Evaluating the Effect of a Whole-Class Intervention to Enhance Mathematical Resilience and Reduce Mathematics Anxiety: A Mixed-Methods Study

Thesis submitted to the University of Nottingham for the degree of Doctor of Applied Educational Psychology

May 2025

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Word Count: 41,644

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Abstract

Research shows that mathematics anxiety (MA) can appear early in formal education in the UK. Although early intervention has been identified as important for reducing MA and improving positive long-term outcomes, universal strategies in primary schools have received little attention until now. A structured approach aimed at fostering mathematical resilience (MR) has emerged as a promising method for helping learners manage and reduce MA. This study examines the effectiveness of integrating key principles of this approach into a whole-class MR intervention in primary schools, focusing on the "Growth Zone Model" (GZM) and its practical application in the classroom.

A cohort of Year 4 children and their teaching staff participated in this research. A sequential explanatory mixed-methods study was conducted. Phase one of the research employed an AB single-case experimental design (SCED), where school staff delivered a whole-class MR intervention to their Year 4 class over thirteen weeks. Six pupil participants were selected for SCED analysis, based on initial high levels of MA. Subsequently, in phase two of the research, qualitative interviews were conducted to explore perceptions regarding the implementation of the intervention. Semi-structured interviews were conducted with the six focus children, along with a focus group of the school staff who facilitated the intervention.

For three of the six focus children, there was an overall decrease in the mean level of MA and an increase in MR between the baseline and intervention phases. Tau-U analysis demonstrated a statistically significant improvement in self-reported MA ($p < .05$) for one of the focus children. From phase two of the research, five themes emerged from the data concerning the teacher and teaching assistants, as well as the six focus children's, perceptions of the whole-class intervention. The identified themes emphasised the intervention's role in fostering reflections on teaching and learning culture, enabling timely responses to children's

academic and well-being needs, and supporting self-regulation to enhance behaviour for learning. Additionally, the findings highlighted the intervention's feasibility and a desire for broader implementation.

Overall, the research presents some promising outcomes regarding a whole-class MR intervention, with staff advocating for its implementation at a whole-school level. The study highlights the potential for further investigation and advancement of whole-class approaches to support children with MA.

Acknowledgements

I would like to express my sincere gratitude to the staff, children, and parents at the school where this research was conducted. This project would not have been possible without your support. I am incredibly fortunate to have worked alongside such enthusiastic and passionate staff and children, who wholeheartedly embraced this intervention.

A special thank you to Sue Johnston-Wilder for allowing me to use her toolkit in this research project.

To my placement supervisor, Dr Wendy Fitzsimmons, thank you for all of your support over the past two years. I will forever be grateful for your words of wisdom and containment.

To the university tutor team, especially my research supervisor, Dr. Victoria Lewis, thank you for your encouragement and insight throughout my TEP journey. And to Cohort 17, for the laughter, friendship, and shared experiences that have made these three years unforgettable.

Tom, thanks for the endless supply of tea, fried egg sandwiches, friendship, laughter, and love that carried me through to the end.

And to my mum, sister, and the rest of my family and friends. Thank you for your patience, unwavering support, and understanding throughout this course and beyond. I would not be where I am today without you.

And to all the brave, outspoken, and independent women in my life who continually inspire me every day - thank you.

List of Abbreviations

AMAS	*Abbreviated Maths Anxiety Scale*
AfL	*Assessment for Learning*
BCMRS	*Baker Children's Mathematical Resilience Scale*
DFE	*Department for Education*
EIF	*Education Inspection Framework*
EP	*Educational Psychologist*
GZM	*Growth Zone Model*
HMB	*Hand Model of the Brain*
KS2	*Key Stage 2*
MA	*Mathematics anxiety*
mAMAS	*Modified Abbreviated Maths Anxiety Scale*
MAS	*Maths Anxiety Scale*
MR	*Mathematical resilience*
MRS	*Mathematical Resilience Scale*
NA	*Number Anxiety*
NC	*National Curriculum*
OECD	*Organisation for Economic Co-operation and Development*
Ofsted	*Office for Standards in Education, Children's Services and Skills*
PISA	*Programme for International Student Assessment*
RR	*Relaxation Response*
UK	*United Kingdom*

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Chapter 1: Introduction

1.1 An Introduction to the Current Research

This study investigates the effects of a whole-class intervention in primary school classrooms on children's mathematics anxiety (MA). Specifically, the research focuses on implementing principles from "*A Toolkit for Teachers and Learners, Parents, Carers and Support Staff: Improving Mathematical Safeguarding and Building Resilience to Increase Effectiveness of Teaching and Learning Mathematics,*" (Johnston-Wilder et al., 2020) into an early whole-class intervention with Year 4 students. The study places particular emphasis on the concept of Johnston-Wilder et al.'s (2013) Growth Zone Model (GZM) and its practical application in the classroom. To explore the potential efficacy of the approach, children's self-reported ratings of mathematics anxiety (MA) were collected using the Modified Abbreviated Maths Anxiety Scale (mAMAS), which was triangulated with a measure of mathematical resilience (MR); Baker Children's Mathematical Resilience Scale (BCMRS). In a second qualitative phase, the perceptions of school staff and children who participated in this research regarding the implementation of a whole-class MR intervention were also explored to enhance the findings.

1.2 Personal Interest in the Research

My personal interest in the research topic grew from my experience as a primary school teacher and having completed a mathematics specialism during teacher training. I was passionate about teaching the subject, but as I set out in my career, I began to observe the impact of mathematics anxiety. No matter the teaching approach I took or adaptation to the materials I used, I found it challenging to support some of my learners to access the curriculum because of an emotional barrier. After taking on an assistant psychologist role alongside teaching, I began to combine my knowledge of psychological theory with my skillset in teaching mathematics. I recognised that I needed to support children to regulate and have good relationships with their teacher, peers and the subject of maths before attempting to support them in acquiring new learning. This led me to this research project. As a Trainee Educational Psychologist (TEP), I hope that this research can contribute to our understanding of how to support and empower school staff to alleviate mathematics anxiety.

1.3 Aims of the Research

This research aims to contribute to the existing literature which examines how school-based interventions can help children cope with mathematics anxiety (MA) and develop mathematical resilience (MR). It aims to provide a unique contribution to understanding the impact of both early and universal intervention in UK primary schools. In particular, the study seeks to enhance our understanding of how primary school children can be supported in managing MA through a whole-class approach. It focuses on collecting data and evaluating the implementation of a whole-class intervention designed to foster MR, assisting teachers in addressing the emotional aspects of mathematics. Additionally, the study hopes to expand the knowledge base on how Educational Psychologists (EPs) can support schools in understanding and implementing universal interventions to alleviate mathematics anxiety and enhance mathematical resilience for all.

1.4 Rationale

The research suggests that MA can be observed when formal education begins (Maloney & Beilock, 2012) and that its prevalence increases with age (Dowker et al., 2016). It has been found that apprehension of maths, leading to fear of failure and avoidance, is present in children as young as four years old (Petronzi et al., 2017). Thus, it is argued that universal provision should be offered in schools early to proactively address MA.

Despite recognising the importance of early intervention in preventing or reducing MA for long-term outcomes (Petronzi et al., 2021), little attention has been given to investigating universal interventions in UK primary schools until now. Primary teachers in the UK have been found to generally exhibit limited awareness and understanding of MA, and staff training, including the use of Johnston-Wilder et al.'s (2020) toolkit, has been shown to help promote their confidence and have practical implications for their teaching practice (Io, 2023).

1.5 Overview of Thesis Chapters

The subsequent chapter of this research presents a systematic review of research underpinning this study. It begins by providing an overview of mathematics education in the context of the UK before exploring the affective domain of mathematics, specifically, mathematics anxiety (MA) and mathematical resilience (MR). The review then focuses on the relationship between MA and MR, as well as exploring interventions thought to promote MR. The chapter concludes by providing the aims of the present research and outlining the research questions.

The methodology of this study is detailed in Chapter 3. The chapter establishes the study's theoretical and methodological framework by exploring the complexities of educational research and outlining the ontological and epistemological positions adopted. The rationale for using a sequential explanatory mixed-methods approach to assess an intervention's effectiveness is then explained, along with a description of the specific quantitative and qualitative methods employed.

Chapter 4 presents the data analysis and findings of the study in two sequential phases. Phase one details the quantitative results, while phase two describes the findings produced from the qualitative analysis. The chapter concludes with an integrated summary of both phases of data.

Chapter 5 presents the study's findings within the context of existing literature, with the outcomes of each phase discussed in relation to the research questions. The chapter then critically evaluates the study's strengths and limitations before exploring the implications for educational providers, schools, and Educational Psychologists (EP). Suggestions for further research are then made and the chapter concludes by underscoring the unique contribution of this research.

Chapter 2: Literature Review

2.1 Structure of the Literature Review

This chapter outlines the existing research relevant to the current study through a systematic search. This literature review will begin by providing a brief introduction to mathematics education in the United Kingdom (UK) to situate the research within its national context. The chapter then introduces the affective domain of mathematics, focusing specifically on mathematics anxiety (MA) and the concept of mathematical resilience (MR). The chapter includes a rationale for the use of Johnston-Wilder et al.'s (2020) toolkit to form the basis for universal intervention, as well as the unique contribution to the evidence base that this study will provide in doing so.

The systematic literature review (SLR) specifically concentrates on the relationship between MR and MA, including the impact of interventions said to promote MR. The initial search sought to explore research conducted in the same manner as this study, a universal or whole-class approach; however, the search yielded nil results. Therefore, the search strategy was widened by removing the whole-class intervention format from the inclusion criteria. Following the systematic literature review, the research questions that the study seeks to answer will be outlined.

2.2 Mathematics in the Context of the United Kingdom (UK)

2.2.1 Curriculum and Attainment

At the heart of this research sits the teaching and learning of mathematics. Therefore, to begin this literature review, the context in which this research sits is discussed. In the United Kingdom (UK), mathematics is considered a ‘core subject’ in the National Curriculum (NC) and there are prescribed programmes of study beginning in Key Stage 1 (KS1)

(Department for Education, DfE, 2013). This compulsory curriculum takes place primarily at primary and secondary schools for students aged five to sixteen years.

As outlined in the mathematics programmes of study in the National Curriculum (NC) (DfE, 2013, p. 30), by the end of Key Stage 2 (KS2) (11 years), children are expected to solve a wide range of mathematics problems with 'increasingly complex properties of numbers and arithmetic, and problems demanding efficient written and mental methods of calculation'. Within the NC used in England, children are expected to have mastered the written methods for all four operations, including long multiplication and division. Additionally, children are taught and expected to work with fractions, decimals, percentages, and basic algebra.

According to results published by the Programme for International Student Assessment (PISA) in 2022, England's performance in mathematics remains high compared to that of other education systems, including those in the United States, Vietnam, Israel, New Zealand, and several countries across Europe. The average score of English pupils in mathematics, at age fifteen, was found to be significantly above the Organisation for Economic Co-operation and Development (OECD) average as of 2022, with only eight out of seventy-nine participating countries scoring significantly higher than England: Singapore, Macao, Taiwan, Hong Kong, Japan, South Korea, Estonia and Switzerland (Ingram et al., 2023). However, the attainment gap between the lowest and highest achievers in England is large, and in the 2022 PISA results, this gap was significantly wider than the OECD average. However, it is worth being cautious of these conclusions as England did not meet PISA's sampling standards, as an insufficient number of schools, one hundred and sixty-five in total, took part in the assessment (Ingram et al., 2023).

It has been argued that low attainment in mathematics represents one of the most pressing challenges within the British education system (Hodgen et al., 2022; Marshall, 2013). Numerous policy developments, over the last sixty years, contain discourse concerning low attainment with an agenda to equalise mathematics education in the UK (Hodgen et al., 2022). In recent years, following the COVID-19 pandemic and the subsequent closure of schools, the socio-economic attainment gap or ‘disadvantage gap’ in maths has widened when assessed by primary school leaving data (Department for Education (DfE), 2024; Rose et al., 2023). The end of Key Stage 2 (KS2) data also highlights that, though girls outperform their male counterparts in other subjects, boys continue to outperform girls in maths (DfE, 2024). A meta-analysis of thirty-nine studies synthesising the impact of COVID-19 on attainment has found that the pandemic’s effect on student achievement resulted in greater losses in mathematics and science compared to other subjects (Di Pietro, 2023). Now more than ever, there seems to be a growing disparity between high and low performers across the mathematics attainment scale.

2.2.2 Political Discourse Surrounding Mathematics Education

In 2023, the Conservative government established a mathematics advisory group composed of mathematicians, education leaders and business representatives and introduced a ‘Maths to 18’ plan (Lewis, 2023). The ‘Maths to 18’ plan would see all children study meaningful maths until they are eighteen. If this plan is to go ahead, children will no longer have autonomy over the decision to cease studying mathematics at age sixteen.

In the July 2024 general election, the Labour Party secured a majority in Parliament, thereby instigating a recent change in government. In their 2024 change manifesto, the party pledged to improve the quality of maths teaching across primary and early years settings (The Labour Party, 2024). This was echoed in a press release which stated that the party will prioritise “driving improvements at primary level” and reform the ‘Maths to 18’ working group (The Labour Party, 2023). The press release indicates that the party intends to assess the existing curriculum, advocate for the concept of ‘bringing maths to life,’ and initiate reforms within the curriculum to emphasise the application of mathematics in real-world scenarios. We are currently in a transition period, which brings uncertainty around the current state of the mathematics curriculum in the UK, including whether the study of mathematics will become compulsory until 18. In a recent speech from the UK's Education Secretary, maths attainment was stated to make up one of the four national priorities for the Department for Education (DfE & Phillipson, 2025).

2.2.3 Beliefs About Mathematics Ability

A rhetoric surrounding an innate ability to excel in mathematics versus a natural difficulty with the subject seems to pervade our general discussions about it, and surprisingly, also appears in UK government policy. In their research review, Ofsted (2021) states the following: "Despite its [mathematics] importance, for many the subject remains mysterious and difficult, the preserve of those who seem to be 'naturals'." In their analysis of sixty years of education policy in England, Hodgen et al. (2022, pp. 11–12) identified a "growing emphasis on numeracy for all and mathematics for *some"* as a theme within policy. They found discourse which suggests that for low-attaining children, it is not necessary for them to access more than the basic concepts and skills of numeracy (See Vorderman et al., 2011).

Research indicates that our culture influences our perspectives on the nature of intelligence (Heine et al., 2001; Hwang et al., 2016). In Western culture, mathematical ability is said to often be conceptualised as an innate skill, such that our capacity to learn the subject is determined at birth (McDonald, 2022). The belief that some people are just 'maths people' appears to be commonly accepted (Baker, 2020; Coles & Sinclair, 2022; McDonald, 2022). These beliefs have also been referred to as *field-specific ability beliefs* (FABs), which refers to the acceptance that an individual has to possess 'brilliance' to be successful in a specific field; in their study, Jenifer et al. (2024) discovered that FABs linking success in maths to an innate intellectual talent existed in children aged between six and ten years. FABs have also been found to be stronger in trainee teachers for subjects with a strong mathematical component (Asbury et al., 2023). Chinn (2020) argues that experiencing difficulty in maths in Western culture holds no social stigma. He suggests that many will openly acknowledge their difficulty in discussion with others, whereby they are often met with shared empathy, demonstrating an acceptance that we are either 'maths people' or not.

The idea that success in maths requires innate skill or brilliance is frequently portrayed in the media. Hall (2020) considers the influence of children's media, including the narrative of films such as 'Good Will Hunting', and television programmes such as 'The Big Bang Theory', on how maths and mathematicians are conceptualised. Their research suggests that popular media portrays the message that 'maths is hard', "difficult and mystifying, [and] only accessible by a select few," (Hall, 2020, p. 10).

Mindset theory (Dweck et al., 1995; Dweck & Leggett, 1988) suggests that each of us holds an implicit theory about intelligence, ranging from thinking that intelligence is fixed or predetermined to believing that intelligence is dynamic and that, through effort, we can grow our intellect. Dweck's (1999) research gave rise to the concept of a 'fixed' versus a 'growth mindset'. Those with a 'fixed mindset' believe that their level of intelligence cannot be changed; in the context of mathematics, you are either a 'maths person' or not. Given this, one might suggest that culturally, many hold a 'fixed mindset' view of mathematics. Despite this, the UK sits above the OECD average for holding a growth mindset. The PISA 2018 assessment (OECD, 2020) found that, when asked to rate the statement, '*Your intelligence is something about you that you can't change very much*', 70% of 5,174 children from the UK disagreed, suggesting that the majority of children hold a growth mindset.

However, the statement did not distinguish between subjects or domains of intelligence. The mind is argued to be formed of multiple intelligences (Gardner, 2011) and there is research to suggest that beliefs about intelligence and our growth mindsets are context-specific (Goldhorn et al., 2023; Scott & Ghinea, 2014). There is also growing evidence to suggest that people have stronger fixed-mindset beliefs about maths than other subjects (Heyder et al., 2021).

2.3 Introducing the Affective Domain of Mathematics and Mathematics Anxiety

It is evident that supporting children's academic attainment in mathematics is a priority for the United Kingdom (UK) government. However, whilst it seems we are often concerned with children's mathematical performance, it is recognised that there is a clear distinction between cognitive (or academic) and emotional mathematics problems (Devine et al., 2018). In the context of mathematics, whilst the cognitive domain is concerned with intellect, the affective domain involves our emotions, attitudes, beliefs and values (Beltrán-Pellicer & Godino, 2020; Hui & Mahmud, 2023). The influence of the affective domain on learning in mathematics is now a well-established line of research (Beltrán-Pellicer & Godino, 2020) with McLeod (1989) paving the way in his analysis of the affective domain in mathematics.

Before any empirical research was published, early reflections in the literature concerning emotional responses observed in mathematics alluded to the concept of 'mathemaphobia' (Gough, 1954). In her research paper, Gough (1954), a teacher, raised her concerns about the number of students struggling in mathematics. She coined the term 'mathemaphobia', which she described as a disease which needed treating in the same vein as physical wellbeing. Gough (1954) noted that:

> The poor, struggling student may soon begin to reason that mathematicians are just born that way, and he will probably begin to fear that he doesn't have the magic gift. If the teacher lets him catch a glimpse occasionally of the vast expanses of mathematical area which he or she has not explored, and shows him that one-yes, even a teacher acquires skills little by little as a result of application and thought, perhaps then the student's fears will in some measure be dissipated. (p. 291)

This is arguably one of the first pieces of literature to consider the role of the teacher in supporting the affective domain of mathematics and the potential for adults to alleviate fear or anxiety in the subject by changing their approach to teaching. Gough (1954) appears here to link a fixed-mindset about mathematics with the development of a fear of the subject.

The notion of a specific form of anxiety surrounding maths appeared first in the research literature as 'Number Anxiety' (NA) (Dreger & Aiken, 1957). In the first example of experimental research on anxiety in maths, Dreger and Aiken (1957) proposed that NA is distinct from general anxiety, not linked to overall intelligence and that individuals with higher levels of NA perform less well in mathematics examinations. Subsequently, mathematics anxiety (MA) has garnered increasing attention in research fields.

2.3.1 Defining Mathematics Anxiety (MA)

Dowker et al.'s (2016) paper critically reflects on the research that has shaped our understanding of mathematics anxiety (MA) over the past sixty years, while drawing attention to what remains to be explored. Their review of the research reveals the broad scope of the literature that has explored MA, including its relationship with attainment, brain function, age, gender, culture, and genetics, as well as potential interventions for MA. One accepted definition of MA states that it is "a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations," (Richardson & Suinn, 1972, p. 561).

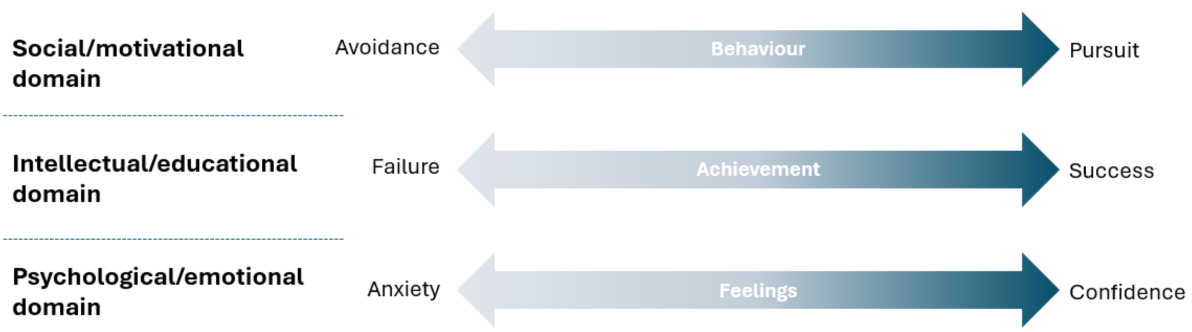
As was suggested by Dreger and Aiken (1957), MA is argued to be a distinct form of anxiety that is separable from the experience of other forms (Dowker et al., 2016); it is situation-specific (Marshall et al., 2017) and separable from generalised or test anxiety (Luttenberger et al., 2018). MA is said to manifest differently for each individual and can be exhibited as worry, dislike, frustration and fear (Devine et al., 2018). Emerging evidence also suggests that some topics, such as statistics and fractions, may result in differing levels of

MA (Halme et al., 2022; Sidney et al., 2021). MA has also been found to increase with age (Dowker et al., 2016; Zhuo et al., 2025).

MA is thought to manifest itself physiologically, emotionally and cognitively (Haase et al., 2019); it is an uncomfortable affective experience arising when tasked to work with numbers or mathematical problem-solving, both in the classroom and beyond. The emotional component of MA differentiates it from cognitive maths difficulties (Khasawneh et al., 2021). It is suggested that the development of MA can be divided into three domains; social (or motivational), intellectual (or educational) and psychological (or emotional) (Olango, 2016). Olango (2016) suggests that whilst these domains are separable, there is inevitably some overlap and each exists on a continuum (See Figure 2. 1).

Figure 2. 1

Olango's (2016) Domains of Mathematics Anxiety



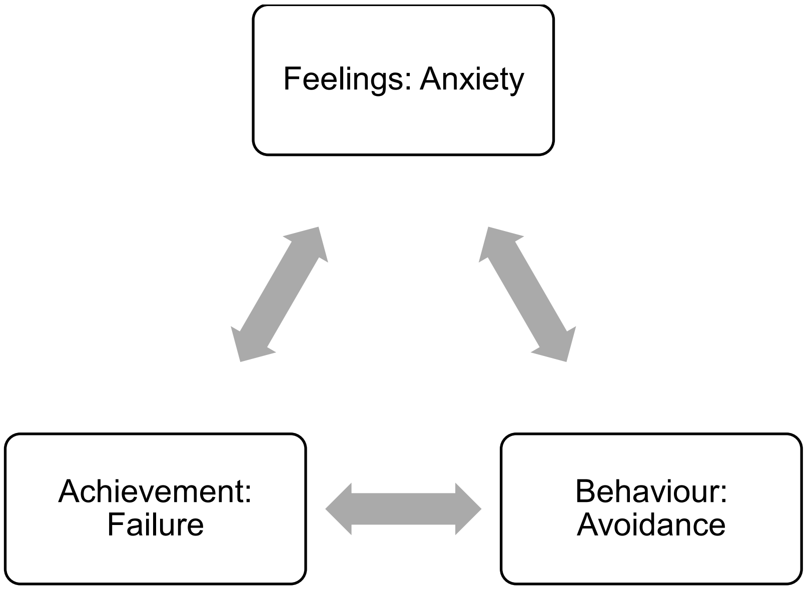
Note. This figure illustrates the three domains of mathematics anxiety. Higher anxiety is associated with avoidance, failure, and distress, while lower anxiety is reflected in pursuit, success, and confidence.

Olango (2016) argues that MA is comprised of social, emotional and cognitive responses due to the perception of a threat to one's self-esteem. The social/motivational domain's continuum is encapsulated as *behaviour* ranging from avoidance to the pursuit of mathematics. It is argued that avoidance or pursuit is associated with the value one holds of mathematics. The *achievement* continuum refers to an individual's subjective evaluation of their skill in the subject, with failure and success at opposing ends. Finally, the psychological domain encompasses our affective response; the continuum associated with this domain is *feelings*. Olango (2016) suggests that this domain is associated with our historical experiences with the subject and subsequent emotional response when exposed to mathematical stimuli.

Individuals with MA experience psychological symptoms such as tension and negative thought patterns associated with mathematics (Hunsley, 1987), tend to avoid mathematics (Andrews & Brown, 2015) and experience physiological symptoms such as increased heart rate (Faust, 1992). Research has also shown differential neural activations in individuals with high MA when exposed to math stimuli, including increased amygdala reactivity (Lyons & Beilock, 2012; Pizzie & Kraemer, 2017). Feeling anxious about mathematics can trigger an acute stress response (fight-flight-freeze), leading to the avoidance of mathematics, even at the level of attention to stimuli (Pizzie & Kraemer, 2017). This avoidance behaviour can impact our success and lead to further anxiety about math, perpetuating a reinforcing cycle (Field et al., 2019). Figure 2. 2 visualises Olango's (2016) domains in how they are theorised to interact in the development of MA.

Figure 2. 2

Olango's (2016) Reinforcing Cycles of Interaction



2.3.2 Mathematics Anxiety in the Classroom: Prevalence and Population

The most commonly experienced form of subject-specific anxiety in educational settings is suggested to be MA (Luttenberger et al., 2018). However, estimates of its prevalence differ, ranging from 2% to 68%, due to variance in the population sample, measures used and categorisation of those considered to be "highly maths anxious." There appears to be no consistent agreement on MA prevalence (Dowker et al., 2016). However, research has shown that young children experience MA in primary schools (Krinzinger et al., 2009; Van Mier et al., 2019; Witt, 2012) and is argued to be present in children as young as four years old (Petronzi et al., 2017). In their sample of 1,757 mainstream primary and secondary school children in the UK, Devine et al. (2018) determined that 11% of children had high MA. However, the data did not explore the prevalence of children with low or moderate MA.

Whilst there are several theories which aim to explain the relationship between MA and attainment, there appears to be a general agreement that MA impedes learning (Vukovic et al., 2013). It has been shown in the literature that there is a robust negative correlation between MA and attainment in mathematics (See Zhang et al., (2019) for meta-analysis). Therefore, it has been suggested that MA is most commonly experienced by those children considered to be low attainers. Within educational settings, there is a common assumption that children grappling with MA are those who encounter challenges with the subject and demonstrate lower performance compared to their peers. However, this association between MA and performance fluctuates between geographical regions with Zhang et al.'s (2019) meta-analysis suggesting that this link is weakest in studies with Western European children. There was also a longitudinal study whose results suggest that there is no causal relationship between MA and ability (Krinzinger et al., 2009). Additionally, there is evidence in the UK literature base to suggest that the majority of those experiencing high MA fall within the average or above-average mathematics performance range (Devine et al., 2018). These findings suggest that elevated levels of MA do not exhibit bias based on academic achievement in our UK classrooms.

What is known is that MA interferes with the process of teaching and learning, is more often associated with decreased academic performance and discourages individuals from pursuing careers in mathematics-related fields (Dowker et al., 2016). MA has been described as an “emotional handbrake” which impairs an individual's thinking and problem-solving ability in mathematics (Johnston-Wilder & Lee, 2017).

2.3.3 The Educational Psychologist’s (EP) Role in Addressing Mathematics Anxiety

Mathematics anxiety (MA) is a widespread concern, argued to require both educators and researchers to focus their efforts on improving outcomes for children and young people (Ramirez et al., 2018). Educational psychologists (EP) can enhance the connection between educational practice and research, particularly in their ability to bring the real world to the research they conduct (Campbell & Green, 2022).

Promoting educational and well-being outcomes for children is a principle to be upheld as outlined in the Special Educational Needs and Disability (SEND) Code of Practice (DfE, 2015) including difficulties with mathematics, such as MA. EPs are “involved in enhancing children’s achievement and well-being,” (Beaver, 2011, p. 15) and with MA an issue of concern for schools, EPs should be part of seeking solutions to promote well-being in the maths classroom.

2.3.4 Interventions that have been used to Support Mathematics Anxiety

Ofsted's (2019) education inspection framework (EIF) states that schools are expected to help children and young people “gain enjoyment through a growing self-confidence in their ability” in mathematics. Interventions which focus on supporting children’s affective and regulatory skills in maths have shown promise in reducing MA (Petronzi et al., 2021). It is argued that focusing on well-being and emotions in mathematics is becoming a fundamental part of initiatives to mitigate the impact of MA (Neufeld et al., 2018).

In a recent meta-analysis of fifty studies, interventions targeting the regulation of emotions toward maths were shown to reduce MA and improve math performance (Sammallahti et al., 2023). The review indicated that these interventions reduced MA and led to a more positive attitude toward the subject. They also found a small, significant increase in mathematics performance in response to these interventions.

In a systematic review of school-based MA research, Balt et al. (2022) distinguished between mathematical (or academic) interventions and cognitive-behavioural interventions (CBI) to reduce MA. CBI interventions were those that were considered to support children in coping with negative thoughts and feelings associated with the subject. They found that over half the studies, categorised as CBI, had reported positive outcomes of the intervention on the level of MA when compared with a comparison or control.

2.4 Addressing Mathematics Anxiety by Building Mathematical Resilience (MR)

2.4.1 Defining Mathematical Resilience (MR)

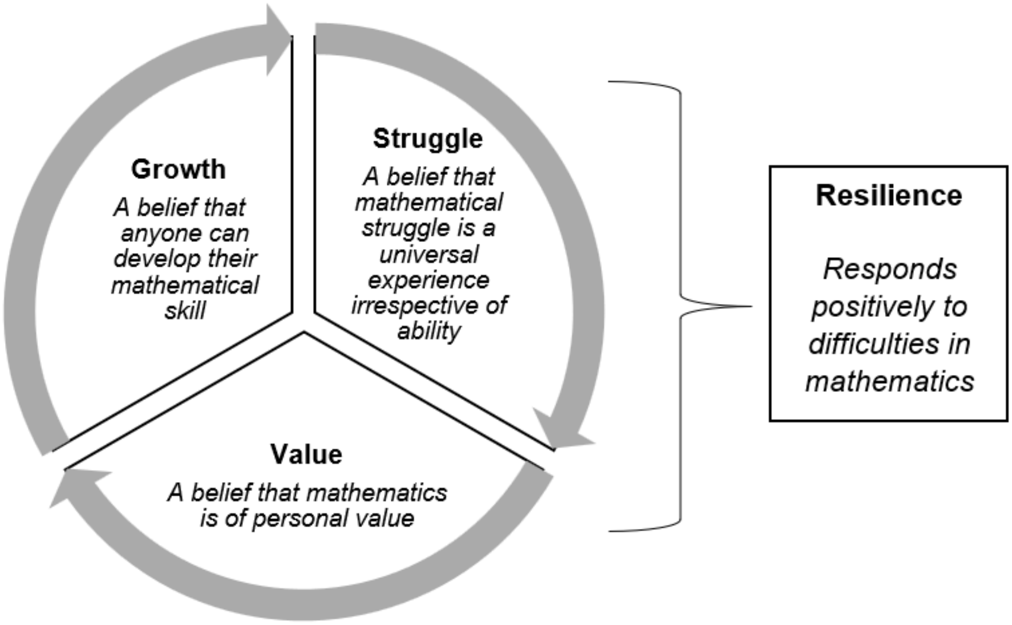
Ishak et al. (2020, p.38) define mathematical resilience (MR) as a "positive stance when a person finds mathematics is challenging, and they will find new strategies to overcome it". They state that MR is a personal quality grounded in growth mindset theory, specific to mathematics (Dweck et al., 1995; Dweck & Leggett, 1988) which supports the alleviation of mathematics anxiety (MA) and learner helplessness.

This study will consider MR as a psychological characteristic, as defined by Johnston-Wilder and Marshall (2017). The construct encompasses the positive attributes that empower learners to effectively engage with, comprehend, and apply mathematical concepts both in educational settings and in real-world situations (Johnston-Wilder & Marshall, 2017). Learners who have developed MR are thought to be better equipped to handle setbacks and the negative emotional states which arise, such as avoidance, anxiety, and helplessness and therefore, better able to continue to engage in learning (Kooken et al., 2016).

The three components of MR have been conceptualised as *struggle, value*, and *growth* (Ishak et al., 2020; Kooken et al., 2013) (See Figure 2. 3). MR is suggested to be composed of a belief that math is valuable, a belief that mathematical struggle is a universal experience, a belief that anyone can develop their mathematical skills, and the ability to respond positively to difficulties in mathematics (Kooken et al., 2016). MR is also thought to be more developed when a learner has access to resources that enable them to respond positively to challenges in mathematics. These resources include relationships with more knowledgeable others, as well as physical resources such as textbooks (Baker, 2020; Ishak et al., 2020).

Figure 2. 3

Illustration of the Correlated Factors of Mathematical Resilience



Note. Developed by the researcher, drawing upon the work of Ishak et al. (2020) and Kooken et al. (2013) on the components of MR.

2.4.2 Building Mathematical Resilience: A Toolkit

Across the literature, there has been a focus on how MR impacts both cognitive processes and affective features. Regarding affective features, this has included anxiety, attitudes, values, and beliefs. Whilst a negative correlation between MR and anxiety has been found (Trigueros et al., 2020), review of the MR literature highlights the need for future research to examine the relationship between MR and other affective features (Akkan and Horzum, 2024).

