight that mathematics teaching in Ireland has often been characterised by a highly didactic and procedural culture, where students tend to learn the "how" rather than the "why" of mathematics. Similarly, the NCCA (2005) cautioned that while procedural skills are important, an over-emphasis on them can ultimately be detrimental to students' conceptual understanding. Lessons typically followed a familiar structure: a review of prior learning, direct teaching of new content, guided practice with the whole class, and independent exercises and a brief review summary at the end. While this format provided order and predictability, it primarily reinforced procedural competence and recall, rather than creating opportunities for students to develop connections or engage with the conceptual meaning behind the mathematics.

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This approach was shaped by implicit assumptions about how students learn Mathematics. I believed that procedural fluency would build confidence and eventually lead to understanding. However, my reconnaissance phase and reflective practice revealed that this assumption was flawed. Students who could successfully perform calculations often struggled to explain why procedures worked or apply their knowledge flexibly in new contexts. This inability to transfer knowledge across contexts reflects what Hiebert and Grouws (2007) describe as the limitations of procedural teaching for developing adaptive expertise. For others, the focus on speed and accuracy reinforces Maths Anxiety (Dowker et al., 2019) and strengthens their belief that being "good at Maths" was an innate trait, inaccessible to them.

Much of my practice at this stage was also influenced by the structure of the curriculum, pressures of curriculum coverage and reliance on textbooks which prioritised breadth over depth. This left limited room for rich classroom discussions, the unpacking of misconceptions, or the exploration of multiple solution strategies – all of which are central to fostering relational understanding (Skemp, 1976; Boaler, 2016).

Reflecting on this practice, I recognised a disconnect between my educational values – which emphasise inclusivity, meaning-making, and collaborative knowledge-building – and my classroom reality. While I wanted students to experience Mathematics as a creative and sense-making discipline, my methods often mirrored the very instrumental teaching described by Skemp (1976) that had failed to engage them meaningfully. This misalignment between values and practice became an important driver for change in my teaching.

The pre-intervention practice provides a clear baseline for this study. It was functional in achieving surface-level competence but insufficient for addressing students' emotional needs, conceptual gaps, and fragile Maths Identities. Recognising these limitations became the impetus for redesigning my approach.

The teaching intervention described in Chapter 3 was developed with teaching for conceptual understanding at its core. It aimed to create a classroom culture where mistakes were normalised, curiosity was encouraged, and students had meaningful opportunities to ask "why" and engage with Mathematics as active sense-makers. Such practices are associated with improved engagement and deeper learning, as evidenced by Boaler (2016) and Anthony & Walshaw (2007). In doing so, the intervention aimed to align my practice more closely with my epistemological belief in knowledge as constructed collaboratively and my

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ontological commitment to inclusive and democratic education (Glenn, Curtis & Naughton, 2023).

1.6 My Values

My values as an educator are rooted in my personal experiences with Mathematics, my professional journey as a teacher, and my developing understanding of the broader purposes of education. Ontologically, I view education as a democratic and relational process where all students are entitled to access meaningful, intellectually engaging learning. Epistemologically, I hold a constructivist stance: knowledge is not transmitted in one-directional flow from teacher to student but is co-constructed through dialogue, inquiry, and reflection (Freire, 1970; Vygotsky, 1978). These positions shape my teaching philosophy and inform my responsibilities as a Mathematics educator.

These values were shaped significantly by my own schooling, where Mathematics was frequently presented as a set of procedures to be memorised and applied without context. This instrumental approach (Skemp, 1976), limited my opportunities to make sense of mathematical ideas in relational, interconnected ways, leaving me disengaged from the subject. My later experiences – particularly studying Mathematics at a deeper level and teaching across diverse settings – revealed the transformative potential of conceptual approaches. When concepts were explored for their underlying logic and connections, rather than simply their procedural outcomes, learning became challenging, rewarding, and personally fulfilling. This personal shift illustrates the transformative power of conceptual engagement, aligning with Dewey's (1938) view of education as an experiential and meaning-making process.

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From these experiences, I developed the following guiding values:

- Mathematics should be taught for conceptual understanding. While both conceptual and procedural knowledge are necessary and should be developed concurrently, I view conceptual understanding as the starting point, providing the foundation upon which procedural fluency can be meaningfully built (Skemp, 1976). This means encouraging students to explore the why behind procedures, rather than relying solely on memorisation or routine application.
- Teachers must possess strong Mathematical Knowledge for Teaching (MKT). I

believe that deep understanding of the content, its underlying structures, and common misconceptions is essential before attempting to teach it. Without this, it is difficult to respond flexibly to students' thinking, make meaningful connections between ideas, or design tasks that truly promote understanding (Ball et al., 2008).

- Education must be democratic and inclusive. Every student, regardless of background or prior achievement, deserves access to learning that is both challenging and meaningful, within an emotionally safe environment, and that prepares them to contribute positively to society.
- Knowledge is co-constructed. Learning should recognise and value students' prior experiences, voices, and interpretations positioning them as active participants in meaning-making.

However, as McNiff (2005) observes, educators often face a tension between their espoused values and their enacted practice. In reflecting on my teaching before this research, I recognised that although I valued conceptual understanding and democratic participation, my reliance on procedural methods and teacher-led instruction often undermined these principles. This dissonance became a driving force behind the study, compelling me to design an intervention that authentically reflected my values in practice.

AR provided a framework for addressing this tension. By engaging in cycles of planning, acting, observing, and reflecting (McNiff & Whitehead, 2010), I aimed to critically examine my teaching, embed my ontological and epistemological commitments into classroom practice, and ultimately create a Mathematics learning environment that prioritised understanding, participation, and student agency.

1.7 Chapter Conclusion

The purpose of this study is to interrogate my teaching practice and address the barriers preventing students from developing positive Maths Identities and engaging meaningfully with Mathematics. This research is framed by several key issues:

- Understanding how conceptual teaching of Mathematics can positively influence students' engagement, confidence, and attitudes.
- Challenging my assumptions about how students learn Mathematics and evaluating the impact of those assumptions on my practice. This includes interrogating how my

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ontological commitment to democratic education and my epistemological belief in knowledge as co-constructed can be embedded more fully into my Mathematics teaching.

- Examining the limitation of procedural-focused teaching in fostering long-term understanding and engagement.
- Considering how classroom culture, student beliefs, and emotional responses - such as Maths Anxiety – interact with teaching practices to shape students' Maths Identities.

This research is therefore an exploration of my practice through a values-driven lens, seeking to align my teaching more closely with my ontological and epistemological assumptions about education. These assumptions – centred on respect for the learner, collaborative meaning-making, and knowledge as a shared process – position teaching as a democratic and transformative act. By engaging students as co-constructors of knowledge and analysing their lived experiences of Mathematics, I aim to bridge the gap between educational values and my classroom practice.

In this way, the study blurs the boundaries between research and practice. My students are not merely participants in this inquiry; they are collaborators whose voices and experiences shape its direction. This participatory orientation reflects the principles of AR, which Cohen et al. (2018) describe as inherently values-laden, aiming to improve practice through cycles of reflection, action, and refinement.

1.8 Dissertation Overview

This dissertation is structured to provide a clear narrative of how this study was conceived, implemented, and evaluated:

- Chapter Two provides a critical review of literature related to mathematics teaching, Maths Identity, conceptual understanding, and classroom practice. It also outlines the theoretical frameworks underpinning this study.
- Chapter Three details the methodological approach, justifying the use of AR and outlining the research design, teaching intervention, and data collection instruments. It also discusses the ethical considerations and steps taken to ensure trustworthiness.
- Chapter Four presents the findings of the study, focusing on the different dimensions of the research question. It combines student voices, reflective journaling, and

analysis of data to provide a holistic picture of the intervention's impact.

- Chapter Five offers a discussion of the findings in light of the research questions, connecting them back to the literature review and reflecting on their implications for my practice and for Mathematics education more broadly.
- Chapter Six concludes the thesis, synthesising contributions, limitations, recommendations, and directions for future research.

Through this structure, the dissertation demonstrates how a values-driven, reflective approach to teaching – specifically through prioritising conceptual understanding – can support meaningful change in both classroom practice and students' experiences of learning Mathematics. By explicitly centring conceptual understanding as a pedagogical aim, this study contributes to ongoing conversations about how Irish primary education can bridge the gap between procedural proficiency and meaningful mathematical engagement.

Chapter 2: Literature Review

2.1 Introduction

The purpose of this literature review is to establish a clear rationale for teaching mathematics with the aim of achieving Conceptual Understanding (CU) and to examine how such an approach can influence students' engagement, confidence, and overall relationship with the subject. In doing so, it directly supports the central research question guiding this study:

What impact can teaching with the aim of achieving Conceptual Understanding have on my students' engagement, confidence and developing Mathematical Identities?

This chapter has three main objectives. First, it will explore the theoretical underpinnings of Conceptual Understanding, drawing on key research to distinguish it from exclusively procedural approaches to mathematics teaching. Second, it will consider how students' Maths Identities and experiences of Maths Anxiety influence their learning and how these can be positively shaped by conceptual teaching. Third, it will review pedagogical strategies - such as addressing common misconceptions, incorporating Maths Journals, and embedding meaningful contexts, each of which are central to this study's intervention.

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In doing so, the chapter will highlight how existing research and policy support a shift toward meaningful, relational mathematics teaching. It will also lay the conceptual groundwork for the analysis in later chapters, where the impact of these strategies on students' understanding, confidence, and attitudes will be examined.

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The review will proceed by outlining how instructional choices shape students' mathematical experiences, then it will consider Mathematical Identity and Maths Anxiety, and finally it will examine the pedagogical strategies that inform this study.

Traditional models of Mathematics instruction have prioritised procedural fluency over the development of deep conceptual understanding, focusing on speed, accuracy, and memorisation without sufficient attention to the underlying concepts (Skemp, 1976; Willingham, 2009). Although memorisation and procedural fluency are essential components of mathematical proficiency, research indicates they are most effective when developed alongside conceptual understanding (Kilpatrick et al., 2001; Rittle-Johnson and Schneider, 2015). At the same time, other studies emphasise the importance of procedural practice in its own right, particularly for enabling efficiency and supporting more advanced mathematical

Commented [EC25]: do you have any other references to support this description of traditional maths. Look up "reform math" in the USA which was the solution to trad maths...might get some useful info there thinking (Baroody, Feil and Johnson, 2007). This mixed evidence highlights the need to investigate how different emphases on procedural and conceptual teaching influence students' learning and identities.

In response to such concerns, the "reform mathematics" movement in the United States, led by the National Council of Teachers of Mathematics (NCTM), called for curricula that emphasised sense-making, real-world contexts, communication, and mathematical connections, while still maintaining attention to procedural skills (NCTM, 1989, 2000). This shift contributed to the so-called "math wars," where critics argued reform downplayed basic skills, while proponents highlighted its success in developing conceptual understanding and problem-solving.

Research has shown that heavy emphasis on procedural drill can contribute to disengagement (Boaler, 1998) and may exacerbate anxiety or negative self-beliefs in some learners (Dowker, Sarkar and Looi, 2016). Procedural fluency is often contrasted with conceptual understanding, which Kilpatrick et al. (2001) describe as one of five interrelated strands of mathematical proficiency. Unlike procedural knowledge alone, conceptual understanding supports flexibility, problem solving, and long-term retention. This review examines the role of conceptual teaching in developing these proficiencies.

The issue of Maths Anxiety is also central to the research area. Anxiety is both a cause and consequence of poor mathematical experiences and often emerges during the primary years of education (Maloney and Beilock, 2012; Finlayson, 2014). It is frequently associated with experiences of failure, time pressure, or exposure to abstract procedures that lack meaningful context. Identifying and managing MA is therefore a pedagogical concern, not simply an emotional one. Teaching approaches that allow for discussion, exploration of mistakes, and real-world connections have been found to reduce anxiety and build student confidence (Boaler, 2016; Swan, 2005).

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This review also considers the connection between instruction that contributes to conceptual understanding and students' Mathematical Identities. This topic is important because by making learning more relevant, coherent, and supportive, teachers can influence students' beliefs about their ability and enjoyment of the subject. Ultimately, by presenting both the benefits and limitations of procedural and conceptual approaches, the review establishes the rationale for investigating how a conceptual focus might reshape the students' classroom experiences.

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2.2 Mathematical Proficiency

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In mathematics education, the development of mathematical proficiency is widely recognised as a core goal. The National Research Council's landmark report *Adding It Up* (Kilpatrick et al., 2001) outlines five interrelated strands that define mathematical proficiency, which are also reflected in the Primary Mathematics Curriculum (NCCA, 2023: 12).

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- Conceptual Understanding: Comprehension of mathematical concepts, operations, and relationships.
- Procedural Fluency: Skill in carrying out procedures accurately, efficiently, and flexibly.
- Strategic Competence: The ability to formulate, represent, and solve mathematical problems.
- Adaptive Reasoning: Capacity for logical thought, reflection, explanation, and justification.
- Productive Disposition: A positive view of mathematics as useful and belief in one's own competence.

Of these strands, this study focuses primarily on Conceptual Understanding (CU) because of its central role in promoting meaningful learning, reducing anxiety, and supporting the development of positive Maths Identities (Boaler, 2016; Skemp, 1976). When students understand the *why* behind mathematical ideas, they are more able to engage confidently, connect new learning to prior knowledge, and apply their understanding in unfamiliar contexts. By situating CU within this wider framework, this review justifies its emphasis on understanding as the foundation for deeper engagement and longer-term mathematical success.

Contemporary curricula also reflect this integrated vision. The Primary Mathematics Curriculum (NCCA, 2023) places strong emphasis on building understanding, connecting ideas, and applying knowledge to meaningful contexts. These goals align with the idea that all students can develop a positive Maths Identity, especially when learning environments support conceptual or relational understanding rather than just memorisation. This approach is similarly embedded in international frameworks. For example, New Zealand's refreshed Mathematics and Statistics curriculum *Te Mātaiaho* (Ministry of Education (New Zealand), 2023: 14) for Years 0-8 became official policy from 1 January 2025, with phased implementation across Years 0-13 by 2027. Its Purpose Statement makes clear, "as they achieve deep conceptual understanding and procedural fluency in the learning area, students can accurately and efficiently use mathematics and statistics as a foundation for new learning and to solve problems."

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2.2.1 Conceptual Understanding

Conceptual understanding involves grasping the principles and structures underlying mathematical procedures (Kilpatrick et al., 2001). It goes beyond memorising steps to include an understanding of why mathematical ideas work and how they relate to each other. This deeper grasp enables students to solve problems flexibly and to transfer learning to new contexts.

As outlined by Skemp (1976), relational understanding contrasts with instrumental approaches, the latter emphasing rule-following without insight. While instrumental knowledge can yield short-term success, it often leads to fragile learning and frustration when developed exclusively and when students are faced with non-routine problems. In contrast, relational understanding supports meaningful engagement and longer-term retention.

Boaler (2016) argues that students taught for conceptual understanding are more likely to see Maths as logical and connected. This has powerful implications for motivation, enjoyment, and identity. When students understand the logic behind mathematical processes, they are more confident and willing to persist through challenge.

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Curriculum documents reinforce this approach. The *Primary Mathematics Curriculum* (NCCA, 2023: 21) states that students should "develop a robust understanding of mathematical ideas, enabling them to make connections and apply their knowledge in various contexts". Conceptual understanding, therefore, supports both competence and a productive disposition, aligning with the broader goal of nurturing positive Maths Identities.