MR is believed to counter MA by providing strategies to manage avoidance, anxiety, and helplessness, which are often associated with learning mathematics (Lee & Johnston-Wilder, 2017). Thus, the development of children's MR is said to be key to improving mathematical well-being and relief from MA (Johnston-Wilder et al., 2021). Johnston-Wilder and Lee (2010) suggest that focusing on MR supports learners in changing their mindset and overcoming negative attitudes toward mathematics. They propose three tools, underpinned by psychological principles, that can be used to support children in building their MR and thus reduce MA. They also suggest that this approach has the potential to increase student attainment and self-efficacy and help teachers avoid causing psychological harm in maths.

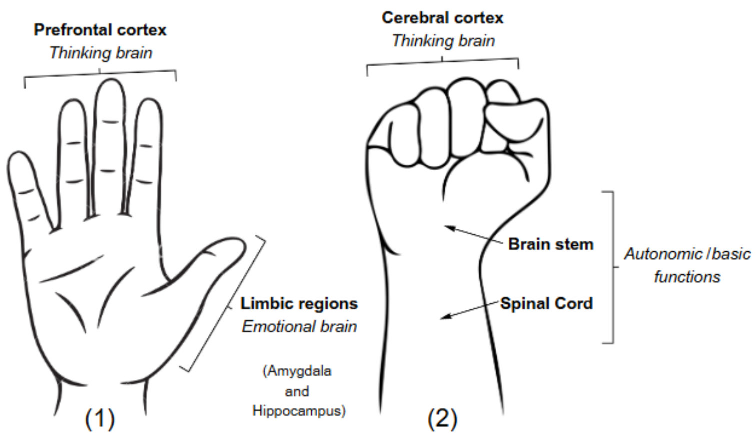
Johnston-Wilder et al.'s (2020) approach suggests that teachers and support staff must be aware when learners feel an elevated level of arousal or anxiety, and help reduce these symptoms and enable learners to return to a productive level of arousal. They refer to this as mathematical safeguarding, and as such, adults are responsible for the welfare of learners in their mathematics classroom as well as upskilling learners in their ability to self-safeguard. Johnston-Wilder et al. (2020) developed a toolkit that aims to upskill adults, including school staff, in their understanding of how to psychologically safeguard against MA and support the development of MR.

The toolkit is comprised of three existing tools and was developed as a new educational intervention in response to addressing MA by applying concepts of regulation. Johnston-Wilder et al. (2020, p. 1424) state, “These tools can help teacher educators, teachers, parents/carers and learners to understand better how teaching and learning approaches can be adjusted to reduce the impact of anxiety and to help learners build resilience.” These tools include the hand model of the brain (HMB) (Siegel, 2010), the ‘relaxation response’ (RR) (Benson, 2000) and the Growth Zone Model (GZM) (Johnston-Wilder et al., 2013).

Hand Model of the Brain. The Hand Model of the Brain (HMB), developed by Dan Siegel (2010), is a practical metaphor to support the understanding of how our brain processes and regulates emotions, particularly in response to anxiety and acute stress (See Figure 2. 4). The open hand (1) represents dysregulation between the emotional (limbic regions) and thinking (cortical) parts of the brain, referred to as a fight-flight-freeze response or 'a flipped lid'. The closed fist (2) represents a regulated brain, ready to learn. Johnston-Wilder et al. (2020) suggest that this tool can help learners understand MA and the fight-flight-freeze response in three ways. First, it makes the neuroscientific principles behind an anxious response to mathematics more accessible, which in turn fosters a growth mindset. Second, it supports and encourages the development of a shared language, allowing learners to effectively communicate their 'brain state'. Finally, it aids in the early identification of learners who may be experiencing dysregulation in mathematics, providing opportunities for timely intervention and support.

Figure 2. 4

Hand Model Of The Brain



Note. A visual representation of Siegel's (2010) Hand Model of the Brain (HMB)

Relaxation Response. The approach suggests that after a learner recognises their emotional state, they should be introduced to the 'relaxation response (RR) (Benson, 2000) to support them in regulating and re-engaging with learning. Johnston-Wilder et al. (2020) argue that the concept of RR should be used in mainstream mathematics classrooms in response to MA. The toolkit conceptualises this tool as activities which will support learners with relaxation. They suggest that this should include a variety of techniques based on individual needs and could include breathing, grounding or mindfulness techniques.

Growth Zone Model (GZM). The first two tools provide a basis for the learner to understand the Growth Zone Model (GZM), which is described as a "simple, cohesive framework for becoming aware of, describing and communicating emotions," (Johnston-Wilder et al., 2020, p. 1427). Case studies have shown the potential promise of positive change as a result of applying the toolkit in practice (See Pará & Johnston-Wilder, 2023; Thomas, 2020). There is also qualitative evidence of the benefits of using the GZM with a sample of highly MA secondary school children (Baker, 2021) and teacher reports of the GZM enhancing classroom practice (Johnston-Wilder & Moreton, 2018).

The GZM (Johnston-Wilder et al., 2013) consists of three concentric zones which represent different layers of a learner's affect (See Figure 2. 5). Drawing upon Vygotsky's 'zone of proximal development' (ZPD), Johnston-Wilder et al. (2013) conceptualise their GZM as an emotional model which is divided into three zones; *comfort*, *growth* and *anxiety*.

Figure 2. 5

Growth Zone Model

Note. A figure of the Growth Zone Model (Reprinted with permission from Johnston-Wilder et al., 2013)

The *comfort* or *safe zone* (green) is described as the area where a learner accesses activities that they can complete independently. In this zone, the learner is completing tasks that are familiar to them and provides them with an opportunity to practice their skills comfortably and build self-confidence. Within the green circle, a learner feels relaxed, safe and confident in their ability. This zone has been described as 'unchallenging' and where little growth takes place; it is suggested that many learners are content to remain in this zone (Heshmati, 2020).

The *growth zone* (yellow) has been referred to as a discomfort or stretch zone (Johnston-Wilder et al., 2013). This zone is where the most growth is seen and where individuals experience challenges in acquiring new knowledge. In this zone, it is encouraged that teachers create a safe space for mistakes, promote collaboration and give time for questions to promote a learner's growth (Johnston-Wilder et al., 2020). The toolkit emphasises that learners must be explicitly informed that it is safe to make mistakes and that they will require support to progress with challenging activities. This zone may see learners acquire the knowledge to approach a task with a new strategy and experience increased competency (Heshmati, 2020). Johnston-Wilder et al. (2013) suggest that it is useful to reason that MR is what is needed for learners to remain within their growth zone.

The *anxiety zone* (red) encompasses the outer part of the GZM and when in this zone, a learner is exposed to mathematical challenges beyond the scope of their ability (Johnston-Wilder et al., 2013). Even with support, what is being asked of the learner is not perceived to be within their ability, and they cannot self-safeguard or regulate their anxiety. This gives rise to the learner becoming anxious and experiencing feelings of stress, anger, hopelessness and overwhelm (Johnston-Wilder et al., 2020). The toolkit suggests that this increase in stress results in a decrease in the ability to engage cognitively, and therefore, minimal learning can occur.

The GZM is said to expand upon Siegel's (2010) HMB as it “gives a framework for learners to distinguish between perceived challenge and threat, enabling them [learners] to name and communicate current feelings,” (Johnston-Wilder et al., 2020, p. 1428). In Johnston-Wilder and Moreton's (2018) research, they conducted semi-structured interviews with three teachers who had been part of a ‘Building Mathematical Resilience’ workgroup. The workgroup comprised sixteen teachers across primary, secondary, and further education settings. The application of the GZM in mainstream mathematics classrooms was perceived as useful, although more rigorous testing would be required.

2.5 Universal Approaches to Supporting Mathematics Anxiety

A universal or school-wide approach to intervention targets all children, is typically low in cost in comparison to other levels of intervention, and aims to proactively promote protective factors such as self-regulation (Greenberg & Abenavoli, 2017). The advantages of implementing educational interventions at a universal level include the potential for coping strategies learnt to transfer to other experiences, their inclusivity since they are delivered to children regardless of the current level of risk, and their sensitivity to the possibility of problems developing later in life (Greenberg & Abenavoli, 2017). However, it must be considered that methodological issues and small effect sizes have inhibited the ability to draw concrete conclusions about the effectiveness of universal school-based interventions that promote mental health, emotional well-being and psychological resilience (Mackenzie & Williams, 2018).

Johnston-Wilder et al. (2020) indicate that their toolkit is appropriate as a strategy for teachers to implement in mainstream mathematics classrooms. The idea that MA is experienced by a range of learners irrespective of ability (Devine et al., 2018), suggests that exposure to an intervention to promote the development of MR at a universal level would be a beneficial research avenue. Schukajlow et al. (2023) states:

> [There is] a need for research that can transcend the intervention approach and explore how affectively sound changes in educational practices can be implemented in the mathematics classroom and in educational institutions more generally on a large scale. For example, researchers should investigate how instructional settings and practices can support students in regulating their emotions and motivation in ways that promote their development. (p. 263)

To provide an overview of the current literature base regarding universal MA interventions, the supplementary materials from two recent systematic reviews were considered to identify interventions delivered at a whole-class or universal level (for a list of the studies, see Appendix A).

The following criteria were adopted to identify evidence:

- **Population**: children attending school settings aged between four and seventeen years of age
- **Intervention**: delivered universally or on a whole-class basis; categorised as affective or emotion-based
- **Measure**: A measure of MA (not test or trait anxiety)

A summary of the studies identified can be found in Appendix B. Of the twenty-five studies categorised as MA intervention targeting emotions, Sammallahti et al.'s (2023) meta-analysis revealed that only two studies employed a universal approach. Of the school-based interventions to address MA, Balt et al.'s (2022) systematic review contained three cognitive-behavioural interventions (CBI) delivered at a whole-class level. One study appeared in both reviews; therefore, a total of four studies were considered to meet the above criteria. Each of the four studies delivered an intervention targeting MA for all students, irrespective of their attainment in mathematics or level of MA, and were thus regarded as universal approaches. This section now summarises the outcomes of these four research papers.

Brandenberger and Moser (2018) delivered workshops in Swiss schools for low-attaining secondary-aged students alongside their teachers, covering the topics of emotions and motivation, learning goals, learning strategies and self-regulation. The results showed that the group receiving these workshops alongside their teacher experienced the greatest reduction in self-reported MA compared to when the intervention was delivered in the absence of the teacher and a wait-list control group. Their intervention included teaching the students about emotional regulation and the positive handling of mistakes and failures.

Passolunghi et al. (2020) delivered MA training to Italian primary-aged children (equivalent to UK Year 5) but excluded those with SEND needs. This intervention included activities on recognising mathematics-related emotions and introducing strategies to reduce MA. The intervention was delivered over eight weeks, with three of these focusing on strategies to reduce MA. The MA training group saw a significant reduction in MA in comparison to the wait-list control. However, they did not see an increase in mathematical ability.

Kim et al. (2017) delivered anxiety-treating messages alongside an electronic mathematics algebra programme to one hundred and thirty-eight students aged 13 – 17 in the USA. These messages were aimed at helping the students recognise their mathematics anxiety, manage uncertainty, and confront challenges. Their results indicated that MA was reduced following the intervention; however, this was not significant in comparison to a control group.

Mesghina and Richland (2020) explored the efficacy of using expressive writing techniques as an intervention to reduce MA in two hundred and fifty children aged 10–12 (equivalent to UK Year 6 and 7) in the USA. The rationale underpinning this research was the view that expressing thoughts and emotions through writing may lessen the working memory load caused by pressure and anxiety. However, their results contradicted their expected finding as they found an increase in anxiety and reduced learning gains. They found that expressive writing increased children's anxiety; in particular, girls with higher working memory experienced more difficulty with the writing task and greater decreases in their learning and retention post-intervention.

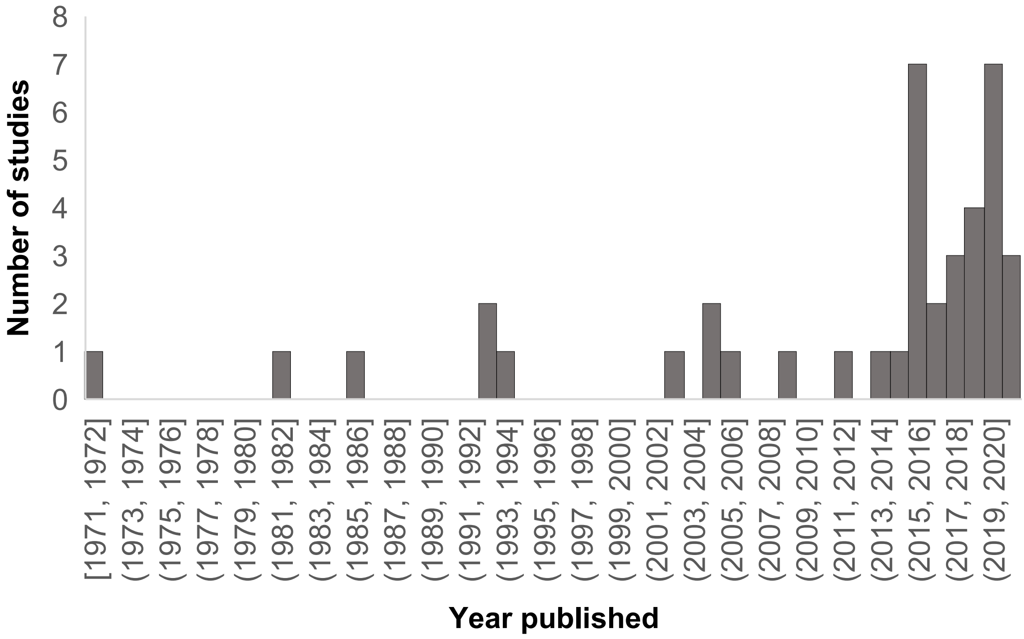
2.5.1 Summary and Rationale for a Systematic Literature Review

The universal interventions that seem to have had the most positive impact on MA were those focusing on building children's knowledge and awareness of their emotions and teaching self-regulation skills. Reference to children's MR did not appear in the above literature as an approach to supporting school settings in managing MA. This may be due to the literature covered only running up until 2021. In addition, all of these studies were conducted outside of the UK and with children over the age of nine years.

Looking at the literature included in these reviews by date indicates a growing interest in MA interventions (See Figure 2. 6). Therefore, a systematic review of the most recent literature concerning MA interventions, which also includes references to MR, would be an appropriate next step in identifying relevant literature for this research study.

Figure 2. 6

Histogram of the Literature



Note. Number of studies, by year, that concern interventions for mathematics anxiety, as included for review by Sammallahti et al., (2023) and Balt et al. (2022).

2.6 Systematic Review

This section first discusses the existing systematic reviews that explore mathematical resilience (MR) and then outlines the purpose of the systematic literature review (SLR) conducted to inform this study. Then, an SLR is performed to establish the evidence base for the relationship between mathematics anxiety (MA) and MR, including interventions that promote the development of MR to reduce MA.

2.6.1 Existing Reviews and Objectives for this Study's Systematic Review

The EPPI Centre (Evidence for Policy and Practice) and Campbell Systematic Review libraries were referred to establish if there were any existing systematic literature reviews

(SLR) exploring the evidence base for MR interventions. Both libraries, which hold SLRs in education, returned no results when searching for ‘math* resilience” as a key term. Two systematic reviews on the topic of resilience in mathematics were located via a search conducted using the University of Nottingham’s online library (NUsearch):

1. *Resilience* in mathematics education research: a systematic review of empirical studies (Xenofontos & Mouroutsou, 2022)
2. Illuminating the Landscape of Mathematical Resilience: A Systematic Review (Akkan & Horzum, 2024)

Each of these reviews considers papers published up until 2021 with Akkan and Horzum (2024) highlighting that most research was published in 2021. As noted, the recent increase in the literature indicates that interventions concerning MA are a growing area of research. This systematic literature review aims to complement existing reviews and enhance the current MR research knowledge base, including studies published post-2021. In addition, this review aims to explore inquiries about the relationship between MR and MA, a topic that was not the primary focus of either review.

2.6.2 Review Questions

This systematic review aimed to answer the following questions:

1. What does current research tell us about the relationship between mathematical resilience (MR) and mathematics anxiety (MA)?
2. What is the impact of mathematical resilience (MR) promoting approaches on improving outcomes for individuals with mathematics anxiety (MA)?

2.6.3 Literature Search Strategy and Inclusion Criteria

Using five electronic databases (PsycINFO, ERIC, MEDLINE, PubMed and Web of Science) and NUsearch, a comprehensive and systematic search of the literature was conducted in July 2024. The databases outlined above provide access to research studies that are pertinent to the fields of education, psychology, mental health, and the social sciences. Initial searches using “math* resilience” and “math* anxiety” returned limited results; therefore, additional terms were added to expand the search.

Table 2. 1 shows the search terms applied when searching the databases. A flow diagram of the screening process used to identify the studies for review can be seen in Figure 2. 7.

Table 2. 1

Search Terms

Search terms

All fields/text		*All fields/text*
“math* resilience” OR “resilience in math*”	AND	“math* anxiety” OR “anxiety”

Note. A table to show the search terms applied when searching databases.

Initial searching of the databases produced 153 articles: 20 from Web of Science, 56 from PsycINFO, 9 from ERIC, 1 from MEDLINE, 67 from PubMed and 15 from NuSearch. The initial searches were saved into a systematic review software (EPPI Reviewer) and the titles were screened to identify duplicate reports. After removing eleven duplicates, 142 studies remained. Eighty-seven of these articles were removed following review of the titles, and a further thirty-six were removed following review of abstracts (See Appendix C). The remaining nineteen research papers were retrieved in their entirety, and twelve were excluded based on the exclusion and inclusion criteria in Table 2.2 (Further details are provided in Appendix D). Six studies were therefore considered for this review (See Table 2. 3).

Table 2. 2

Exclusion and Inclusion Criteria

Study feature	Inclusion criteria	Exclusion criteria	Rationale
1. Key term	Studies that consider the efficacy of 'Mathematical Resilience (MR)' as a mechanism or construct	Studies that do not include constructs of Mathematical Resilience (MR) (*growth mindset, value* or *struggle*)	To ensure that the studies reflect upon the construct of MR
2. Study design	Studies with a quantitative or qualitative measure of Mathematics Anxiety (MA) providing data to explore the relationship between MR and MA	The study does not explore a relationship between MR and MA	The design of the study must include an evaluation of the relationship between MR or MR-promoting approaches and MA to establish what the research evidence is for the implementation of MR-building strategies on MA
3. Type of research paper	Peer-reviewed journal article or thesis	Not a peer-reviewed journal article or thesis	To ensure that high-quality research is considered for review
4. Participant age	Studies involving participants of any age (children, adolescents, and adults)	None specified	To explore the relationship between MA and MR across developmental stages, and to capture a broad picture

			of intervention design, applicability and efficacy
5. Locality	Studies conducted in any geographical locality	Studies inaccessible due to institutional or locality access restrictions (e.g., not available via Nottingham University)	Due to the limited research pool, broad inclusion across localities allows for the capture of international and cross-cultural research around MR, while acknowledging practical constraints in literature accessibility
6. Language	Studies published in any language	Studies that could not be accessed in a translatable format	To maximise inclusivity and capture relevant literature globally, while recognising practical limitations in accessing and interpreting non-translatable sources
7. Publishing year range	Studies published between 2014 and 2024 (past 10 years)	Studies published before 2014	MR and interventions to support MR is a relatively recent construct; limiting literature to the past decade ensures relevance and currency, and includes literature post-2021 that has not been captured in earlier systematic reviews

Note. This table details the exclusion and inclusion criteria for this systematic review.

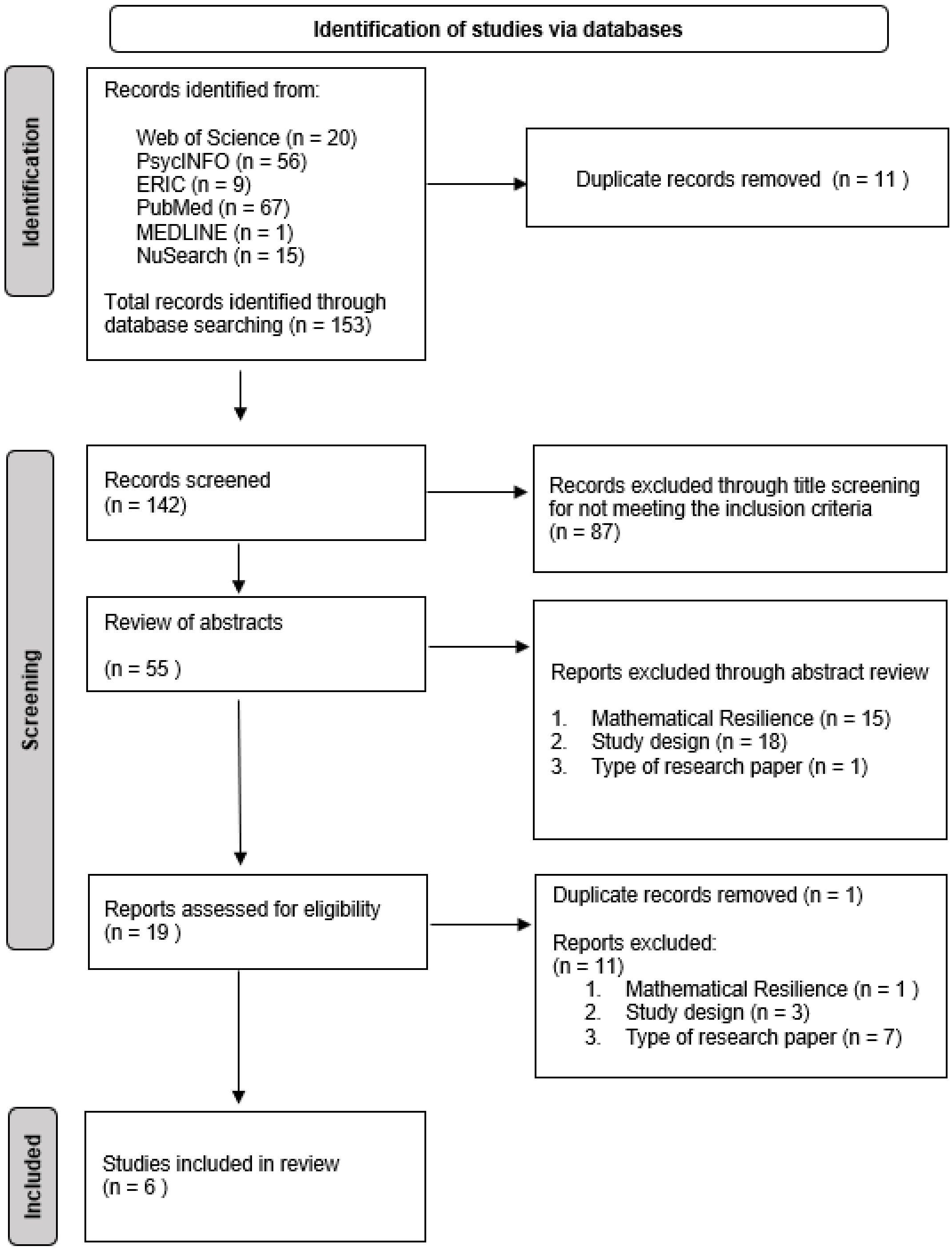
Table 2. 3

Studies Included for Review

Researcher/s (Year of publication)	**Title**	**Publication**
Cropp (2017)	Using peer mentoring to reduce mathematical anxiety	Research Papers in Education
Hunt & Maloney (2022)	Appraisals of previous math experiences play an important role in math anxiety	Annals of the New York Academy of Sciences
Lovelace (2022)	Does Mathematical Resilience Address Mathematics Anxiety? A Measurement Validation Study for High School Students	*Doctoral dissertation, California State University*
Passolunghi et al., (2020)	Math anxiety and math achievement: The effects of emotional and math strategy training	Developmental science
Samuel et al., (2023)	"I Can Math, Too!": Reducing Math Anxiety in STEM-Related Courses Using a Combined Mindfulness and Growth Mindset Approach (MAGMA) in the Classroom	Community College Journal of Research and Practice
Talaoc (2019)	Attending to the affective domain: Mathematics in a suburban community college	*Doctoral dissertation, California State University*

Figure 2. 7

PRISMA Flowchart of the Search and Screening Procedure



2.6.4 Data Extraction and Synthesis

Summary of Study Methodologies. The studies identified for review included a wide scope of study designs, resulting in both quantitative and qualitative data for review.

The studies include a case study design (Cropp, 2017), surveys (Hunt & Maloney, 2022; Lovelace, 2022), and quasi-experimental designs (Passolunghi et al., 2020; Samuel et al., 2023; Talaoc, 2019). As the inclusion criteria did not specify a particular study design and the included studies report quantitative and qualitative data, a narrative synthesis approach was chosen. A narrative synthesis allowed for the inclusion of quantitative data whilst textually telling the story of the research (Popay et al., 2006) around the relationship between MR and MA, including the impact of the interventions delivered. The key information from the studies is summarised under the headings of study design, participants, interventions, measures and results. Being driven by the research questions, only findings associated with MA and MR are considered here.

Preliminary Synthesis. Key information was extracted from each of the included studies using a data extraction sheet (See Appendix E). A narrative description of each study was written, including information about location and setting, participants, study design, outcome measures, and findings.

Quantitative analysis. Due to the heterogeneity between the quantitative research designs, a meta-analysis was not carried out. Therefore, quantitative data will be presented within the textual narrative synthesis.

2.6.5 Quality Assessment

The Mixed-Methods Appraisal Tool (MMAT) (Hong et al., 2018) was used to assess the quality of the included studies; this quality appraisal tool was selected as it allows the methodological rigour of studies with various designs to be evaluated using a singular process (Hong et al., 2018). Both qualitative and quantitative studies are evaluated through the use of two screening questions followed by four research design-specific questions to assess each study's methodological quality (Hong et al., 2018). The MMAT has been continually developed, with the most recent version being content validated (Hong et al., 2019). The category for rating each study was selected using the algorithm provided as part of the MMAT guidance (Hong et al., 2018). Table 2. 4 shows the overall quality score calculated for each study following the suggested reporting procedure outlined by Hong (2020); full quality assessments for each study can be found in Appendix F.

Table 2. 4

Quality Scores

Researcher/s (Year of publication)	**Category of study design**	**Study design**	**Quality score (% of quality criteria met)**
Cropp (2017)	Qualitative	Case study	***** (100%)
Hunt & Maloney (2022)	Quantitative descriptive	Survey	**** (80%)
Lovelace (2022)	Quantitative descriptive	Survey	*** (60%)
Passolunghi et al., (2020)	Quantitative non-randomised	Quasi-experimental design	***** (100%)
Samuel et al., (2023)	Mixed Methods	Quasi-experimental design	** (20%)
Talaoc (2019)	Mixed Methods	Single-group pre- and post-design*	**** (80%)

Note. This table presents the quality scores for included studies as a result of quality assessment using the MMAT and based on the perceptions of the researcher. *Intended to use a quasi-experimental design.

One of the six studies appeared to have a comparatively lower quality score (Samuel et al., 2023). Despite this, Hong et al. (2018) discouraged the exclusion of studies with low methodological quality when using the MMAT. Therefore, the study quality should be taken into account when considering its inclusion in the synthesis.

2.6.6 Narrative synthesis

Study design. Of the studies that met the inclusion criteria for review, a range of study designs were implemented as outlined in Table 2.4. Due to the inclusion criteria not specifying that an intervention was a requirement, two of these studies did not implement an intervention procedure. Two of the studies carried out quantitative data collection via a survey (Hunt & Maloney, 2022; Lovelace, 2022), one was a qualitative case study (Cropp, 2017), two studies were considered mixed methods (Samuel et al., 2023; Talaoc, 2019) and one a non-randomised quantitative study (Passolunghi et al., 2020). As the MMAT was used to quality appraise the study designs, the study design did not effect the quality score.

Both Hunt and Maloney (2022) and Lovelace’s (2022) studies were considered quantitative descriptive designs as they conducted surveys to explore the statistical relationship between self-reported measures of MA and MR. Cropp's (2017) study provided a case illustration of the use of peer mentoring to explore if MA could be reduced through building MR. Three of the studies conducted pre- and post-test analysis following the implementation of an intervention to review its efficacy on the reduction of MA; two of the studies were considered quasi-experimental designs with an experimental and control group (Passolunghi et al., 2020; Samuel et al., 2023). Due to an interruption in their study design, Talaoc’s (2019) study was no longer considered a quasi-experimental design despite its intent to be. The study became a single-group pre- and post-test design.

Participants. Across the six studies, 1,589 young people and 308 adults participated. Of the studies that implemented an intervention with young people, sample sizes ranged from 5 to 224 participants (See Appendix E). Across these studies, the young people were aged between 9 and 18 years old. It was evident that all studies, which explored the use of an affective mathematics intervention, were conducted with young people who would be considered in Key Stage 2 (KS2) or above in the UK. Only Passolunghi et al.'s (2020) study included children who would attend a primary school (those aged < 11 years).

Of the total sample, 1,077 were female, therefore the majority (67.8%) of participants were female. A small minority of participants identified as non-binary in Lovelace's (2022) study (n = 23). The participants for the studies where an intervention was delivered were as follows: United States (US) college students undertaking a science, technology, engineering and mathematics (STEM) course (Samuel et al., 2023), UK secondary school-aged children identified as MA by their teacher (Cropp, 2017), Italian children in fourth grade (UK Year 5 equivalent) (Passolunghi et al., 2020), and US college students undertaking a pre-statistics course (Talaoc, 2019). It was noted across the studies that children with Special Educational Need or Disability (SEND), were either excluded or not referred to in the analysis.

Interventions. Four studies implemented an intervention that the researchers hypothesised would result in a reduction in MA. The interventions included a mindfulness and growth mindset approach (MAGMA) (Samuel et al., 2023), an affective domain intervention (ADI) (Talaoc, 2019), MA training (Passolunghi et al., 2020) and peer mentoring (Cropp, 2017). Though MR is not explicitly referred to in Samuel et al.'s (2023) intervention, this paper was selected for inclusion based on the intervention's association with the factors of MR and the commonality between the MAGMA intervention and Johnston-Wilder et al.'s (2020) toolkit, including references to growth mindset, relaxation, and mindfulness principles.

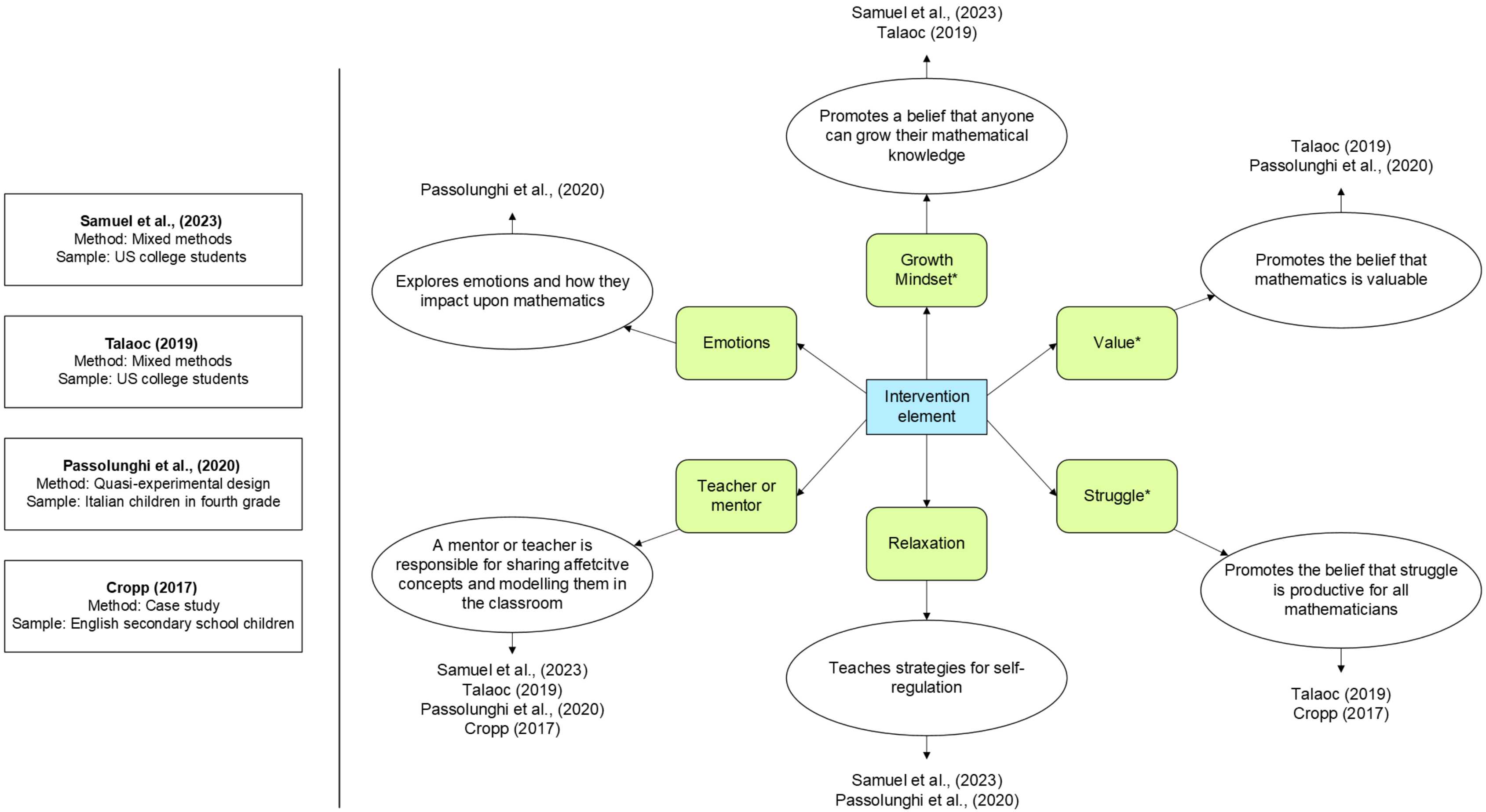
Talaoc (2019) reviewed the implementation of affective domain interventions (ADI), which were described as any activity conducted by the teacher which promoted a growth mindset, the belief that struggle is productive, and highlighted the future value of mathematics as a subject. Samuel et al.'s (2023) MAGMA intervention included sharing the concepts of a growth mindset and mindfulness principles with students. The teachers in this study were also encouraged to consistently remind students of these concepts throughout their lessons and began each lesson with a deep breathing exercise and saying growth mindset affirmations aloud. Passolunghi et al.'s (2020) study introduced the value of mathematics in the real world and the impact of emotions on mathematics. Their intervention also included the introduction of regulating strategies such as deep breathing, visualisation and reframing negative thoughts. Finally, Cropp's (2017) intervention prompted mentors to model a positive attitude toward struggle, support mentees to seek resources and provide their mentees with ample time to complete activities.

The commonality between these affective interventions appears to be underlined by the concepts addressed in Johnston-Wilder et al.'s (2020) toolkit as well as the conceptions of what it means to be mathematically resilient. The interventions address *struggle, growth mindset* and/or *value*. A number of the studies also teach and promote relaxation response strategies such as deep breathing.

Figure 2. 8 illustrates the associated elements of each intervention. Interestingly, it was an important aspect of all studies that a teacher or mentor was responsible for sharing the concepts and modelling their implementation in mathematics.

Figure 2. 8

Intervention Elements



Note. An idea map of intervention elements and the corresponding studies. * = components of Mathematical Resilience.

Outcome measures. Several standardised measures were used to assess participants' MA and MR. All studies that assessed self-reported MA used a singular measure. Measures included the Abbreviated Mathematical Anxiety Scale (AMAS) (Hopko et al., 2003), the Mathematics Anxiety Scale (MAS) (Betz, 1978) and the Mathematics Anxiety Scale-UK (MAS-UK) (Hunt et al., 2011). Three out of the six studies used the AMAS (Passolunghi et al., 2020; Samuel et al., 2023; Talaoc, 2019) with only one study using the MAS (Lovelace, 2022) and one using the MAS-UK (Hunt & Maloney, 2022). Of the studies that completed a self-report measure of MR, all studies used the Mathematical Resilience Scale (MRS) (Kooken et al., 2016). In addition, three studies used qualitative reports gained via semi-structured interviews to interpret the impact of their intervention on MA (Cropp, 2017; Samuel et al., 2023; Talaoc, 2019).

Results. This section presents the results of the studies under the questions identified for this systematic review.

1. What does current research tell us about the relationship between Mathematical Resilience (MR) and Mathematics Anxiety (MA)? Of the six studies, three quantitatively explored the relationship between self-reported measures of MA and MR. All three studies observed a significant, negative correlation between self-reported measures of MA and MR. The negative correlations that were reported were described as moderate correlations: Talaoc (2019) ($r = -0.34$; $p < 0.001$); Hunt and Maloney (2022) ($r = -0.52$, $p < 0.001$), and Lovelace (2022) ($r = -0.339$, $p < .001$).

2. What is the impact of Mathematical Resilience (MR) promoting approaches on improving outcomes for individuals with Mathematics Anxiety (MA)? Of the four studies that evaluated the impact of an MR-promoting approach, all studies reported a reduction in MA. The three studies which quantitatively explored their results found statistically significant reductions in MA following the implementation of their intervention. Talaoc

(2019) found both a significant increase in self-reported MR as well as a significant reduction in self-reported MA following the implementation of affective domain interventions. Both Passolunghi et al. (2020) and Samuel et al. (2023) found a significant difference between groups; they found that groups that received the intervention had significantly reduced MA scores at post-testing compared to a control group.

For those studies that evaluated the impact of their intervention qualitatively, a reduction in MA was reported. The following quote was drawn from (Samuel et al., 2023, p. 622) study and indicates that participants reported a positive effect of the intervention on their MA, "*Qualitative analysis indicated that students found the MAGMA intervention to be quite effective in reducing math anxiety in the classroom, and had also utilized it in other stress-induced contexts*." Cropp (2017, p. 491) also reported a positive effect of their peer mentoring intervention on MA for the majority of their participants, "*The findings suggest that mathematical anxiety improved after the intervention, for all students except Student D*." They suggested that for the one student who reported an increase in their anxiety, this may be due to a range of factors, including the interview provoking anxiety itself, the student having a bad day, or that the intervention possibly increased awareness of MA.

2.6.7 Conclusion

This systematic literature review searched the available literature and selected six papers which considered the relationship between MA and MR. The results suggest that across a range of participants, there is a significant negative relationship between MR and MA. The results suggest that a higher level of MR is associated with less anxiety about mathematics. Whilst we cannot assume causality from any correlations, of the studies which implemented an intervention to promote an element of MR (including *growth mindset*, a *value* of mathematics or a belief that *struggle* is productive), they all reported a reduction in self-reported MA. Thus, suggesting that interventions to promote MR can effectively support learners who have MA. However, based on the heterogeneity between the studies and a lack of research in primary schools in the UK, one would suggest that more research is needed which adopts a rigorous design in exploring the impact of such an intervention in UK primary schools. A single-case experimental design (SCED), which takes repeated measures over time, may offer a clearer insight into how an approach that promotes MR universally interacts with MA for individual learners.

2.7 Aims of this Research

The purpose of the current study is to explore how primary school children can be supported to manage and cope with mathematics anxiety (MA) through a whole-class approach, which, to the researcher's knowledge, has a limited evidence base. With the suggestion that Johnston-Wilder et al.'s (2020) toolkit can be implemented in mainstream mathematics classrooms to promote mathematical safeguarding by building mathematical resilience (MR) to support MA, the study aims to contribute to the existing literature by exploring how effectively it can be implemented as an early intervention for Year 4 primary pupils.

2.8 Research Questions

Based on the rationale behind this research, the proposed study seeks to answer the following research questions*:*

1. Does a whole-class mathematical resilience intervention, incorporating a practical Growth Zone Model (GZM) resource, reduce children's self-reported levels of mathematics anxiety?
2. What are the perceptions of key stakeholders (teachers, teaching assistants, and children) regarding the implementation of a whole-class mathematical resilience intervention, including the use of the Growth Zone Model (GZM)?

Chapter 3: Methodology

3.1 Introduction

This QUAN-qual mixed methods study aims to evaluate the effectiveness of a whole-class intervention designed to reduce mathematics anxiety (MA) by fostering mathematical resilience (MR) in children aged eight to nine years in a UK primary school. A mixed-methods approach was adopted, incorporating repeated measures of MA. The main data sample primarily involves quantitative data collection techniques. The quantitative analysis involved six single-case experimental designs (SCEDs). Following this, semi-structured interviews were conducted with the six children, and a focus group with the class teacher and teaching assistants provided further insight. The qualitative data was analysed using Reflexive Thematic Analysis (RTA) to provide deeper insights into the SCED phase.

This chapter outlines the methodological considerations and theoretical underpinnings that shaped the design of this study. It begins by discussing the aims of educational research and evidence-based practice while examining their complexities. This is followed by a discussion of the philosophical assumptions that shape social research before defining the ontological and epistemological stance adopted. The chapter then examines the study's design in detail, including how potential threats to validity and reliability were addressed to ensure methodological rigour and trustworthiness.

3.2 The Role and Importance of Research in Educational Psychology

Research is conducted to acquire meaningful knowledge about the world, and psychologists, operating as a ‘learned society’ (The British Psychological Society (BPS), 2017), collaborate to advance knowledge and expertise in their field to provide an evidence base for practice.

Educational research has been described as “a deliberate, complex, subtle, challenging, thoughtful activity and often a messier process than researchers would like it to be," (Cohen et al., 2017, p. 3). It is proposed that applied researchers, such as Educational Psychologists (EP) who work with dynamic matters of inquiry, should forgo the control maintained in laboratory environments (Gulliford, 2015) as practice-based evidence can play a crucial role in strengthening the research base (Kratochwill et al., 2012). Although controlled experiments in laboratory conditions offer precision, they do not reflect the complexities of our educational environments and findings from controlled conditions often fail to be replicated in real-world settings (Robson & McCartan, 2016). Real-world research, despite its inherent challenges, allows for investigation within the relevant context, leading to insights that can address real-world social issues and enhance the impact of psychological science (Maner, 2016). This type of research is highly valued in education and psychology, as researchers can conduct small-scale studies directly with systems where problems exist, with an emphasis on understanding and motivating change (Robson & McCartan, 2016).

This study is considered real-world research conducted within an educational setting with the view to eliciting change by evaluating an intervention.

3.3 What is Evidence-Based Practice?

This study grew out of a desire to promote understanding of and change for children and young people with mathematics anxiety (MA). The research provides an opportunity to contribute to the limited evidence base in this area. The American Psychological Association (APA) (2005, p. 1) define evidence-based practice in psychology as "the integration of the best available research with clinical expertise in the context of patients' [peoples'] characteristics, culture, and preferences." The drive for evidence-based practice arose from the political agenda to improve public services, particularly in the health sector, following Cochrane's (1972) idea that health services' processes and procedures should be informed by scientific evidence. Cochrane suggested that identifying evidence-based practice from the research is just the first step; evaluation of the efficacy of these practices relies on the skills and wisdom of practitioners in the field. This process of combining evidence with practitioners' expertise has also since been adopted to support practice and policy development in education (Anwer & Reiss, 2023; Wiseman, 2010) and educational psychology (Gulliford, 2015).

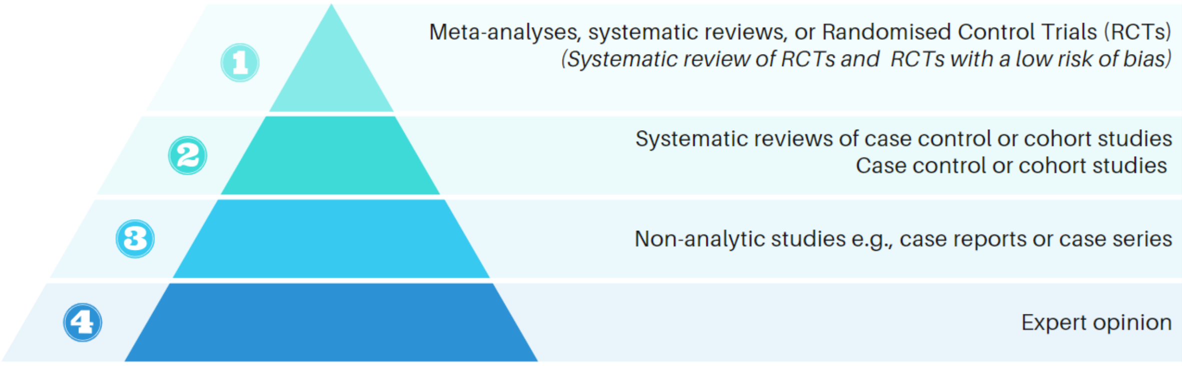
Evidence-based practice occupies a central position in applied educational psychology; EPs acting as 'agents of change' is rooted in their review of the evidence they generate and consume to inform their practice (Boyle & Kelly, 2017). Evidence-informed or evidence-based practice relies on the examination of evidence to assess the efficacy of an approach, principle, strategy, or intervention to be applied in practice; it draws a clear link between the research base and professional practice (Fox, 2003). The implementation of educational interventions, which have been evaluated and have an evidence base to suggest their effectiveness, is promoted in the UK (BPS, 2021; BPS, 2017; Wiggins et al., 2012). Real-world research informs evidence-based practice, contributing to the development of quality and effective psychological interventions (de la Fuente et al., 2022).

A hierarchy of evidence informs the weight given to research findings. When assessing the value of evidence presented by a research study, meta-analyses, systematic reviews, and randomised controlled trials (RCTs) are frequently regarded as the most reliable forms of evidence (Murad et al., 2016). These designs are those which have high internal validity and the hierarchy would suggest that these designs provide the most valid and reliable evidence from which applied practitioners can draw upon.

Figure 3. 1 outlines the Scottish Intercollegiate Guidelines Network (SIGN, 2019) 'levels' of evidence hierarchy which is ordered by study design.

Figure 3. 1

*An Evidence Hierarchy***:** *SIGN's (2019) grading system*



RCTs are considered the 'gold standard' for assessing the efficacy of interventions or treatments (Robson & McCartan, 2016). These designs facilitate comparisons of pre- and post-test scores between groups that are assigned randomly. Typically, one group receives the intervention, while the other serves as a control. This methodology is believed to mitigate confounding variables, thus allowing any observed effects to be directly attributed to the intervention (Cohen et al., 2017). However, it is acknowledged that for applied researchers, executing a true RCT is neither practical nor ethical (Robson & McCartan, 2016). As Cohen et al. (2017, p. 3) highlight*,* research in the context of education can be very difficult. Practical challenges in conducting research in natural settings include the inability to assign conditions systematically, validity of measures, ethical implications and limited control over variables (Robson & McCartan, 2016).

Where applying 'gold standard' research practices is unfeasible based on the research question, such as in educational psychology, researchers must carefully consider their methodology. They then must establish their philosophical stance and chosen research paradigm.

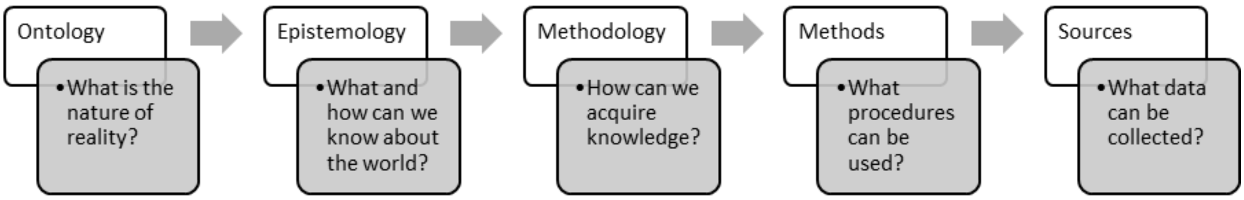
3.4 Research Paradigms and Philosophical Assumptions

A paradigm is a model for understanding, providing guidelines for observing and addressing research problems. Each paradigm encompasses a distinct set of beliefs, methods, and theories that are collectively accepted by the practitioners who adopt its fundamental principles (Anand et al., 2020). A paradigm includes several critical elements: ontology, epistemology, and methodology (Scotland, 2012).

To truly “understand the nature of the challenges to contemporary research and professional practice,” we must initially reflect on our ontology, epistemology, and methodology (Moore, 2005, p.105) (See Figure 3. 2). The knowledge this research yields will inevitably be influenced by the researcher's assumptions about the world, particularly regarding the nature of reality (ontology) and beliefs about how knowledge is derived (epistemology).

Figure 3. 2

Grix's (2002) Paradigmatic building blocks



The theoretical foundations and assumptions explored here are grounded in critical realism (CR), which, based on the researcher’s philosophical assumptions, is the research paradigm that has directly informed the study’s methodology.

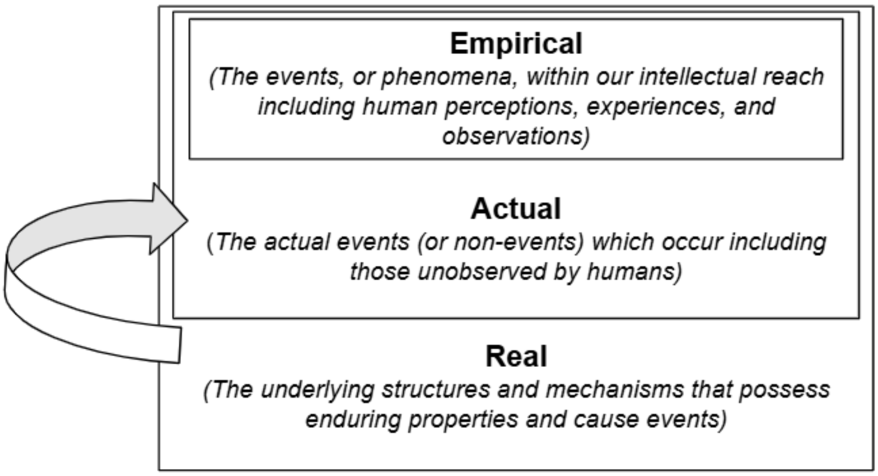
3.4.1 Ontological and Epistemological Beliefs: Critical Realism

Researchers instinctively start by reflecting on their ontological stance through consideration of the question, "*What is the nature of reality?"* (Grix, 2002) (See Figure 3. 2). Grix (2002) proposes that all is shaped by the researcher's worldview, which is influenced by their personal experiences. Ontological assumptions relate to the fundamental nature of the subject matter; researchers may therefore ask whether reality exists independently and can be objectively measured, or if it is constructed through individual human experiences (Cohen et al., 2017). In the latter case, reality would be subjective, meaning there would be as many realities as there are consciousnesses (Scotland, 2012).

Here, the researcher adopts a critical realist ontology, with the belief that one subjective reality exists independently of human perception, yet acknowledges that we should not simply accept our observations as the complete truth (Pilgrim, 2019). Critical realist ontology posits that reality is stratified; our reality is suggested to be composed of differentiated layers; the empirical, the actual, and the real. The *empirical* layer is what we observe or perceive in the world, the *actual* layer is the phenomena or events that occur, and the *real* layer consists of the structures and mechanisms that explain empirical and actual events (Kozhevnikov & Vincent, 2019) (see Figure 3. 3).

Figure 3. 3

Critical Realism: A Stratified Reality



Note. Figure adapted from Hoddy (2019, p. 113)

When considering their epistemology, researchers must ask themselves, "*What and how can we know about the world*?" (Grix, 2002). The researcher's epistemological view is that our knowledge of reality is fallible and dependent on human construction – a constructionist epistemology. The researcher believes that the knowledge we can acquire is only that which is observable, and our knowledge production is mediated by human experience, language, culture and the social context (Pilgrim, 2014).

With the given ontological and epistemological beliefs, this study therefore comes from a philosophical standpoint of critical realism (CR). CR separates itself from the positivist paradigm; although both share a form of realist ontology, they diverge in their epistemological stances. Critical realism "recognises the need for critical reflexivity about our epistemological assumptions,"(Pilgrim, 2019, p.46). On the other hand, positivism adheres to objectivism as its epistemology, emphasising a deductive approach that relies on direct observation, experimentation, and the application of randomised control trials (Scotland, 2012). Positivism considers only empirically verified information as valid knowledge

(Robson & McCartan, 2016). However, it is argued that positivism inadequately addresses human behaviour due to its inherent complexity, as social experiences are often either unobservable or unquantifiable (Cohen et al., 2017). Human experience lies at the core of educational psychology, making a positivist research paradigm seem inappropriate to those working in social endeavour.

The post-positivist paradigm emerged from positivism to address its criticisms as a social research method (Robson & McCartan, 2016). While post-positivists aim to uncover causality and possess similar ontological and epistemological perspectives, they also acknowledge human experiences and perspectives (Scotland, 2012). This perspective embraces the existence of multiple realities, recognising that knowledge is subjective (Cohen et al., 2017). Although a measurable reality is thought to exist, it is argued to be imperfectly known, as evidence is assumed to be flawed. This perspective is based on the post-positivist principle of falsification (Popper, 2002); a scientific theory cannot be deemed true until all attempts to disprove it fail, making every theory tentative (Scotland, 2012). This notion is particularly relevant for EPs working with children and young people, where evidence-based practices may benefit one child but not necessarily another. However, similar to its predecessor, a post-positivist stance predominantly favours quantitative methods (Robson & McCartan, 2016).

The researcher's ontological and epistemological beliefs have led them to adopt a stance of critical realism (CR). As CR contends that reality is stratified, it is assumed that not everything that is real can be observed. In contrast to the aforementioned paradigms, CR argues that reality is mediated through social context and human perception, and as such, our understanding of the world is both subjective and imperfect (Kozhevnikov & Vincent, 2019). A CR stance supports the adoption of a mixed-methods approach, which views the triangulation of both quantitative and qualitative data as crucial in uncovering the structures and mechanisms that influence social phenomena (Boyle & Kelly, 2017). Additionally, it emphasises the researcher's pivotal role in forming theories and investigating the reality being studied (Pilgrim, 2014). The focus of this research is rooted in the belief that MA is a genuine phenomenon that exists independently of how it is perceived; however, human experiences of it may differ. It is believed that a mixed-methods approach facilitates a comprehensive exploration of this phenomenon, with a dual approach aligning with CR.

3.5 This Mixed Methods Design

The study aims to utilise mixed methods to investigate and assess the effects of a whole-class intervention on students' mathematics anxiety (MA). A mixed-methods design integrates qualitative and quantitative methodologies within a single research study (Robson & McCartan, 2016). These designs usually involve the systematic sequencing of quantitative and qualitative data collection, with a tendency to place considerable emphasis on one over the other (Robson & McCartan, 2016).

The benefits of the approach deemed valuable for addressing the research questions here included the capacity to corroborate findings between quantitative and qualitative data (triangulation), the ability of qualitative data to explain results generated through quantitative methods, and the use of supplementary qualitative findings to illustrate and expand upon numerical data (Bryman, 2006; Robson & McCartan, 2016). The justification for the integration of quantitative and qualitative methods stems from the conviction that neither approach, in isolation, is capable of comprehensively capturing the trends and intricacies of the concept under study (Ivankova et al., 2006).

3.5.1 The Application of an Explanatory Sequential Design

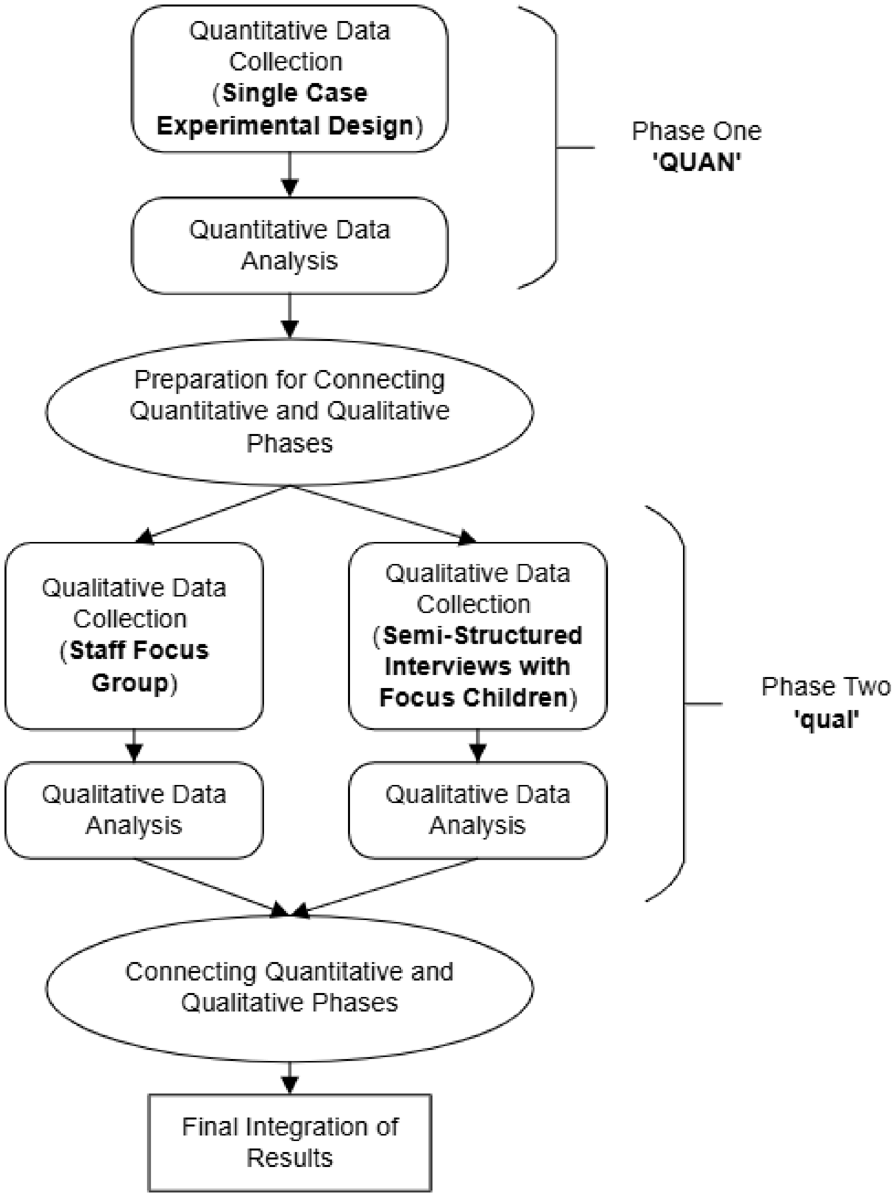
This mixed-methods study adopts an explanatory sequential design (QUAN → qual), defined as an approach that places greater weight on the quantitative data collected first, followed by qualitative methods to support the explanation of the numerical findings (Creswell & Creswell, 2022; Leavy, 2017). Following an explanatory sequential design, the qualitative data was gathered to illuminate results by offering the researcher insight into the factors that supported the intervention and its effectiveness or lack thereof (Creswell & Plano Clark, 2007; Ivankova et al., 2006).

This approach is justified because quantitative data and their analysis can offer a broad understanding of the research issue, embracing a realist perspective of the world, striving to ascertain the efficacy of an intervention. In contrast, qualitative data and its analysis enhance and clarify the statistical findings by delving deeper into participants' perspectives (Creswell & Creswell, 2022; Rossman & Wilson, 1985; Tashakkori & Teddlie, 2010).

In this study, the researcher first obtained quantitative data, which was analysed before conducting qualitative interviews. The second (qualitative) phase builds upon the quantitative findings to illustrate and support the explanation of the results obtained in the first phase. Data triangulation can help to address threats to validity (Robson & McCartan, 2016) and as this study follows a sequential explanatory design, qualitative methods will be applied and used as one triangulation tool. A procedural diagram of this study can be seen in Figure 3. 4 (Creswell & Plano Clark, 2007; Fetters, 2020a)

Figure 3. 4

Procedural Diagram of the Explanatory Sequential Design Employed



Note. The figure illustrates how the quantitative phase preceded the qualitative phase, with the capital letters for 'QUAN' signifying it as the dominant phase of this research.

3.6 Whole-Class Intervention to be Investigated

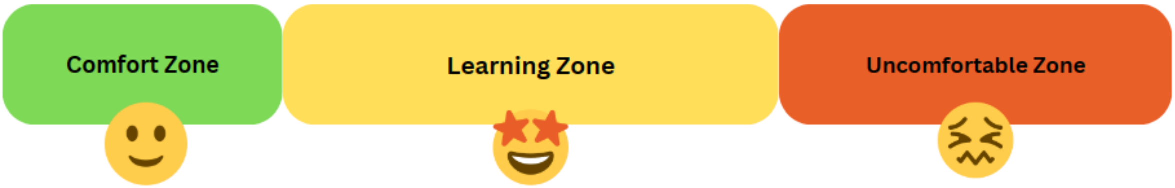
The application of a mathematical resilience (MR) intervention, as it applies to this research, is grounded in Johnston-Wilder et al.'s (2020) toolkit, which is freely available online. A one-and-a-half-hour training session, developed and delivered by the researcher, introduced the class teacher and teaching assistants to the toolkit and the Growth Zone Model (GZM), of which a copy of the training slides can be found in Appendix G. This training included dissemination of the toolkit, which staff were instructed to read and refer to as necessary. This training session was presented to the school staff after a baseline phase (see Section 3.7.5).

Following this training, the class teacher delivered an introductory session to the whole class, familiarising Year 4 students with each tool and their objectives. The researcher developed and refined a single lesson plan and resources using Johnston-Wilder et al.'s (2020 toolkit as a guide. Each tool described in the toolkit was incorporated into this lesson plan (see Section 2.4.2 for a description of each tool). This lesson took approximately thirty minutes for the class teacher to deliver. An overview of this lesson plan can be seen in Appendix H.

This introductory session marked the beginning of a thirteen-week implementation phase of the toolkit's principles within the classroom. Each child also received a physical copy of an adapted GZM (Figure 3. 5). Children were asked to use a peg or a paperclip to indicate their position along the GZM during mathematics lessons whenever necessary (see Section 2.4.2 for a description of each zone). School staff were instructed to monitor and respond proactively to children's use of the GZM, ensuring that their reported feelings informed support and intervention. It is important to note that the GZM was made available to children only during mathematics lessons for the duration of the study; the GZM was kept attached to their mathematics books.

Figure 3. 5

Growth Zone Model Resource



Note. Adapted from Johnston-Wilder et al., (2013) who proposed a circular model (See Section 2.4.2)

The duration of this whole-class intervention approach was set at ten weeks, aligning with research findings suggesting that longer interventions (those exceeding three weeks) are more effective at reducing MA (Sammallahti et al., 2023). However, as discussed in Section 5.4.3, phase B was extended to thirteen weeks.

3.6.1 Piloting Intervention Materials

Before full implementation, the resources were piloted to assess their suitability for use with Year 4 children. The same mainstream primary school that conducted the pilot of the measures conducted this pilot (see Section 3.7.7). The class teacher was asked to present a sample of Year 4 children with the GZM and ask them to reflect on what they felt was the most suitable method to indicate their emotions. This teacher also met with the researcher to discuss the suitability of the introductory lesson for Year 4 pupils.

Following the feedback received and in consultation with the research school, it was agreed that children would use small pegs or paper clips to indicate their emotions when using the GZM. The teacher's complete response to the first activity can be found in Appendix I.

The second activity involved the researcher meeting with the Year 4 class teacher to ensure the suitability of the resources created for the intervention based on Johnston-Wilder et al.'s (2020) toolkit. The researcher captured the teacher's feedback during this meeting, confirmed these points via email, and adapted the lesson plan accordingly. Table 3. 5 outlines the feedback received and can be found in Appendix J.

3.6.2 Intervention Fidelity

Fidelity assumes that the independent variable, the intervention in this case, was implemented as intended by the researcher. It has been defined as "the determination of how well an intervention is implemented in comparison with the original program design during an efficacy and/or effectiveness study" (O'Donnell, 2008, p. 33). A fidelity check was implemented to observe how the toolkit, including the GZM resource, was being employed based on the training the school staff received and if it was in line with the researcher's intentions. With this in mind, the researcher observed the use of the GZM in both the mainstream class and a small group during a mathematics lesson.

3.7 Phase one: Quantitative Strand

3.7.1 Single-Case Experimental Designs (SCED)

Single-case experimental designs (SCED) emerged from the psychology field's aim to enhance its scientific methodology (Aydin, 2023). It is an adaptable experimental design that contributes to the knowledge base of best practices (Kratochwill et al., 2012; Maydew & Atkinson, 2022) while also recognising potential threats to validity due to the belief that environmental variables are inherently uncontrollable. SCEDs provide an inductive framework that has led to insights into effective instructional methods for children and young people facing challenges in the classroom (Plavnick & Ferreri, 2013). This methodology was chosen here due to the complexities of educational environments, and with SCEDs offering a strong alternative for assessing the effectiveness of interventions, particularly in applied psychology and education (Kazdin, 2019; Kratochwill et al., 2012).

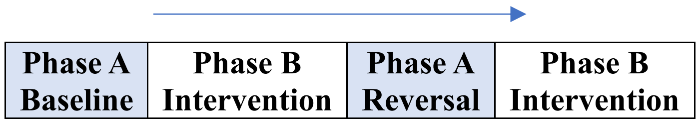
SCEDs were applied to this research due to their ability to measure the dependent variable against repeated conditions, facilitating intensive, within-subject comparisons by systematically measuring a single case's response to an intervention over time (Robson & McCartan, 2016). Each ‘case’ behaves as its own control, through the collection of the data over time across differing phases; this typically includes a baseline phase followed by an intervention phase (Maydew & Atkinson, 2022). SCED allowed the response to intervention to be evaluated without a control group and with few participants.

Various forms of single-case experimental designs exist. However, each comes with its own accompanying limitations and capacity to minimise threats to internal validity, influencing the strength of the relationship which can be established (See Table 3. 1).

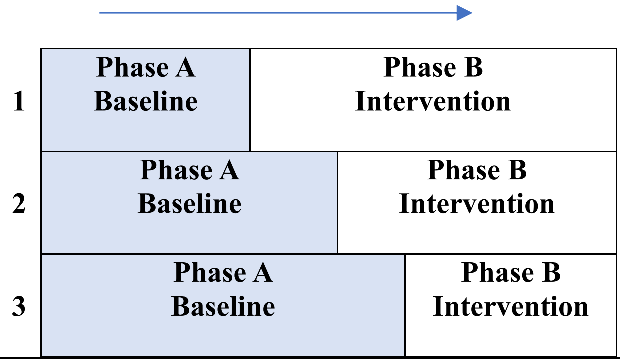
Table 3. 1

Classes of SCED

Design	Description	Limitations
A-B	A measurement is conducted repeatedly during a baseline period (A). This is then followed by the continuation of the same measurement in a subsequent phase (B), during which the intervention is implemented. **Phase A Baseline** | **Phase B Intervention**	It is considered a pre-experimental design because of the many threats to its validity (e.g., history and maturation) Achieving a stable baseline can be challenging The generalisability of the findings needs to be considered
A-B-A	This design includes a reversal phase (A), restoring the condition to its baseline by removing the treatment or intervention once more. To assess the success of the intervention, the researcher looks for evidence that the data returns to baseline performance. This design's reversal seeks to enhance the reliability and validity of conclusions about the causal relationship between the intervention and outcome variables. **Phase A Baseline** | **Phase B Intervention** | **Phase A Reversal**	Ethical considerations surrounding the removal of the intervention Maintenance of the intervention's effect may mean there is no return to baseline performance

<table>
<tr><td>A-B-A-B</td><td>This design builds on an A-B-A design by adding another intervention phase.
</td><td>Ethical concerns arise again regarding the cessation of the intervention, but this design reintroduces the intervention for the final phase.