2.2.2 Procedural Fluency

Procedural fluency refers to the ability to perform calculations and algorithms with accuracy, efficiency, and flexibility (Kilpatrick et al., 2001). It is an essential component of mathematical proficiency, particularly for solving routine problems and building confidence through mastery.

However, procedural fluency developed in isolation can lead to surface-level understanding. Skemp's (1976) concept of *instrumental understanding* cautions against this overemphasis on rule-following without insight. Boaler (2002) similarly critiques traditional, procedure-heavy teaching as alienating and anxiety-inducing, especially for students who struggle to memorise steps without context.

Kilpatrick et al. (2001) argue that fluency and understanding are not competing goals but mutually reinforcing. When students understand *why* procedures work, they are more likely to apply them correctly, adjust them when needed, and retain them over time. Conversely, fluent procedures help students gain confidence and free up cognitive resources for deeper reasoning.

The integration is echoed in the *Primary Mathematics Curriculum* (NCCA, 2023: 32), which states: "Fluency in carrying out procedures accurately and efficiently is essential; however, it should be grounded in understanding to promote flexible thinking."

2.2.3 Conceptual and Procedural – A Balanced Approach

The debate over prioritising conceptual understanding or procedural fluency has shifted toward recognising the importance of both. Research shows that teaching one without the other can be limiting, whereas an integrated approach leads to richer, more transferable learning.

Hurrell (2021: 3) states that "conceptual knowledge supports procedural knowledge, and procedural knowledge helps supports conceptual knowledge," illustrating their reciprocal relationship. Hattie (2009) similarly argues that the most effective learning occurs when students are supported in making links between ideas and processes. Rittle-Johnson and Schneider (2015) provide empirical evidence of this, showing that students who developed both types of knowledge were better able to transfer learning to new contexts than those taught either in isolation. Hiebert and Grouws (2007) also highlight that instruction focusing on connections between ideas improves retention and transfer, reinforcing the value of a balanced approach.

By contrast, approaches that emphasise procedures exclusively – what Skemp (1976) termed instrumental understanding – may support short-term fluency but risk leaving students unable to explain why procedures work or to adapt them in unfamiliar contexts (Ma, 1999; Boaler, 2002). This can contribute to disengagement and the perception that mathematics is arbitrary or inaccessible. Conversely, a purely conceptual focus may leave students without the efficiency and accuracy required for routine tasks (Rittle-Johnson and Schneider, 2015).

The need for balance is therefore clear. Kilpatrick et al. (2001: 115) insist both types of knowledge must be "interwoven" to support true proficiency. Haylock (2010) notes that such integration can also reduce anxiety by giving students both confidence in procedures and understanding of meaning. This alignment is echoed in the Primary Mathematics Curriculum (NCCA, 2023), which highlights that fluency must always be grounded in understanding.

2.2.4 Mismatches in Teaching and Their Impact

Skemp (1976) describes two critical mismatches in teaching:

- When a teacher teaches procedurally but students want to understand conceptually.
- When a teacher teaches conceptually but students expect procedural instruction.

These mismatches can lead to frustration, disengagement, and negative beliefs about Maths. In particular, when students crave understanding but receive only rules, they may conclude that Maths is arbitrary and inaccessible. This can damage confidence and identity (Boaler, 2016; Ma, 1999).

Ma (1999) found that students benefit most when teachers explicitly connect procedures to underlying concepts. Teachers who emphasise both forms of knowledge not only improve mathematical outcomes but also foster positive attitudes. Sfard (1991) refers to this balance as the interplay between *structural* (conceptual) and *operational* (procedural) understanding, both of which are essential.

Mismatches can be avoided by recognising students' developmental needs, anticipating misconceptions, and building coherence between ideas and methods (Carpenter et al., 1989). In this way, conceptual understanding can become the foundation for confident, flexible problem-solving.

2.2.5 Mathematical Knowledge for Teaching

The successful implementation of conceptual teaching depends significantly on teachers' knowledge of both mathematical content and how to teach it effectively. Ball, Thames, and Phelps (2008) conceptualise this as Mathematical Knowledge for Teaching (MKT) - a specialised form of professional knowledge that includes understanding the content itself, anticipating student misconceptions, and selecting or designing tasks that make concepts accessible.

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They outline six interrelated domains within MKT:

- Common Content Knowledge (CCK): the mathematical knowledge used in everyday contexts.
- Specialised Content Knowledge (SCK): deeper, often invisible knowledge unique to teaching, such as recognising multiple solution strategies or analysing student errors.
- Knowledge of Content and Students (KCS): anticipating common misconceptions.
- Knowledge of Content and Teaching (KCT): sequencing content and choosing representations.
- Knowledge of Curriculum (KC): understanding how topics are structured across years.
- Horizon Content Knowledge (HCK): seeing how present learning connects with future mathematics.

Teachers with strong MKT are better equipped to provide clear explanations, make meaningful connections between ideas, and adapt their instruction in response to student thinking (Hill et al., 2005). These abilities are critical for fostering conceptual understanding, as they enable teachers to go beyond procedural instruction and support students in constructing deeper meaning.

Conversely, limited MKT can restrict teachers to surface-level procedural teaching, which may perpetuate misconceptions and disengagement (Ma, 1999). This has implications not only for mathematical outcomes but also for student confidence and identity. In this way, attending to the various domains of MKT is central to supporting conceptual teaching, reducing anxiety, and fostering all five strands of mathematical proficiency (Kilpatrick et al., 2001).

2.3 Beliefs, Identity, and Barriers to Conceptual Understanding

Research shows that from the earliest years of schooling many students develop deeply held beliefs about their mathematical abilities, often viewing themselves as either "maths people" or not (Boaler, 2016). These beliefs can strongly influence their willingness to engage with mathematical thinking. Willingham (2009) suggests that these identities are not necessarily a reflection of true ability but often stem from repeated experiences of confusion or failure. This sense of failure is frequently intensified by instruction that emphasises procedures at the expense of understanding (Skemp, 1976).

When students internalise these failures, they may develop negative Maths Identities – the beliefs, attitudes, and self-perceptions they hold about themselves as mathematical learners (Leathem & Hill, 2010). Boaler (2016) argues that students who believe they are incapable of understanding Maths tend to avoid it altogether, reinforcing a cycle of underachievement and disengagement. These fixed beliefs, often formed early in schooling, can become significant obstacles to developing the conceptual understanding required for deep mathematical thinking.

Leathem and Hill (2010) describe three belief dimensions that influence students' Maths Identities. These include beliefs about what it means to be good at Maths, beliefs about the nature and purpose of the subject, and beliefs about one's own mathematical ability and desire to engage. These dimensions provide a useful framework for understanding how identity is shaped and how it can be influenced by classroom experience.

In their study, which explored secondary students' perceptions of success in mathematics through surveys and interviews, Leathem and Hill asked participants to rate the importance of traits such as "obedience" and "brilliance" for success in Maths. One student, despite being placed in advanced calculus, believed she would never be truly good at Maths because she was not brilliant. This shows how damaging fixed ideas about ability can be, even among high achievers.

These perceptions are often reinforced through procedural-focused teaching instruction (often associated with traditional approaches), which emphasises procedural fluency and rule-following, often with limited attention to meaning-making. Skemp (1976) refers to this as instrumental understanding – knowing how to carry out a rule without knowing why it works. However, it is important to note that not all traditional instruction is exclusively instrumental, and research increasingly recognises the value of combining procedural fluency with conceptual understanding (Kilpatrick et al., 2001). Students who learn mathematics primarily through procedural methods may succeed with familiar tasks but struggle to apply their knowledge in unfamiliar situations. Over time, this can lead to frustration, anxiety, and the belief that they are simply not "maths people". A fuller comparison of procedural-focused, conceptual-focused, and integrated approaches to mathematics teaching is provided in Section 2.4.4.

Alternatively, when students are encouraged to make connections between ideas and to understand the reasoning behind procedures, they develop what Skemp (1976) calls relational understanding - knowing both what to do and why it works. This corresponds to the broader notion of conceptual understanding described by Kilpatrick et al. (2001), which supports flexibility, problem solving, and confidence in mathematics.

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The recently updated Primary Mathematics Curriculum (NCCA, 2023) now places strong emphasis on developing positive dispositions in students, such as confidence, curiosity, and perseverance. These goals align with the idea that all students can develop a positive Maths Identity, especially when learning environments support conceptual understanding rather than just memorisation. This idea is reinforced by wider policy initiatives, with documents like Project Maths (DES, 2010) and the STEM Policy Statement (DES, 2017) also promoting maths teaching that is meaningful and applicable to students' lives.

Beliefs about mathematical ability and the nature of the subject are not fixed; rather they are malleable. Dweck (2006) distinguishes between a fixed mindset – the belief that ability is innate and unchangeable – and a growth mindset, which frames ability as something that can be developed through effort, strategy and feedback. These are shaped by how students experience Maths in the classroom. By teaching for conceptual understanding, we support the development of proficiency while also challenging the psychological barriers that prevent many students from seeing themselves as mathematically capable. Conceptual teaching aligns with a growth-mindset approach because it treats mistakes and struggle as normal parts of learning rather than evidence of low ability. These barriers are closely connected to experiences of Maths Anxiety, which will be explored in the next section.

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2.4 Mathematics Anxiety

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Maths Anxiety (MA) refers to the feelings of tension, fear, or apprehension that can interfere with mathematical performance and engagement (Ashcraft & Moore, 2009). MA is not only an emotional response; it also has cognitive consequences that can disrupt working memory and impair learning. Crucially, it plays a major role in shaping students' Maths Identities, often reinforcing the belief that students are "bad at maths" and creating a cycle of avoidance and underachievement (Boaler, 2016).

In the context of this study, MA is particularly significant because teaching for Conceptual Understanding - by focusing on meaning-making, connection-building, and reasoning – can offer a powerful counterpoint. Research shows that MA is widespread among primary-aged learners and often goes unrecognised (Dowker et al., 2016). Maloney and Beilock (2012) note that even a single negative experience can create lasting anxiety, while Cargnelutti et al. (2017) report that children as young as six can exhibit measurable signs of MA. This provides strong motivation for exploring classroom practices that reduce the conditions typically associated with anxiety.

2.4.1 Defining Mathematics Anxiety

Ashcraft and Moore (2009) describe MA as a sense of tension or uneasiness that arises when individuals engage with mathematical tasks, whether in the classroom or in everyday situations. Tobias (1978) famously captured the extremity of this experience, likening it to a mental "curtain" that drops, cutting off access to reasoning. While dramatic, this metaphor underscores the very real cognitive shutdown that anxiety can cause.

Research shows that high levels of MA impair working memory, the system responsible for holding and manipulating information during problem-solving (Beilock, 2010). Instead of devoting full attention to the task, anxious learners are consumed by negative thoughts and fear of failure (Ashcraft et al., 2007). This leads to poorer performance, which can affirm their negative self-beliefs, reinforcing a fixed mindset and eroding motivation.

2.4.2 How Mathematics Anxiety Develops

Understanding the origins of MA is crucial for developing effective interventions to mitigate its impact. In the context of this study, this discussion is particularly relevant because addressing root causes of anxiety is a necessary step toward creating a classroom where conceptual understanding can flourish (Boaler, 2016; Finlayson, 2014). Recent research identifies several factors contributing to the development of MA:

- Negative early experiences: Public failure, especially in front of peers, can be deeply formative. Maloney and Beilock (2012) note that even one such episode can create long-lasting anxiety and disengagement.
- Rigid, procedural-focused instruction: Finlayson (2014) highlights how this approach, when overemphasing speed and memorisation, discourages curiosity and contributes to the fear of "getting it wrong". In contrast, classrooms that value exploration and reasoning are more likely to support students emotionally and cognitively.
- Societal stereotypes: Widespread cultural beliefs that Maths requires innate talent can create self-fulfilling prophecies, especially for girls and other underrepresented groups (Gunderson et al., 2012). These stereotypes interact with early experiences and teacher messages to undermine students' confidence.
- Individual differences: Students with lower working memory capacity may find Maths tasks more demanding, making them more vulnerable to anxiety in high-pressure or fast-paced environments (Ashcraft & Krause, 2007).

2.4.3 Classroom Implications and Reducing MA through CU

The consequences of MA are far-reaching: diminished confidence, lowered achievement, and ultimately, the formation of negative Maths Identities. If left unaddressed, Maths Anxiety becomes a barrier not only to mathematical success but to participation and enjoyment (Boaler, 2016; Finlayson, 2014).

However, research suggests that teaching for conceptual understanding offers a viable and effective remedy:

- Focus on reasoning over rules: When teachers prioritise explanation over memorisation, students gain a sense of control and agency. This reduces anxiety by showing that mistakes are learning opportunities, not personal failures (Boaler, 2016; Skemp, 1976).
- Normalising mistakes: Activities such as addressing common misconceptions help to

de-stigmatise errors and build resilience. Research by Smith et al. (1993) and Swan (2005) highlights that when misconceptions are surfaced and discussed openly, students are more willing to take risks and reframe errors as part of the learning process, which can reduce anxiety.

- Creating space for dialogue: Student-centred classrooms where questions are encouraged allow students to voice confusion without fear. This supports a safer learning environment and helps teachers better respond to gaps in understanding (Finlayson, 2014).
- Making Maths relevant to real-world contexts: Demonstrating the application of Maths beyond the classroom can increase motivation and participation. The STEM Education Policy Statement (DES, 2017) emphasises that relevance is key for engaging learners, while classroom-based research shows that meaningful contexts also reduce anxiety(Boaler, 2016; Finlayson, 2014).
- Confident, empathetic teaching: The teacher's attitude plays a vital role in shaping the emotional tone of the Maths classroom. When teachers model confidence, adapt flexibly, and respond supportively to student needs, they create a learning space where students feel safe to take risks and engage with challenges. Such an environment is particularly important for conceptual teaching, where students are encouraged to explore, question, and make meaning rather than simply follow procedures. This aligns with research by Hammond (2015), who emphasises that teacher dispositions – particularly empathy and responsiveness – are central to fostering emotionally safe learning environments where anxiety is reduced and engagement can thrive.

2.5 Reflective Tools in Conceptual Teaching

Conceptual understanding does not develop through instruction alone; it requires students to actively reflect, make connections, and express their thinking (Hiebert et al., 1997). In moving towards a conceptual approach to teaching mathematics, certain reflective tools can play a vital role in supporting both students' understanding and their emotional relationship with the subject. Among these, student Maths Journals (Borasi & Rose, 1989; Mevarech & Kramarski, 2014), explicit engagement with common misconceptions (Smith et al., 1993; Swan, 2005), and teaching strategies such as increasing wait time to encourage student

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reasoning (Clarke et al., 2014) have emerged in the literature as valuable approaches that support both cognitive development and affective growth.

2.5.1 Journals as Tools for Thinking and Understanding

Writing about mathematical thinking is increasingly recognised as a powerful method for deepening conceptual understanding. According to Borasi and Rose (1989), journals allow students to externalise their thought process, reflect on problem-solving approaches, and articulate reasoning in a less pressured format. This aligns with Vygotsky's (1978) sociocultural theory, which views language – including written language – as central to the development of higher-order thinking.