The lasting impact of the intervention might not necessarily result in a return to baseline performance.</td></tr>
<tr><td>Multiple baseline</td><td>In a multiple-baseline design, the intervention phase is implemented at different times. This approach can occur in various settings where the participant is observed in diverse contexts. It can also be applied across behaviours, enabling the measurement of multiple dependent variables. Additionally, the intervention can be introduced at staggered times for different participants.

The design aims to increase both the validity and reliability of interpreting the causal relationship between variables, while addressing the ethical issues associated with ABA/ABAB designs.
</td><td>This design has practical and organisational challenges.

The same ethical issues and concerns about validity mentioned earlier for the other SCED designs are applicable here.</td></tr>
</table>

Note. Table 3.2 shows the formation of SCED designs. Information has been drawn from Robson and McCartan (2016)

3.7.2 Baseline Phase

Any SCED is argued to require each phase to comprise at least three data points, with a preference for five (Kazdin, 2011). This ensures sufficient opportunity has been given for any effect to be observed. It is also suggested that researchers should extend their baseline phase until stability on the repeated measure has been achieved (Kratochwill & Levin, 2014). However, there is also an argument against withholding intervention for this purpose (Maydew & Atkinson, 2022).

As per the suggestion, the researcher intended to collect five baseline data points of self-reported measures of mathematics anxiety (MA) completed once a week over five weeks. However, the baseline was reduced to four data points because of a one-week delay in starting the research caused by school constraints. The baseline period ended in the penultimate week before a one-week school half-term. The baseline phase was not extended further due to concerns that doing so would be unethical, as it would withhold the intervention for too long, considering the researchers' timelines and the desire for the intervention to be implemented over ten weeks before the two-week Christmas break.

3.7.3 AB Design

This study employs an AB SCED design (See Table 3. 1); the limitations of which will be discussed in the Section 5.4.3. To conduct this design, a clearly defined outcome measure needs to be identified and measured repeatedly over a baseline (A) and intervention (B) phase. This measure is selected based on the changes which will be used to evaluate progress (Kazdin, 2021). In the case of this study, where a child is struggling with anxiety specific to mathematics, a self-report measure of MA will be administered (See Section 3.7.7).

There was a natural cessation of the intervention due to a two-week school holiday, and the intervention was therefore not implemented during this time. However, children also did not attend maths lessons during this time. Thus, this was not considered a return to baseline (A). After one school term of implementing the intervention, discussions with the class teacher indicated a desire to continue using the intervention resources and a reluctance to withdraw them. Therefore, employing a reversal design was deemed both unethical and impractical, especially given the hope that the intervention would have a lasting impact on children's MA, in which a beneficial effect would be maintained.

3.7.4 Triangulation Measure

Despite concerns about the validity and reliability of collecting data points at single points in time (e.g., pre- and post-intervention) (Marsden & Torgerson, 2012; Robson & McCartan, 2016), repeated measures can be enhanced by triangulating data collected at single time points (Krasny-Pacini & Evans, 2018). As discussed in the literature review, mathematical anxiety (MA) and mathematical resilience (MR) are inversely related. Specifically, a reduction in MA correlates with an increase in MR. Consequently, measuring MR at consistent time points across the phases was identified as a means of triangulating quantitative data. This method uses generalisation measures to continuously probe across phases (Tate et al., 2016). A measure of MR (see Section 3.7.7) was taken at four time points: one pre- and post-baseline phase (A) and two during the intervention phase (B).

It is important to acknowledge that using MR as a triangulation tool presupposes a relationship between the two constructs. As such, the researcher exercises caution when interpreting these findings. A critical reflection on the outcomes and interplay between the two measures is essential for a comprehensive understanding.

3.7.5 Independent and Dependent Variables

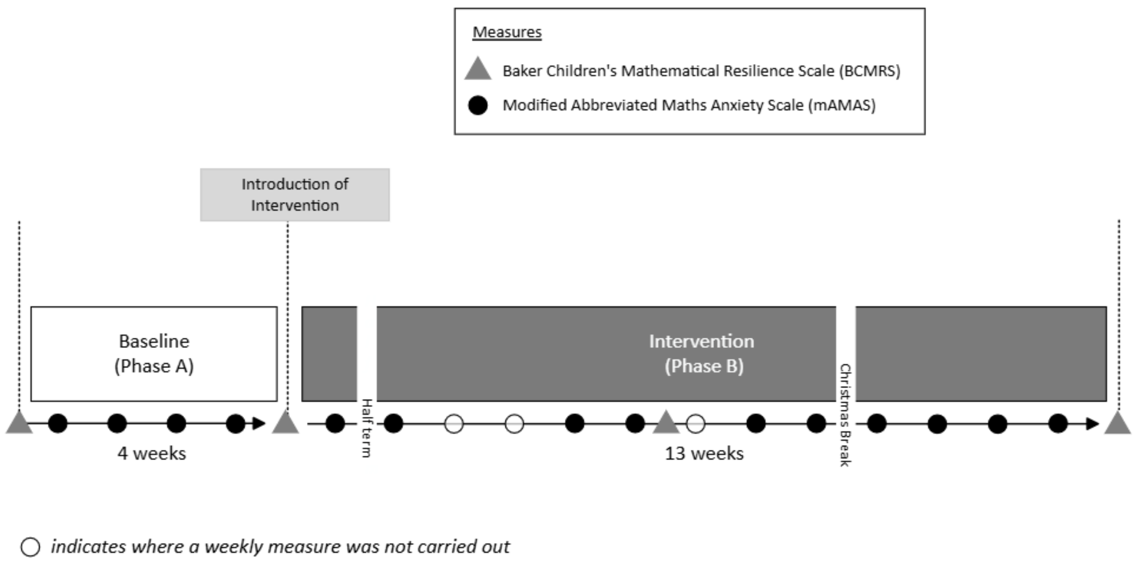
Experimental designs involve the control and manipulation of variables by the researcher. This typically involves the manipulation of an independent variable (*IV*) and subsequent measurement of the effects on a dependent variable (*DV*) (Robson & McCartan, 2016).

In this study, the *IV* is the researcher-developed intervention: a whole-class intervention session combined with the use of a practical resource known as the 'Growth Zone Model' (GZM). The intervention is outlined in Section 3.6; fundamentally, it represents a training model designed to assist staff in understanding the impact of MA and how they may foster the development of MR to mitigate MA. This intervention took place during phase B of the study, which lasted for thirteen weeks. The *DV* was participants MA levels measured weekly using the modified Abbreviated Maths Anxiety Scale (mAMAS) (Carey et al., 2017); a self-report questionnaire for children to assess their level of MA (refer to Section 3.7.7).

The figure below outlines the data collection timeline during this study's baseline and intervention phases (see Figure 3. 6).

Figure 3. 6

Timeline of Data Collection



Note. A figure to represent the timeline across both phases of the study, including where repeated and triangulation measures were taken.

3.7.6 Sampling and Recruitment

The researcher is a Trainee Educational Psychologist (TEP) on a bursary placement within a local authority (LA) in the East Midlands, and the school involved in this study is a mainstream primary school located within this LA. The school is a faith school situated on the city's periphery, which is recognised as one of the largest multi-faith communities in the UK. It serves children aged three to eleven and is part of a large multi-academy trust. The school has approximately 250 enrolled students, with around 25% qualifying for free school meals, 20% of children with an identified SEND need, and 30% considered to have English as an additional language (EAL). Therefore, an above-average proportion of pupils speak English as an additional language. The proportion of pupils from minority ethnic backgrounds at this setting is above the national average (approximately 60% in the setting vs. 38% nationally as of 2024/25 (Department for Education (DfE), 2025)), with the largest groups being of Indian heritage. However, this figure is lower than that of the ten nearest schools, where minority ethnic representation exceeds 80%. This perhaps reflects the school’s faith designation, with admissions criteria that prioritise applicants of that faith.

The school was identified for participation as they had acknowledged they were struggling with managing children’s MA in conversation with their link EP, who was also the TEP’s supervisor. Therefore, the researcher approached the school as suggested by their supervisor. Participation was voluntary and offered to the school freely. The researcher had no other affiliation with the school and, therefore, maintained a separable position as a TEP and a researcher and, in this context, solely as a researcher.

The target population for this study was the Year 4 cohort, born between 2015-2016, with the involvement of their class teacher and teaching assistants. The class teacher being one of the school’s mathematics subject leads. Year 4 was chosen based on the reasoning that universal provision for MA should be introduced early, and there is limited evidence in UK primary schools regarding interventions aimed at reducing it. In addition, the measures identified for use, developed by Carey et al., (2017), were validated for children as young as eight years, corresponding to Year 4 in UK schools.

The study involved a cohort of thirty-four children, comprising nineteen girls (55.9%) and fifteen boys (44.1%). Concerning attainment, the majority of the cohort could be considered to be achieving below age-related expectations in mathematics. Among the cohort, fifteen children (44.1%) were identified as having Special Educational Needs and Disabilities (SEND). Additionally, nine children (26.5%) were bilingual, with English being their second language, and ten children (29.4%) were eligible for free school meals. Approximately half of the class were White British (48.5%), eight children were Asian British (24.3%), five were Black British (15.2%), and two were of Mixed Ethnicity (6.1%). The remaining children were categorised under 'other ethnic group'. As is typical for a Year 4 class, all participants were between eight and nine years old, with the majority being eight years old at the beginning of the intervention.

After the school agreed to participate, it was discovered that mathematics was taught across two groups: the mainstream class was taught by the class teacher supported by a teaching assistant, and a small group of nine children were taught by another teaching assistant, receiving a significantly differentiated maths curriculum in another classroom. This added another layer of nuance to the implementation of the intervention, and it was decided that all children should be included in the study, regardless of the class in which they were taught.

The school was contacted by the researcher via email to share initial details of the aims of the research, along with a proposed timeline for the study (See Appendix K). Following the school's expression of interest, the researcher met with the school's Special Educational Needs Coordinator (SENCo), Year 4 class teacher, and teaching assistants. This meeting acquainted the staff with the research process and allowed for questions to be raised and discussed. As a result of the meeting, the school agreed to participate in the study, expressing a strong interest and investment in the research. The class teacher and teaching assistants gave their informed consent in this meeting after reviewing the information sheet (see Appendix L).

As the intervention was delivered at a whole-class level, parental consent was sought for all children (see Appendix M). An information sheet was also shared with the participating children, along with an explanation that they could withdraw from completing the measures or engaging with the intervention materials if they wished (See Appendix N).

Six children became the focus of the SCEDs. The primary goal was to evaluate its impact on high levels of MA, and while within-child factors were identified across the cohort (e.g., an identified SEND need), they were not a basis for exclusion, as the intervention aimed to be fully inclusive. The first baseline measure of MA, using the mAMAS, was used to determine the six children with the highest scores, and these were selected as focus participants. Two participants with high MA were not selected due to a number of absences across baseline and intervention phases, and therefore, their data was insufficient for use as a SCED. Demographic data, including gender, age, home language, ethnicity, special educational needs and disabilities (SEND) status, and academic attainment, were provided by school staff for the focus children. Table 3. 2 provides a brief descriptive profile of the six focus children (names are pseudonyms).

Table 3. 2

Focus Children

Focus Child	Descriptive Profile
Aisha	Female Black British Working towards age-related expectations* No identified SEND need First language is English Taught in the mainstream class
David	Male White British Working towards age-related expectations* Identified SEND need First language is English Taught in the mainstream class Summer born
Emily	Female Mixed Ethnic Heritage Working towards the expected standard for year two (more than three years below expected)* Identified SEND need First language is English Taught in a small group with a differentiated curriculum
Isabel	Female White British Working at age-related expectations* No identified SEND need First language is English Taught in the mainstream class
Ryan	Male White British Working at age-related expectations* No identified SEND need First language is English Taught in the mainstream class
Zachary	Male Black British Working at age-related expectations for year two (three years below expected)* Identified SEND need First language is English Taught in a small group with a differentiated curriculum

Note. A table providing descriptive demographic information for the six focus children, centred around gender, ethnicity, attainment and SEND needs. Academic attainment pertains to mathematics only*

3.7.7 Measures

This section outlines the measures used in this study, discussing their selection rationale, reliability, and validity, as well as the data collection methods. Additionally, it refers to the piloting phase conducted prior to the data collection, during which some adjustments were made to the self-report scales.

Modified Abbreviated Maths Anxiety Scale (mAMAS). The modified Abbreviated Maths Anxiety Scale (mAMAS) (Carey et al., 2017) is a tool designed to measure mathematics anxiety (MA) in children aged eight to thirteen. The scale consists of nine self-report items on which children rate their anxiety along a 5-point Likert scale, ranging from low to high. Total scores on the scale can range from nine to forty-five, with higher scores indicating a greater level of MA. The measure can also be divided into two subscales: Learning Anxiety (assesses anxiety related to learning mathematical concepts) and Evaluation Anxiety (centres on anxiety experienced during mathematics tests and assessments). The author of the mAMAS recognises MA as a distinct form of anxiety, and therefore, it is recognised as a valuable tool for targeted MA interventions. Example statements include:

- *Taking a maths test (Evaluation)*
- *Starting a new topic in maths (Learning)*

Carey et al., (2017) validated the mAMAS with a large cohort of 1,746 British children and young people aged eight to thirteen. Regarding the scale's reliability, the internal consistency of the overall scale was demonstrated to be excellent, with an ordinal alpha of 0.89. Both subscales also demonstrated strong reliability, each with ordinal alpha values of 0.83. Critical to this study, these high-reliability values were seen for Year 4 children. Factor analysis also demonstrated that the mAMAS is capable of measuring MA as a distinct construct, separate from related constructs like test and general anxiety (Carey et al., 2017).

The measure was selected over other MA scales (for example, the Mathematics Anxiety Scale for Children (MASC) (Chiu & Henry, 1990) and the Children's Mathematics Anxiety Scale UK (CMAS-UK) (Petronzi et al., 2019)) because of the high internal consistency of the scale. In comparison to the CMAS-UK, validated with a mainly white British middle-class population, the mAMAS was validated with a larger, more diverse group of British children, making it more suitable for this study's context.

Baker Children's Mathematical Resilience Scale (BCMRS). The Baker Children's Mathematical Resilience Scale (BCMRS) is a tool which was developed by Baker (2020) to assess children's MR and was validated for use with children aged five years and above. The BCMRS is a twelve-item self-report scale on which children rate statements along a 5-point Likert scale. Statements are rated using a pictorial scale ranging from 'strongly agree' to strongly disagree'. This pictorial scale was slightly adapted for this study based on the piloting of the materials (see below). The scale has three subscales: *growth*, *struggle*, and *value*. The BCMRS was developed as an adaptation to the Mathematical Resilience Scale (MRS) (Kooken et al., 2016) in which the three subscales were defined:

> *Value* addresses the belief that math is essential for future success. The factor labelled *Struggle* gauges respondents' belief that experiencing challenges and difficulties is a normal part of working on math. Finally, *Growth* refers to the belief that math can be learned by anyone and is not limited to those with a predisposition or "math gene". (p. 237)

Example statements from the BCMRS include:

- *Maths will help me when I grow up (Value)*
- *Everyone finds maths tricky sometimes (Struggle)*
- *Some people can't learn maths (Growth) (Reverse scored)*

Each statement of the BCMRS is scored from -2 to 2 with a positive score indicating that a child has a higher level of MR. To determine the MR total, the subscale scores are first calculated, and then the following formula is used to provide an overall MR score:

$$MR\ Total = \frac{Growth\ Total}{4} + \frac{Struggle\ Total}{5} + \frac{Value\ Total}{3}$$

The formula ensures equal weighting for each subscale in the MR total, which ranges from -6 to 6, with 6 as the highest and -6 as the lowest level of MR.

The scale's internal consistency was acceptable (Cronbach's alpha >.7), and confirmatory factor analysis supported its factor structure. Despite poor test-retest reliability, it was deemed reliable and valid for research due to discrepancies in testing intervals during validation. (Baker, 2020). This measure was chosen for use because, at the time of the study's development, the researcher was not aware of any other validated measures of MR for children.

Considerations when using Child Self-Report Measures. Research has shown that children may provide less accurate assessment of their own mental health and wellbeing. Children can have difficulty accessing the vocabulary on self-report measures and they tend to respond based on their immediate feelings rather than broader experiences (Deighton et al., 2014). Researchers must, therefore, exercise caution when interpreting the data gathered.

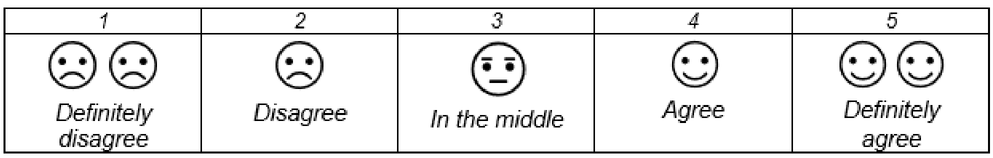
However, adopting a person-centred view, the child has the greatest access to detailed insights into their own experiences (Wigelsworth et al., 2010). Despite concerns surrounding the reliability of self-report measures, evidence indicates that children possess an understanding of their own challenges and can provide valuable insights (Deighton et al., 2014). The rationale for using solely child self-report measures was that other informants, such as parents and school staff, may have differing perspectives on a child's internalising symptoms (Tran et al., 2024). It has also been found that parents can underestimate a child's internal experience of anxiety (Tran et al., 2016, 2024). In their study exploring the impact of parental MA, Guzmán et al. (2023) argue that child self-report data is reliable and eliminates the possibility of the social desirability bias from parents.

Pilot Testing of Measures. To ensure that the self-report measures were accessible to Year 4 children in the context of the research school's local authority, one school was invited to pilot the measures. This school was another mainstream primary school and part of the same multi-academy trust as the research school. The class teacher was asked to read the mAMAS and BCMRS statements aloud to the class and encourage children to reflect on their understanding of the language and concepts used. They also measured and recorded the time taken to read the statements and introduced the pictorial 5-point scale from the BCMRS to explore the children's understanding of scaling using the thumbs.

Based on the outcomes of this pilot, the scale employed here merges the original pictorial scale used in the BCMRS with the concept of smiley faces, where two faces signify 'definitely agree/disagree'. Text and numbers were added following teacher feedback (See Appendix I), allowing children to compare the pictorial scale with the numerical scale (See Figure 3. 7).

Figure 3. 7

Pictorial Scale



Note. The scale used alongside the BCMRS in this study was adapted based on the pilot feedback provided.

3.7.8 Data Collection and Procedures

The measures were implemented by school staff weekly, whenever possible, on Friday mornings. The BCMRS (Baker, 2020) was only implemented at four specified time points across the study. The implementation of the measures was discussed with school staff to ensure they were delivered as intended by the researcher. Children were asked to self-report on each statement by circling their responses; school staff read the questions aloud to the whole class and provided support to children with access difficulties, as they typically would. After collecting the paper measures, the researcher calculated the scores using the mAMAS and BCMRS calculators they developed in Excel to compute the overall and subscale scores, entering the data into a sheet to store the raw data.

3.7.9 Data Analysis

Analysis in the quantitative strand of this study was used to observe the effects on the *DV*. The researcher applied visual analysis as a method to identify different patterns in the data between phases to determine whether outcomes improved following the intervention (Robson & McCartan, 2016). Differences in the mean scores (level), linear trends and stability in the data points (Lane & Gast, 2014) were visually analysed (Krasny-Pacini & Evans, 2018) (See Appendix U). One type of effect size, Tau-U, was also calculated.

The Reliable Change Index (RCI) (Jacobson & Truax, 1991) was also calculated for each child's score on the BCMRS between the phases. The results chapter of this thesis will offer a more comprehensive description and rationale for the analysis methods.

3.8 Phase Two: Qualitative Strand

Phase two of the research involved collecting qualitative data to complement and support the explanation of the results obtained in phase one, following a QUAN → qual sequential explanatory design. While considerable weight has been given to the quantitative phase of this research, the qualitative phase was considered essential for interpreting the data more accurately, informed by the researcher's stance of critical realism. Qualitative data was gathered to help uncover the underlying mechanisms and contextual factors influencing the intervention's outcomes (Zachariadis et al., 2013).

3.8.1 Semi-Structured and Focus Group Interviews

Phase two of this study involved a staff focus group and individual interviews with the six focus children. The staff focus group explored broader perceptions and implementation issues, while individual semi-structured interviews with the six focus children aimed to provide insight into their personal experiences and perceptions of the intervention. The approach, aligning with constructionism, emphasised the importance of understanding human perceptions to theorise about the underlying mechanisms and structures influencing the observed outcomes produced by the quantitative data (Pilgrim, 2014).

A focus group with staff was selected based on its primary use as an evaluation tool within this sequential explanatory design. It was also selected over individual interviews because of its efficiency in gathering qualitative data; allowance for collective decision-making and, thus, serving as a natural quality control; and provides the researcher with an opportunity to easily observe if there was a shared perspective between the staff (Robson & McCartan, 2016).

Individual semi-structured interviews were chosen to provide the researcher with a better opportunity to reflect on whether there was heterogeneity in perceptions of the intervention. Semi-structured interviews were also chosen as they blend elements of formal interviews (fixed time limits, defined roles for interviewer and interviewee, and a structured interview agenda) with characteristics of informal conversations, by using a small number of open-ended questions with a focus on the child's lived experience of the intervention (Willig, 2022).

3.8.2 Sampling and Recruitment

Please consult Section 3.7.6 of this chapter for a detailed overview of the sampling and recruitment procedures. Specific to phase two of this research, a focus group was conducted with the Year 4 class teacher and both teaching assistants. Individual pupil interviews were conducted with the six focus children. Due to pupil absence, only five focus pupils could be interviewed on the day.

3.8.3 Data Collection and Procedures

Following the completion of phase B of this study's quantitative strand, staff focus groups and individual pupil interviews were conducted. The researcher led the focus group at the research school with a discussion lasting approximately one hour. A complete outline of the questions presented to the focus group can be found in Appendix O. The researcher took extensive field notes during the focus group, which involved secretarial transcription. At the end, the researcher reflected on the points they had captured to confirm their understanding with the focus group, which the participants confirmed.

Individual semi-structured interviews with the focus children were also conducted at the research school on the same day. Parents gave additional consent for their child to participate in this phase of the research (see Appendix M). To capture feedback for each question, the researcher used a worksheet of the questions asked (see Appendix P) and recorded the children's answers verbatim. This included asking the children about their understanding of the intervention concepts and their perspectives on what they thought worked well or did not. These interviews lasted between ten and fifteen minutes.

Field Notes. The decision to record qualitative data using field notes rather than audio recordings was driven by careful consideration of the purpose of conducting this phase of the study and the factors that might have influenced data collection. Nordstrom (2015) contends that there are theoretical consequences to placing importance on recording devices in qualitative research. Recording may have an influence on the data such that it can affect the flow of interviews, disrupt conversational spontaneity, and hinder the openness of participants' responses (Nordstrom, 2015; Seale et al., 2004). It is argued that qualitative researchers may consider not recording interviews as the optimal approach and that the use of field notes in their place is effective, especially when research questions are direct and clear (Rutakumwa et al., 2020). With this phase of the study being given relatively less weight, as well as the potential impact of audio recordings on participant bias, field notes were chosen as they reduced the time required for data collection and analysis while still being able to capture pertinent data comprehensively (Hill et al., 2022; Rutakumwa et al., 2020).

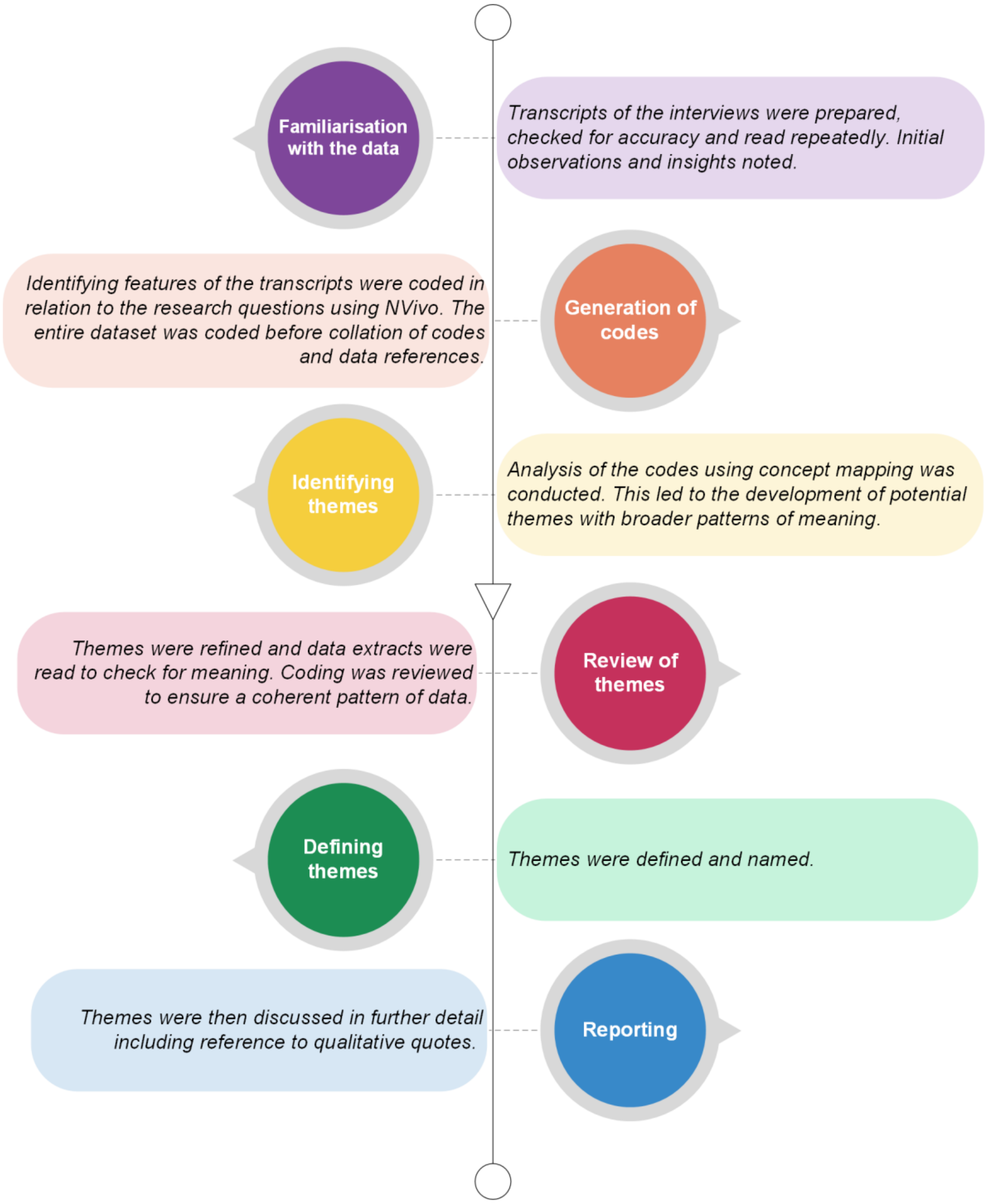
3.8.4 Data Analysis

Reflexive Thematic Analysis (RTA) was used to analyse the qualitative data produced by this study, recognising the researcher's role as central to the development and interpretation of themes, with an emphasis on subjectivity (Braun & and Clarke, 2019). Braun and Clarke's (2006) 'six phase guide' was used to complete this analysis and identify themes within the data (See Figure 3. 8). Utilising RTA, the coding process remained open, meaning codes were not predetermined at the start of the process, allowing them to develop throughout coding (Liamputtong, 2019). NVivo 12 for Windows (QSR International Pty Ltd., 2018) software was used to help store and manage coding, supported by guidance developed by Gibbs (2002).

The analysis of the qualitative data aimed to "provide a coherent and compelling interpretation of the data, grounded in the data. The researcher is a storyteller, actively engaged in interpreting data through the lens of their own […] theoretical assumptions […], as well as their scholarly knowledge," (Liamputtong, 2019, p. 1026). Thematic techniques were applied to elaborate on and help explain the quantitative results (Ivankova et al., 2006).

Figure 3. 8

Reflexive Thematic Analysis Process



Note. This figure represents the secondary set of data analyses in relation to this QUAN-qual enquiry.

3.9 Ethical Considerations

The British Psychology Society's (BPS) Code of Human Research Ethics defines 'research ethics' as "the moral principles guiding research from its inception through to completion and publication of results," (Oates et al., 2021, p. 5). An ethical researcher is defined by the BPS as one who respects the rights and dignity of participants in their studies and explicitly takes into account the interests of potential stakeholders. The code stipulates that researchers are morally obligated to conduct psychological research ethically. Ethical conduct ensures "mutual respect and trust between investigators and participants," which also fosters participants' confidence in the researcher, a prerequisite for conducting effective psychological research (Oates et al., 2021, p. 4).

The researcher consulted the relevant guidance, Code of Ethics and Conduct (BPS, 2021), Code of Human Research Ethics (Oates et al., 2021), Standards of Conduct, Performance and Ethics (Health and Care Professions Council (HCPC), 2024), and the Code of Research Conduct and Research Ethics (University of Nottingham, 2023), to ensure that the underlying principles guiding psychological research and practice were fully considered when making decisions and/or taking actions regarding the conduct of this study. The University of Nottingham's Ethics Committee Review provided ethical approval for this study (refer to Appendix Q). The ethical considerations considered for this study are outlined in Table 3. 6 which can be found in Appendix R .

3.9.1 Stakeholders

As per the BPS Code of Human Research Ethics (Oates et al., 2021) the potential stakeholders involved in the study are outlined below:

- **University of Nottingham**; this research was completed to partially fulfil the requirements of the Doctorate in Applied Educational Psychology. The researcher was supported in the design and implementation of this study through academic tutorials provided by the University.

- **Research Setting**; one school was responsible for the implementation of the intervention. The intervention was designed to enhance the teaching and learning of mathematics in this environment, making staff and children key stakeholders.
- **Local Authority (LA) Psychology Service**; the LA where the researcher is on placement may benefit from the research outcomes and dissemination, with the potential for findings to inform subsequent practice. The LA also expressed their support throughout the research provided in supervision.
- **Author of the Toolkit**; The authors of the toolkit, Johnston-Wilder et al. (2020), are referenced throughout the study as the original author. They supported the researcher in meeting with them before the study's commencement.
- **Professionals with an interest in school-based interventions addressing MA**; The study aims to contribute to the evidence base that other professionals, interested in early intervention for addressing MA, can engage with.

3.10 Mixed Methods Research Integrity

Mixed-methods researchers must ensure that both strands of their research produce reliable and valid data to ensure the quality and integrity of their findings. While the quantitative phase requires focus on the notions of validity and reliability, the broader concept of trustworthiness needs to be considered for the qualitative phase (Fetters, 2020b). Further discussion regarding the research quality will also be addressed in the Discussion chapter (See Section 5.4).

3.10.1 Quality of the Quantitative Phase

This section will focus on the design considerations related to the quantitative phase of this study. The most frequently considered criteria in quantitative research are reliability and validity (Fetters, 2020b). Table 3. 3 summarises the threats to external and internal validity and issues related to reliability that the current study has addressed.

Table 3. 3

Validity and Reliability Threats Related to this Study

Quality Criteria*	Specific Threat to Quality and Integrity*	Actions Taken to Reduce Threat
Internal Validity *The ability to attribute any effect observed on the dependent variable to the independent variable.*	**History** Events in the environment that co-occur with the delivery of the intervention may be the cause of the observed outcomes.	Events (e.g., teacher/pupil absence) or factors which occurred throughout both phases of the study will be considered by the researcher within the data analysis. The mixed-methods nature of this study supports triangulation of data, with the view that qualitative data will provide a more accurate interpretation of quantitative data.
	Maturation Changes that occur naturally over time lead to the observed outcome.	Multiple focus children were identified for this study. The presence of a stable baseline can reduce this threat. However, for some focus children, this was not achieved, and therefore, it will need to be considered as a limitation in the discussion.
	Testing Repeated testing might have influenced subsequent test outcomes.	In addition to the self-report weekly measures of MA, four measures of MR were carried out across the study as a triangulation measure. In comparison, MR measures were implemented less frequently. The mixed methods nature of this study supports triangulation between quantitative and qualitative data.
	Diffusion of Treatment When participants (in the control condition) inadvertently receive aspects of the	With participants acting as their own control, it was of concern that they would receive elements of the intervention prior to phase B of the study. Therefore, the teacher training session was delivered at the end of phase A to minimise this

	intervention intended only for a specific group.	threat. However, it was unethical to withhold information about the overall purpose and concept of this study from key stakeholders prior to the commencement of the baseline phase, and this will be discussed in the Discussion chapter.
External Validity *The capacity to generalise the findings of the study to other populations, contexts, or periods*	**Ecological and Population Validity** The generalisability of the research to other populations and/or settings	The small sample size of this study makes generalising conclusions to other children and/or schools challenging. However, this study intended to begin exploring the effectiveness of the intervention specifically for these focus children and contribute to the minimal evidence base for whole-class MA interventions. Efforts were made to increase the external validity of the research by including multiple cases and adopting a mixed-methods approach, which allowed for data triangulation. Specific details concerning the sample and the context of the intervention delivery have been provided in Section 3.7.6.
Internal and External Validity *As above*	**Hawthorne Effect** Participation alone in the intervention may influence the participants' behaviour and thus the outcomes	The use of mixed-methods aimed to reduce this threat. The qualitative strand allowed for the exploration of how the intervention was received and how it may have influenced outcomes.
Reliability *The measures adopted produce stable and consistent results*	**Participant Error** Participants' outcomes may vary on a random basis, influenced by events outside the control of the study	Data collection was completed on the same day and time, where possible. The nature of a SCED means that measures are taken repeatedly, and the presence of a stable baseline can indicate a reliable reference point to begin with before implementing the intervention. This can assist in making inferences about the intervention's role in any changes observed.