Journals also allow students to slow down and move beyond procedural performance, offering space for metacognitive engagement (Mevarech & Kramarski, 2014). When students write about how they approach problems or explain concepts in their own words, they are constructing a deeper understanding rather than rehearsing facts. In this way, journalling becomes a tool that reinforces conceptual learning. At the same time, some studies caution that journalling can be demanding in terms of classroom time and may disadvantage students who struggle with literacy, potentially reducing its effectiveness if not carefully scaffolded (Burns & Silbey, 2000; Miller & England, 1989). Taken together, this suggests that while journals can be powerful tools for conceptual learning, their impact depends on thoughtful implementation.

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From an emotional standpoint, journal writing can reduce anxiety by offering a low-stakes space for expressing uncertainty or confusion (Taylor & McDonald, 2007). Students who may be hesitant to speak up in class are often more willing to reflect honestly in writing, which provides teachers with valuable insight into student thinking and misconceptions.

2.5.2 Addressing Misconceptions

A central aim of conceptual teaching is to uncover and address misunderstandings that obstruct learning. Literature strongly supports the explicit treatment of common misconceptions as an effective pedagogical tool. Smith et al. (1993) argue that misconceptions are not random but represent students' attempts to make sense of new ideas using existing knowledge frameworks.

Rather than ignoring or correcting these errors in isolation, effective conceptual teaching surfaces them deliberately, treating them as opportunities for reasoning and re-conceptualisation (Ball et al., 2008). Techniques such as diagnostic questioning (Jones & Inglis, 2015) or presenting "frequently made errors" helps students confront their own misunderstandings and develop more robust mental models.

This approach aligns with research on Maths Anxiety, which shows that fear of making mistakes contributes significantly to student disengagement (Ashcraft & Krause, 2007). By normalising error and making it visible, teachers can shift the classroom culture from performance-oriented to learning-oriented.

2.5.3 Amplifying Student Voice

Giving students regular opportunities to express their views, reflect on their experiences and ask questions either orally or written, is key to building positive Maths Identities. Boaler (2016) emphasises that students are more likely to develop confidence and motivation when they feel their thinking is valued.

The literature supports this notion. Clarke et al. (2014) found that increasing wait time in mathematics classrooms supported student reasoning and participation. By giving students more space to formulate and share responses, teachers created environments where engagement and deeper learning were more likely. This highlights the importance of classroom practices that amplify student voice.

Classroom environments where student voice is regularly solicited show increased levels of engagement and deeper learning. Encouraging students to comment on their learning, especially on what made something easier or harder, not only improves teaching responsiveness but helps students feel seen as thinkers, not just performers.

This also connects with growth mindset research (Dweck, 2006). When students see learning as developing understanding rather than proving ability, they are more likely to take risks, persist through challenges, and value feedback. Including student voice in the learning process helps create the conditions for these shifts in belief and behaviour.

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2.6 Conclusion

This literature review has examined how teaching for conceptual understanding can support students' mathematical development, particularly in addressing negative beliefs and fostering more positive relationships with the subject. Central to this exploration is the recognition that many students develop negative Maths Identities due to repeated failure, rigid teaching practices, experiences of Mathematics Anxiety (MA; Boaler, 2016; Ashcraft and Moore, 2009). These affect not only how students feel about mathematics, but also how they perform and engage with it.

A key strand running throughout this review has been the role of conceptual understanding in helping students make sense of mathematical ideas, transfer their knowledge, and build confidence. The literature (Skemp, 1976; Kilpatrick et al., 2001; Boaler, 2016) clearly supports the value of relational understanding over purely procedural approaches, particularly in promoting engagement, flexible thinking, and meaning-making. While procedural fluency remains important, it is most effective when developed in tandem with conceptual depth, not in isolation.

Furthermore, mismatches between how mathematics is taught and how students prefer or need to learn can negatively shape their attitudes and beliefs (Skemp, 1976; Ma, 1999). This is especially true when instruction is procedural, and students are seeking conceptual understanding. These mismatches, if left unaddressed, risk reinforcing fixed mindsets, anxiety, and disengagement.

The review also highlighted the importance of teachers' MKT (Ball et al., 2008), particularly in their ability to explain mathematical ideas clearly, respond to misconceptions, and foster meaningful connections. Teachers who are confident and knowledgeable are better positioned to create environments that reduce anxiety and support all strands of mathematical proficiency (Kilpatrick et al., 2001).

Aligned with national and international curricular priorities (NCCA, 2023; Ministry of Education, 2007), this research builds on existing understandings of how teaching with the aim of achieving conceptual understanding can positively shape student attitudes, beliefs, and outcomes in mathematics. By embedding CU in practice, this research aims to explore how learners can develop stronger Mathematical Identities and experience success through deeper engagement with the subject.

Chapter 3: Methodology

3.1 Introduction

This chapter outlines the methodology used in this Action Research (AR) study. It begins by presenting the rationale for choosing an AR paradigm and describing the research setting and participants. It then moves on to a detailed explanation of the intervention, including the structure of lessons implemented during the study, followed by a description of the research design and AR cycles. This is complemented by a discussion of the data collection instruments, including how and when they were used, and the rationale for their selection. Ethical considerations such as consent, assent, confidentiality, data storage, and power dynamics are also addressed.

The intervention is outlined in Section 3.5. While the focus of the intervention is to develop conceptual understanding, it is important to note that this sits within the broader context of developing mathematical proficiency, as described in Section 2.3 of the Literature Review. According to Kilpatrick et al. (2001), mathematical proficiency consists of five interrelated strands: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and a productive disposition. This research emphasises conceptual understanding because of its potential to shape how students think about Maths, but the other strands are recognised as essential and complementary.

3.2 Action Research Paradigm

A research paradigm refers to the set of beliefs and assumptions that guide how knowledge is understood and generated. According to Cohen et al. (2018: 8), paradigms are "ways of looking at the world, different assumptions about what the world is like and how we can understand or know about it." For this study, an AR paradigm was chosen, as it aligns with both the aims of the research and my own professional values. Specifically, AR allows me to investigate and improve my teaching practice in real time, focusing on fostering conceptual understanding and reducing negative student attitudes towards Mathematics – goals that reflect my belief in education as a tool for meaningful, transformative learning.

Bassey (1999) outlines three key paradigms in educational research: positivist, interpretivist, and AR. AR is most appropriate for practice-based inquiry, where the aim is not simply to observe phenomena, but to improve practice through cycles of action and reflection. Piggot-Irvine, Rowe and Ferkins (2015: 548) define AR as "a collaborative transformative approach with joint focus on rigorous data collection, knowledge generation, reflection and distinctive action/change elements that pursue practical solutions." Unlike traditional educational research where the researcher remains external, in AR the researcher is embedded within the context — what McNiff and Whitehead (2010) call a "self-study" perspective.

While the term A*ction Research* can be applied across a range of professional contexts, Educational Action Research (EAR) refers specifically to inquiry conducted by educators within their own schools or classrooms. Cohen, Manion and Morrison (2018) explain that while general AR focuses on personal or organisational change, EAR places a particular emphasis on curriculum, pedagogy and student learning outcomes. This form of research is inherently tied to the dual identity of the teacher as both practitioner and researcher, with the goal of improving practice *and* generating useful, context-rich knowledge. In this study, the focus on Maths Identity, conceptual learning, and classroom environment aligns strongly with this educational AR orientation.

My decision to use an AR paradigm is rooted in my belief that negative Maths Identities are not inherent, but can be changed through reflective, values-driven teaching. These values include a commitment to conceptual understanding as the foundation for meaningful learning (Skemp, 1976), a belief in teachers' responsibility to develop strong Mathematical Knowledge for Teaching (Ball et al., 2008), and an understanding of education as a democratic, inclusive process where knowledge is co-constructed (Freire, 1970; Vygotsky, 1978). This aligns with Glenn, Curtis and Naughton (2023, p.17), who describe AR as a "deeply values-based" methodology, often triggered when practitioners realise they are acting in contradiction to what they believe in — what Whitehead (1993) calls a "living contradiction." Framing the study in this way underscores the central role in both methodology and practice, a theme I return to in the final chapter when reflecting on my professional learning.

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In my case, the *living contradiction* lay in recognising that, while I wanted my students to view Mathematics as meaningful and achievable, my earlier reliance on procedural methods often reinforced the very negative identities I hope to change. This realisation prompted me to adopt an AR approach, enabling me to align my practice more closely with my belief in conceptual, student-centred learning.

In this study, I seek to examine how teaching for conceptual understanding — supported by meaningful contexts and emotionally safe pedagogy — might positively impact students' engagement, confidence, and attitudes toward Maths. The AR process enables me to reflect critically on my role in shaping student experiences and to iteratively adapt my teaching through cycles of planning, acting, observing and reflecting (McNiff and Whitehead, 2006).

While AR focuses on improving one's own practice, it also has a social aim — to influence others' learning. McNiff and Whitehead (2010: 19) describe this dual purpose, stating that the aim of AR is to "improve my practice and behaviours as a teacher in order to contribute to other people's learning to help them improve their behaviours." In this study, that dual focus means not only refining my own teaching of Mathematics but also generating insights that could inform colleagues' practice and contribute to broader discussions on fostering conceptual understanding in primary education.

3.3 The Role of Reflection in Action Research

While reflection is embedded in the AR cycle, I also drew on more formal models of reflective teaching to strengthen the rigour of this inquiry. Schön (1983) distinguishes between "reflection-in-action" (thinking while teaching) and "reflection-on-action" (thinking after the fact), both of which will are used in this study.

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Brookfield (1995) argues that critical reflection involves questioning taken-for-granted assumptions and using multiple sources of feedback to inform change. This study used student journals, student voice, and questionnaires as feedback loops to prompt that questioning. In particular, students' reflections often highlighted what they valued about conceptual teaching. For example, when several students noted in their journals that they appreciated knowing the "why" behind VAT or Interest, it indicated that conceptual framing was not only effective but also highly valued by learners themselves.

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In this way, reflection was not an afterthought but a central driver of the research design, ensuring that each cycle was grounded in lived classroom realities and responsive to student needs.

3.4 Research Design: Action Research Cycles

Action Research (AR) is typically structured as an iterative cycle of planning, action, observation, and reflection, allowing practitioners to continuously refine their practice in response to emerging insights. This process, often described as a spiral, highlighting its iterative and evolving character rather than a simple closed loop (Kemmis & McTaggart, 1988). Each phase informs the next: planning involves identifying an area for improvement and designing an intervention; action refers to implementing that plan in practice; observation focuses on systematically gathering evidence about its effects; and reflection involves critically analysing outcomes to inform future cycles. This cyclical approach ensures that learning is embedded within authentic classroom contexts and evolves through practitioner responsiveness.

In this study, two full AR cycles were undertaken, drawing on the four-phase structure proposed by McNiff and Whitehead (2006): *Plan, Act, Observe, Reflect*. This cyclical process allowed for ongoing inquiry, adaptation, and improvement within the real-time context of the classroom. Each phase was deliberately documented and informed by student responses, my reflective teaching journal, and classroom-based evidence such as student work and observations.

3.4.1 Cycle 1

Cycle 1 commenced on the 10th of February 2025 and included three topics (Lines and Angles, Money and The Circle) taught over four instructional weeks, with a midterm break occurring after Week 1. The initial planning phase focused on developing lessons that prioritised conceptual understanding, emotional safety, and meaningful contexts. Specific strategies for delivering this conceptual approach are outlined in Section 3.5 (Teaching Intervention).

Lessons were implemented with flexibility, incorporating adjustments made in response to classroom dynamics and emerging student needs. Observations were recorded through my reflective journal, student journals, photographs of work samples, and informal dialogue with students. I paid particular attention to student engagement, emotional responses, and depth of reasoning.

Reflection took place after each lesson and was captured through my teacher journal. These reflections documented my evolving practice and highlighted areas for refinement, including the need for clearer sequencing, more explicit connections to students' real-world experiences, and earlier integration of misconception strategies. Access to the students' Maths Journals provided particularly helpful insights to guide adaptations within and between cycles.

3.4.2 Cycle 2

The second cycle built directly on the findings from Cycle 1 and took place from March 25th to April 11th, 2025, covering the topics of 3D Shapes and Chance. Over this period, approximately 13 lessons were delivered, maintaining the same 50-minute structure outlined in Section 3.5.

New lesson components were introduced during Cycle 2 to address recurring student misunderstandings identified in Cycle 1. For example, slides explicitly highlighting and explaining common conceptual errors were developed to help normalise mistakes and deepen student reasoning. Similarly, prompts in the Maths Journals were refined to encourage students to express their thinking more clearly and reflect on their processes in greater depth.

This reflective and iterative process exemplifies the dynamic nature of AR. McNiff and Whitehead (2010) describe AR as cyclical, often represented as a spiral to emphasise its iterative and evolving character. In my case, each cycle led to deeper insight, not only into student learning but into my own identity as a teacher committed to conceptual clarity and emotionally safe pedagogy.

3.5 The Teaching Intervention

This section outlines the design and implementation of the teaching intervention, explaining how lessons were planned and delivered across the two AR cycles. The intervention, implemented across both AR cycles, aimed to develop conceptual understanding within the broader framework of mathematical proficiency (Kilpatrick et al., 2001). As outlined in Section 2.3, conceptual understanding is a core strand of mathematical proficiency and was prioritised because of its potential to improve student engagement, reduce Maths Anxiety, and support the development of positive Maths Identities (Boaler, 2016; Skemp, 1976).

In planning the intervention, it was necessary to consider both curricular goals and logistical factors. The lessons were designed using the Primary Mathematics Curriculum (NCCA, 2023) to ensure alignment with national expectations. Key Learning Outcomes for each topic – Lines and Angles, Money, The Circle, 3D Shapes, and Chance – were identified and are summarised in Appendix IV. I deliberately avoided relying on procedural 'rules' unless I could explain the underlying reasoning, encouraging students to seek understanding rather than memorisation. Teaching for conceptual understanding required more time than traditional methods, as lessons often involved extended discussion and the unpacking of abstract ideas. As a result, some topics took longer than initially scheduled, but this was necessary to ensure deeper comprehension.

The pedagogical strategies were grounded in research highlighting the need to connect conceptual understanding with procedural fluency. Approaches such as visual models, worked examples, and real-life applications were central to lesson design. For example, using an area model to explain long division can build both understanding and fluency (Boaler, 2016). Other strategies included embedding mathematics in meaningful contexts, explicitly addressing misconceptions, and integrating reflective tools such as maths journals. These strategies were not only supported in the literature but also shaped the practical choices made in this intervention.

To establish starting points for instruction, assessment for learning tasks were carried out at the beginning of each topic. These helped me identify students' prior knowledge and avoid both unnecessary repetition and premature complexity. To further promote a culture of inquiry and critical thinking, I encouraged students to "ask me a question" before we moved on, instead of relying on prompts such as "does that make sense?" which often lead to superficial agreement. This approach aimed to elicit genuine engagement and deeper questioning.

The intervention was applied across five curricular areas – Lines and Angles, Money, The Circle, 3D Shapes and Chance – between February and April 2025. While each topic had unique content, the same pedagogical approach was applied throughout: lessons were carefully structured to support conceptual understanding, create emotional safety, and promote engagement.

3.5.1 Lesson Structure

The intervention followed a consistent lesson structure designed to combine teacher clarity, collaborative discussion, and independent practice. Table 3.1 outlines the typical 50-minute lesson format, which was then expanded upon in the subsections that follow.