Participant Bias	The researcher did not meet with the children until phase B of the study was complete. This approach was believed to reduce participant bias, so repeated measures were implemented by the school staff. It was emphasised to school staff to communicate that there were no right or wrong answers to reduce bias. The method for scoring the measures was not communicated to school staff with the aim of preventing any potential bias from those wishing to achieve favourable results.

Note. *Definitions are paraphrased from Matthay & Glymour (2020) and Robson and McCartan (2016)

3.10.2 Quality of the Qualitative Phase

Reflecting on the quality of qualitative research is often considered under the umbrella term of trustworthiness. Given that the researcher is fully integrated into the qualitative process, "the researcher is the instrument" when it comes to qualitative data collection and interpretation (Flick & Mertens, 2018, p. 33). Therefore, reflection on the potential impact of values, assumptions, and beliefs on data collection and interpretation, as well as clearly addressing the measures taken to safeguard the accuracy and credibility of results is considered (Creswell & Creswell, 2017; Mertens, 2005).

Key to ensuring the quality of qualitative research includes reflection on the study's credibility, confirmability, dependability and transferability (Lincoln and Guba, 1985). Table 3. 4 provides an overview of the criteria considered in the context of phase two and the relevant actions taken to promote the accuracy and credibility of findings.

Table 3. 4

Reflection on Trustworthiness Criteria and Researcher Actions

Criteria	Actions Taken
Credibility *Confidence exists in the accuracy of the data and its interpretation*	The researcher included a summary section in the focus group to offer an opportunity for participants to check the researcher's understanding of their views. Engagement with the school staff from the initial meeting concerning the research through to the end of Phase B and beyond, which supported the building of trust and rapport with staff. Triangulation of qualitative data was achieved by gathering data from both staff and children to validate data through multiple perspectives.

Confirmability *There exists a level of objectivity, and the researcher's interpretations are based on the data*	An audit trail, including the raw data, method of data analysis, and reflexive notes, is included to enhance transparency and evidence the decisions made by the researcher.
Dependability *The findings are considered reliable in that they could be replicated*	The qualitative analysis phase of this research has been conducted and reported in accordance with Braun and Clarke's (2006) guidelines, and the qualitative methods employed are described and reported in this chapter.
Transferability *Findings are generalisable to other contexts or groups*	The procedure and data analysis have been outlined in this chapter, including a detailed description of the context in which the research was conducted as well as a description of the participants.

Chapter 4: Findings

4.1 Introduction

This research explores the effectiveness of a whole-class intervention aimed at enhancing outcomes for children experiencing mathematics anxiety (MA). This chapter presents the findings from this mixed-methods study. The initial findings will be considered separately for phase one (quantitative) and phase two (qualitative), followed by reflections on their integration. The visual and statistical analyses conducted for phase one, which focus on the SCED aspect of the study, are detailed, with findings represented for each case graphically and descriptively. In phase two, Reflexive Thematic Analysis (RTA) is employed, and the findings are presented.

4.2 Phase One Findings: Single Case Experimental Design (SCED)

Phase one of this research aimed to explore research question one: **'Does a whole-class mathematical resilience intervention, incorporating a practical Growth Zone Model (GZM) resource, reduce children's self-reported levels of mathematics anxiety?'** Table 4. 1 presents this research question alongside the corresponding hypotheses.

Table 4. 1

Phase One Research Question and Corresponding Hypothesis

RQ	Research Question	Null hypothesis	Experimental hypothesis
1	Does a whole-class mathematical resilience intervention, incorporating a practical Growth Zone Model (GZM) resource, reduce children's self-reported levels of mathematics anxiety?	Participation in a whole-class MR intervention using a practical GZM resource does not impact self-report measures of MA in Year 4 children with high MA scores.	Participation in a whole-class MR intervention using a practical GZM resource leads to a reduction in self-report measures of MA in Year 4 children with high MA scores.

Phase one of this study's design used SCED methodology to address the question. The optimal methods for SCED analysis remain a topic of debate, with visual and statistical analysis techniques in question. Whilst visual analysis remains the "cornerstone" of SCED research (Krasny-Pacini & Evans, 2018; Lane & and Gast, 2014, p. 445), there is a growing consensus among scholars that researchers can and should complement their visual analyses with relevant statistical analysis (Wendt & and Rindskopf, 2020). Both visual and statistical analyses were conducted as part of this study.

4.2.1 Visual Analysis

Visual analysis requires the researcher to visually examine trends and patterns in continuous data across phases to establish the effects of an intervention or treatment (Lane & and Gast, 2014; Morley, 2017). Data is presented graphically, creating a picture of the data, which enables the variability in the baseline, change between phases, the onset of change and stability to be seen visually (Vlaeyen et al., 2020). To investigate the hypotheses, various features of the SCED data were visually analysed, including the mean level change, variability in the data, trend lines, overlap of data points, and point of change. Appendix U presents these features and describes the analysis process (See Table 4. 15). Guidance has been taken from the following sources to inform the method of analysis: Kratochwill et al. (2010), Lane and Gast (2014) and Morley (2017).

4.2.2 Statistical Analysis

The statistical analysis conducted for this study aims to complement the visual analyses and to provide some systematic examination of the data quantitatively, which may potentially identify effects that may be overlooked when the analysis relies solely on visual methods (Morley, 2017; Wendt & and Rindskopf, 2020). Non-overlap statistical testing was deemed appropriate for use in this study. Tau-U (Parker et al., 2011), was applied, which analyses the collective separation of data points between phases. This test combines

Kendall's rank correlation test (Tau) with the Mann-Whitney U statistic to analyse the non-overlap of pairs (Morley, 2017), selected due to its ability to account for any trends observed in the baseline phase (Parker et al., 2011). Tau-U provides an effect size that can provide an indication of overall improvement (Parker et al., 2011). The change is suggested to be considered moderate between 0.20 and 0.60, large between 0.60 and 0.80, and very large when over 0.80 (Vannest & Ninci, 2015). This statistic was calculated using an online Tau-U calculator for single-case research (Vannest et al., 2016).

A Reliable Change Index (RCI) is proposed by Jacobson and Truax (1991) as a statistical approach to determine the magnitude of change for an individual after intervention. RCI is considered a straightforward and valuable tool for practice-based psychological research, aiding in the assessment of intervention effectiveness (Blampied, 2022). This approach seeks to determine the reliability of change at an individual level and uses information about the reliability of the measure to do so. During the study, a measure of self-report MR, using the BCMRS, was probed across phases at four given time points. These scores have been presented visually, and RCI has been calculated between the measures taken. The Leeds RCI calculator (Morley & Dowzer, 2014) was utilised to compute these values by examining the magnitude of change between each of the four measures. The BCMRS has an acceptable Cronbach's alpha value ($\alpha = .70$), suggesting internal consistency, and this was used in calculating the RCI for each case (Baker, 2020).

4.2.3 Presentation of Phase One Findings

The following sections of this chapter present the visual and statistical analysis for each focus case. Six children, with the highest initial MA scores, were selected as focus cases for this study. To answer research question one, six individual SCEDs were conducted and analysed to determine whether scores on the mAMAS changed across the baseline and intervention phase of this study. Each child's demographics and descriptive statistics are presented in Appendix V.

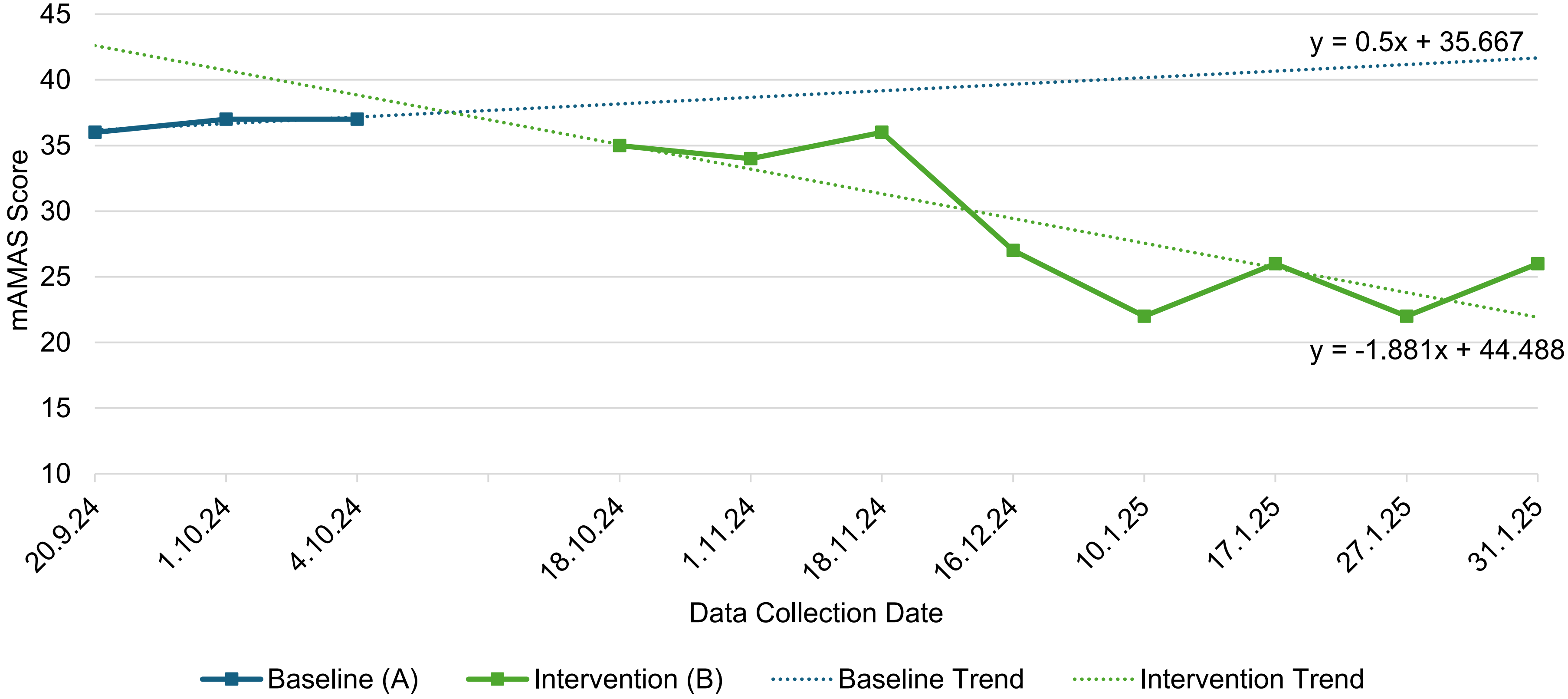
4.2.4 Aisha

Aisha is a Black British female in Year 4 who is taught in the context of her mainstream classroom. She has no identified SEND need. Aisha is currently assessed as working towards age-related expectations. This means that whilst she is accessing the Year 4 maths curriculum, she is potentially working at around twelve months behind her chronological age.

Figure 4. 1 below displays Aisha's self-report scores on the mAMAS, collected weekly during the baseline and intervention phases. Figure 4. 2 displays graphs that visualise the mean level of central tendency, the broadened median level change, the split-middle trend lines, and the range lines. Table 4. 2 summarises the findings of the visual and statistical analysis for Aisha.

Figure 4. 1

Aisha's Mathematics Anxiety Across Phases



Note. A line graph showing Aisha's mathematics anxiety (MA) reducing across the intervention phase according to total scores on repeated measures of the mAMAS

Figure 4. 2

Visual Analysis of Aisha's mAMAS Scores Using the Shiny SCDA Programme

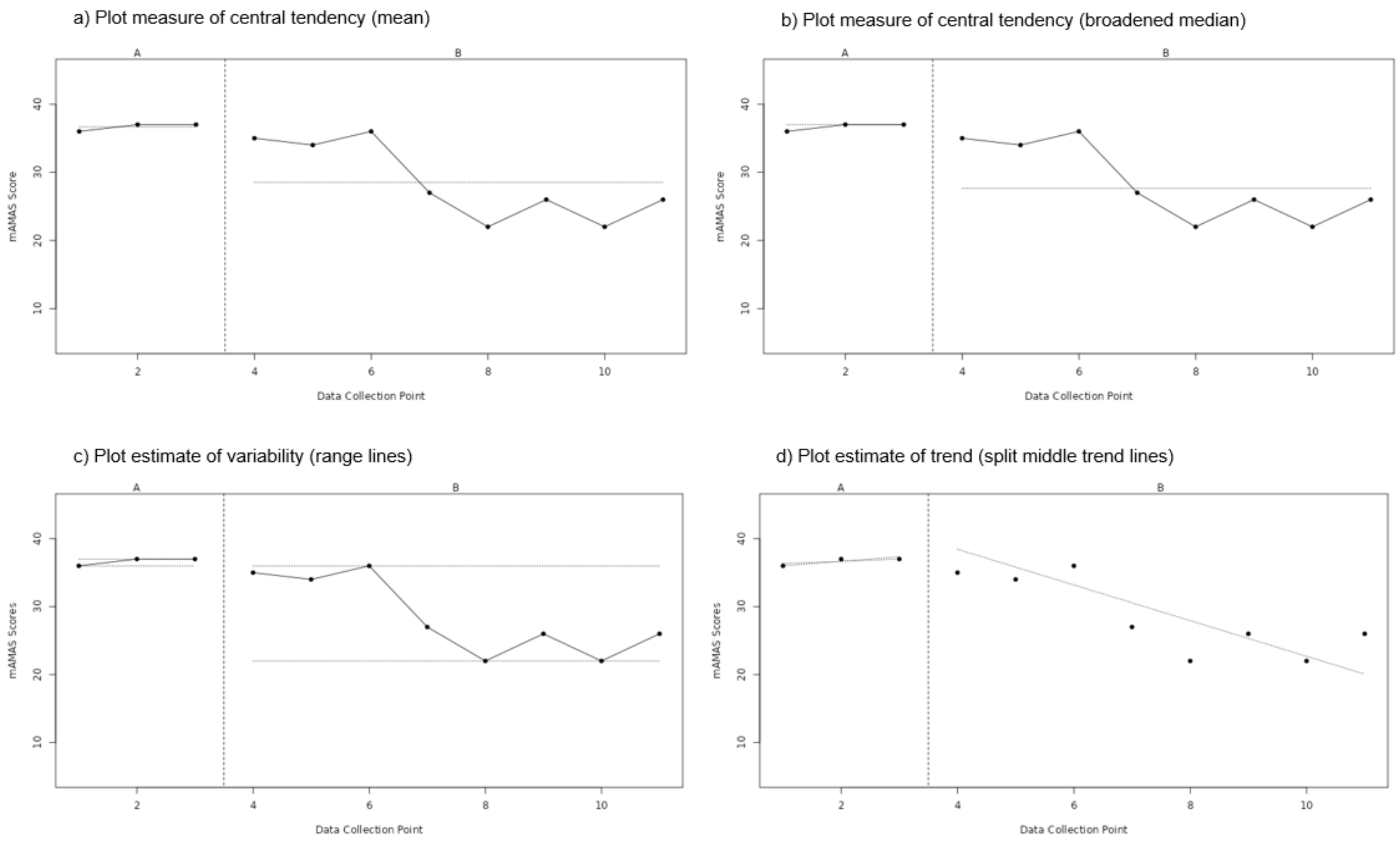


Table 4. 2

Analysis of Aisha's Scores on the mAMAS

Analysis	Characteristic	Description	Quantitative Data
Visual Analysis	Central Tendency (Level + Mean Level Change)	Aisha's mean scores decreased between the baseline and intervention phase. This indicates a decrease in anxiety as measured by the scales in this study. The same can also be seen for the broadened median level change in Figure 4.2.	Baseline phase (A) mean = 17.75 Intervention phase (B) mean = 12.30 Mean change = -5.45 Percentage change: -30.70%
	Variability	The range and standard deviation of scores in the baseline phase (A) suggest a low level of variability with three points of stability within three weeks. Much more variability was seen in the intervention phase (B) indicated by the wider range lines as seen in Figure 4.2 .	Baseline phase (A) range = 1.00 Baseline phase (A) SD: 0.58 Intervention phase (B) range = 14.00 Intervention phase (B) SD:5.71
	Trend	The baseline phase has a slight accelerating trend, which is indicative of worsening MA. The intervention phase has a steep decelerating trend which is indicative of improvement in MA.	Baseline phase (A) trend = +0.5 Intervention phase (B) trend = -1.88 Magnitude of change between phases = 2.38
	Immediacy of Effect	There appears to be no immediacy of effect. There is a very small decrease between the last baseline data point and the first intervention data point. Visually, there appears to be a point of change at the fourth data collection point, which was during the eighth week of the intervention phase.	Change between last baseline (A) and first intervention (A) data point = -1.00
	Overlap	Figure 4.1 illustrates that there is one overlapping data point between phases with most data points showing improvement.	Percentage of data overlap = 12.50%
Statistical Analysis	Tau-U	There was no significant trend identified in Aisha's baseline phase therefore the non-corrected Tau statistic is reported for baseline vs intervention. Phase comparison using Tau-U indicated a significant improvement between baseline and intervention phase.	Baseline vs Baseline (Trend) Tau = 0.67, z= 1.04, p = 0.30 Baseline vs. Intervention (Phase) Tau = -0.96, z = -2.35 p =0.02*

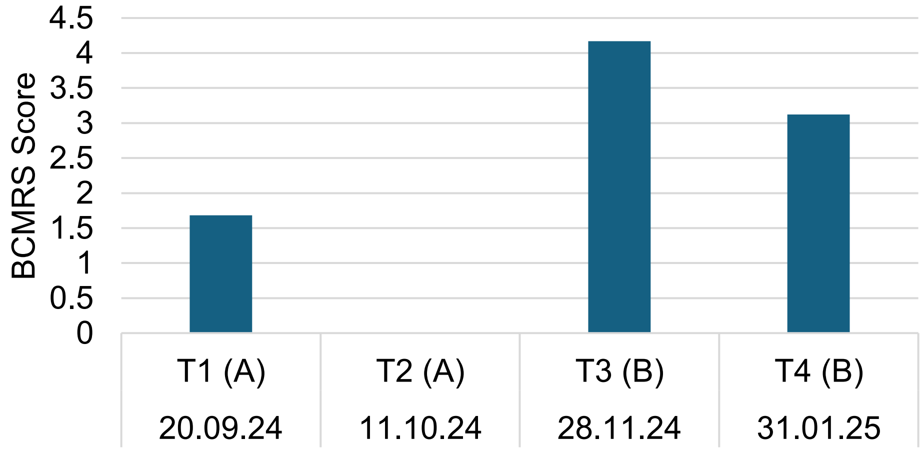
Note. A table detailing the visual and statistical analysis of Aisha's scores on the mAMAS across phases

These findings suggest that the intervention reduced Aisha's self-reported MA. Aisha's MA appeared relatively stable in the baseline phase, contrasting with the steep downward trend in the intervention phase. There was only one overlapping data point (12.50%) between phases, with all other intervention scores falling below those in the baseline phase. Results of the Tau-U test suggest that this reduction between phases in self-report MA scores is statistically significant (p = 0.02*) and would be considered a very large change (τ = >0.80). This indicates that, for Aisha, it would be appropriate to reject the null hypothesis at the 0.05 significance level, as these findings suggest that her participation in the whole-class intervention significantly reduced her scores on a self-report measure of MA.

Triangulation Measure. Figure 4. 3 below shows Aisha's scores on the BCMRS across baseline and intervention phases. Aisha was absent for the collection of the second data point (T2). Visually, the graph shows that Aisha's self-reported MR in the intervention phase is greater than in the baseline phase.

Figure 4. 3

Aisha's Mathematical Resilience Scores



Note. A column chart displaying Aisha's self-reported scores on the BCMRS, which shows her level of mathematical resilience increased between the baseline (A) and intervention (B) phases.

Figure 4.4 shows Aisha's scores on the mAMAS and BCMRS at the first and last data collection points. There is an increase between measures of MR and a decrease between the first and last measures of MA. Therefore, as Aisha's self-report MA decreased, her self-report MR increased.

Figure 4. 4

Aisha's Score on the Initial and Final Assessments of MA and MR

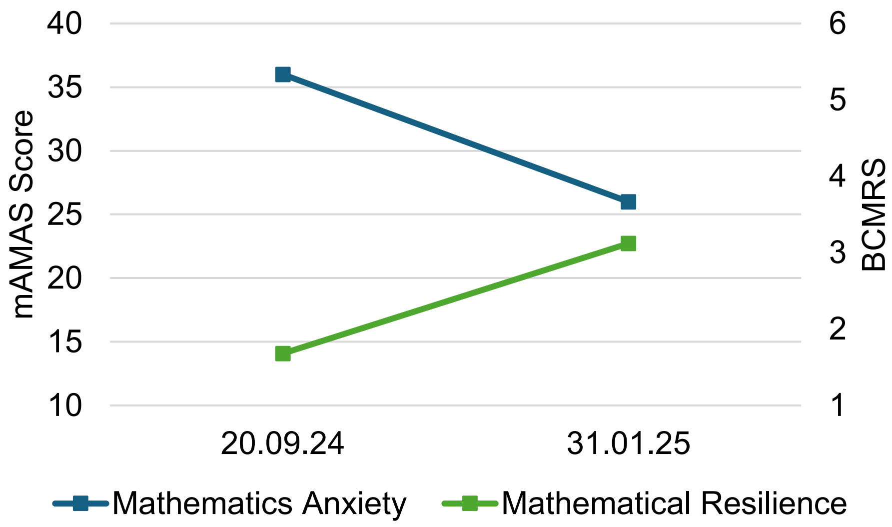


Table 4. 3 presents the pair-wise comparisons between Aisha's scores on the BCMRS at three time points, one before intervention and two during the intervention phase.

Table 4. 3

Comparison of Aisha's Mathematical Resilience Scores

Pair-wise comparison	Difference	RCI	Significance
T1 (Baseline) vs. T3 (Intervention)	Increase	+4.51	Yes, p<0.05
T1 (Baseline) vs. T4 (Intervention)	Increase	+2.61	Yes, p<0.05
T3 (Intervention) vs. T4 (Intervention)	Decrease	-1.90	No

Note. Reliable Change Index (RCI).

The results indicate that Aisha's scores on the BCMRS increased significantly between the baseline and intervention phases for both measures taken at times three (T3) and four (T4) using the RCI. No significant changes were observed in scores during the intervention phase. These findings suggest that an increase in MR was associated with a reduction in self-reported MA seen across repeated measures.

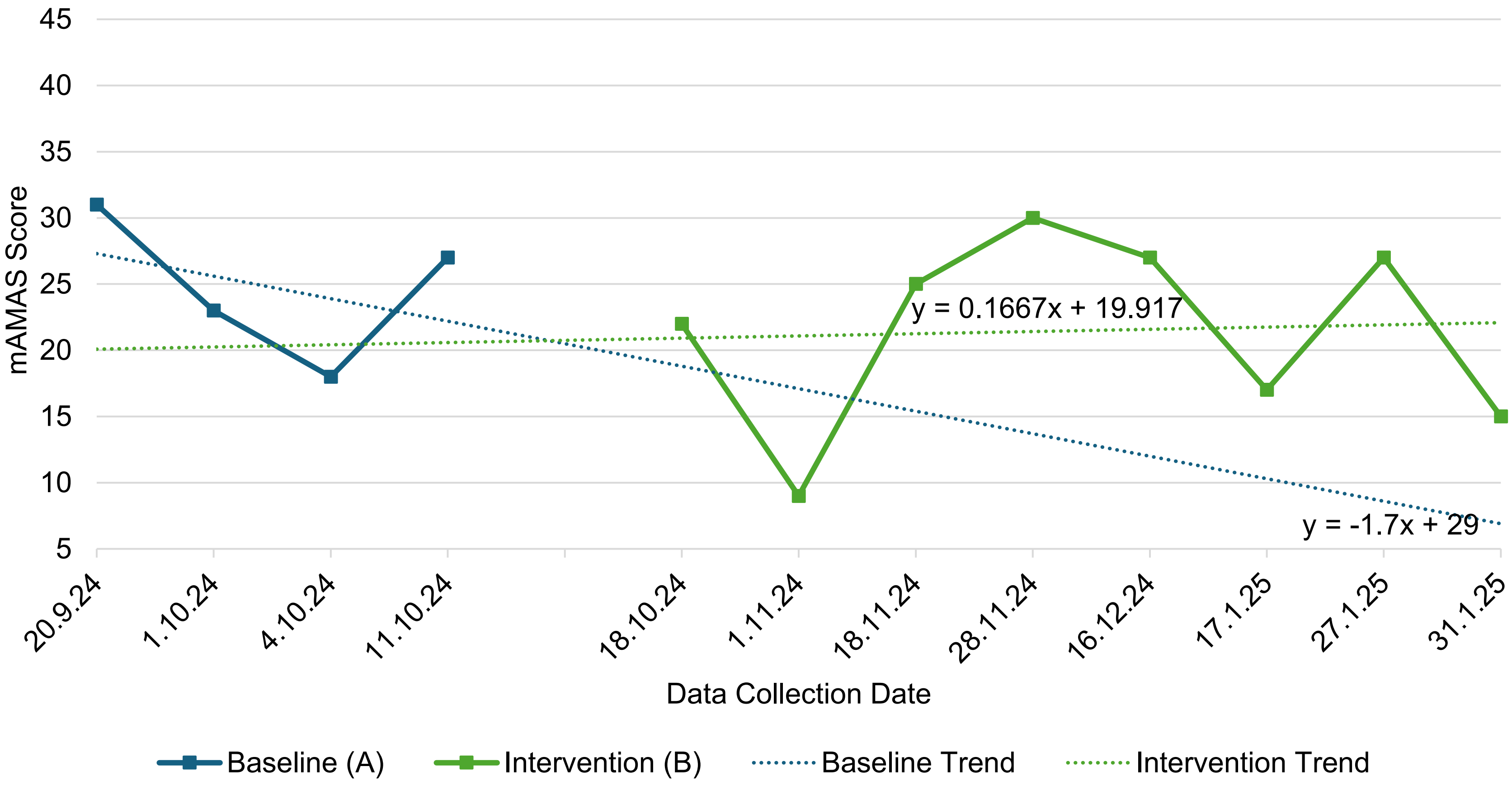
4.2.5 David

David is a White British male in Year 4 who, for maths, is taught in the context of his mainstream class. David has been identified as having Special Educational Needs and Disabilities (SEND), with a diagnosis of Attention Deficit Hyperactivity Disorder (ADHD). He receives additional support in class, including movement breaks, to help with his regulation and engagement with learning. According to his class teacher, David struggles with concentration and task focus. David is currently assessed as working towards the expected standard for his age in maths, which means he is accessing the Year 4 curriculum. David's class teacher also reported that his home life was very unsettled over Christmas and remained unsettled through January.

Figure 4. 5 below displays David's self-report scores on the mAMAS, collected weekly during the baseline and intervention phases. Figure 4. 6 displays the additional graphs created using the Shiny SCDA programme. Table 4. 4 summarises the findings of the visual and statistical analysis for David.

Figure 4. 5

David's Mathematics Anxiety Across Phases



Note. A line graph showing David's total scores on repeated measures of the mAMAS showing considerable variability across baseline and intervention phases.

Figure 4. 6

Visual Analysis of David's mAMAS Scores Using the Shiny SCDA Programme

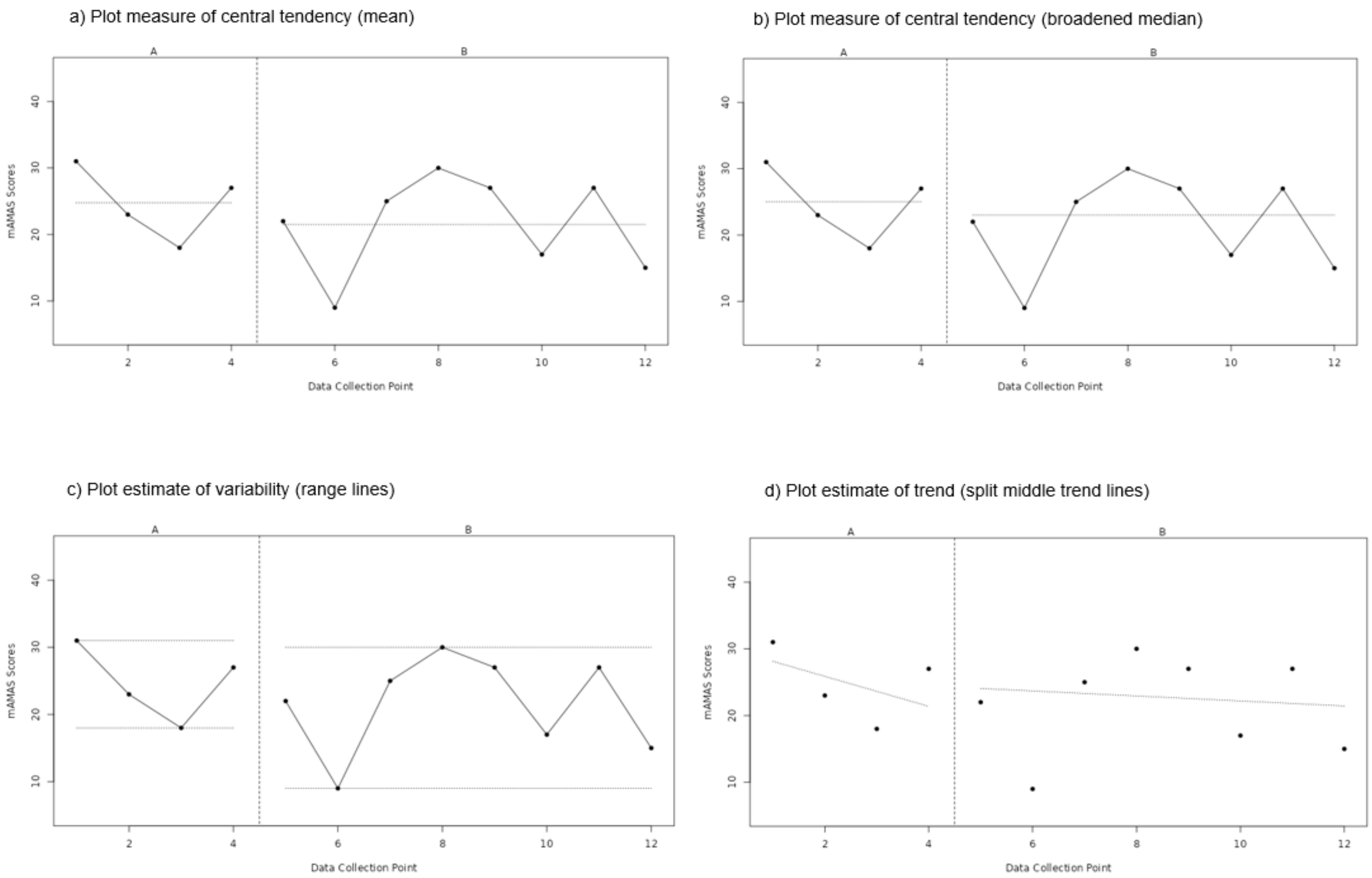


Table 4. 4

Analysis of David's Scores on the mAMAS

Analysis	Characteristic	Description	Quantitative Data
Visual Analysis	Central Tendency (Level + Mean Level Change)	David's mean scores decreased between the baseline and intervention phase. This indicates a improvement in mathematics anxiety. The same can also be seen for the broadened median level change in Figure 4.6.	Baseline phase (A) mean = 24.75 Intervention phase (B) mean = 21.50 Mean change = -3.25 Percentage change: -13.13%
	Variability	The range and standard deviation of scores in both phases suggest a high level of variability. This variability can be seen in the illustration of the range lines in Figure 4.6 There is slightly more variability in the intervention phase.	Baseline phase (A) range = 13.00 Baseline phase (A) SD: 5.56 Intervention phase (B) range = 21.00 Intervention phase (B) SD:7.21
	Trend	The baseline phase has a decelerating trend, which is indicative of improvement in mathematics anxiety. The intervention phase has a slight accelerating trend which is indicative of deterioration in anxiety.	Baseline phase (A) trend = -1.70 Intervention phase (B) trend = +0.17 The magnitude of change between phases = 1.87
	Immediacy of Effect	There is a decrease of five points in scores between the last baseline data point and the first intervention data point, suggesting some immediacy of effect. However, later data points in the intervention phase exceed this initial data point.	Change between last baseline (A) and first intervention (A) data point = -5
	Overlap	Figure 4.5 illustrates that there are five overlapping data points between the intervention and baseline phase.	Percentage of data overlap = 62.50%
Statistical Analysis	Tau-U	The trend observed in David's baseline phase was found not to be significant. Therefore, the non-corrected Tau statistic is reported for baseline vs intervention. Phase comparison using Tau-U indicated no significant improvement between baseline and intervention phase.	Baseline vs Baseline (Trend) Tau = -0.33, z= -0.67, p = 0.49 Baseline vs. Intervention (Phase) Tau = --0.31, z = -0.85 p =0.40

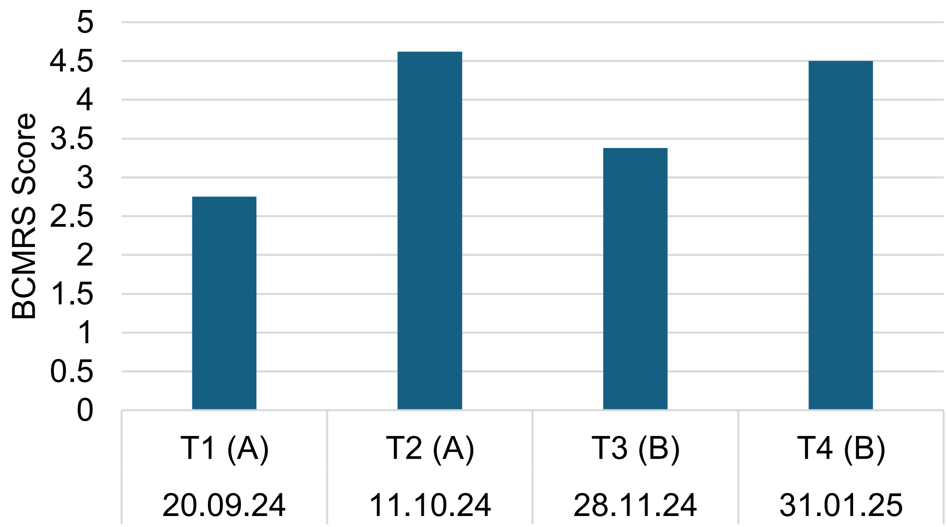
Note. A table detailing the visual and statistical analysis of David's scores on the mAMAS across phases.