Time	Step	Explanation
5 Minutes	• Share the Learning Intention. • Reminder to keep *why* at the forefront of our minds.	• Explaining to the students what I hope for them to have achieved by the end of the lesson.
5 Minutes	• Assessment for Learning.	• What do the students already know?
10 Minutes	• Concept Introduction. • Meaningful Connections.	• Linking topic with meaningful examples. • Beginning to teach topic – Direct Instruction
15 Minutes	• Common Misconceptions. • Guided Practice.	• Explanation of common mistake ideas and/or approaches. • Students and teacher work through questions on the whiteboard together.
10 Minutes	• Independent work. • Correction of questions.	• Could be questions from a workbook. • Allows teacher to circulate room for 1-1 if needed.

5 Minutes	• Refer back to learning intention. • Questions for question box.	• Did we achieve learning intention, or do we need another day? • Are there any further questions for me or the question box?

Table 3.1: Lesson Structure

3.5.2 Making students aware of the Learning Intention

Each lesson began by clearly communicating the learning intention to students, which was displayed on the board and discussed at the outset. Hattie (2009) highlights the importance of teacher clarity as a major influence on student achievement – noting that clearly defined goals help students understand what is expected and why it matters. Similarly, Fisher et al. (2016) argue that when learning intentions are made explicit, students are more likely to recognise the relevance of the lesson and remain focused on the underlying concepts.

3.5.3 Remember the 'Why'

A key message I wanted to embed in the classroom culture was the importance of understanding *why* we do what we do in Maths. To reinforce this, I displayed the phrase "*Remember the Why*" prominently above the whiteboard and referred to it regularly throughout lessons. This daily reminder encouraged students to ask questions, seek meaning, and engage with the underlying concepts rather than rely on surface-level procedures. Because conceptual understanding was central to my teaching, this mantra signalled to students that making sense of the mathematics was more important than simply arriving at the right answer.

3.5.4 Assessment for Learning

Where a topic was new, an initial assessment for learning (AfL) task was conducted to establish students' prior knowledge. This formative approach helped ensure an appropriate entry point for instruction and avoided both unnecessary repetition and premature complexity. AfL is widely recognised as a tool for responsive teaching that enhances learning outcomes. Black and Wiliam (1998) famously highlighted its importance in shaping instruction and improving student achievement, and in this study, it provided valuable insight into the class's baseline understanding, allowing me to tailor lessons accordingly.

3.5.5 Maths Journal Prompt Questions

Before introducing new material, students were presented with a prompt question to answer in their Maths Journals. These questions did not always involve numerical problem-solving but were designed to spark mathematical thinking and dialogue. As Mertler (2019) notes, reflective writing enables learners to process new ideas, make connections, and surface misconceptions – all of which were essential for building conceptual understanding in this intervention.

3.5.6 Conceptual Instruction and Meaningful Connections

The core of each lesson was devoted to teaching for conceptual understanding. Rather than relying on rote procedures or isolated rules, I emphasised *why* mathematical concepts work, using carefully chosen examples and classroom discussion to build deep, relational knowledge. Boaler (2016) argues that when students understand the meaning behind mathematical ideas, they become more confident, flexible thinkers and are better able to transfer their understanding to new contexts.

For example, when teaching VAT, I drew on my own experience working in a hardware store, explaining how inputting stock, applying VAT rates, and setting prices affected the business – including the consequences of forgetting to include VAT. I also connected the concept to students' lives, referencing one student's father who ran his own business and claimed back VAT. These deliberate links to both everyday and professional contexts helped students see mathematics as purposeful, while also supporting the development of positive Maths Identities. As Sullivan et al. (2016) note, when students connect learning to real-life probabilities, they are more likely to value the subject and imagine themselves using it in the future.

3.5.7 Addressing Common Misconceptions

In the final two weeks of the study (Cycle 2), during the Chance topic, I incorporated the use of "Common Misconception" slides into my instruction. These were prepared in advance and shown during lessons to spotlight typical errors related to the concept being taught. Each slide presented a mistaken idea - sometimes drawn from research, other times based on misconceptions I had observed in class. These slides helped to reduce Maths Anxiety by making errors visible and normalising them. Students often commented that they had made similar mistakes and expressed relief when they saw that other people had thought the same.

Boaler (2016) emphasises that directly confronting misconceptions supports deeper learning, while Swan (2005) argues it fosters cognitive conflict - a catalyst for change in thinking. Askew (2012) adds that tackling misconceptions in a low-stakes environment can build students' confidence and resilience.

3.5.8 Independent Practice

Students were given the opportunity to engage in independent work, consolidating their learning through tasks designed to apply the concepts covered. During this time, I circulated the room to offer one-to-one support where needed. This blend of guided and independent learning reflects Vygotsky's (1978) concept of the Zone of Proximal Development, in which learners progress most effectively when supported just beyond their current level of mastery.

3.6 Research Site

The study was conducted in a senior primary school (3^{rd} - 6^{th} Class) in a suburban area in Co. Dublin. The school has approximately 300 students across 14 mainstream classes and one special educational needs class. It is adjacent to a feeder junior school (Junior Infants – 2^{nd} Class), providing a seamless educational transition for students within the community.

The school has DEIS status, meaning it participates in the Department of Education's programme for Delivering Equality of Opportunity in Schools. This context is important, as students in DEIS schools may be more likely to experience lower academic confidence or hold negative views about their abilities (Smyth et al., 2006). The student body is diverse, reflecting a range of cultural backgrounds and learning needs.

My own Sixth Class of 22 students (aged 11-12) formed the focus of this research. Among them was one child with autism who followed an individualised curriculum and spent much of the day in the special educational needs classroom, and four students who attended differentiated learning groups for targeted Mathematics support. Consequently, the typical number of students present during my Maths lessons was 17.

The school is known for its supportive and child-centred ethos, with a strong emphasis on ensuring students feel safe, welcomed and motivated. The staff are committed to prioritising student well-being and engagement. Although this was my first-year teaching at this particular school, I brought four years of teaching experience in the senior classes to the role and joined the Mathematics curricular group, collaborating with colleagues to enhance the teaching and learning of Mathematics across the school.

The setting was particularly suitable for the study due to observed low motivation toward learning and academic work in general, alongside noticeable negative attitudes towards Mathematics. Many students were accustomed to a procedural style of Maths instruction – a tendency described by the National Council for Curriculum and Assessment (NCCA, 2005) as highly didactic and focused on rote procedures - making the introduction of conceptual approaches both unfamiliar and potentially transformative. My dual role as teacher and researcher enabled me to build trust, observe emotional responses, and document change over time – a key feature of AR (McNiff & Whitehead, 2010). Further analysis of Irish mathematics textbooks indicates that while the Project Maths reform created more opportunities for problem-solving, tasks continue to rely heavily on routine procedures (O'Sullivan, Breen & O'Shea, 2023). This broader national picture helps contextualise why students at primary level may also be accustomed to procedural teaching.

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3.7 Sampling

A convenience sampling approach was used, as the research took place within my own classroom where I was both teacher and researcher (Cohen, Manion and Morrison, 2018). All students in the class participated in the lessons as part of their normal classroom learning. However, only those who provided informed assent, along with parental consent, were included in the formal data collection.

In total, 17 out of 22 students returned signed consent and assent forms. This provided a varied sample with a mix of abilities and learning needs, allowing for meaningful analysis while adhering to ethical considerations appropriate for classroom-based research (BERA, 2018).

3.8 Data Collection Instruments

Sullivan et al. (2016: 79) advise that "in deciding how to gather data, be creative and seek out ways that are relevant and valid in your own context". To achieve this, I used multiple instruments to gather complementary types of data, supporting triangulation (Cohen et al., 2018). This strengthened the credibility by allowing me to cross-check themes across different sources.

The instruments captured students' beliefs, attitudes, levels of anxiety, and reflections on their learning, providing both quantitative and qualitative insights needed to answer the research question. The following subsections outline each instrument and its purpose.

3.8.1 Questionnaires

Questionnaires gathered both qualitative insights and quantitative measures about students' beliefs regarding mathematics and their perceptions of their own mathematical competence. The literature indicates that these beliefs are contributing factors to the participants' Maths Identities. Consistent with the literature, these beliefs fall into three broad categories: beliefs about mathematics, beliefs about the effectiveness of mathematics, and Maths Anxiety. For the first two categories, questionnaires created by Leathem & Hill (2010) were used and for the third category, the Abbreviated Math Anxiety Scale (AMAS) was used. All three questionnaires were adapted slightly to ensure age-appropriate language and comprehension for the participants. The three questionnaires are presented below.

3.8.1.1 Beliefs about Maths Ability

This questionnaire (see Appendix III) is a descriptive word task which Leathem and Hill (2010: 226) explain "can reveal students' beliefs about what it means to be good at mathematics". Students were given a number line ranging from 0 to 5 as well as a list of fifteen adjectives such as *curious, motivated,* and *organised.* On the scale, 0 indicated that the word does not describe someone who is good at maths, while 5 indicated that it strongly describes someone who is good at maths. The instruction on the task reads "*Place each of these words on the number line according to how well you think the word describes someone who is good at maths.*"

Commented [EC44]: what does either end of the scale mean/ imply?

This gave me insight into the traits my students associate with mathematical competence – a core part of their Maths Identity. For example, if students associated success with traits they did not see in themselves, such as being *gifted*, this helped to explain negative attitudes or low confidence.

3.8.1.2 Beliefs about the Effectiveness of Mathematics

This questionnaire (see Appendix III) allowed me to investigate if any students view Mathematics as something that only has academic relevance and no meaning outside of school. Leathem and Hill (2010: 228) explain that this mathematical category task "is a valuable tool that can help students consider how they themselves define mathematics". The students were presented with twenty-eight tiles, each of which has a different activity written on it. The students were asked what, if any, maths is used in the given activities. The activities ranged from what may be deemed as obvious maths-related examples (playing sudoku) to less obvious examples (hanging a picture on the wall).

3.8.1.3 Mathematical Anxiety

The Abbreviated Maths Anxiety Scale (AMAS) (see Appendix III) allowed me to gain deeper insight into students' anxiety levels when approaching Mathematics lessons, starting new topics, or preparing for tests. Understanding these levels was highly relevant to the study as Maths Anxiety can significantly affect students' engagement, confidence, and willingness to persist with challenging tasks. Since a key aim of this research was to explore how conceptual teaching might reduce negative attitudes and promote positive Maths Identities, establishing a baseline and post-intervention measure of anxiety was essential for evaluating the intervention's impact.

Schillinger et al. (2018) explain that the AMAS is comprised of 9 items which are responded to using a 5-point Likert-type scale, ranging from 1 (low anxiety) to 5 (high anxiety). It consists of two subscales: Learning Math Anxiety (LMA) for example, "Listening to another student explain a math formula", and Maths Evaluation Anxiety (MEA) - for example, "Thinking about an upcoming math test one day before". For each student, the total score is the sum of the nine items (Hopko et al., 2003).

3.8.2 Maths Journals

Maths Journals were employed as a central data collection instrument to capture students' reflections and evolving perceptions of Mathematics throughout the research intervention. A sample list of prompt questions used in the Maths Journals is included in Appendix VII. Prompt questions were designed to encourage pupils to articulate their attitudes towards Maths, their understanding of key concepts, and their responses to the teaching approaches used. This reflective practice provided insights that may not have emerged through observation alone, offering a more nuanced view of student thinking. Consistent with Brookfield's (1995) emphasis on adopting the learner's perspective, the journals helped me to better consider classroom experiences from the students' point of view, making it possible to identify both the conceptual and emotional dimensions of their engagement. This data was vital for answering the research question, as it offered direct evidence of how the intervention influenced students' understanding, attitudes, and developing Maths Identities over time. As Mertler (2019) notes, written reflections can empower learners to make sense of their engagement with the subject.

3.8.3 Reflective Journal

Sullivan et al. (2016) argue that reflective journaling enables teachers to recognise changes in their thinking and practice, and that this process is central to developing theory from professional experience. The reflective journal in this study was used to document my observations, thoughts, and reactions throughout the research. This instrument allowed me to critically evaluate my teaching methods, student responses, and the effectiveness of interventions in real time. My reflective journal was particularly valuable in informing the refinements made in Cycle 2.

3.8.4 Photographs

Photographs of student work and classroom activities documented the learning process and captured evidence of engagement and understanding. These images served as qualitative data and were used within the thesis to illustrate key findings and convey the impact of the intervention visually. They include visual representations of conceptual understanding, examples of student work that demonstrate progression in understanding, and photographs of hands-on activities to build conceptual connections.

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A summary of the data collection instruments, their purposes, and the timing of their use across the two AR cycles is provided in Table 3.2 below.

Instrument	Purpose	Timing
Teacher Observation & Reflective Journal	To document lesson delivery, student engagement, emerging misconceptions, and pedagogical reflections.	Ongoing throughout both cycles
Maths Journals	To capture students' reflections on their understanding, attitudes, and responses to the teaching approaches.	Ongoing throughout both cycles
Questionnaire on Maths Beliefs	To explore students' initial beliefs about Maths and their perceptions of what it means to be "good at Maths."	Week 2
Abbreviated Maths Anxiety Scale (AMAS)	To establish a baseline and measure any shifts in students' Maths Anxiety.	Week 1 (Pre-intervention) & Week 7 (Post-intervention)
Photographs of Student Work	To visually document engagement, conceptual understanding, and progression in learning.	Weeks 3 and 5
Questionnaire on Effectiveness of	To gather student perspectives on the impact of the conceptual teaching approach.	Week 6

Maths

Table 3.2: Overview of Data Collection Instruments and Timing

3.9 Trustworthiness

While the dual role of teacher and researcher may introduce potential limitations, such as the possibility of bias or the influence of the teacher's authority on student responses, this positioning is also a defining feature of AR. To address these challenges, I implemented several strategies to enhance the trustworthiness of my findings.

First, I prioritised using the students' voices as the primary source of data. Through Maths Journals, questionnaires, and classroom dialogue, students were unable to express their experiences and perceptions in their own words, minimising the risk that my interpretations would overshadow their perspectives. Where interpretation of their responses was required, I actively engaged in reflexive practice, questioning my own assumptions and considering alternative explanations before drawing conclusions. Input from my critical friend – the learning support teacher working with students in my class – further reduced the potential for individual bias by providing an external perspective on my interpretations. This emphasis on student voice directly served the focus on engagement, confidence, and identities.

Second, triangulation was central to establishing credibility. Multiple data sources – questionnaires, AMAS results, Maths Journals, photographs of student work, classroom observations, and my reflective journal – were used to confirm and cross-verify findings. This approach allowed me to identify patterns that were consistent across different types of evidence, strengthening the plausibility and depth of my conclusions.

Finally, validity was supported through transparency and consistency in the research process. Data collection and analysis were conducted systematically, with iterative cycles of planning, acting, observing and reflecting ensuring responsiveness to emerging insights. My reflective journal created a clear and traceable record of decisions, interpretations, and changes to practice, contributing to the overall dependability and confirmability of the research.

3.10 Ethical Considerations

In conducting this study, several ethical considerations are essential to ensure the research adheres to professional and ethical standards. Ethical approval was granted by my supervisor before any of the cycles were carried out. I was guided by the Maynooth University Research Ethics Policy throughout the study.