Whilst a decrease in central tendency is seen for David's self-reported MA between the baseline and intervention phase, statistical analysis using Tau-U suggests this effect is not significant (p =0.40). The baseline trend indicates that David's MA began to improve before rising again, which makes interpretation of the findings challenging and warrants caution. There was also a large amount of variability in David's scores in both phases, and over half of the data points in the intervention phase overlap with those in the baseline phase. This indicates that, for David, it would be appropriate to accept the null hypothesis as these findings do not suggest that his participation in the whole-class intervention reduced his scores on a self-report measure of MA.

Triangulation Measure. Figure 4. 7 below shows David's scores on the BCMRS across baseline and intervention phases. Visually, the graph shows that David's scores increased during the baseline phase before reducing and increasing again in the intervention phase.

Figure 4. 7

David's Mathematical Resilience Scores



Note. A column chart showing David's self-report scores on the BCMRS, reflecting his varying level of mathematical resilience across the baseline (A) and intervention (B) phases.

Figure 4.8 shows David's scores on the mAMAS and BCMRS at the first and last data collection points. As the graph indicates, there is an overall increase in MR paired with a decrease in self-reported MA, reflecting a negative correlation.

Figure 4. 8

David's Score on the Initial and Final Assessments of MA and MR

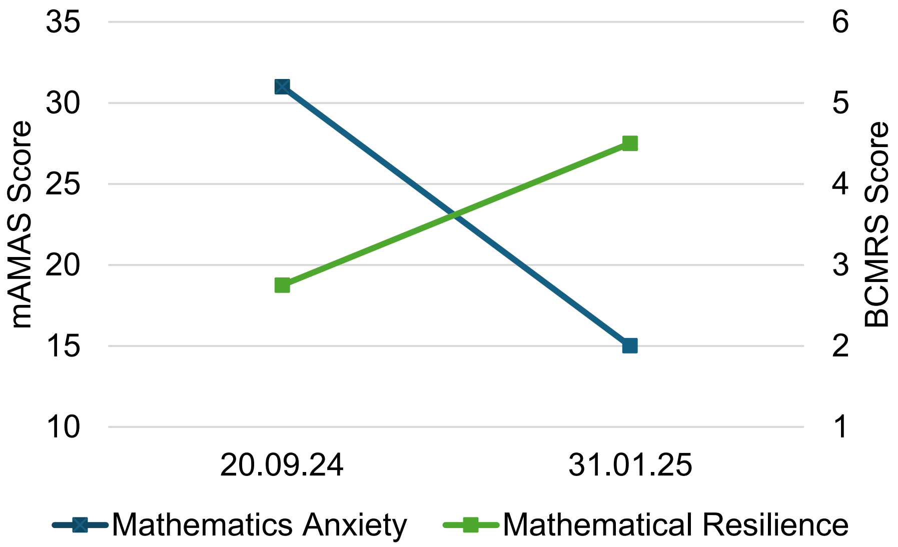


Table 4.6 presents the RCI pair-wise comparisons between David's scores on the BCMRS at four time points, two before intervention and two during the intervention phase.

Table 4. 5

Comparison of David's Mathematical Resilience Scores

Pair-wise comparison	Difference	RCI	Significance
T1 (Baseline) vs. T2 (Baseline)	Increase	+3.39	Yes, $p<0.05$
T1 (Baseline) vs. T3 (Intervention)	Increase	+1.14	No
T1 (Baseline) vs. T4 (Intervention)	Increase	+3.17	Yes, $p<0.05$
T2 (Baseline) vs. T3 (Intervention)	Decrease	-2.25	Yes, $p<0.05$
T3 (Intervention) vs. T4 (Intervention)	Increase	+2.03	Yes, $p<0.05$

Note. Reliable Change Index (RCI).

These results indicate that David's scores on the BCMRS increased significantly between the first baseline measure (T1) and last intervention measure (T4) of mathematical resilience (MR). However, there was also a significant increase in scores during the baseline phase and a significant decrease between times two and three (T2 and T3). The considerable variability and overall increase in David's self-reported MR scores are reflective of his self-report measures of MA.

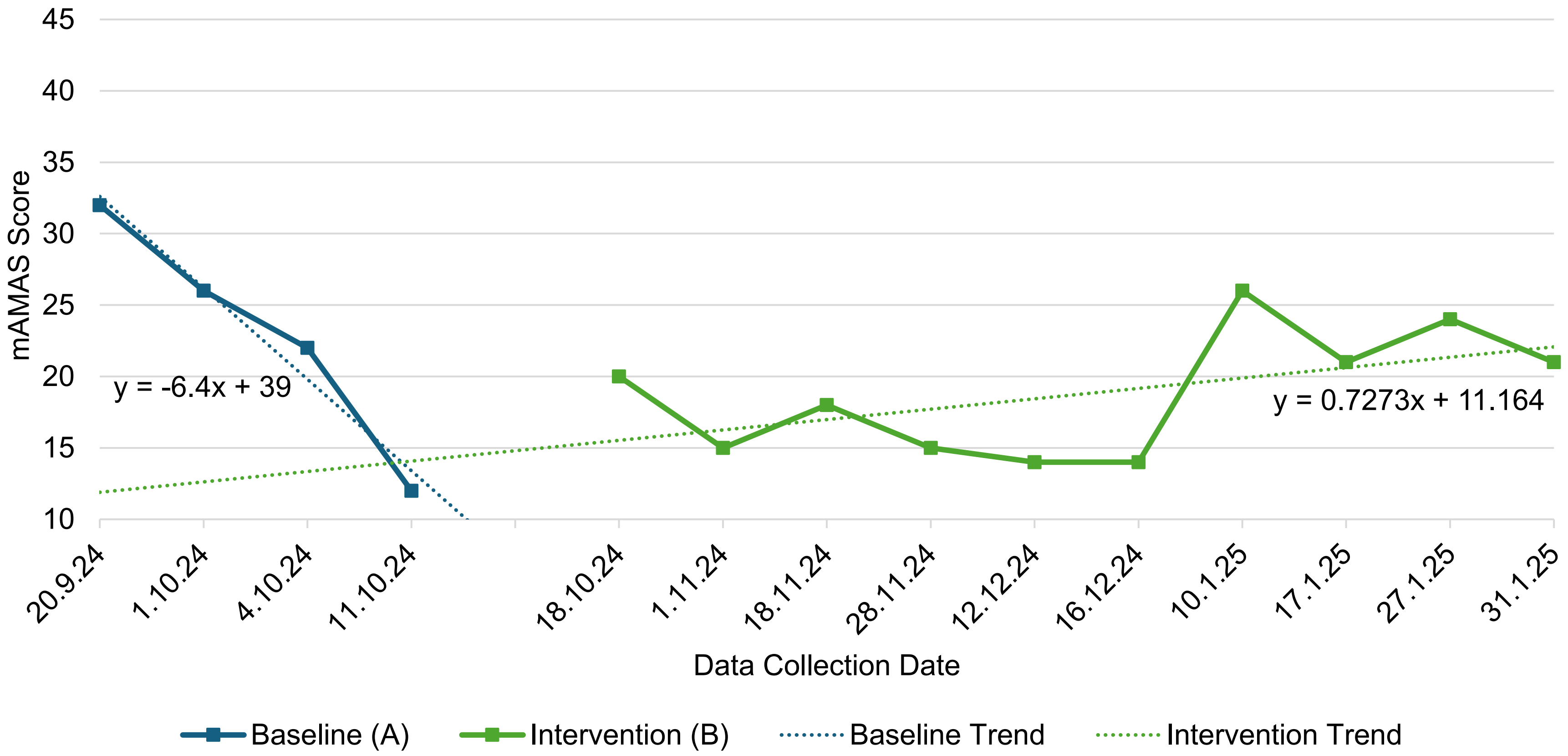
4.2.6 Emily

Emily is a Year 4 pupil of mixed ethnic heritage who, for maths, is taught in a small group and receives a differentiated curriculum. Emily has been identified as having a SEND need in the area of cognition and learning. The class teacher noted that Emily struggles to keep pace when working independently. Emily is currently assessed as working below the expected standard for her age in maths; she is working towards the expected standard for Year 2.

Figure 4. 9 below displays Emily's self-report scores on the mAMAS, collected weekly during the baseline and intervention phases. Figure 4. 10 displays the additional graphs created using the Shiny SCDA programme. Table 4. 6 summarises the findings of the visual and statistical analysis for Emily.

Figure 4. 9

Emily's Mathematics Anxiety Across Phases



Note. A line graph showing Emily's total scores on repeated measures of the mAMAS, showing an initial reduction in anxiety levels over the baseline phase and the first six weeks of the intervention phase

Figure 4. 10

Visual Analysis of Emily's mAMAS Scores Using the Shiny SCDA Programme

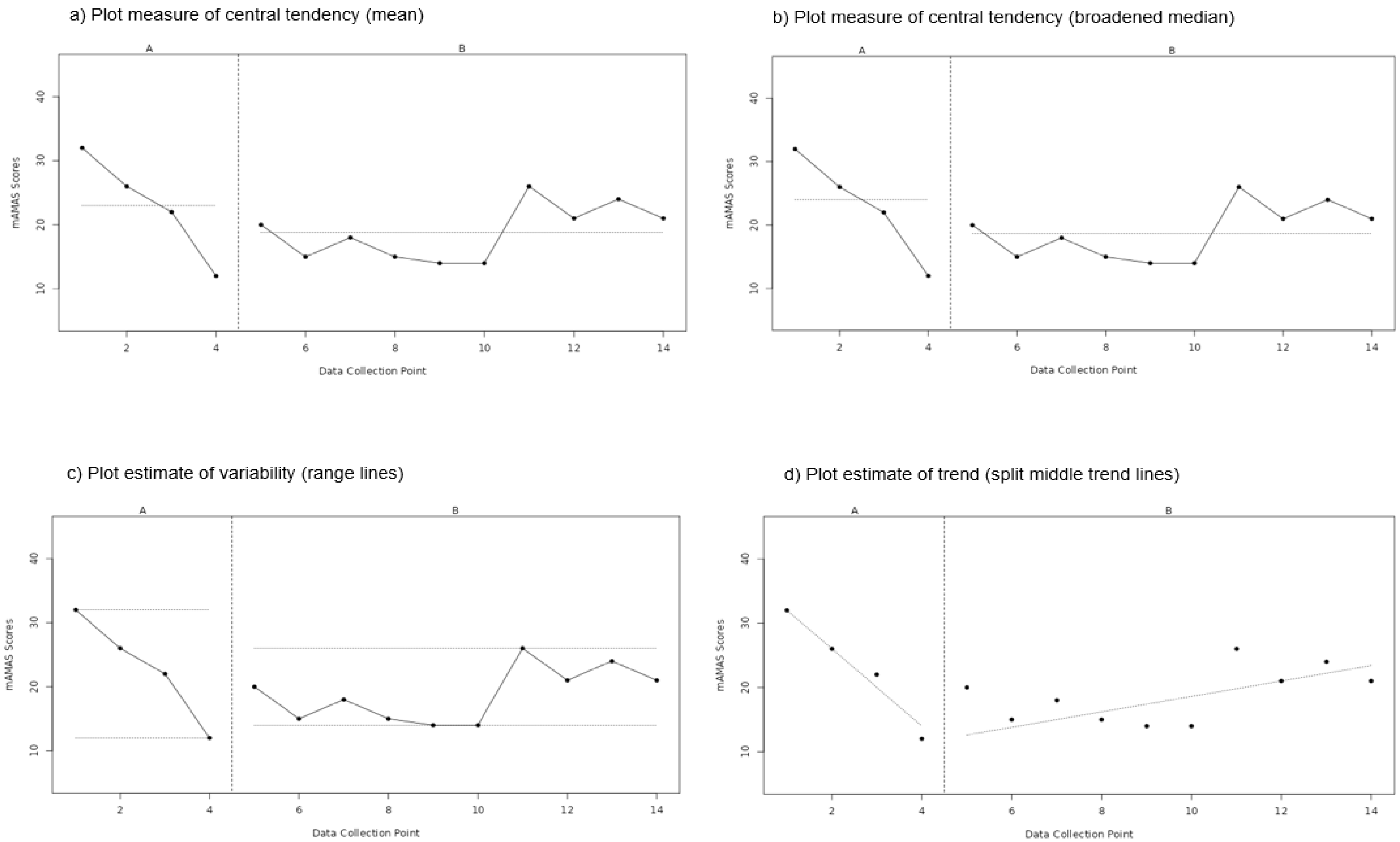


Table 4. 6

Analysis of Emily's Scores on the mAMAS

Analysis	Characteristic	Description	Quantitative Data
Visual Analysis	Central Tendency (Level + Mean Level Change)	Emily's mean scores decreased between the baseline and intervention phase. This indicates a reduction in self-reported anxiety. The same can also be seen for the broadened median level change in Figure 4.10.	Baseline phase (A) mean = 23.00 Intervention phase (B) mean = 18.80 Mean change = -4.20 Percentage change: -18.26%
	Variability	The range and standard deviation of scores in both phases suggest high variability. This variability can be seen in the illustration of the range lines in Figure 4.10 There is more variability seen in the baseline phase. .	Baseline phase (A) range = 20.00 Baseline phase (A) SD: 8.41 Intervention phase (B) range = 12.00 Intervention phase (B) SD:4.29
	Trend	The baseline phase has a steep decelerating trend, which is indicative of improvement in mathematics anxiety. The intervention phase has an accelerating trend which is indicative of deterioration in mathematics anxiety.	Baseline phase (A) trend = -6.40 Intervention phase (B) trend = +0.73 The magnitude of change between phases = 7.13
	Immediacy of Effect	There is a increase of eight points in scores between the last baseline data point and the first intervention data point suggesting an initial increase in mathematics anxiety in response to the intervention.	Change between last baseline (A) and first intervention (A) data point = +8
	Overlap	Figure 4.10 illustrates that all data points overlap between phases which suggests minimal effect of the intervention.	Percentage of data overlap = 100%
Statistical Analysis	Tau-U	The trend observed in Emily's baseline phase was to be significant. Therefore, the baseline corrected Tau statistic is reported for baseline vs intervention. Phase comparison using Tau-U indicated a no significant improvement between baseline and intervention phase.	Baseline vs Baseline (Trend) Tau = -1.00, *z*= -2.03, *p* = 0.04* Baseline vs. Intervention (Corrected baseline) Tau = -0.23, z = -0.64, *p* =0.52

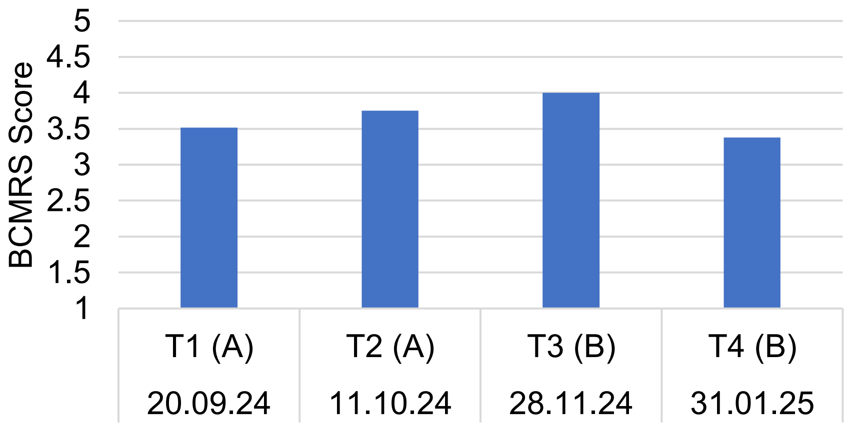
Note. A table detailing the visual and statistical analysis of Emily's scores on the mAMAS across phases

A decrease in central tendency is seen for Emily's self-reported MA between the baseline and intervention phase. Statistical analysis using Tau-U suggests this change is moderate (τ = -0.23) but not significant (*p* =0.52) across the entire experimental phase. However, the first six weeks indicate a greater effect (see Figure 4. 9). The visual analysis of the baseline trend indicates that Emily's MA decreased without any intervention, complicating the interpretation of her results. There was also a great amount of variability in Emily's scores in both phases, and all data points in the intervention phase overlapped with those in the baseline phase. We can also see an increase in MA following the Christmas break for Emily. This indicates that, for Emily, it would be appropriate to accept the null hypothesis; the analysis does not indicate that her involvement in the whole-class intervention was related to a reduction in her self-reported MA.

Triangulation Measure. Figure 4. 11 below shows Emily's scores on the BCMRS across baseline and intervention phases.

Figure 4. 11

Emily's Mathematical Resilience Scores



Note. The graph shows that Emily's scores remained relatively stable throughout both phases, with a slight reduction at time four (T4).

Figure 4. 12 below shows Emily's scores on the mAMAS and BCMRS at the first and last data collection points. It indicates a decrease in the measures of MA and stability across the measures of MR.

Figure 4. 12

Emily's Score on the Initial and Final Assessments of MA and MR

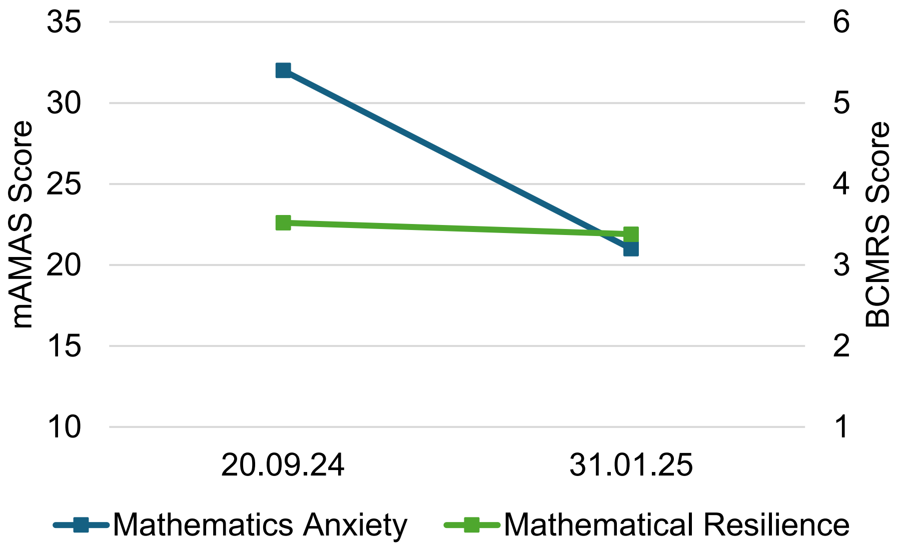


Table 4. 7 presents the pair-wise comparisons between Emily's scores on the BCMRS at four time points, two before intervention and two during the intervention phase.

Table 4. 7

Comparison of Emily's Mathematical Resilience Scores

Pair-wise comparison	Difference	RCI	Significance
T1 (Baseline) vs. T2 (Baseline)	Increase	+0.42	No
T1 (Baseline) vs. T3 (Intervention)	Increase	+0.88	No
T1 (Baseline) vs. T4 (Intervention)	Decrease	-0.25	No
T3 (Intervention) vs. T4 (Intervention)	Decrease	-1.12	No

Note. Reliable Change Index (RCI).

The results in Table 4.7 indicate that there was no statistically significant change in Emily's scores on the BCMRS. These findings suggest that her self-reported MR did not correlate with a reduction in self-reported MA.

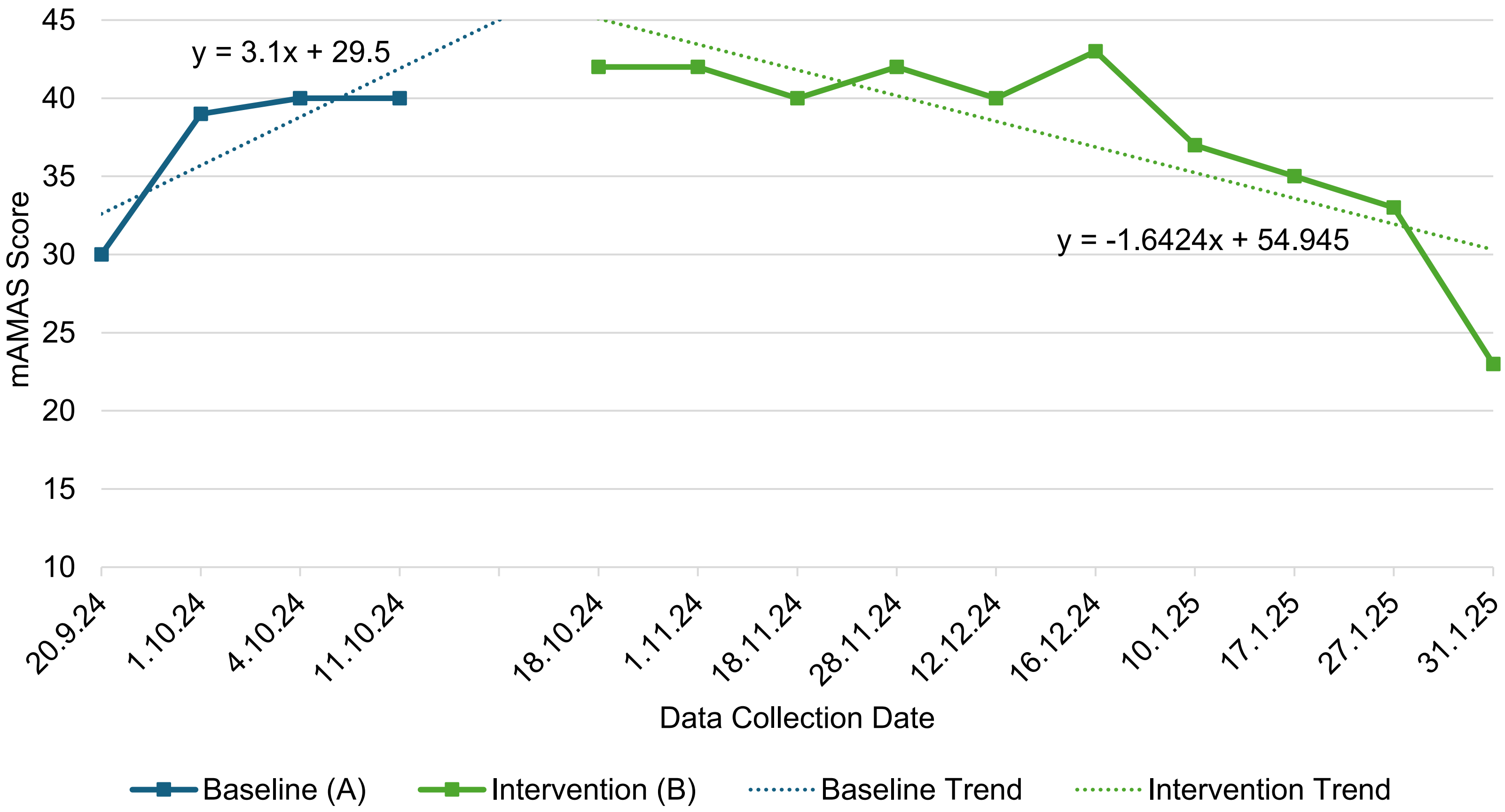
4.2.7 Isabel

Isabel is a White British female in Year 4 who, for maths, is taught in the context of her mainstream classroom. Isabel has no identified SEND need and is currently assessed as working at the expected standard for her age in maths. It is important to note, in the context of this study, that the class teacher reports that Isabel has been experiencing some general anxiety, a matter that the school is actively seeking to understand, along with some intermittent issues related to friendships.

Figure 4. 13 below displays Isabel's self-report scores on the mAMAS, collected weekly during the baseline and intervention phases. Figure 4. 14 displays the additional graphs created using the Shiny SCDA programme. Table 4. 8 summarises the findings of the visual and statistical analysis for Isabel.

Figure 4. 13

Isabel's Mathematics Anxiety Across Phases



Note. A line graph showing Isabel's total scores on repeated measures of the mAMAS across baseline and intervention phases, showing a change in trend towards improvement between phases.

Figure 4. 14

Visual Analysis of Isabel's mAMAS Scores Using the Shiny SCDA Programme

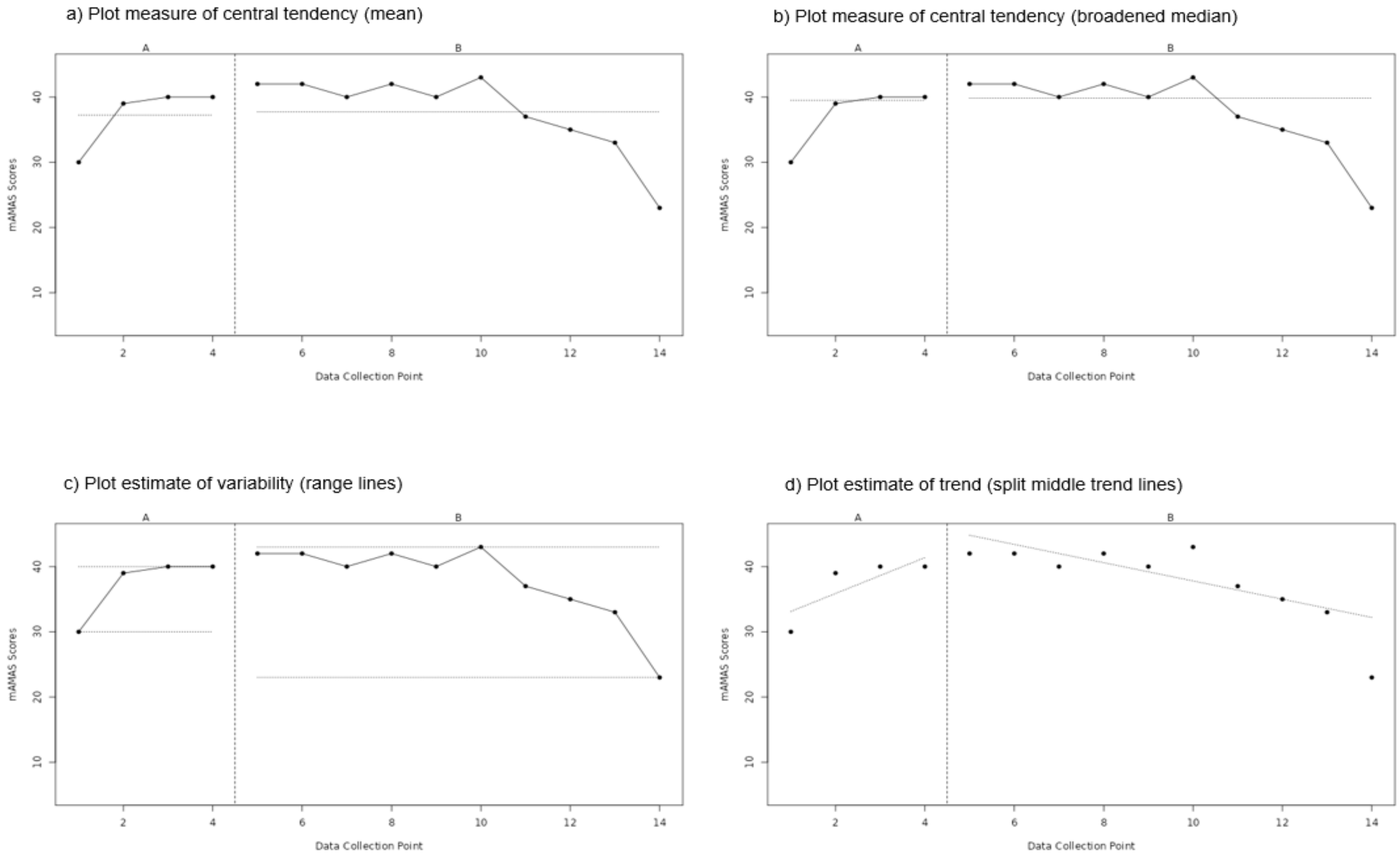


Table 4. 8

Analysis of Isabel's Scores on the mAMAS

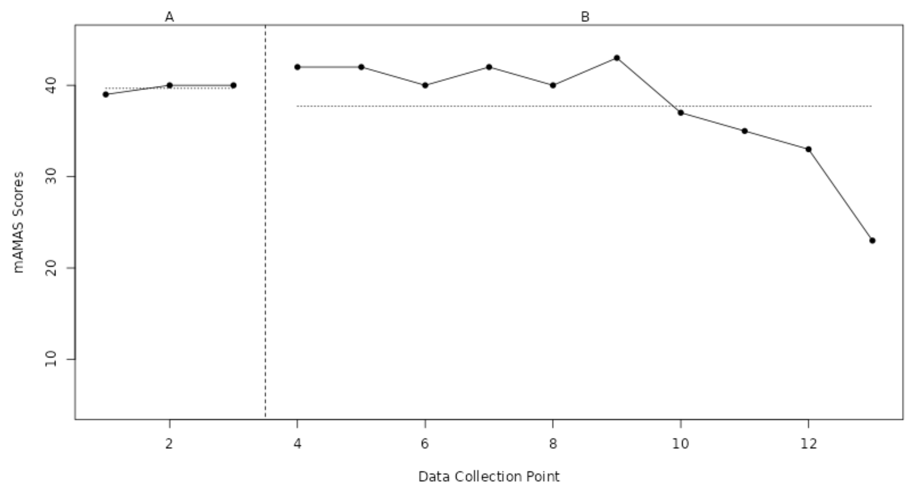
Analysis	Characteristic	Description	Quantitative Data
Visual Analysis	Central Tendency (Level + Mean Level Change)	Isabel's mean scores very slightly increased (less than one point score) between the baseline and intervention phases. The same trend is also evident in the broadened median level change shown in Figure 4.14.	Baseline phase (A) mean = 37.25 Intervention phase (B) mean = 37.70 Mean change = +0.45 Percentage change: 1.21%
	Variability	The range and standard deviation of scores are greater in the intervention phase suggesting higher variability. This variability can be seen in the illustration of the range lines in Figure 4.14.	Baseline phase (A) range = 10.00 Baseline phase (A) SD: 4.86 Intervention phase (B) range = 20.00 Intervention phase (B) SD:6.15
	Trend	The baseline phase has a steep accelerating trend, which is indicative of deterioration in anxiety. The intervention phase has an decelerating trend which is indicative of improvement in mathematics anxiety.	Baseline phase (A) trend = +3.10 Intervention phase (B) trend = -1.64 The magnitude of change between phases = 4.74
	Immediacy of Effect	There is an increase of two points in scores between the last baseline data point and the first intervention data point, suggesting an initial increase in anxiety. The reduction in anxiety levels appears to happen at the seventh intervention data point after at least eight weeks of the intervention.	Change between last baseline (A) and first intervention (A) data point = +2
	Overlap	Figure 4.14 illustrates that nine of the intervention data points overlap with the baseline phase.	Percentage of data overlap = 90%
Statistical Analysis	Tau-U	The trend observed in Isabel's baseline phase was found not to be significant. Therefore, the standard Tau statistic is reported for baseline vs intervention. Phase comparison using Tau-U indicated a no significant improvement between baseline and intervention phase.	Baseline vs Baseline (Trend) Tau = 0.83, z= 1.70, *p* = 0.09 Baseline vs. Intervention (Phase) Tau = 0.25, z = 0.71, *p* =0.48

Note. A table detailing the visual and statistical analysis of Isabel's scores on the mAMAS across phases

Isabel's scores achieved stability in the baseline phase, with three stable baseline points before introducing the intervention. There was a slight increase in her self-reported MA following the introduction of the intervention over seven data points, which may explain the slight increase in mean level. However, we observe an overall change from an upward to a downward trend between phases, suggesting an improvement in self-reported MA. After the seventh intervention data point (10.01.2025), Isabel's self-reported MA scores start to fall below the three stable baseline data points. Isabel's self-reported MA worsened during the baseline phase, likely due to the presence of an outlier in the data points. Figure 4. 15 shows that if we remove the outlier from the baseline phase, we would be better able to suggest that the intervention had a positive impact on self-reported MA and tentatively accept the experimental hypothesis. Possible explanations for these findings will be suggested in the discussion chapter.

Figure 4. 15

Isabel's Scores on the mAMAS with Baseline Outlier Removed

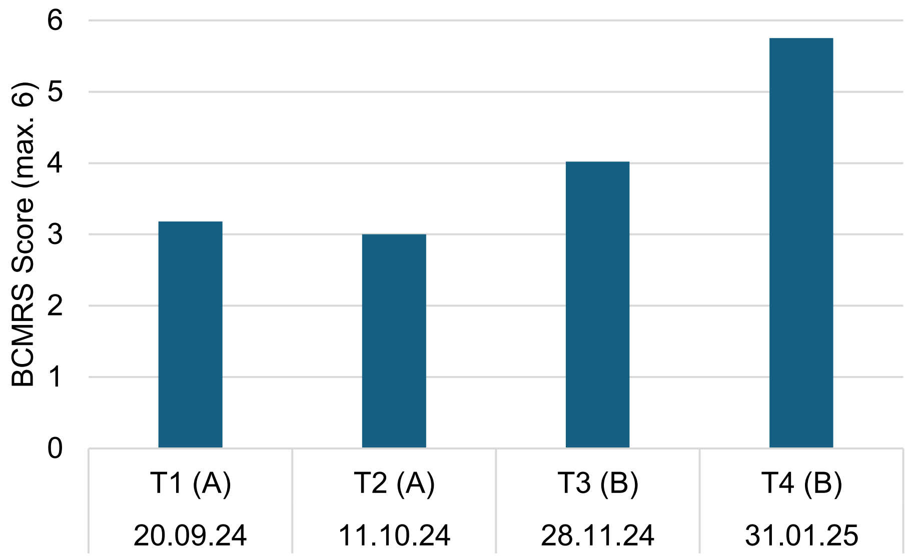


Note. A graph showing Isabel's scores on repeated measures of the mAMAS across baseline and intervention phases, including a visual representation of the central tendency (mean level).

Triangulation Measure. Figure 4. 16 below shows Isabel's scores on the BCMRS across baseline and intervention phases. It shows that Isabel's scores remained relatively stable during the baseline and increased during the intervention phase.

Figure 4. 16

Isabel's Mathematical Resilience Scores



Note. A column chart showing Isabel's self-report scores on the BCMRS, reflecting her level of mathematical resilience across the baseline (A) and intervention (B) phases.

Figure 4.17 below shows Isabel's scores on the mAMAS and BCMRS at the first and last data collection points. The graph shows an increase in MR and a decrease in MA.

Figure 4. 17

Isabel's Score on the Initial and Final Assessments of MA and MR

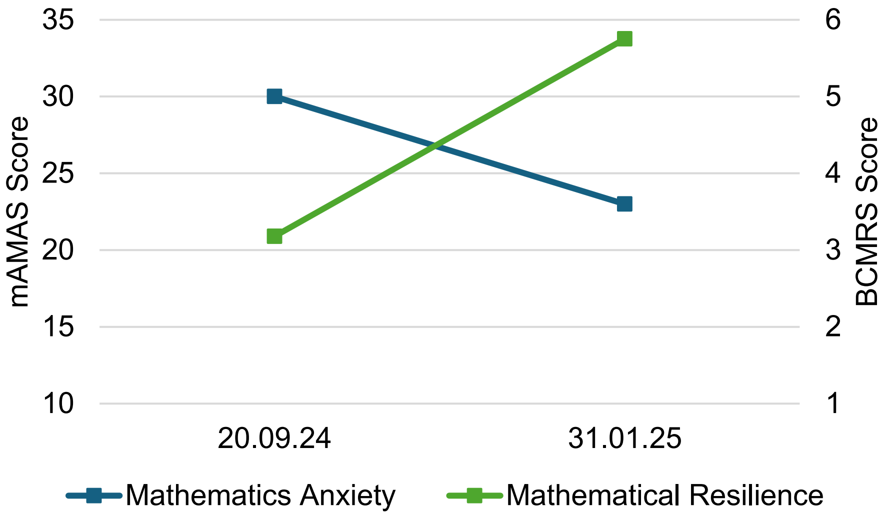


Table 4. 9 presents the pair-wise comparisons between Isabel's scores on the BCMRS.

Table 4. 9

Comparison of Isabel's Mathematical Resilience Scores

Pair-wise comparison	Difference	RCI	Significance
T1 (Baseline) vs. T2 (Baseline)	Decrease	-0.33	No
T1 (Baseline) vs. T3 (Intervention)	Increase	+1.52	No
T1 (Baseline) vs. T4 (Intervention)	Increase	+4.65	Yes, $p<0.05$
T3 (Intervention) vs. T4 (Intervention)	Increase	+3.14	Yes, $p<0.05$

Note. Reliable Change Index (RCI)

These results show a statistically significant change in Isabel's scores on the BCMRS between the baseline phase and the final measure taken in the intervention phase (T4). While there was no significant increase between the baseline and first intervention measure (T3), a significant increase in her scores occurred between the measures taken during the intervention phase. This suggests a potential latent impact of the intervention, as the significant increase in her self-reported MR occurred over the latter half of the intervention phase. This finding aligns with the discussion of Isabel's results in Section 4.2.7.

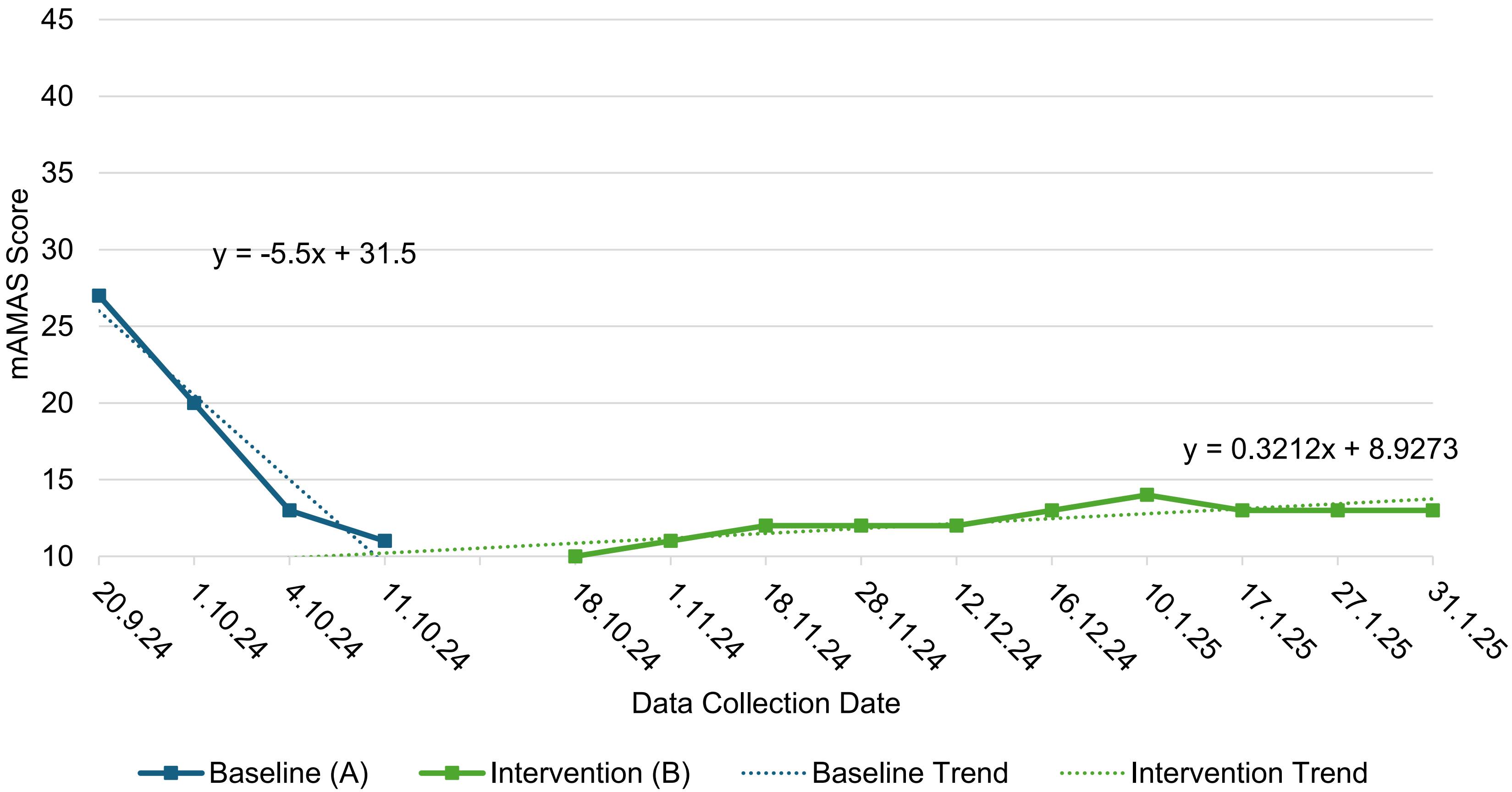
4.2.8 Ryan

Ryan is a White British male in Year 4 who is taught maths in the context of his mainstream classroom. Ryan has no identified SEND need and is currently assessed as working at the expected standard for his age in maths.

Figure 4.18 and 4.19 below display Ryan's self-report scores on the mAMAS, collected weekly during the baseline and intervention phases. Table 4.11 summarises the findings of the visual and statistical analysis.

Figure 4. 18

Ryan's Mathematics Anxiety Across Phases



Note. A line graph showing Ryan's total scores on repeated measures of the mAMAS, showing a reduction in MA over the baseline phase and subsequent maintenance throughout the intervention phase.

Figure 4. 19

Visual Analysis of Ryan's mAMAS Scores Using the Shiny SCDA Programme

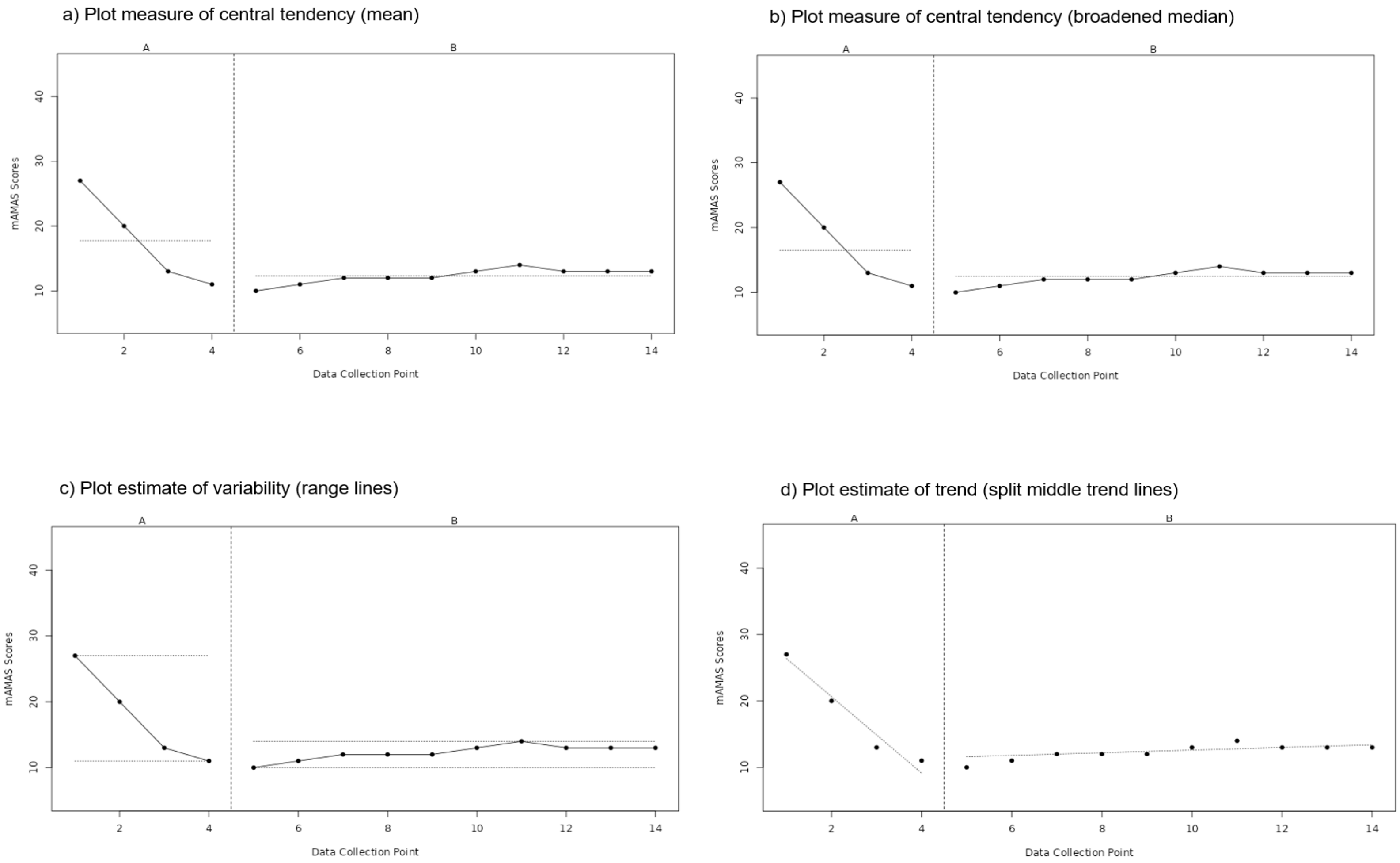


Table 4. 10

Analysis of Ryan's Scores on the mAMAS

Analysis	Characteristic	Description	Quantitative Data
Visual Analysis	Central Tendency (Level + Mean Level Change)	Ryan's mean level of mathematics anxiety decreased between the baseline and intervention phases. This trend is also evident in the broadened median level change shown in Figure 4.19.	Baseline phase (A) mean = 5.50 Intervention phase (B) mean = 12.30 Mean change = -5.45 Percentage change:-30.70%
	Variability	The range and standard deviation of scores are greater in the baseline phase, suggesting higher variability. This variability is evident in the illustration of the range lines in Figure 4.19.	Baseline phase (A) range = 16.00 Baseline phase (A) SD: 7.27 Intervention phase (B) range = 4.00 Intervention phase (B) SD: 1.16
	Trend	The baseline phase has a steep decelerating trend, which is indicative of improvement in mathematics anxiety. The intervention phase shows a slight accelerating trend, yet remains generally stable; his scores consistently stay near the lowest possible score on the measure.	Baseline phase (A) trend = +3.10 Intervention phase (B) trend = +0.32 The magnitude of change between phases = 3.42
	Immediacy of Effect	There is a one-point decrease in scores between the last baseline data point and the first intervention data point.	Change between last baseline (A) and first intervention (A) data point = -1
	Overlap	Figure 4.19 illustrates that nine of the intervention data points overlap with the baseline phase.	Percentage of data overlap = 90%
Statistical Analysis	Tau-U	The trend observed in Ryan's baseline phase was found to be significant. Therefore, the baseline corrected Tau statistic is reported. Phase comparison using Tau-U indicated a no significant improvement between baseline and intervention phase.	Baseline vs Baseline (Trend) Tau = -1.00, z= -2.03, p = 0.04* Baseline vs. Intervention (Phase) Tau = -0.28, z = -0.78, p =0.44

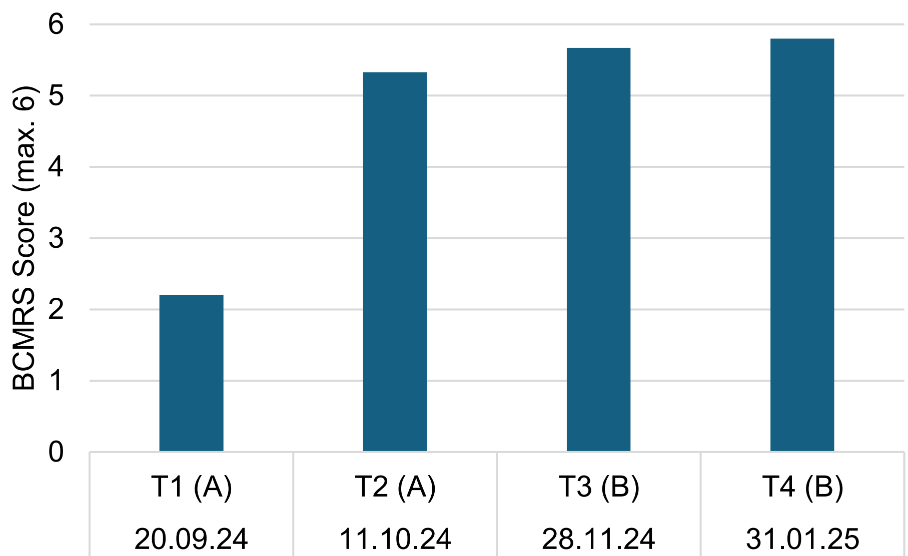
Note. A table detailing the visual and statistical analysis of Ryan's scores on the mAMAS across phases

A significant decelerating trend in Ryan's mAMAS scores was seen in the baseline phase, followed by a relatively stable trend in the intervention phase. His scores plateau around the minimum score on the mAMAS. This finding suggests that Ryan's self-reported MA was reduced to a minimum before the onset of the intervention and remained so throughout the intervention phase. Therefore, it is challenging to interpret the impact of the intervention using his data.

Triangulation Measure. Figure 4. 20 shows Ryan's scores on the BCMRS across baseline and intervention phases. It shows that Ryan's score increased during the baseline period.

Figure 4. 20

Ryan's Mathematical Resilience Scores



Note. A column chart showing Ryan's self-report scores on the BCMRS, reflecting his level of mathematical resilience across the baseline (A) and intervention (B) phases.

Figure 4.21 below shows Ryan's scores on the mAMAS and BCMRS at the first and last data collection points. The graph shows an increase in MR and a decrease in MA.

Figure 4. 21

Ryan's score on the initial and final assessments of MA and MR

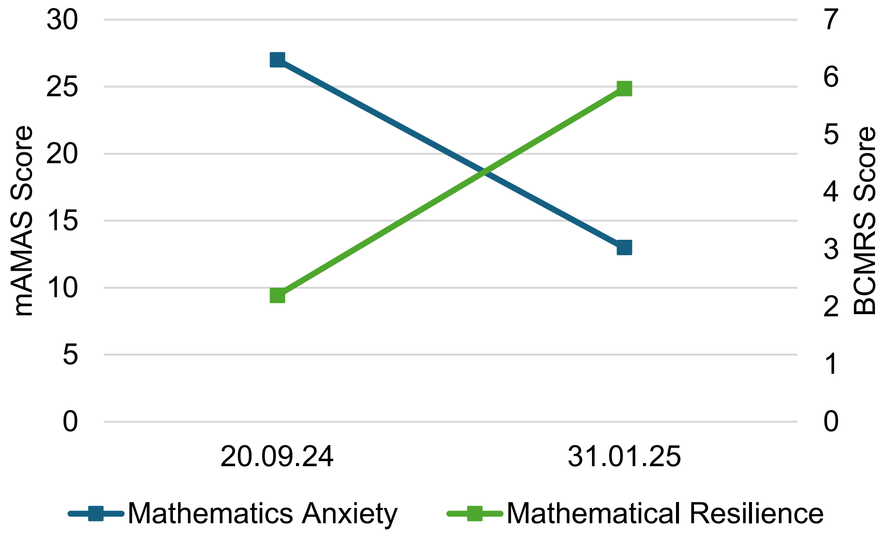


Table 4. 11 presents the pair-wise comparisons between Ryan's scores on the BCMRS.

Table 4. 11

Comparison of Ryan's Mathematical Resilience Scores

Pair-wise comparison	Difference	RCI	Significance
T1 (Baseline) vs. T2 (Baseline)	Increase	+5.68	Yes, $p<0.05$
T1 (Baseline) vs. T3 (Intervention)	Increase	+6.29	Yes, $p<0.05$
T1 (Baseline) vs. T4 (Intervention)	Increase	+6.53	Yes, $p<0.05$
T2 (Baseline) vs. T3 (Intervention)	Increase	+0.62	No
T3 (Intervention) vs. T4 (Intervention)	Increase	+0.24	No

Note. Reliable Change Index (RCI)

These results demonstrate a statistically significant increase in Ryan's scores on the BCMRS during the baseline phase, followed by no statistical change between the last baseline measure (T2) and the first intervention measure (T3). These findings show that Ryan's self-reported MR increased during the baseline phase and then remained stable. This is consistent with Ryan's self-reported MA scores, which improved during the baseline phase, followed by stability (see Section 4.2.8). In line with the analysis of Ryan's self-reported MA, we cannot conclude that any change in self-reported MR resulted from the intervention.

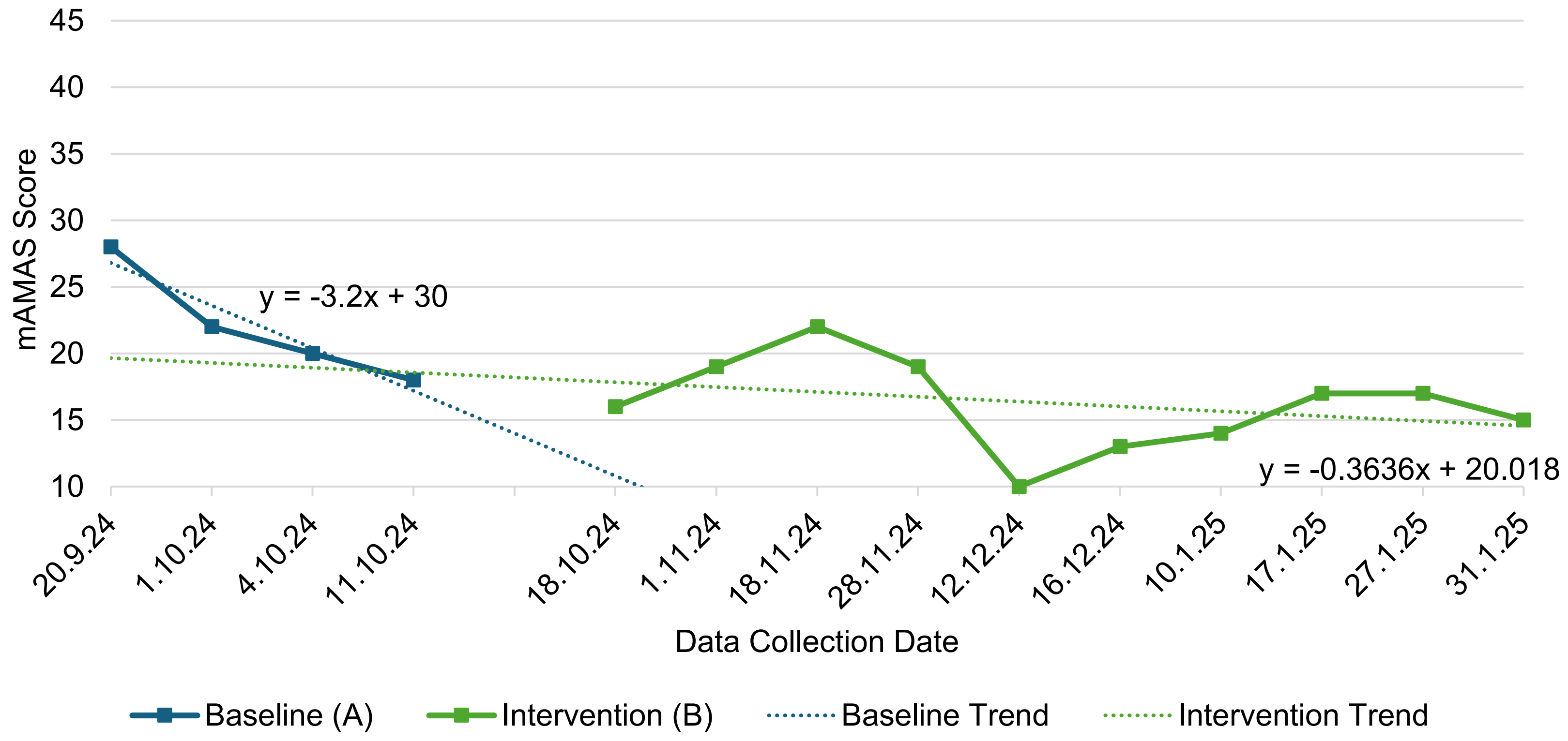
4.2.9 Zachary

Zachary is a Black British male in Year 4 who, for maths, is taught in a small group and receives a differentiated curriculum. Zachary has been identified as having SEND needs; his primary need is recorded as social, emotional, and mental health (SEMH), associated with possible ADHD. In class, he receives frequent check-ins to ensure he is happy and on task. Zachary is currently assessed as working below the expected standard for his age in maths, and is working at the expected Year 2 standard.

Figure 4.22 and 4.23 below display Zachary's self-report scores on the mAMAS, collected weekly during the baseline and intervention phases. Table 4. 12 summarises the findings of the visual and statistical analysis.

Figure 4. 22

Zachary's Mathematics Anxiety Across Phases



Note. A line graph of Zachary's total scores on repeated measures of the mAMAS showing an initial increase in MA during the intervention phase. There is some evidence of a reduction in anxiety when compared to the baseline phase, evident in the last six data points.

Figure 4. 23

Visual Analysis of Zachary's mAMAS Scores Using the Shiny SCDA Programme

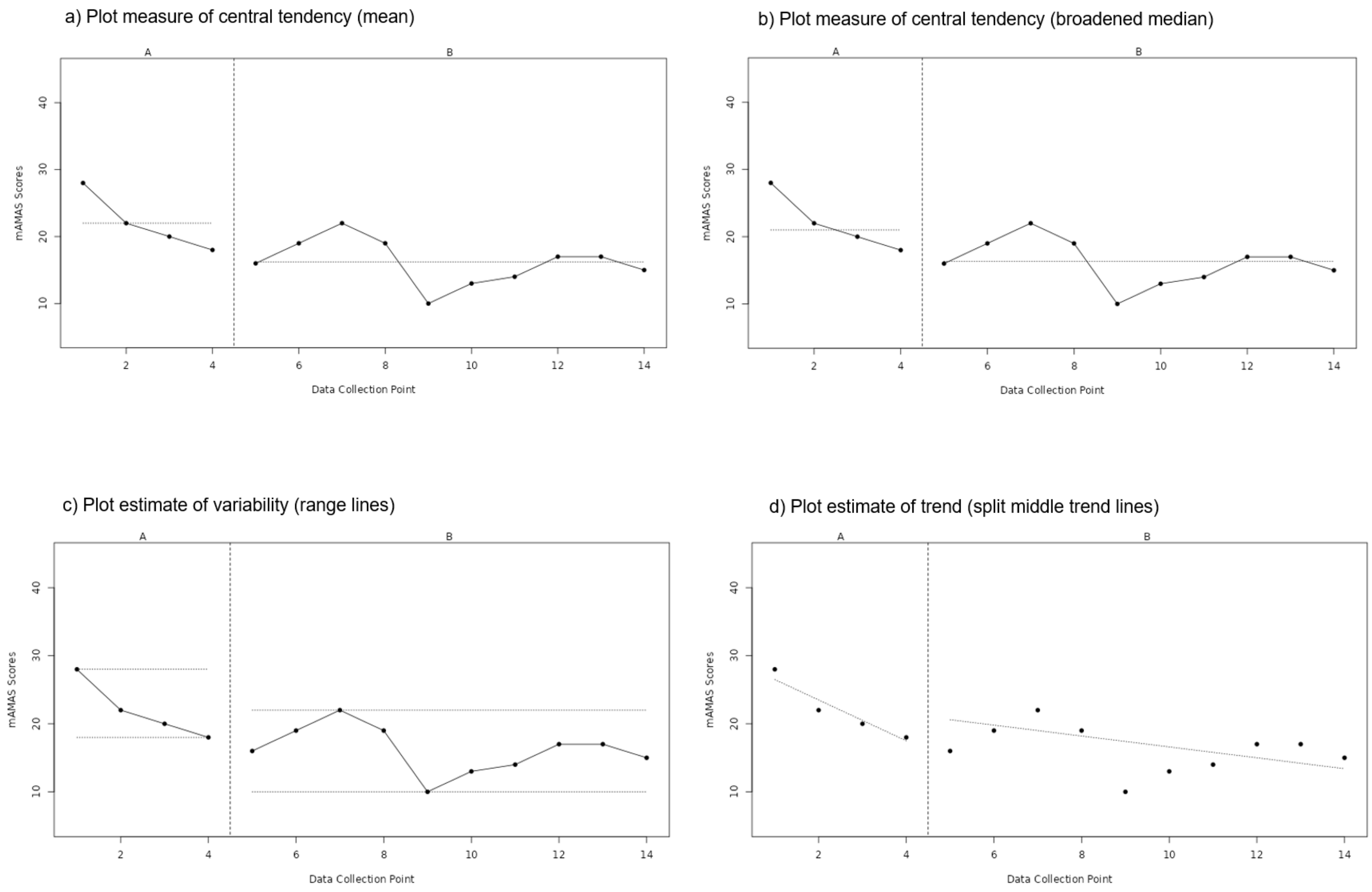


Table 4. 12

Analysis of Zachary's Scores on the mAMAS

Analysis	Characteristic	Description	Quantitative Data
Visual Analysis	Central Tendency (Level + Mean Level Change)	Zachary's mean level of mathematics anxiety decreased between the baseline and intervention phases. This trend is also evident in the broadened median level change shown in Figure 4.23.	Baseline phase (A) mean = 22.00 Intervention phase (B) mean = 16.20 Mean change = -5.80 Percentage change:-26.36%
	Variability	The range and standard deviation of scores are reasonably similar across the baseline and intervention phases, suggesting some variability in both phases. This can be seen in the illustration of the range lines in Figure 4.23.	Baseline phase (A) range = 10 Baseline phase (A) SD: 4.32 Intervention phase (B) range = 12 Intervention phase (B) SD: 3.34
	Trend	The baseline phase has a steep decelerating trend, which indicates improvement in mathematics anxiety. The intervention phase has a very slight decelerating trend, suggesting further improvement in anxiety.	Baseline phase (A) trend = -3.20 Intervention phase (B) trend = -0.36 The magnitude of change between phases = 2.84
	Immediacy of Effect	There is a decrease of two points in scores between the last baseline data point and the first intervention data point.	Change between last baseline (A) and first intervention (A) data point = -2
	Overlap	Figure 4.23 illustrates that five of the intervention data points overlap with the baseline phase.	Percentage of data overlap = 50%
Statistical Analysis	Tau-U	The trend observed in Zachary's baseline phase was found to be significant. Therefore, the baseline corrected Tau statistic is reported. Phase comparison using Tau-U indicated no significant improvement between baseline and intervention phase.	Baseline vs Baseline (Trend) Tau = -1.00, z= -2.04, *p* = 0.04* Baseline vs. Intervention (Corrected baseline) Tau = -0.62, z = -1.77, *p* =0.08

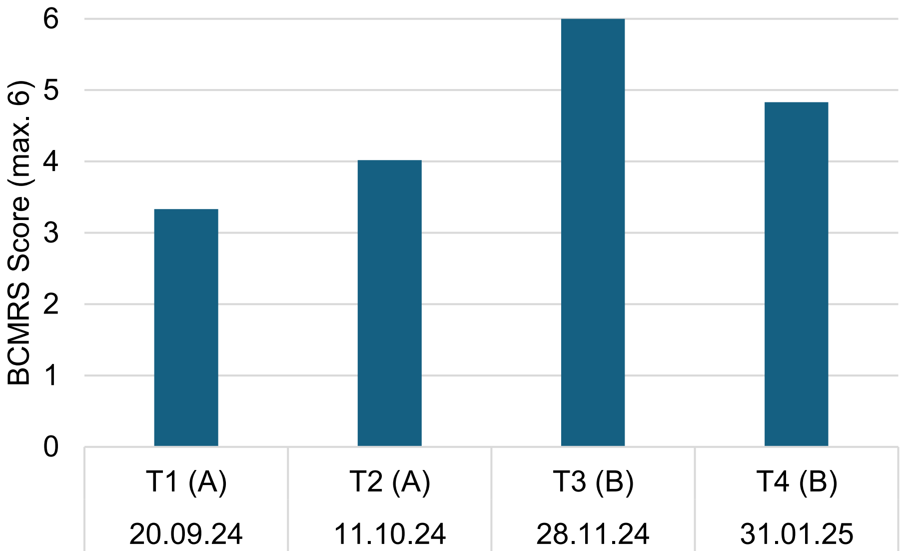
Note. A table detailing the visual and statistical analysis of Zachary's scores on the mAMAS across phases.

An improvement trend in Zachary's mAMAS scores was seen in the baseline phase, followed by a further decelerating trend in the intervention phase, suggesting continued improvement. In the intervention phase, his scores initially decreased before rising, then fell again, rose, and fell once more, indicating a degree of fluctuation in his self-reported mathematics anxiety over time. An overall mean level change indicates an improvement in MA. The baseline corrected Tau-U statistic suggests that this change is large ($\tau = -0.62$) and has a trend close to significance ($p = 0.08$). These findings suggest that it is possible that the intervention supported a reduction in MA. However, based on the significant improvement trend in the baseline phase, we must be cautious in accepting the experimental hypothesis.

Triangulation Measure. Figure 4. 24 shows Zachary's scores on the BCMRS across baseline and intervention phases. It shows that Zachary's self-report MR initially increases in the intervention phase but reduces again at time four (T4).

Figure 4. 24

Zachary's Mathematical Resilience Scores



Note. This column chart shows Zachary's self-report scores on the BCMRS, reflecting his level of mathematical resilience across the baseline (A) and intervention (B) phases.

Figure 4. 25 shows Zachary's scores on the mAMAS and BCMRS at the first and last data collection points. The graph shows an increase in MR and a decrease in MA.