Consent and assent were prioritised to respect the autonomy of all participants, requiring both parental consent and student assent before data collection as the participants in my research were under eighteen. Measures to minimise risk of harm were implemented to create a safe and supportive environment, avoiding any undue stress or discomfort related to discussions of Maths Anxiety or performance. Confidentiality and anonymity were upheld to protect the identities of the students, ensuring that all collected data cannot be traced back to the school or students. Given the dual role of teacher and researcher, addressing power dynamics is critical to ensure students feel free to participate honestly and voluntarily without fear of negative repercussions. Finally, data storage protocols were established to securely store all data in compliance with institutional guidelines. All of these considerations are now discussed in the section below in further detail.

3.10.1 Informed Consent

To ensure ethical participation, informed consent was sought before the research began. Cited in Cohen (2018: 122) Diener and Crandall (1978: 51) define informed consent "as those procedures for individuals to choose whether or not to participate in the research, once they have been told what it is about and what it requires". As I am working with children for this research, I am obligated to obtain consent from parents (see Appendix I) on their child's behalf as well as the child's (the participant's) assent (see Appendix I). To achieve this, parents received detailed information sheets (see Appendix I) explaining the study's purpose, methods and their child's role. These documents emphasised that participation is voluntary and that they or their child could withdraw at any time without repercussions.

Student assent was gathered through both written and verbal explanations of the study, presented in age-appropriate language to ensure clarity (see Appendix I). Where English was an additional language, I checked understanding carefully and used simplified explanations to make sure all students could make an informed choice.

No data collection occurred until both consent and assent were secured. Parents and students were encouraged to ask questions at any stage, with my contact details provided in the information letter to facilitate open communication. In practice, no questions or responses were received, which I interpreted as an indication that the information provided was clear and sufficient for informed decision-making.

3.10.2 Minimising Risk of Harm

According to Cohen et al. (2018: 127) "the research should not damage the participants physically, psychologically, emotionally, professionally, personally and so on". They explain that it is the responsibility of both the researcher and participants to examine possible consequences of the research. This was a core ethical priority in the design and implementation of the study.

Although the intervention was considered low-risk, possible consequences included students feeling embarrassed if they struggled with a concept in front of peers, becoming more aware of their own Maths Anxiety, or experiencing frustration during unfamiliar tasks.

To mitigate these risks, all research activities were embedded into regular classroom routines to minimise disruption and maintain a sense of familiarity. Sensitive topics such as anxiety were handled carefully and always framed in constructive, forward-looking ways. One key strategy was the use of *Common Misconception* slides, which normalised mistakes by showing that misunderstandings were a regular and expected part of the learning process. In addition, anonymous surveys and questionnaires gave students safe spaces to express their thoughts and experiences without fear of judgement. Together, these measures helped reduce the emotional risk and support a psychologically safe learning space.

Moreover, the potential benefits of the study - such as fostering greater mathematical confidence, reducing anxiety, and improving students' engagement with the subject – were considered to significantly outweigh these minimal risks. This balance of risk and benefit was central to the ethical justification for carrying out the research.

3.10.3 Power Dynamics

Brooks et al. (2014: 106) say that "power relations are immanent in all research settings" and when it comes to AR there may be a perceived line separating teacher and students. Cohen et al. (2018) highlight the point that when working with children, it is vital they feel at ease and important in the research. As both teacher and researcher, mitigating power dynamics is crucial to ensure that students feel free to participate without coercion or consequences. Students were assured that their decision to participate or their responses would not impact their standing in the class or relationship with the teacher. Given my dual role as teacher and researcher, I remained aware of the potential for social desirability bias — a phenomenon where participants may adjust their responses to align with perceived expectations, rather than expressing their genuine views (Nederhof, 1985; Grimm, 2010). This is when students may tell the teacher what they think the teacher wants to hear, rather than expressing their true thoughts and feelings. To mitigate this risk, students were assured that their honest reflections, whether positive or critical, were equally valued and would not impact their standing in the classroom.

As the research was carried out as part of my normal mathematics lessons, any student who did not choose to participate in the study was still fully engaged in the learning. However, data was not collected from these individuals.

3.10.4 Confidentiality and Anonymity

Confidentiality and anonymity were essential in ensuring data was ethically gathered. Confidentiality was achieved through "not disclosing information from a participant in any way that might identify that individual or that might enable the individual to be traced" (Cohen et al., 2018: 130). With regards to anonymity, "a participant is considered anonymous when the researcher or another person cannot identify the participant from the information provided" (Cohen et al., 2018: 129). Anonymity is a way of applying confidentiality.

In this research, pseudonyms were assigned to all participants, and identifying details were excluded from the final thesis. Raw data, such as survey and questionnaire responses, were anonymised before data analysis to ensure that individual students could not be identified from the data or conclusions.

To track pre- and post-intervention responses while maintaining anonymity in the final reporting, a key linking pseudonyms to individual students was created. This key was stored separately from the raw data in a password-protected digital file accessible only to me as the researcher. This allowed for meaningful analysis of change over time without compromising confidentiality.

It is not unusual for a class teacher to keep records on all their students including assessment notes and observations to inform practice. As such, some data was not anonymised during collection to allow for differentiation and instructional planning. However, this data was not shared as part of the research process.

3.10.5 Data Storage

Digital files such as typed transcripts were stored on a password-protected device only accessible to the researcher. Physical copies of consent forms were kept in a locked drawer.

All data, both physical and digital, were stored in accordance with Maynooth University's *Research Data Management Policy,* which mandates secure, encrypted storage, restricted access, regular backups, and appropriate retention to ensure ethical reliability and research integrity (Maynooth University, 2021). The data will be stored for a period of six years in accordance with this policy.

3.11 Data Analysis

Commented [EC46]: you need something on AMAS

The qualitative data generated during both research cycles were analysed using Braun and Clarke's (2006) six-phase framework for thematic analysis. This provides a systematic yet flexible approach to identifying and interpreting patterns in the data.

The process began with repeated reading of all student Maths Journals, classroom discussion notes, and entries from my reflective teaching journal to ensure familiarity. An inductive coding process was then applied, in which a broad set of initial codes was generated from the data without imposing pre-existing categories. These codes were subsequently reviewed and refined, with similar or overlapping codes being merged where appropriate.

Student journal entries were analysed first to ensure that student voice remained central to theme development. These were then triangulated with classroom discussion notes and my reflective journal to enhance the credibility and trustworthiness of the findings.

The initial coding process produced four major thematic areas. However, ongoing analysis identified overlap between some of these areas, leading to their consolidation into three final themes that best represented the core findings. A sample of the coding framework, showing how raw data developed into codes and themes, is provided in Appendix V, with a full list of initial codes in Appendix VI.

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Alongside this qualitative analysis, quantitative data from the adapted Abbreviated Maths Anxiety Scale (AMAS) were analysed descriptively. Pre- and post-intervention mean scores were calculated for each of the nine items and compared to identify patterns of change in students' reported anxiety levels. Given the small sample size (n = 16), no inferential statistics were applied; instead, the descriptive results are used to complement the qualitative findings, providing an additional lens on how the intervention influenced students' experiences of Mathematics.

3.12 Conclusion

This chapter outlined the methodological approach taken to explore how teaching for conceptual understanding can influence students' Mathematical Identities and reduce Maths Anxiety. It described the AR design, the teaching intervention, and the range of qualitative and quantitative data collection methods used to capture both cognitive and affective dimensions of student experience. Ethical considerations, sampling procedures, and the rationale for each methodological choice were also detailed to ensure transparency and rigour.

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The chapter concluded by explaining the inductive thematic analysis process, which combined student voice, classroom observations, and my reflective journal to generate themes grounded in multiple data sources. The multi-perspective approach was chosen to enhance credibility and to ensure that the findings reflected the lived experiences of the participants as authentically as possible.

The next chapter presents the results of this analysis, beginning with an overview of the themes and moving into detailed exploration of how the intervention shaped student engagement, confidence, and perceptions of mathematics.

Chapter 4: Data Analysis

4.1 Introduction

This chapter presents the analysis of qualitative data collected during Cycle 1 and Cycle 2 of this AR study, which explored how teaching for conceptual understanding can positively influence students' Maths Identities and reduce Maths Anxiety. The analysis draws on three primary data sources: student Maths Journals, classroom discussion notes, and my reflective teaching journal, as well as quantitative data from the adapted Abbreviated Maths Anxiety Scale (AMAS).

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Thematic analysis was conducted using Braun and Clarke's (2006) six-phase framework, providing a systematic yet flexible process for identifying patterns in the data. This process enabled the development of themes that were firmly grounded in student voice while supported by triangulation with classroom observations and teacher reflections. The AMAS data were analysed descriptively to compare pre- and post-intervention responses, providing an additional lens on changes in students' reported anxiety.

Three themes emerged from the analysis, each representing a significant pattern in how students engaged with and responded to conceptual teaching:

1. **Meaningful Contexts Enhance Engagement**
2. **Conceptual Understanding Builds Confidence**
3. **Conceptual Teaching Requires Preparation and Subject Knowledge**

Alongside these themes, the AMAS results are presented to highlight trends in students' self-reported anxiety levels and to complement the qualitative findings. The chapter begins with an overview of these themes and the initial codes that supported them (Section 4.2), followed by a concise summary of the key findings (Section 4.3), and finally, a detailed thematic narrative integrating evidence from the data with relevant theoretical perspectives (Sections 4.4 - 4.6). The AMAS results are reported in Section 4.7.

4.2 Overview of Themes and Codes

The three themes above capture the most important patterns in which conceptual teaching influenced student engagement, confidence, and perceptions of Mathematics. Each theme was supported by multiple initial codes, generated through inductive analysis and refined through triangulation across data sources. A full list of these initial codes is provided in Appendix VI.

4.3 Final Themes and Associated Findings

Each of the three themes is supported by multiple findings, which emerged through the identification of repeated patterns in student reflections, classroom discussions, and my reflective journal.

Theme 1: Meaningful Contexts Enhance Engagement

Finding:

- Connecting maths to real-life contexts and careers boosted student engagement by making the content feel purposeful and relevant.

Theme 2: Conceptual Understanding Builds Confidence

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Findings:

- Students responded positively to Maths Journals, often expressing that writing reflections didn't feel like traditional "Maths work."
- Drawing attention to 'Common Misconceptions' created a sense of relief, as students realised, they weren't alone in their confusion.

Theme 3: Conceptual Teaching Requires Preparation and Subject Knowledge

Findings:

- Teaching for conceptual understanding required a high level of planning and task design. A strong grasp of MKT was essential for anticipating misconceptions and adapting explanations in real-time.

Quantitative Findings: AMAS Results

The adapted Abbreviated Maths Anxiety Scale (AMAS) was administered pre- and post-intervention to 16 students.

Item	Pre-Mean	Post-Mean	Difference
1. Using the times-tables book	1.13	1.06	-0.07
2. Thinking about a maths test the day before	2.13	2.06	-0.07
3. Watching the teacher work on problems on the board	1.81	1.75	-0.06
4. Doing a test at the end of the chapter	2.19	2.00	-0.19
5. Being given difficult questions for homework	2.38	2.25	-0.13
6. Listening to the teacher during the lesson	1.31	1.31	0.00
7. Listening to someone in your class explain their answer	1.50	1.13	-0.37
8. Being given a random mini test in Maths class	1.75	3.19	+1.44
9. Starting a new chapter in the maths book	1.56	1.56	0.00
Overall Mean	**1.75**	**1.81**	**+0.06**

Table 4.1: Pre and Post-Intervention AMAS Scores (n=16)

Note: Response scale ranged from 1 = No Anxiety/Not nervous to 5 = High anxiety/I feel fear (See Appendix III).

Overall, mean scores across eight of the nine AMAS items either decreased slightly or remained stable, suggesting a general trend toward reduced anxiety. The main exception was Item 8 (random mini test), which rose sharply from 1.75 to 3.19, indicating the unpredictability in testing remained a significant source of discomfort. The overall mean remained broadly stable (Pre = 1.75; Post = 1.81).

These themes and findings provide a framework for the detailed exploration that follows. Students' voices, drawn from Maths Journals and classroom discussions, are presented alongside extracts from my reflective teaching journal to illustrate and interpret the findings in context.

4.4 Theme 1: Meaningful Contexts Enhance Engagement

This theme explores how embedding Mathematics in meaningful, real-life contexts enhanced student engagement and curiosity. It shows that connecting content to students' lived experiences and future aspirations helped make Mathematics feel purposeful, relevant, and worth engaging with.

4.4.1 Connecting Maths to Real-Life Contexts and Employment Increased Student Engagement

This section explores how student engagement increased when mathematical content was taught through real-life and meaningful contexts, focusing on shifts in practice, student reflections on the impact, and links to curriculum and literature.

4.4.1.1 Changing Practice to Incorporate Real-Life Mathematics

In the earlier years of my career, I often relied on the maths textbook: I opened it, identified the concept to be taught, and worked through the content on the whiteboard. Lessons prioritised curriculum coverage over meaning, with little context provided. It was therefore no surprise that students rarely asked questions, focusing instead on memorising algorithms rather than making sense of concepts.

This research changed that. When teaching topics like VAT and Interest, I deliberately avoided procedural teaching at the outset. Instead, I focused on ensuring students understood why these concepts mattered, who they affected, and how they functioned before introducing formal algorithms.

Students responded particularly well to personalised, real-life examples. For instance, one student shared that after our lesson on VAT, they had discussed the topic with their father, who ran his own business – a clear sign that the concept resonated beyond the classroom.

This shift made lessons feel purposeful. In practice, this meant deliberately setting context before introducing procedural content – ensuring students first understood why a concept mattered before exploring how to calculate it. Previously, I would have been concerned if a lesson involved little work on the board, but in this case, I valued the rich discussions more than procedural practice. As I reflected:

"Out of all the lessons I have taught so far, this one involved the most discussion. The students seemed so engaged. They related it back to their own savings and were really thinking about if they were accumulating more money through interest" (Hammel, D. 'Reflective Journal': 3rd March 2025).

Commented [EC51]: any more supporting data? even from students?

Student feedback echoed this perception. One student wrote, *"Yes because usually when I learn about money other teachers just do sums like €50 + €43.23 and word problems but Mr. Hammel talked about it more"* (Student Maths Journal: 28th February 2025). Comments like this showed me that students had noticed the change in my approach and were beginning to connect it with their own understanding. These reflections reinforced that students were making meaningful connections between learning and their own lives.

4.4.1.2 Students' Reflections on the Impact of this Approach

Students' reflections confirmed that this approach helped them engage with the material. In their Maths Journals (February 28th, 2025), many students described the lessons as noticeably different, often highlighting the focus on meaning, slower pacing, and the use of real-life examples. For instance, one student wrote, *"Yes, it was different because Mr. Hammel told us the why and how to do it,"* while another noted, *"You gave real life examples."* No responding students described the lessons as the same as before or less helpful, indicating that, at least among those who gave feedback, the shift in approach was perceived positively.

One student explicitly connected the learning to his aspirations:

"It feels nice to understand VAT and money because for me, I want to be a businessman." (Student Maths Journal: 21st March, 2025).

This demonstrated that for some students, real-life contexts did more than improve understanding – they reframed Maths as a tool for personal empowerment, tied to future ambitions.

In classroom observations, I also noted a rise in purposeful questions. During a lesson on *value for money,* students compared holiday packages and spontaneously discussed budgeting, likely connecting it to their family experiences:

"Once again, the students engaged really well with the meaningful contexts, especially with the Holidays. It even brought up a brief discussion about budgeting."

(Hammel, D. 'Reflective Journal': 26th February 2025).

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4.4.2 Connections to Curriculum and Literature that Support These Findings

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The student reflections and classroom observations described above align closely with Boaler's (2016) argument that meaningful, relevant learning contexts are essential to student motivation and to the development of positive Maths Identities. When students can visualise where and why Mathematics matters, they are more likely to see themselves as competent and capable users of mathematical knowledge.

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From a cognitive perspective, Willingham (2009) suggests that students remember what they think about, so personally or socially meaningful situations act as cognitive anchors that improve their ability to process, retain, and apply abstract concepts such as exchange rates or interest.

This finding also reflects the Primary Mathematics Curriculum (NCCA, 2023), which emphasises that children should experience Maths as connected to the world around them. It also aligns with Dewey's (1938) view that learning becomes meaningful when tied to real-life and future-oriented thinking.

In summary, placing mathematical ideas within real-world, personally meaningful contexts increased engagement, fostered richer classroom discussions, and reshaped how students perceived Maths. These lessons not only improved conceptual understanding but also gave students a sense of purpose. This aligns with Boaler's (2016) work on Maths Identity and with the NCCA (2023) emphasis on contextual learning. This foundation created a bridge for the deeper conceptual understanding explored in Theme 2.

4.5 Theme 2: Conceptual Understanding Builds Confidence

This theme explores how teaching for conceptual understanding supported students' confidence in Mathematics, focusing on the use of Maths Journals as reflective tools and the inclusion of "Common Misconceptions" slides which normalised error and reframed struggle as part of the learning process.

4.5.1 Students Responded Positively to Maths Journals

Maths Journals emerged as one of the most consistent and encouraging aspects of the intervention. They functioned as reflective spaces where students could explain their reasoning, process their thinking in their own words, and acknowledge confusion without fear of judgment. Unlike oral responses, which can create performance pressure, journals gave students time and emotional safety to explore ideas. From my perspective as a teacher, they also provided invaluable insights into student thinking, revealing misconceptions or uncertainties that might otherwise have remained hidden and enabling me to give more targeted and responsive feedback.

Students' reflections confirmed the positive impact of this approach. When asked, "What do you find easier or more enjoyable about Maths now compared to before?" in their Maths Journals, (11th April 2025), students shared:

- *I like writing about our thinking more than sums.*
- *I like talking or writing about Maths.*
- *There is still more work but there is a lot less work. For example, instead of doing 50 sums I can talk about the maths.*

These comments suggest that students valued opportunities to express their reasoning and reflect on their learning in a less rigid, more expressive format. While specific samples of written work are provided in Appendix VIII, these quotes alone indicate a shift toward valuing metacognition. Further research could explore how such written reflections translate into deeper conceptual understanding over time.

Other journal entries (Student Maths Journals: February – April 2025) revealed how students used the space to process emotional experiences with Maths:

- *I thought I was bad at maths but with your help I feel now that I am a Maths person.*
- *I feel relieved because I now know the reason I was getting it wrong.*
- *No absolutely not, I would just stare at the paper. After like 10 mins of staring, I would start guessing.*

While these reflections were not always accompanied by detailed mathematical explanations, they suggest a growing confidence and willingness to engage. In some cases, the emotional response – moving from helplessness to clarity – was itself a meaningful shift, even if not always paired with explicit conceptual breakthroughs.

Some students even used the journals to provide honest feedback about my teaching, revealing their dual function as both reflective tools for learners and feedback mechanisms for me. One student wrote:

"Sometimes you don't explain a problem well. I sometimes get stuck. Just because a few others understand what you're saying" (Student Maths Journal: March 2025).

This kind of comment illustrates how journals gave students a safe avenue to express confusion and critique instruction, allowing me to reflect on and adapt my teaching accordingly. They also helped de-centre the right answer narrative, giving students a more active role in constructing their own understanding and revealing blind spots in my practice.

4.5.2 Connections to Literature

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This finding aligns with Boaler's (2016) argument that alternative representations of mathematical thinking – written, verbal, or visual – are critical for developing deeper conceptual understanding. Maths Journals acted as a bridge between students' informal reasoning and formal mathematical language, making their understanding more visible and explicit.

From an emotional perspective, journaling reduced the pressure of public participation, creating a safer space for reflection. This echoes Dweck's (2006) work on growth mindset: where learning is framed as a process of exploration rather than performance, encouraging students to take risks and engage deeply. Philipp (2007) also emphasised the link between affective experiences and Maths Identity, suggesting that tools like journals can strengthen students' self-concept as capable learners.

Taken together, these findings show that Maths Journals not only supported conceptual understanding by giving students time and space to reflect and reason, but also empowered them to express themselves honestly and safely. In doing so, they helped to build a classroom culture grounded in trust and open communication.

4.5.3 Drawing Attention to Common Misconceptions Created a Sense of Relief

Another powerful strategy was the inclusion of "Common Misconceptions" in lessons, followed by a "Conceptual Truth" explanation. This strategy was introduced in the final two weeks of the research, during the Chance topic in Cycle 2 (see Section 3.5.7), but it quickly emerged as one of the most impactful elements of my teaching intervention. The slides normalised errors, made confusion visible, and reframed mistakes as opportunities for learning. Instead of students silently wondering whether they were the only ones struggling, misconceptions became part of the collective process.

The psychological effect of this strategy was notable. In their Maths Journals (11th April 2025), 6 out of 8 students (75%) who responded explicitly described feeling calmer, less isolated, or more reassured after seeing that others had made similar mistakes. As one student put it:

"It helped me see that other people have the same answer as me which makes me feel more relaxed."

Others highlighted how the strategy reframed errors as opportunities for learning:

"I realised that making mistakes is part of learning," and *"Common Misconceptions lets me know what I did wrong."*

Another student reflected on a specific example from a lesson: *"It made it easier, like when we were doing the deck of cards when you put '1 in 4 because there is 4 queens' - that is a common misconception, so I learned from it."*

Although the sample size was small, the fact that three-quarters of respondents reported a reduction in anxiety or an increase in reassurance provides clear evidence of the strategy's emotional impact. These reflections suggest that the strategy did more than clarify content. It normalised error, reduced feelings of isolation, and created a more emotionally supportive environment for learning.

4.5.4 Connections to Literature

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This finding supports Maloney and Beilock's (2012) assertion that Maths Anxiety often stems from a fear of failure or public embarrassment. By making misconceptions explicit, students no longer equated error with incompetence but saw it as a natural part of the learning process.

From a teaching perspective, the slides also provided me with insight into predictable patterns of misunderstanding, allowing for more responsive and targeted explanation. This reflects Hattie & Timperley's (2007) view that the effective feedback requires accurately diagnosing student thinking and addressing it meaningfully.

Overall, the "Common Misconceptions" strategy reduced anxiety, normalised error, and helped students make better sense of mathematical ideas. By reframing mistakes as part of the learning journey, it created a more supportive classroom atmosphere where students felt safer to engage and take risks.

4.6 Conceptual Teaching Requires Preparation and Subject Knowledge

This theme explores the demands that teaching for conceptual understanding placed on my practice, particularly in relation to planning, task design, and the need for strong MKT.

4.6.1 Teaching for Conceptual Understanding Requires a High Level of Planning and Task Design

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This section outlines why planning demands increased when teaching conceptually, how tasks were designed to prioritise "why" over "how," and the impact this has on classroom dynamics.

4.6.1.1 The Demands of Planning

Teaching for conceptual understanding placed substantial demands on lesson preparation. Unlike procedural lessons, which often follow predictable textbook structures, conceptual lessons required deliberate sequencing, purposeful questioning, and anticipatory planning of potential student responses.

Each lesson had to surface the underlying meaning behind mathematical ideas, not simply deliver methods. This meant designing prompts that sparked curiosity before formal instruction even began. For example, when introducing Interest, I opened with:

"Imagine you borrow €100 from your friend but they say you must return €110. Where did that extra €10 come from?"

This generated a rich discussion before the concept was even named, creating a meaningful entry point for students. Reflecting on this lesson, I wrote:

"I think what really worked was the prompt Q at the start about the friend borrowing money. The word 'Interest', which I think is such an abstract concept especially at the students' age, wasn't even mentioned."

(Hammel, D. 'Reflective Journal': 3rd March 2025).

This approach aligns with Willingham's (2009) principle that students remember what they think about: when tasks are cognitively engaging and conceptually anchored, understanding deepens.

4.6.1.2 Designing Tasks that Prioritised "Why" Over "How"

An important dimension of the planning process was designing tasks that required students to focus on understanding why a concept worked before they learned how to perform it. This shift away from rote procedures toward relational understanding (Skemp, 1976) was central to the intervention.

As outlined in Section 3.5.6, this meant that lesson tasks were deliberately structured to surface meaning before methods, creating space for discussion, questioning, and exploration.

This approach reflects Anthony and Walshaw's (2007) assertion that conceptual tasks must be designed to promote reasoning, sense-making, and discussion rather than mere answer production. In my classroom, this translated into a slower, more dialogical pace, where students were encouraged to grapple with ideas, share their reasoning, and link concepts to real-world contexts before being introduced to formal procedures. It also supported students' emotional engagement: when they understood the purpose of a concept, they were far more willing to persist with challenging problems.

4.6.1.3 Impact on Classroom Dynamics

Students consistently described three lessons as slower paced but easier to understand, as one journal response reflected:

"His lessons were slow so we can understand."

(Student Maths Journal: 28th February).

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Other students echoed this perception, writing for example, "You were slow for teaching Money which is good" and "Instead of doing questions in our book we do fun little questions on the board" (Student Maths Journals: 28th February).

This slower, more dialogical pace created space for discussion, misconception exploration, and reflection, resulting in richer learning experiences for students.

Several students also commented that this approach made it easier to link Maths to real life, such as one who wrote, "We get to connect questions to real life scenarios" (Student Maths Journal: 28th February), showing how pacing and context combined to support understanding.

Overall, teaching for conceptual understanding required significant pre-planning, but the payoff was clear: lessons felt more meaningful, discussions became a central vehicle for learning, and students engaged more deeply with the content.

4.6.2 A High Level of Mathematical Knowledge for Teaching Was Essential

This section addresses: (1) the role of MKT, (2) my experience navigating challenging moments, and (3) the implications for teacher practice.

4.6.2.1 The Role of MKT in Conceptual Understanding

Delivering conceptual lessons revealed the critical importance of MKT (Ball et al., 2008). It was not enough to know procedures; I needed to deeply and flexibly understand the "why" so that I could adapt explanations in real time, particularly when students asked unexpected or challenging questions.

One example came during a Probability lesson:

"It happened by the way. I got confused. I got a bit mixed up between the probability of outcomes and combinations. It was a student who brought it to my attention as well. Luckily, with the new addition of my 'Common Misconception' (which is actually what I got confused on) and my 'The Conceptual Truth' slides, I was able to find my feet and explain it."

(Hammel, D. 'Reflective Journal': 9th April, 2025).

This moment underscored that teaching conceptually is not about having all the answers ready, but about reasoning alongside students and modelling how to navigate uncertainty – something that is impossible without adequate MKT.

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Students' deeper engagement also meant their questions were more probing, often challenging me to extend my own understanding of the content. As I reflected after a lesson in the Money strand:

"Also, I can see how a teacher's competency levels must be to a good standard because in order to achieve the level of CU I want, I need to be able to provide context. In most cases this is fine, but being completely truthful, I didn't know much about Interest Rates before it became a topic for my research."

(Hammel, D. 'Reflective Journal': 4th March 2025).

This reinforced that conceptual teaching requires more than procedural fluency – it requires flexible, deep content knowledge. When students engaged critically with concepts like Interest or Probability, I needed to reason alongside them, sometimes exploring ideas I had not fully anticipated. This echoes Schön's (1983, p.6) idea of the reflective practitioner, where teachers "think on their feet," adapting their explanations based on emerging classroom dialogue. As I reflected, I realised that when teaching a topic at surface level, students tend to ask surface-level questions. In contrast, when teaching for depth, I needed to be prepared for in-depth and often more challenging questions.

Building on Schön's distinction, I observed that my most immediate insights - such as noticing confusion in the moment or spotting an opportunity to extend reasoning – arose during “reflection-in-action,” whereas more strategic adjustments were planned afterwards through “reflection-on-action.” These paired cycles of in-the-moment noticing and post-lesson planning became a consistent pattern across both AR cycles.

4.7 Quantitative Findings: AMAS Results

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The AMAS results, presented earlier in Section 4.3 (Table 4.1), provide useful context for the qualitative themes. Overall, students reported slightly lower or stable levels of Maths Anxiety across most items, consistent with the qualitative evidence that strategies such as addressing misconceptions and journaling reduced feelings of isolation and built confidence.

The one clear exception was anxiety linked to random mini tests, which increased substantially. This suggests that unpredictability in assessment may remain a source of discomfort for some students, a finding consistent with research on evaluation pressure and anxiety (Maloney and Beilock, 2012).

In sum, the AMAS data support the qualitative finding that conceptual teaching can foster greater emotional safety and reduce anxiety in many contexts, but also point to the persistence of assessment-related stress as a challenge for future practice.

Chapter 5: Discussion

This chapter explores the broader significance of the findings presented in Chapter 4, drawing together insights from student responses, teacher reflections, and student work samples. It considers how these findings respond to the research questions and how they align with, challenge, or extend existing literature on conceptual understanding, Maths Identity, and Maths Anxiety. The chapter also discusses the implications for classroom practice and teacher professional learning.

5.1 Shifting Beliefs: What It Means to Be "Good at Maths"

At the outset of the research, students completed a task adapted from Leathem and Hill's (2010) study, in which they rated a list of 15 traits based on how essential they believed each was to being "good at Maths." This activity revealed that students associated success in Maths primarily with discipline and focus, rather than natural talent or creativity. Traits such as *Focused* (4.9), *Patient* (3.6), and *Open-minded* (4.0) received the highest average scores, while *Gifted* (1.8), *Brave* (1.4), and *Creative* (2.8) were rated among the lowest. This pattern is significant because it highlights how students' views of being "good at Maths" were grounded in compliance and perseverance rather than creativity or risk-taking, providing an important baseline for understanding how their identities shifted during the intervention.

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One of the most striking results from the pre-research trait-rating task was the low score given to *Bravery* — the lowest of all fifteen traits. This suggests that students did not associate being good at Maths with taking risks, making mistakes, or persisting through uncertainty. Instead, their responses reflect a view of Maths rooted in correctness and quiet compliance, where success means getting the right answer efficiently and safely. This aligns with Boaler's (2016) critique of procedural Maths classrooms, where risk-taking is often neither encouraged nor rewarded. The low rating of bravery may also point to avoidance behaviours commonly linked to Maths Anxiety (Maloney & Beilock, 2012), where students prefer not to engage in tasks that require public reasoning or risk of error.

However, as explored in the findings, this view began to shift throughout the research cycle. Through strategies such as journaling, class discussion, and the use of "Common Misconception" slides, students began to engage with Maths differently — not just as a set of rules to follow, but as a subject they could think through, talk about, and explore. This shift suggests that students' Maths Identities are malleable and responsive to the pedagogical approaches used in the classroom.

5.2 Conceptual Teaching and Identity Transformation

5.2.1 Changes in Student Perception

The data revealed that teaching for conceptual understanding — particularly when grounded in meaningful, real-world contexts - supported students in developing a clearer grasp of mathematical concepts, as reflected in their journal entries. For instance, one student wrote *"Yes, I can understand money now because I know how to do VAT and Interest"* (Student Maths Journal, 21st March 2025) while another commented "*One thing I learned in Chance that I didn't know before is what an outcome table was but now I know what it is and what it does"* (Student Maths Journal, 11th April 2025). This also contributed to a transformation in how they saw themselves as Maths learners.

This is strongly aligned with Skemp's (1976) distinction between instrumental and relational understanding. Students who were used to procedural approaches began to engage more deeply when tasks focused on "why" Maths works, not just how to carry it out. Their journal reflections often revealed moments of clarity, pride, or relief when they could explain the reasoning behind a method, rather than simply performing calculations. Examples include:

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- When you understand the meaning behind a maths rule it feels good doing it because you understand it better and there is easier ways to do it also.
- Now it is easier to understand how to learn new things.
- Yes. I have started to enjoy maths more than I have before. I have started to enjoy money and VAT a lot more than I used to because I learned how it can be used in the real world.

(Student Maths Journals: March - April 2025).

This transformation supports Boaler's (2016) argument that student engagement and identity are deeply connected to the kind of Maths they experience. When students see Maths as flexible, meaningful, and discussable, they are more likely to see themselves as capable of doing it — and enjoying it.

5.2.2 Journaling as a Tool for Confidence

Many students shared that journaling "didn't feel like Maths" — a comment that, while initially surprising, reveals the extent to which their previous experiences had been shaped by more rigid, answer-focused instruction. Through writing and discussion, students were given alternative ways to show understanding, which in-turn built confidence. This resonates with Dweck's (2006) work on growth mindset: when learning is framed as a process of exploration, not perfection, students are more willing to take risks and reflect on their thinking.

5.3 Maths Anxiety and the Power of Emotional Safety

Alongside identity transformation, the classroom climate also played a critical role in shaping how students felt about participating in Maths — especially when it came to reducing anxiety and normalising struggle.

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5.3.1 Normalising Mistakes Through Common Misconceptions

The use of Common Misconception slides was labelled by students as helpful and calming. Many reported feeling less alone in their confusion, and relieved after seeing that others had made similar mistakes. This strategy worked not only to clarify content, but to *reposition error* as an expected and productive part of learning.

It felt good that other people had the same Misconceptions as me and made me more relaxed when learning (Student Maths Journal: 11th April 2025).

This echoes findings from Maloney & Beilock (2012), who emphasise the emotional toll that fear of failure can take on learners — particularly in Maths, where public correctness is often prioritised. In contrast, this classroom culture aligned more with Brookfield's (1995) and Boaler's (2016) calls for emotionally safe learning environments, where confusion is normalised and struggle is seen as a pathway to understanding.

The result was a classroom atmosphere that not only supported intellectual risk-taking but appeared to rewrite how students felt about learning Maths. For some, these changes were subtle — increased willingness to speak in class or explain their reasoning. For others, they were more explicit, as students began to identify themselves as "Maths people" for the first time.

5.3.2 Quantitative Insights from the AMAS

As outlined in Section 4.7, the results from the adapted Abbreviated Maths Anxiety Scale (AMAS) provided a useful context for understanding the emotional impact of the intervention. While the overall average score rose slightly from 1.75 to 1.81, this was primarily driven by one item relating to “being given a random mini test.” When this item is excluded, the overall mean instead shows a small decrease (1.77 to 1.67), indicating that for most aspects of mathematical experience, students reported reduced or stable levels of anxiety. At first glance, this appears contradictory to the broader trend of reduced anxiety. However, a more likely interpretation is that this reflects increased cognitive awareness rather than heightened fear. As students engaged more deeply with complex ideas, they likely became more aware of what challenging mathematical thinking actually feels like – a shift that Willingham (2009) suggests is a natural consequence of meaningful learning. In this sense, the small rise does not undermine the findings but adds nuance: it suggests that greater understanding can sometimes bring greater recognition of difficulty – a vital step in genuine growth.

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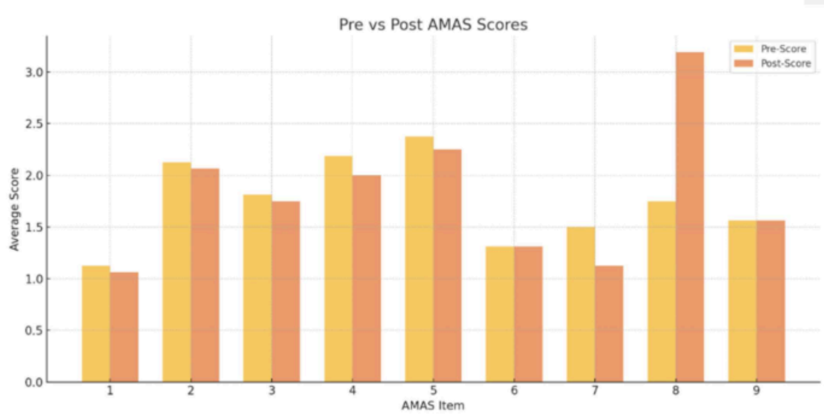

Figure 1: Pre- and Post-Intervention AMAS Scores (n=16)

5.4 The Demands of Conceptual Teaching on the Teacher

While most students responded positively to this shift in practice, a small number expressed more neutral or mixed views. For instance, one student wrote, *"Nothing. Maths never really bothered me but I guess I am more confident"* (Student Maths Journal, April 2025), while another noted that *"Sometimes you don't explain a problem well. I sometimes get stuck. Just because a few others understand what you're saying"* (Student Maths Journal, March 2025). This suggests that while the approach generally improved engagement and understanding, it also required ongoing adjustment and responsiveness to individual student needs.

This reflects Ball et al.'s (2008) argument that MKT — the specialised knowledge needed not just to understand Maths, but to teach it responsively – is essential. It also aligns with Hattie & Timperley's (2007) view that effective feedback depends on accurately diagnosing student thinking and providing conceptually clear explanations. As Schön (1983) highlights, this requires teachers to balance "reflection-in-action" - making on-the-spot adjustments during teaching – with "reflection-on-action" after lessons, when longer-term changes can be planned. Conceptual teaching also demanded considerably more preparation time than procedural approaches, as lessons needed to be carefully structured around meaning and discussion rather than routine coverage.

Moreover, my own experiences highlighted the emotional labour involved in modelling vulnerability and responding authentically to student reasoning — particularly when it surfaced content I had not fully anticipated. These moments, while sometimes uncomfortable, became some of the richest learning opportunities — for both myself and my students.

5.5 Summary of Insights

Taken together, the findings suggest that a shift toward conceptual, student-centred teaching — when grounded in real-world contexts and supported by reflective tools — can have a transformative effect on student engagement, confidence, and identity in Maths.

The data also underscores the dual responsibility of conceptual teaching: while it empowers students, it also demands more of the teacher — in content knowledge, planning, and emotional attunement.

These insights naturally inform a series of recommendations for practice and professional learning, outlined in the next section.

5.6 Recommendations

Drawing on the findings of this research, the following recommendations are proposed to strengthen mathematics teaching and learning. They are directed primarily at classroom teachers, school leaders, and teacher educators and are rooted in student voice, classroom observations, and teacher reflection, and aim to promote conceptual understanding, build positive Maths Identities, and reduce Maths Anxiety.

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1. Prioritise Conceptual Teaching as a Core Approach

Schools and teachers should place conceptual understanding at the heart of mathematics instruction. Lessons should focus on the *why* before the *how*, enabling students to connect procedures to meaning and see mathematics as logical and purposeful.

2. Enhance MKT

Teachers should have opportunities to deepen their subject-specific pedagogical knowledge so they can respond flexibly to student questions, anticipate misconceptions, and provide multiple representations of concepts.

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3. Integrate Meaningful Contexts into Lesson Design

Real-life, relevant contexts should be embedded into mathematical tasks to demonstrate the purpose and application of mathematical ideas, supporting both engagement and retention.

4. Use Common Misconceptions to Build Confidence and Reduce Anxiety

Explicitly addressing misconceptions in lessons helps normalise error, reassure students they are not alone in their misunderstandings, and reframe mistakes as essential learning opportunities.

5. Provide Ongoing CPD Focused on Conceptual Understanding

Professional development should not only introduce teachers to conceptual teaching strategies but also allow them to experience mathematics conceptually themselves. This will equip them to design lessons that foster deeper understanding and greater emotional safety in the classroom.

5.7 Chapter Summary

This chapter has interpreted the qualitative and quantitative findings of the study, exploring their implications for teaching practice, student identity, and Maths Anxiety. It has shown how conceptual, context-rich teaching strategies can shift student perceptions, build confidence, and foster a more positive relationship with mathematics, while also highlighting the demands such an approach places on teachers. The recommendations outlined provide a practical framework for applying these insights in classrooms and for guiding future professional development. The next chapter concludes the thesis, summarising the study's contributions, reflecting on its limitations, and identifying opportunities for further research.

Chapter 6: Conclusion

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Commented [EC70]: like i said use this chapter to close the loop. go back to original problem statement, your original practice and living contradiction....and your values.....highlight your professional growth and what this means for your students. Bring in Dewey and other theorists you think are relevant.

6.1 Introduction

This study set out to investigate the question: *What impact can teaching with the aim of achieving Conceptual Understanding have on my students' engagement, confidence and developing Mathematical Identities?*

The research was motivated by a professional curiosity about whether deliberately prioritising the "why" behind mathematical ideas - rather than focusing solely on procedural fluency – could transform the way students think, feel, and see themselves in relation to Mathematics.

To explore this, I implemented a targeted intervention built around three key strategies: embedding meaningful contexts, explicitly addressing common misconceptions, and using student Maths Journals for reflection and dialogue.

6.2 Summary of Key Findings

Across qualitative and quantitative data, three clear findings emerged:

1. Meaningful contexts enhance engagement – Students became more invested when they saw how mathematical concepts connected to real life, careers, and their own experiences.
2. Conceptual understanding builds confidence – Shifting the focus to reasoning and meaning helped students feel more capable and resilient in their learning, reducing the fear of getting things wrong.
3. Conceptual teaching demands preparation and deep knowledge – Teaching for understanding required significant planning and strong MKT, as well as the flexibility to respond to unexpected questions.

The findings also suggest that explicitly surfacing and correcting common misconceptions reduced feelings of isolation and normalised struggle, contributing to lower levels of Maths Anxiety for many students. The use of Maths Journals further supported identity development by giving students a safe space to process and articulate their thinking.

6.3 Implications for Practice

For teachers, this research reinforces the value of making mathematical learning purposeful and relational. Explaining *why* a method works before teaching *how* to do it can shift classroom dynamics towards richer discussion and deeper engagement. Incorporating student voice – whether through journals, class conversations, or feedback activities – provides insights that can shape and refine teaching in real time. For schools, supporting conceptual teaching may require timetable flexibility, resources for meaningful task design, and professional learning opportunities that deepen teachers' MKT.

6.4 Limitations of the Study

As an Action Research project conducted within a single class, the findings are context-specific and may not fully generalise to other settings or age groups. The relatively small sample size limits statistical analysis, and the dual role of teacher-researcher carries potential bias, despite triangulation measures. Finally, the research was carried out over a limited time frame, meaning longer-term impacts on Maths Identity and Maths Anxiety could not be assessed.

6.5 Suggestions for Future Research

Future studies could explore the long-term impact of conceptual teaching on students' Maths Identity beyond a single academic term or investigate how these strategies work across different school contexts and age groups. Comparative studies between conceptual and procedural-focused teaching approaches could further clarify the specific contributions of each to reducing Maths Anxiety and improving engagement.

6.6 Concluding Remarks

This study began with a professional unease: a recognition that my teaching did not always align with my values. Like many classrooms in Ireland, my practice had often leaned towards procedural instruction, where the goal was coverage and efficiency rather than meaning and dialogue. This created what Whitehead (1993) calls a "living contradiction" - acting in ways that conflicted with my belief in democratic, inclusive, and conceptually grounded education. Undertaking this research was my attempt to resolve that contradiction by testing whether teaching for conceptual understanding could bring my values into fuller expression.

The journey has shown that it could. By embedding meaningful contexts, surfacing common misconceptions, and providing space for reflection through journals, students engaged with mathematics in ways that were relational rather than instrumental (Skemp, 1976). They not only developed stronger conceptual understanding but also began to view themselves differently – as capable participants in mathematics rather than passive recipients of rules. This reflects Dewey's (1938) vision of education as experiential and purposeful, as well as Freire's call for dialogical classrooms where knowledge is co-constructed.

For me as a teacher, the process was transformative. I learned that teaching conceptually demands not just MKT but also vulnerability: a willingness to reason alongside students, to reflect-in-action when explanations faltered, and to adapt practice in response to student voice (Schön, 1983). These moments, though sometimes uncomfortable, became the richest opportunities for growth – both for my students and for myself. They deepened my conviction that mathematics should be taught for understanding, and that every learner deserves access to classrooms where their thinking is valued and their identity as a mathematical person can grow.

The implications reach far beyond this single study. If we want students not only to perform mathematics but to see themselves as mathematical thinkers, then teaching for conceptual understanding is not optional – it is essential. My own growth as a practitioner reinforces that the work of education is relational and values-driven: it is about creating conditions where meaning, identity, and confidence can flourish together. I now see my practice not simply as teaching mathematics, but co-constructing meaning with students – a perspective that will continue to guide my professional growth and enrich their learning experiences.

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Appendices

Appendix I: Parental Information Forms and Consent/Assent Forms

Maynooth University
National University of Ireland Maynooth

Dear Parent(s)/Guardian(s),

I am currently completing a research Masters in Education program at Maynooth University. The aim of my research is to investigate how I can incorporate teaching elements into maths lessons that are most likely to improve student's understanding of the subject and consequently improve their attitudes towards it. In my experience, many primary school pupils have negative beliefs about mathematics, often believing they are "bad at maths". These types of beliefs can limit educational outcomes for children, and this is my motivation for trying to address these issues through the way I will teach maths.

As part of the program, I will be making some changes to the way I teach maths. This will include teaching my maths lessons at whatever pace is necessary in order for the children to understand *why* they are doing what they are at any given problem. The children will engage in loads of discussion with each other and with me so I can observe what they feel leads to better understanding and what does not.

Of course, the children's privacy is of utmost importance. All information will be anonymised and confidential. The child's name and the name of the school will not be included in the thesis that I will write at the end of the research. Your child will be allowed withdraw from the research process at any stage.

The data will be collected using observations during my lessons, surveys, questionnaires, photographs of the work we do and interviews. The children will be asked their opinions on their attitude towards maths and what they think I do in my lessons that makes concepts easier or harder to understand.

All information will be destroyed in a stated timeframe in accordance with the University guidelines. The correct guidelines will be complied with when carrying out this research. The research will not be carried out until approval is granted by the Froebel Department of Primary and Early Childhood Education.

I would like to invite you and your child to give permission for him/her to take part in this project. Thank you all for your continued support so far, this academic year.

If you have any queries on any part of this research project, feel free to contact me by email at [insert email]

Kind regards,

Darragh Hammel

Information Sheet for

Parents and Guardians

What is this Action Research Project about?

Teachers undertaking the Master of Education in the Froebel Department of Primary and Early Childhood Education at Maynooth University, are required to conduct an action research project, examining an area of their own practice as a student teacher. This project will involve an analysis of the teacher's own practice. Data will be generated using observation, reflective notes and questionnaires. The teacher is then required to produce a thesis documenting this action research project.

What are the research questions?

- How can I positively impact student's Mathematics Identity through my teaching?
- How might I incorporate more of a conceptual-style approach to my teaching of Mathematics?

What sorts of methods will be used?

In order to gather the data needed to conduct my research, the methods I plan to use include; observation of the children working and how they interact in my lessons, note-taking in my reflective journal, questionnaires, anonymous surveys, interviews with students. Photographs of the students' work may also be used. Children's consent will be asked before any photographs of their work is taken. Children are welcome to fully take part in the research without consenting to photographs of their work. All data will be gathered in a sensitive and non-stressful manner.

Who else will be involved?

The study will be carried out by myself as part of the Master of Education course in the Froebel Department of Primary and Early Childhood Education. The thesis will be submitted for assessment to the module leaders, Prof. Marie McLoughlin and Dr Suzanne O'Keeffe and will be examined by the Department staff. The external examiners will also access the final thesis.

What are you being asked to do?

You are being asked for your consent to permit me to undertake this study with my class. In all cases the data that is collected will be treated with the utmost confidentiality and the analysis will be reported anonymously. The data captured will only be used for the purpose of the research as part of the Master of Education in the Froebel Department, Maynooth University and will be destroyed in accordance with University guidelines.

Maynooth University
National University of Ireland Maynooth

Hi everyone,

As you know, I have gone back to college this year to learn more about how I can better teach maths in my lessons. I want to figure out different ways that make those tricky topics easier to understand. I don't want anyone thinking they are 'bad' at maths because I think if we work together, we'll be able to make those hard topics easier to understand and you never know, you might even like maths more by the end of the year!

I would love to watch how you get on in our maths lessons and take notes about what you think makes things easier or harder to understand. I might take pictures of the work we do, have a conversation with you and give you surveys to fill out from time to time. At the end of the research, I'll be writing a book all about what I learned about teaching maths. I will explain everything as we go along.

Would you be ok with that? Circle one:

YES NO

I have asked an adult at home to talk to you about this. If you have any questions, I would be happy to answer them. If you are happy with that, could you sign the form that I have sent home?

If you change your mind at any time, that's ok too.

Thanks so much!

Mr. Hammel

Maynooth University
National University of Ireland Maynooth

Parental/Guardian Consent Form

I have read the information provided in the attached letter and all of my questions have been answered. I voluntarily agree to the participation of my child in this study. I am aware that I will receive a copy of this consent form for my information.

Parent / Guardian Signature

Parent / Guardian Signature

Date:

Name of Child

Child's assent to participate

My parent/guardian has read the information sheet with me and I agree to take part in this research.

Name of child (in block capitals):

Signature:

Date:

Appendix II: Letter to the Board of Management

Letter to the Board of Management

Darragh Hammel,
Address
Address

Dear Board of Management members,

As some of you are aware I (Darragh Hammel) have recently started a Master's in Education in Maynooth University. I wish to make the board aware of the research as it will be taking place in the classroom setting.

The research is a self-study action research project where I investigate my own teaching and aim to improve my practice. I will be studying Mathematics Education in my classroom, with a focus on Maths Identity and teaching the students with the aim of them achieving a conceptual understanding of the topics being taught.

I will explain the research to the children in my class and ask for both consent from parents, and assent from children for data to be collected in the classroom. The children will be viewed as co-collaborators who are valued and respected. Data will be collected through surveys, conversations and photographs of the children's work. All data collected will be anonymised. Children's names and the name of the school will not be mentioned in the research as confidentiality and data protection procedures will be strictly followed.

All children are welcome to participate and can choose whether data will be collected from them. As the research will take place as part of our normal mathematics lessons the children will not be impacted in any way if they choose not to take part.

I hope to share the results of the research with my colleagues on the staff of [insert school].

Thank you for taking the time to read my letter and feel free to contact me at [insert email] if you have any queries about the research.

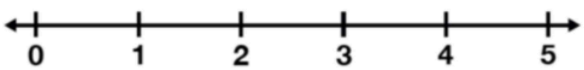
Kindest regards,

Darragh Hammel

Appendix III: Questionnaire Templates

Questionnaire 1: Beliefs about Maths Ability

What does it mean to be good at Maths?



Rate each of these words from 0-5 according to how well you think the word describes someone who is good at Maths.

Brilliant	Careful	Confident
Creative	Curious	Focused
Gifted	Motivated	Obedient
Open-Minded	Organised	Passionate
Patient	Brave	Interested

Questionnaire 2: Beliefs about the Effectiveness of Maths

How Useful is Math?

Arranging trophies by size	**Sorting shapes**	**Cooking with a recipe**	**Memorising times tables**
Playing Sudoku	**Tiling your bathroom**	**Measuring your bedroom**	**Playing the drums**
Driving a car	**Drawing a map**	**Playing the piano**	**Reading a book**
Reading a map	**Writing an essay**	**Playing Solitaire**	**Doubling a recipe**
Working on an electrical circuit	**Hanging a picture on the wall**	**Playing a video game**	**Riding a skateboard**

Arrange these activities into categories related to Maths.

You may include a "No Maths" category for any activity you think is <u>not</u> related to Maths at all.

Questionnaire 3: Abbreviated Maths Anxiety Scale (Adapted)

How much anxiety do you feel when:

1. You have to use the times-tables book? _____
2. Thinking about a Maths Test the day before it? _____
3. Watching the teacher work on problems on the board? _____
4. Doing a test at the end of the chapter? _____
5. Being given difficult questions for Homework? _____
6. Listening to the teacher during the lesson? _____
7. Listening to someone in your class explain their answer? _____
8. Being given a random mini test in Maths Class? _____
9. Starting a new chapter in the Maths book? _____

Response options:

1: No anxiety/Not nervous

2: A little anxious/nervous

3: Tense, nervous, anxious

4: Very anxious

5: High anxiety, I feel fear

Please place the appropriate number beside each statement.

Appendix IV: Learning Outcomes for Topics Covered during the Intervention

Topic: Lines and Angles

Strand	Element	Learning Outcomes
Shape and Space	Spatial Awareness and Location	- compare and classify angles, recognising them as a property of a shape and as a description of a turn.
	Shape	- investigate and construct angles in the context of shape; and solve angle-related problems.

Topic: Money

Strand	Element	Learning Outcomes
Measures	Money	- develop an awareness of money and its uses. - recognise the value of money and use euro and cent in a range of meaningful contexts. - transfer knowledge of the base ten system in number to monetary contexts and use for purposes of calculation. - Solve and pose practical tasks to investigate and

		make informed judgements about transactions and financial plans.

Topic: The Circle

Strand	Element	Learning Outcomes
Shape and Space	Shape	- Explore and recognise properties of 2-D and 3-D shapes. - Represent shapes with drawings and models, and calculate dimensions of shapes.

Topic: 3D Shapes

Strand	Element	Learning Outcomes
Shape and Space	Shape	- Investigate and analyse the properties of 2-D and 3-D shapes and identify classes of shapes based on these properties. - Represent shapes with drawings and models, and calculate dimensions of shapes. - represent shapes with drawings and models and calculate dimensions of shapes. - Construct 2-D and 3-D models or structures given

		defined measurements and/or specific conditions.

Topic: Chance

Strand	Element	Learning Outcomes
Chance	Chance	- describe and test predictability and (un)certainty in events. - use probability to make informed decisions and predictions. - represent and express probability in different forms.

Appendix V: Mapping of Raw Data to Initial Codes and Final Themes

Raw Data Extract	Initial Code	Final Theme
"Yes, it was different because Mr. Hammel told us the why and how to do it." (Student Maths Journal, 28 Feb 2025)	Explaining purpose before procedure	Meaningful Contexts Enhance Engagement
"It feels nice to understand VAT and money because for me, I want to be a businessman." (Student Maths Journal, 21 Mar 2025)	Linking Maths to career aspirations	Meaningful Contexts Enhance Engagement
"Once again, the students engaged really well with the meaningful contexts, especially with the Holidays. It even brought up a brief discussion about budgeting." (Reflective Journal, 26 Feb 2025)	Real-life budgeting examples increase engagement	Meaningful Contexts Enhance Engagement
"I like writing about our thinking more than sums." (Student Maths Journal, 11 Apr 2025)	Journals provide safe space for reasoning	Conceptual Understanding Builds Confidence
"I thought I was bad at maths but with your help I feel now that I am a Maths person." (Student Maths Journal, Feb–Apr 2025)	Increased self-identification as a "Maths person"	Conceptual Understanding Builds Confidence
"It helped me see that other people have the same	Reduced isolation through shared misconceptions	Conceptual Understanding Builds Confidence

answer as me which makes me feel more relaxed." (Student Maths Journal, 11 Apr 2025)		
"Sometimes you don't explain a problem well. I sometimes get stuck. Just because a few others understand what you're saying." (Student Maths Journal, Mar 2025)	Willingness to critique teacher explanations	Conceptual Understanding Builds Confidence
"Imagine you borrow €100 from your friend but they say you must return €110. Where did that extra €10 come from?" (Lesson prompt, Reflective Journal, 3 Mar 2025)	Curiosity-sparking prompts before naming concepts	Conceptual Teaching Requires Preparation and Subject Knowledge
"Also, I can see how a teacher's competency levels must be to a good standard because… I didn't know much about Interest Rates before it became a topic for my research." (Reflective Journal, 4 Mar 2025)	Teacher vulnerability and need for deep content knowledge (MKT)	Conceptual Teaching Requires Preparation and Subject Knowledge
"It happened by the way. I got confused… Luckily… I was able to find my feet and explain it." (Reflective Journal, 9 Apr 2025)	Adapting explanations in real time	Conceptual Teaching Requires Preparation and Subject Knowledge
"His lessons were slow so	Slower pacing supports	Conceptual Teaching

we can understand." (Student Maths Journal, 28 Feb 2025)	depth of understanding	Requires Preparation and Subject Knowledge

Appendix VI: Full List of Initial Codes

- Connecting Maths to real life
- Linking concepts to careers/future goals
- Using slower pacing in lessons
- Building on prior knowledge before new content
- Encouraging classroom discussion
- Students explaining reasoning in journals
- Students valuing “why” over “how”
- Linking topics to personal experiences
- Noticing and addressing common misconceptions
- Students feeling reassured by shared mistakes
- Students recognising mistakes as learning opportunities
- Tasks designed for reasoning before calculation
- Teacher modelling vulnerability and reasoning
- Planning lessons around conceptual entry points
- Anticipating student misconceptions in planning
- Adapting explanations in real time
- Student feedback influencing teaching adjustments

Appendix VII: Sample List of Prompt Questions

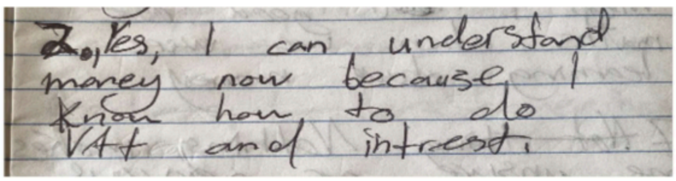
- What does ‘value’ mean to you?
- What makes something a *good deal*?
- Imagine you and your family are going on holiday to the USA. You bring €100, but when you land, the money isn’t in euros anymore! You have to exchange it for dollars. How much do you think you would get? Will this amount always be the same?
- Imagine you borrow €100 from a friend but they say you must return €110. Where did the extra €10 come from?
- Would you rather have €500 that grows by €50 every year OR €500 that grows by 5% every year? Why?
- Which measurement of the circle do you think I have to give you in order for you to draw a circle using a compass? Why?
- When plotting events on a Probability Scale, why might people place the exact same event in different places?
- What makes a game fair or unfair? Have you ever played a game that didn’t feel fair?
- If I roll two dice, and I win if the total is 7, and you win if the total is 2, is that fair?
- If you were in charge of inventing a new game, what are two things you might do to ensure it is Fair?

Appendix VIII – Samples of Student Journal Entries

Theme 1: Meaningful Contexts Enhance Engagement

Sample 1: Applying VAT and Interest to Real Life

(Student Maths Journal, 21 March 2025)



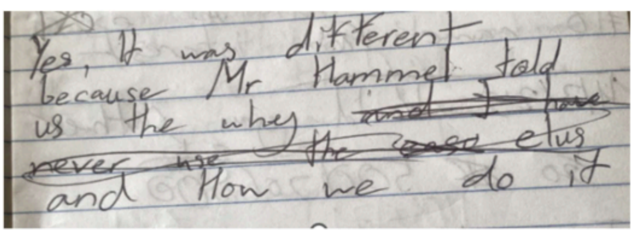
Transcription:

"Yes, I can understand money now because I know how to do VAT and interest."

Theme 2: Conceptual Understanding Builds Confidence

Sample 2: Explaining the "Why" in Maths

(Student Maths Journal, 28 February 2025)

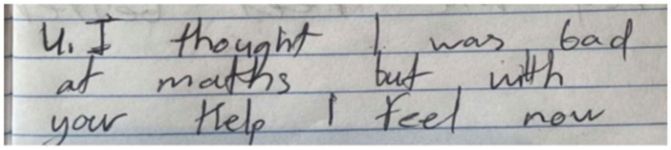


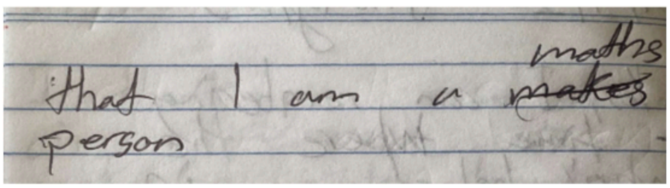
Transcription:

"Yes, it was different because Mr Hammel told us the why and how we do it."

Sample 3: Shifting Self-Perception

(Student Maths Journal, 21 March 2025)





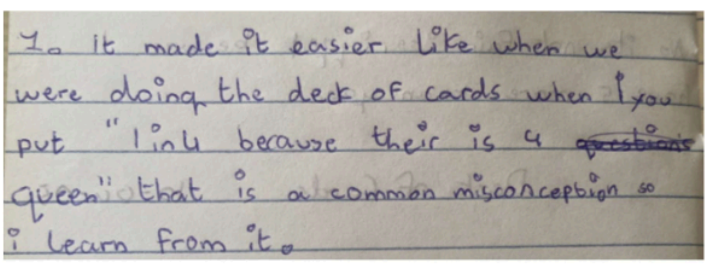
Transcription:

"I thought I was bad at maths but with your help I feel now that I am a maths person."

Theme 3: Conceptual Teaching Requires Preparation and Subject Knowledge

Sample 4: Recognising and Learning from Misconceptions

(Student Maths Journal, 11 April 2025)

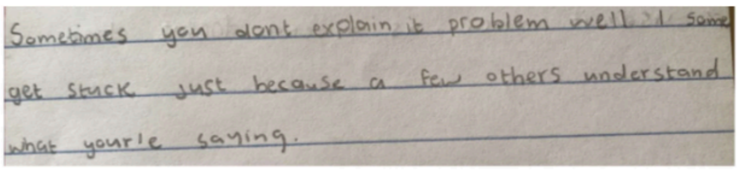


Transcription:

“It made it easier like when we were doing the deck of cards when you put ‘1 in 4 because their is 4 queen’ that is a common misconception so i learn from it.”

Sample 5: Reflecting on Teacher Clarity

(Student Maths Journal, 21 March 2025)


Sometimes you dont explain it problem well I some
get stuck just because a few others understand
what your'e saying.

Transcription:

“Sometimes you don't explain it problem well I some get stuck just because others understand what you’re saying.”