Figure 4. 25

Zachary's Score on the Initial and Final Assessments of MA and MR

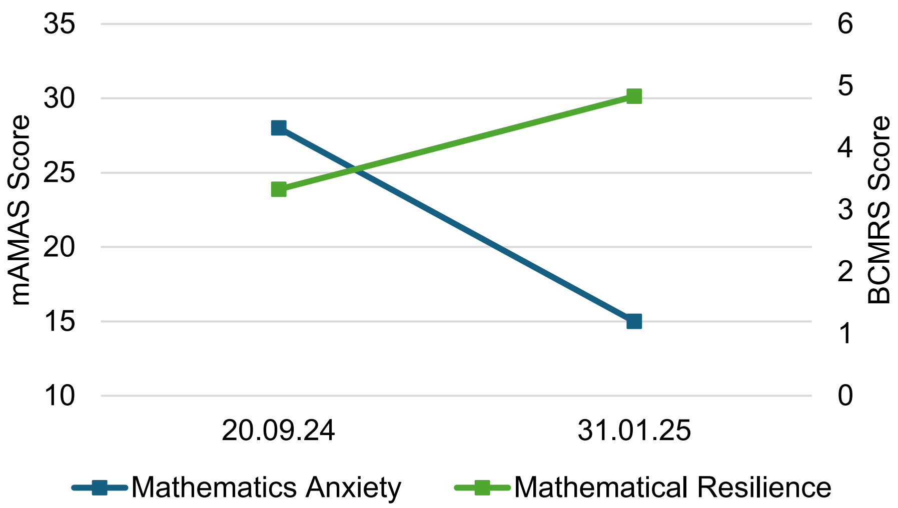


Table 4. 13 presents the pair-wise comparisons between Zachary's scores on the BCMRS.

Table 4. 13

Comparison of Zachary's Mathematical Resilience Scores

Pair-wise comparison	Difference	RCI	Significance
T1 (Baseline) vs. T2 (Baseline)	Increase	+1.25	No
T1 (Baseline) vs. T3 (Intervention)	Increase	+4.84	Yes, $p<0.05$
T1 (Baseline) vs. T4 (Intervention)	Increase	+2.71	Yes, $p<0.05$
T2 (Baseline) vs. T3 (Intervention)	Increase	+3.60	Yes, $p<0.05$
T3 (Intervention) vs. T4 (Intervention)	Decrease	-2.12	Yes, $p<0.05$

Note. Reliable Change Index (RCI)

These results demonstrate a statistically significant increase in Zachary's scores on the BCMRS between the baseline and intervention phases. These findings suggest that his self-reported MR increased following the introduction of the intervention. However, a significant decrease in scores was also seen across the intervention phase.

4.2.10 Inter-rater Agreement

Due to the subjective nature of visual analysis, inter-rater reliability checks were used to support the reliability of the researcher's interpretations. A colleague, who was familiar with SCED analysis, was asked to complete this check. The raters (researcher and colleague) independently reviewed the changes they perceived in mAMAS scores across the baseline and intervention phase (see Appendix W for the table completed by both raters). Raters responded to the following question: *"How certain are you that the child's scores on the modified Abbreviated Maths Anxiety Scale (mAMAS) exhibited improvement from the baseline to the intervention phase?"* Inter-rater reliability was calculated using Cohen's Kappa (Cohen, 1960). The Cohen's Kappa coefficient was 0.538; the checks therefore produced moderate agreement.

4.2.11 Summary of Phase One Findings

Table 4. 14

Summary of Findings in Relation to the Hypothesis

Experimental Hypothesis	Aisha	David	Emily	Isabel	Ryan	Zachary
Participation in a whole-class MR intervention using a practical GZM resource leads to a reduction in self-report measures of MA in Year 4 children with high MA scores.	✓	Null	Null	✓	Null	✓

Note. This table gives an overview of where the experimental hypothesis has been accepted for each focus child.

The research question in phase one aimed to determine whether the implementation of a whole-class intervention designed to facilitate the development of MR would lead to a reduction in self-reported MA. For five of the six focus children, we saw an overall decrease in mean scores between the baseline and intervention phases, indicating improved outcomes and a reduction in MA. However, in three instances (David, Emily, and Ryan), a decelerating trend was observed in the baseline phase, coupled with a substantial overlap of data points, which confounds the interpretation of whether any observed reduction in MA can be attributed to the intervention. This suggests that accepting the null hypothesis is the most suitable choice and this finding will be discussed further in the Discussion chapter.

However, the findings for Aisha, Isabel, and Zachary point toward acceptance of the experimental hypothesis, which was that introducing the intervention contributed to an improvement in their self-reported MA. In Aisha's case, the Tau-U statistic suggests a very large effect and a significant improvement in her mAMAS scores. For Zachary, whilst not significant, the Tau-U statistic suggests the effect of the intervention was large. For Isabel, visual analysis indicated a shift towards an improvement trend and a possible latent effect of the intervention after a full term of its implementation.

A triangulation measure of self-reported MR was used to help ensure the findings were as expected, as discussed in the literature review, where a reduction in MA is seen, this would be paired with an increase in MR. In five cases (Aisha, David, Isabel, Ryan, and Zachary), we observed this correlation. We saw a decrease in self-reported MA paired with an increase in self-reported MR between the initial and final data collection points. Using the Reliable Change Index (RCI), we saw increases in self-reported MR over time for these five cases, along with an overall reduction in self-reported MA. Based on the pair-wise comparisons between phases, it would only be appropriate to accept that this increase was related to the implementation of the intervention for Aisha, Isabel and Zachary, which aligns with the findings for research question one. For Zachary, there was a considerable decrease in MR during the intervention phase, which raises questions about the intervention's long-term impact on MR for him.

4.3 Phase Two Findings: Qualitative Interviews

The aim of phase two was to explore staff and children's perceptions of the intervention. This phase aimed to support the interpretation of phase one results through qualitative triangulation, following a QUAN → qual design. Although phase one focused on six case-study children, the intervention was delivered at the whole-class level. Therefore, it was deemed essential to conduct interviews to capture broader perspectives.

The analysis aimed to address the research question: **What are the perceptions of key stakeholders (teachers, teaching assistants, and children) regarding the implementation of a whole-class mathematical resilience intervention, including the use of the Growth Zone Model (GZM)?**

4.3.1 Reflexive Thematic Analysis

Given the exploratory nature of the overall study and the explanatory nature of this phase, data analysis was conducted using inductive thematic analysis to uncover themes (DeJonckheere et al., 2024) which allowed for an open coding approach, enabling insights to develop organically from the data. Using Reflexive Thematic Analysis (RTA), the researcher’s role in actively producing knowledge is central to the analysis, and the subjectivity of the derived themes is assumed (Byrne, 2022). Braun and Clarke's (2006) six-stage thematic data analysis process was applied as outlined in Section 3.8.4.

Initial coding was carried out separately for the staff focus group and the children’s semi-structured interviews. An example transcript with coding bands can be seen in Appendix X. Two hundred and twenty-four references were drawn across the data, initially producing eighty-four codes. The coding labels were then combined and organised into initial themes. The codes were reflected on and refined, leading to ten broad themes (See Appendix Y). The reflexive nature of the analysis then involved further iterations, resulting in deeper reflection and a review of these themes, culminating in the reduction to five overarching themes. The five themes identified by the researcher are as follows:

- Desire to Implement
- Reflections on Teaching and Learning Culture
- Supports Communication and Timely Response to Needs
- Regulation Supports Behaviour for Learning
- Ease of Implementation

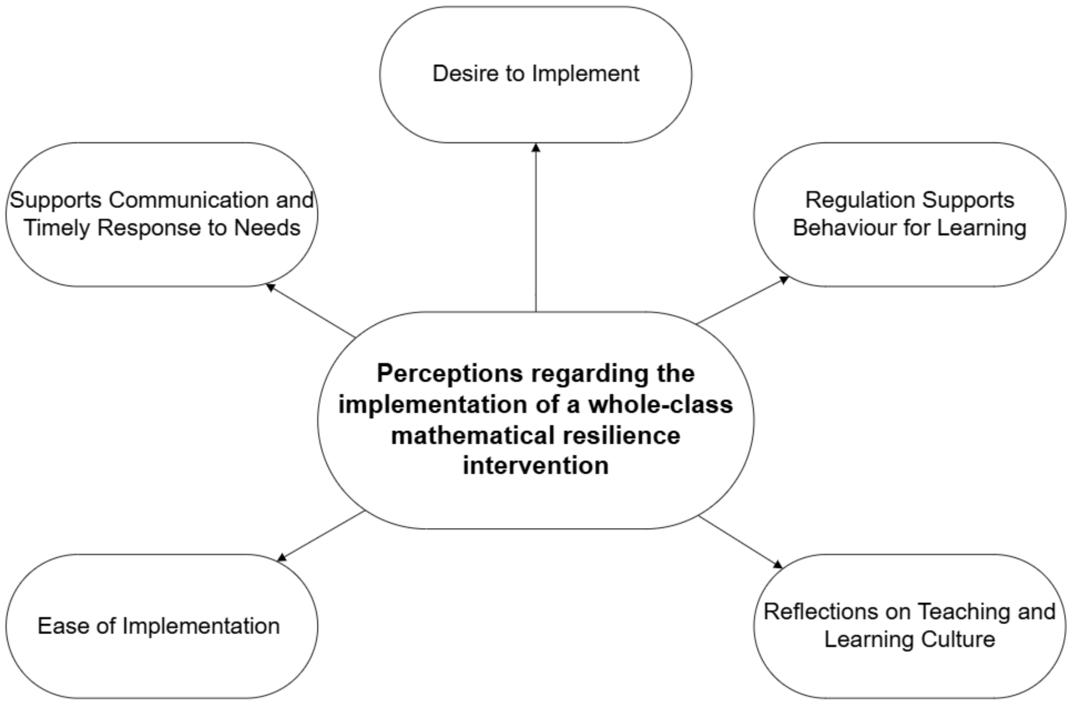
A summary of the thematic analysis process and reflexive comments can be found in Appendix Z.

4.3.2 Presentation of Phase Two Findings

The five themes identified capture the perceptions of the staff and children who participated in this research around the whole-class mathematical resilience (MR) intervention. Figure 4. 26 represents these themes.

Figure 4. 26

Thematic Map of Themes



Note. A figure representing the final thematic themes drawn from phase two of the study, which aims to answer research question two.

4.3.3 Theme One: Desire to Implement

This theme captures the view that staff and children felt positive about the intervention's implementation and were motivated to engage with it. This includes the view that the intervention, particularly the practical GZM resource, should be used more widely within their school setting.

When asked if the intervention had an impact, the class teacher responded, "*A positive yes*." It was clear that the staff felt the intervention was meaningful and relevant to their classroom. For example, the class teacher reflected*, "I just think of myself in this class now; this would help me,"* suggesting their personal and professional investment in the approach.

Staff discussed the importance of implementing the MR intervention at a whole-school level. This included the view that it should be implemented from an earlier age to ensure that it became part of their whole-school practice. The mainstream teaching assistant stated, "*As a school, we need to embrace it in all classes. So when they get into Year 1 and they can do it, it will become a routine*," while the class teacher shared, "*It would be well worth doing a staff meeting on it*." When asked if they would recommend the intervention, the class teacher responded, *"A big fat yes."* These comments suggest that staff believe implementing the intervention earlier and as part of a whole-school framework would be beneficial.

Staff also discussed their hopes for other staff members to positively adopt the intervention, which they viewed as crucial to its implementation across the school. For example, the small group teaching assistant shared, "*The adults need to respond positively to it*." Similarly, the class teacher reflected, *"I would hope that what would happen would be that people [staff] would appreciate the positive effect that it has had."*

Additionally, staff and children talked about implementing the GZM model across a broader range of subjects. For instance, David shared, "*[We could] use it in other lessons: English, PE, French, music, art*." The class teacher echoed this notion, "*I'd be interested to think about it in other subjects because when I was at school, I really struggled with art."*

Staff also discussed the children's motivation to engage with the intervention and noted their enthusiasm for using the GZM tool. The mainstream teaching assistant shared, *"It's [GZM] the first thing they ask for,"* and the small group teaching assistant added, *"Mine tend to use it when they first come into school."* These comments highlight that children engaged with the GZM and expected its continued use as part of their routine, reflecting their desire to engage with the intervention.

Collectively, these reflections convey a shared desire for the intervention to be implemented. The perspective that the intervention should be integrated into a whole-school strategy across a broader range of subjects implies that the staff and children felt the intervention benefited them in the maths classroom and that they are optimistic about these benefits extending further. The insights also suggest that motivation and desire to engage with the intervention are critical for its successful implementation and ongoing use in classroom practice.

4.3.4 Theme Two: Reflections on Teaching and Learning Culture

This theme captures the view that the intervention led to deeper reflections about the teaching and learning culture for mathematics. An overarching theme was that the intervention resulted in a shift in classroom culture and everyday teaching practices. Reflections included the perception that the intervention promoted a supportive learning environment, where mistakes were accepted and emotions were normalised. Staff and children also discussed specific aspects of classroom culture and teaching practices that had become embedded following the introduction of the intervention, including the adoption of language from the intervention, an awareness and understanding of emotions, staff adapting their teaching practices, and peer-to-peer support.

Staff reflected that the intervention had reduced stigma and fostered a safe, supportive environment in the maths classroom. Staff talked about how the intervention helped create a culture where mistakes and struggles in maths were normalised. The class teacher shared, "*In terms of culture, I think [...] we all want to have a culture that children are able to get things wrong in a safe environment and this has helped with that*." The mainstream teaching assistant reflected, "*It's taken away the awkwardness or stigma of 'I can't do it'.*"

Staff also discussed their perception that the intervention had helped promote an understanding and awareness of anxiety within their teaching and learning culture. The class teacher commented, "*It [the intervention] raises awareness of anxiety, and I think that needs to be done. Not just among kids but staff as well. It's a thing, it exists, and we need to be compassionate towards it and understand it,"* and *"Children who are feeling anxiety can be dismissed as just playing up. What we need to do is move away from that as a profession and this sort of thing can help."* Staff talked about the intervention supporting children in understanding that emotions constitute an expected part of the learning process. For example, *"[They] know that emotions are a normal part of learning,"* and "*[It] helps children to understand the normality of feelings and life."*

It was also evident that staff and the children were adopting the language of the intervention. The class teacher commented, *"The wording of it is better rather than using positive and negative - it's comfortable and uncomfortable,"* and added, *"The children are using the language from the initial session."* These perspectives suggest that staff and children have taken to the new vocabulary, which has led to reflections about how emotional vocabulary is integrated into classroom culture.

Staff reflected on how the intervention had led to changes in their interpretation of children's engagement, describing how the GZM had challenged previous assumptions about who was coping. The mainstream teaching assistant shared, "*You don't assume anymore*. *Like with [name], you would assume he could do it. But you don't do that anymore."* One teaching assistant reflected*, "There are times when those more confident children actually need help."* It appears that the intervention had led to staff's deeper reflections about assessment for learning practices and challenged their assumptions about which learners need support.

Staff and children also discussed how the intervention had changed the way staff responded to children's learning needs. Staff spoke about how they had since reflected on their teaching approaches. For example, the small group teaching assistant shared, *"[I] don't rush through it as much as more,"* and the class teacher explained*, "If you can see that a few* *of them are uncomfortable, it might be that we stop the class and go through it again."* Children had also noted this, Ryan shared*, "He might make the lesson a bit easier. Most of the time, he does a different group of children to help them, […], if they are in the red zone."*

Finally, staff reflected on how they felt children had become more attuned and supportive of each other's experiences in mathematics, particularly in recognising the level of struggle another child was experiencing. This was evidenced when Emily explained, "*It worked well because other people in my class like [name] can tell the teacher when he finds it tricky."* The mainstream teaching assistant stated, "*It's not just the teacher supporting them; it's their peers. They talk it through together*." Similarly, the teacher reflected, "*It's helped children to help each other.*" The nature of these reflections suggests that the intervention had contributed to reflections around the benefits of cultivating a collaborative teaching and learning culture in which children are aware of and actively support each other's emotional and academic needs.

Overall, these insights suggest that the intervention was perceived to contribute to reflections about the importance of facilitating a culture of teaching and learning where emotions are normalised, understood, and supported as part of the learning process.

4.3.5 Theme Three: Supports Communication and Timely Response to Needs

A key theme across the data was the view that the intervention enhanced children's ability to communicate with staff, and therefore, enhanced staff's ability to identify and respond to children's needs more effectively. The GZM was suggested to enable better visibility of children's emotional and cognitive states, enabling faster and more targeted support.

The children talked about how the GZM tool helped them tell adults when they felt discomfort in maths. Isabel shared, *"It tells [the teacher] you don't really get it. It tells him* *you need a little more help,"* while Aisha shared, *"It really helps if you're feeling different emotions and your teacher will understand how you feel on the chart,"* and *"I can get the help that I need."* This was echoed by staff, who commented, *"[The GZM] enables us to know there is a problem,"* and, *"then we can adapt what we do."*

Across both staff and children's accounts, there was a perception that using the GZM has reduced the delay between a child's experience of difficulty or discomfort and the teacher's ability to respond. Emily noted, *"We don't have to put our hand up and wait. The GZM helps her see how we're feeling quicker."* Staff also echoed this sentiment, describing the tool as a *"quick solution"* that helped them *"react quickly"* in the classroom environment.

These accounts suggest that staff and children feel the GZM enabled more effective pupil-teacher communication, allowing faster and more emotionally responsive instruction to support children in the maths classroom.

4.3.6 Theme Four: Regulation Supports Behaviour for Learning

This theme illustrates the view that the intervention supported children to become more emotionally regulated in the maths classroom and, consequently, supported children's behaviour for learning. Reflections from staff suggest that the intervention has positively impacted children's ability to manage their emotions, settle into tasks, and engage with learning. The mainstream teaching assistant remarked, "*They are a lot calmer and not fidgeting,"* while the class teacher noted, "*I think they aren't avoiding the work as much."* These reflections suggest that staff held the view that the intervention helped reduce avoidant behaviours, which have often been associated with MA.

A key strategy that appeared to be linked to this perceived increase in regulation was the use of breathing exercises embedded into the lesson structure. The class teacher explained, *"The breathing slide with the circle is the next slide after the starter question now. They know what they are going to be doing and how are they going to feel about the maths* *and relax into it. I find that helps."* Children also referenced the calming impact of the breathing techniques. Ryan shared, "*In maths, we do this belly breathing that makes us calmer."*

These reflections suggest that the intervention has had a positive effect on children by providing them with concrete strategies which promote self-regulation. This regulation appears to have, in turn, contributed to improved readiness for learning.

4.3.7 Theme Five: Ease of Implementation

This theme captures the view that the intervention was easily introduced and embedded into the classroom. It was drawn mainly from reflections by the school staff. Based on the simplicity and accessibility of the resources, the intervention was viewed as efficient and easy to implement.

Staff talked about the efficiency of the intervention's implementation and described the initial intervention session as "*simple and engaging."* The mainstream teaching assistant noted the minimal preparation required: *"A PowerPoint is already done, and the scales don't take long to sort, and then it's done."* Staff also perceived using the GZM as unobtrusive and felt it did not disrupt learners. The mainstream teaching assistant stated, "*It wasn't a distraction,"* while the other assistant added, "*I can't say that there is one child who has messed around or been silly. They have really seen it for the positive*." However, there were some reflections on the practicality of using paperclips or pegs, which were identified as something the staff and children would like to improve in terms of the physical practicality of the tool.

This theme also captures the perception that the intervention, including using the GZM, was accessible and meaningful for all children. Staff talked about how the visual and low-literacy demands of the tool enabled a broad range of learners to engage without the need for additional support. The class teacher explained, "*We genuinely didn't have to explain more* *for children with learning needs or SEND. […] There were lots of images and they could relate to it."* The small group teaching assistant also shared, *"It was accessible to everyone."* These reflections highlight staff's perception of the inclusivity of this tool, which has contributed to its ease of implementation. Interviews with children reinforced this perspective as each focus child was able to demonstrate a good understanding of the GZM. For instance, Ryan explained:

> *"In the uncomfortable zone, is when you don't know it and you panic; you think "I can't do it." In the growth zone, you're happy. You know some, but not all of it. But you're learning. The comfort zone is when you know it and you're happy."*

These reflections suggest that the intervention was easy to implement and accessible for all learners, imposing minimal demands on teacher workload.

4.3.8 Summary of Phase Two Findings

Phase two has provided valuable insights into the perceptions of staff and children regarding the mathematical resilience (MR) intervention. In general, they tended to view the intervention positively, and the analysis indicated a strong desire for its broader implementation. Emphasis was placed on how the intervention had led to reflections about the teaching and learning culture of the classroom. Additionally, it was noted that the Growth Zone Model (GZM) supported pupil-teacher communication and response to need, and that the regulation strategies introduced supported behaviour for learning. Staff also viewed it as an intervention that can easily be implemented. Although some practical limitations were identified across the discussions, they were referenced comparatively less frequently in the data, making it difficult to form a clear theme; therefore, these will be considered in the limitations section of the discussion chapter.

4.4 Integration of Findings

Findings from phase one of the research provide some evidence for the whole-class intervention reducing self-reported mathematics anxiety (MA) levels. However, though most cases exhibited a reduction in self-reported MA, it was challenging to ascertain whether some findings were attributable to the introduction of the intervention, particularly considering the improvement trends over the four-week baseline phase for four of the six focus children. Using statistical analysis (Tau-U), one focus child was found to have significantly reduced MA between this study's baseline and intervention phase. Overall, it was concluded that the experimental hypothesis could be accepted for three focus children; the whole-class MR intervention reduced scores on a self-report measure of MA. However, we could not accept that the intervention was responsible for a reduction in MA for the other children based on the patterns in their repeated measures data.

Using a triangulation measure, the quantitative phase found that children’s scores on a self-report measure of MR aligned with their self-reported MA, which contributes to the evidence of an inverse relationship between MA and MR. It was also observed that, in most cases, from the first to the last data collection point, self-report MA was lower, and their scores on the self-report measure of MR were higher. Overall, this indicates an improvement over time for both MA and MR; however, when combined with the SCED and RCI data, it would be inappropriate to claim that this was a result of the intervention in all cases.

Qualitative interviews conducted with the staff and children who participated in this research were examined during phase two of the study. This phase explored staff and children's perspectives around implementing the whole-class MR intervention. It was also hoped that the data would help substantiate the findings from phase one. A total of five themes were drawn from the data: Desire to Implement, Reflections on Teaching and Learning Culture, Supports Communication and Timely Response to Needs, Regulation

Supports Behaviour for Learning, and Ease of Implementation. These themes, drawn from the qualitative data, suggested an overall positive perception of the intervention. On reflection, these findings also suggest that there may have been other outcomes that were not captured in phase one of the study, such as those related to supporting behaviours for learning.

Whilst there appeared to be an overall sense that the intervention had supported an understanding and awareness of emotions, regulation for learning and pupil-teacher communication, no specific references were made to a reduction in MA in the interviews. These findings could suggest that the measure chosen for phase one of the study may not have captured the breadth of the intervention's effects. However, the perceptions surrounding the implementation of the whole-class MR intervention could help to explain why the phase one findings provide some evidence of a reduction in self-reported MA, as qualitatively, staff and children report that it had been a positive experience. The findings of this mixed-methods study will be further interpreted in the discussion chapter, where references will be made to relevant literature.

Chapter 5: Discussion

5.1 Introduction

This study used a sequential explanatory QUAN→qual mixed-methods design to gather exploratory data on the effectiveness of a whole-class mathematical resilience (MR) intervention for a sample of Year 4 children. The study aimed to specifically address the efficacy of using the principles from Johnston-Wilder et al.'s (2020) toolkit (see Section 2.4.2) to form the basis for a whole-class intervention. Phase one, using a single-case experimental design (SCED), explored the whole-class MR intervention's impact on Year 4 children's self-reports of mathematics anxiety (MA). Phase two employed a qualitative approach to examine perceptions of the intervention with six focus children and the facilitating staff.

This chapter will offer further interpretation of the findings of the present study in alignment with the existing literature. The findings from each phase of this study are discussed according to the research questions, and where relevant, integration of the data between phases will be highlighted. This chapter will also examine the strengths and limitations of the current study, including a critique of the methodology. The implications of the findings for Educational Psychologists (EPs) will be considered, as well as suggestions for future research. The chapter then concludes with a summary including the researcher's personal reflections.

5.2 Research Question One: Does a whole-class mathematical resilience intervention, incorporating a practical Growth Zone Model (GZM) resource, reduce children's self-reported levels of mathematics anxiety?

In phase one of this study, SCED methodology was employed to answer the above research question. Overall, the findings led to the acceptance of the experimental hypothesis for three focus children (Aisha, Isabel and Zachary); implementing a whole-class MR intervention reduced self-reported MA. The findings provided evidence consistent with previous research, as an improvement in self-reported MA was observed following an intervention that promotes elements of MR (Cropp, 2017; Passolunghi et al., 2020; Samuel et al., 2023; Talaoc, 2019). For Aisha and Zachary, the effect sizes calculated using Tau-U suggest that the effects of the intervention were large. These findings suggest that the intervention was successful for these children in developing MR to reduce their self-reported MA.

5.2.1 Heterogeneity of Children Where the Experimental Hypothesis was Accepted

Among the focus children where the experimental hypothesis was accepted, a range of attainment levels were observed: Zachary is performing below age-related expectations, has an identified SEND need, and is taught in a small group setting. Aisha is working towards age-expected levels in the mainstream class, while Isabel is achieving the expected level in the same environment. This suggests that positive outcomes on MA were observed across a diverse spectrum of learners and in both of the classroom settings in this study. This finding was triangulated with data from phase two of the study, in which the theme '*Ease of Implementation'* included the perception that the intervention was accessible for all children. Staff perceived the intervention as inclusive and, in conjunction with phase one findings, this provides evidence for the use of MR interventions at a whole-class level in mainstream primary schools. This is encouraging considering that universal educational interventions are believed to help transfer strategies to different contexts, can be implemented regardless of existing risk levels, and account for the potential that the problem, in this case MA, develops later in life (Greenberg & Abenavoli, 2017).

5.2.2 Initial Increase and Gradual Reduction in Mathematics Anxiety

For five out of the six focus cases, there was an overall reduction in mean self-reported MA between the baseline and intervention phase. For the one child where we did not observe an overall mean decrease between phases (Isabel), it was interpreted, based on the visual analysis of her data, that there was a gradual reduction in MA during the intervention phase (see Section 4.2.7). However, the initial increase in her self-reported MA following the onset of the intervention appears to be the source of the slight increase in mean MA over the intervention phase. It was tentatively accepted that the intervention had supported Isabel's reduction in MA based on the significant shift in trend observed between phases, specifically, a transition from a deteriorating trajectory (increasing MA) to an improving one (decreasing MA). This case suggests a potential latent effect of the intervention.

It is important to reflect on these patterns in the data as they align with similar observations in other focus cases where the reduction in self-reported MA emerged gradually over time, and for some, an initial increase in MA was observed at the beginning of the intervention phase. One could interpret that the initial rise in self-reported MA stemmed from the intervention, potentially increasing children's awareness of their anxiety. This relates to the suggestion that, because it raises awareness, school-based early intervention programmes for anxiety can be subject to an initial period of elevated risk, and that the effects of an intervention may take time to emerge (Neil & Christensen, 2009). This suggests that for some children, the impact of the intervention may involve a temporary increase in MA and improvement in MA can take time to manifest. The findings highlight the potential risk that brief or insufficient exposure to the intervention might amplify MA rather than mitigate it, underscoring the necessity for sustained engagement with the intervention. In the context of Isabel's case, after eight weeks of intervention, a greater reduction in self-reported MA was observed, suggesting that a duration shorter than this may be insufficient for some children.

5.2.3 Reductions in Mathematics Anxiety Across the Baseline Phase

For three of the focus children, it was challenging to ascertain the extent to which the intervention contributed to their reduction in MA. For two of these children, Emily and Ryan, a notable downward trend in self-reported MA was already evident during the baseline phase, such that, by the time the intervention began, their levels of anxiety would no longer be classified as high. Similarly, their scores on a measure of self-reported MR also significantly increased over the baseline phase. Given that this improvement occurred before the intervention was implemented, it is important to consider alternative explanations for the observed reduction in MA. One explanation could be maturation (Robson & McCartan, 2016), where children may naturally become less MA over time. However, the literature suggests that MA typically increases with age as children progress through the education system (Dowker et al., 2016; Zhuo et al., 2025), which would suggest that this explanation may not be appropriate.

Another possible explanation for the reductions in MA observed in the baseline phase could be the presence of a Hawthorne Effect (Landsberger, 1958). Simply participating in the research could have led to a positive change due to participants' awareness of being part of a study (Holden, 2001). Using SCED methodology has been beneficial when considering this, as this effect may not have been as clearly identified using a pre- and post-test design. Based on this explanation, it could be suggested that some children responded to the measures in a way that they thought was expected of them, as they were aware they were participating in a research study.

It was also considered that the researcher's initial interaction with school staff, during the recruitment period, could have influenced a reduction in self-reported MA across the baseline phase. It is possible that staff correctly identified the hoped-for outcomes of the study, to reduce self-reported MA across the repeated measures, and adapted their behaviour accordingly to meet the perceived goal. This is considered as a demand characteristic, which has been defined as "the totality of cues and mutual role expectations that inhere in a social context (e.g., a psychological experiment […]), which serve to influence the behaviour and/or self-reported experiences of the research participant," (Orne & Whitehouse, 2000, p. 469). Staff may have started to consciously or unconsciously modify their teaching methods in mathematics, driven by anticipated study outcomes and based on the role they perceived for themselves as part of this study. Though the staff training was postponed until after the baseline phase in an attempt to minimise this effect, it is possible that the first meeting provided staff with enough cues about the purpose of the research to have an impact on the findings. It was not possible to reduce the amount of contact with the researcher to avoid this effect. With the importance of the role of teaching staff in supporting children's MA being cited throughout the literature (Brandenberger & Moser, 2018; Gough, 1954; Johnston-Wilder et al., 2020), it could be argued that the initial meeting regarding the intervention effectively raised teacher awareness of MA enough to have a positive effect for some children.

Another alternative explanation could be that, at the outset of this study, the children had recently transitioned to a new teacher. It was evident in the qualitative interviews that supporting children's MA was an area of interest for this class teacher. The class teacher is also one of the school's mathematics leads, indicating that they have expertise in teaching this subject. It is possible that this teacher, as a key figure in their learning, may have alleviated MA for some students without any direct intervention, as teacher quality and technique are associated with MA (O'Hara et al., 2022). This could help to explain some of the improvements seen in self-reported MA across the baseline phases, based on the findings that school staff play a critical role in moderating children's levels of MA (Brandenberger & Moser, 2018; Gough, 1954; O'Hara et al., 2022). Research indicates that teacher-related factors and classroom environment, such as the teacher's personality, teaching experience, and instructional methods, are linked to their students' MA (O'Hara et al., 2022).

5.2.4 Variation in Self-Reported Mathematics Anxiety

In some cases, large variations in self-reported MA were observed. An explanation for the variation in self-reported MA across the repeated measures could be attributed to natural fluctuations in MA. As noted in the literature, MA is situation-specific (Marshall et al., 2017), can show up differently for each person (Devine et al., 2018), and specific topics may provoke varying degrees of MA (Halme et al., 2022; Sidney et al., 2021). The latter finding appears to be supported by the class teacher's reflection, "*You can kind of almost see when you start a new concept, a lot of them will go red. And then over a few days, however long, it will gradually slip back into the growth zone*," suggesting that children in the class were communicating an increased level of discomfort or anxiety using the GZM when introduced to a new topic. This, therefore, could explain some of the variation in the SCED data. For example, whilst it did not return to a level above her initial score, Emily's self-reported MA increased during the intervention phase after the Christmas break. We could suggest that this was due to increased curriculum demands, return to school after the Christmas break or a change in topic. Overall, it appears that self-reported MA is likely to fluctuate based on the context in which it is measured; therefore, using it as an indicator of the effect of an intervention may not, in some cases, be the most appropriate measure. This is based on the assumption that self-reported MA is likely to fluctuate depending on the context or environment in which an individual is.

5.2.5 Triangulation Measure of Mathematical Resilience

Following the exploration of the SCED data, it is worthwhile to discuss the outcomes obtained from the use of a quantitative triangulation measure. The Baker Children's Mathematical Resilience Scale (BCMRS) (Baker, 2020) was used to explore children's MR across the phases of the SCED at four discrete time points. The purpose of this measure was to support the reliability and validity of the repeated measures through triangulation (Robson,

2016) with the view that higher reports of MR reflect lower MA. This is based on an assumed negative correlation between them, as supported by the literature (Hunt & Maloney, 2022; Lovelace, 2022; Talaoc, 2019) (see Section 2.6).

For the focus cases where the experimental hypothesis was accepted, we saw an improvement in self-reported MR between the baseline and intervention phases. This may suggest that the intervention supported a reduction in MA by building MR. Additionally, for two of the children where the null hypothesis was accepted (any reduction in self-reported MA was not assumed to have been related to the intervention), their scores showed a significant increase in self-reported MR over the baseline phase, which was consistent with their self-reported MA which had also improved during this phase. Therefore, patterns in the self-reported MR data for five of the six focus children were as expected.

However, for one child, Emily, while her self-reported MR remained relatively stable, her overall self-reported MA improved and was variable during the intervention phase. This finding suggests that, in this case, self-reported MR was not correlated with self-reported MA, which contradicts the literature. This may therefore suggest that the relationship between MA and MR is not as robust as previously assumed, and further study would be needed to explain this effect in this particular case.

Whilst it was not within the scope of this study to explore the individual factors of MR (*struggle, value,* and *growth*), implications for future research are considered in Section 5.5.1.

5.2.6 Conclusions

Whilst there has been some evidence for the effects of Johnston-Wilder et al. (2020) toolkit (Pará & Johnston-Wilder, 2023; Thomas, 2020, Baker, 2021), it was acknowledged that more research was required to determine the effects of its implementation. The findings of phase one of the study suggest that the MR intervention, including the use of a practical

GZM, supported a reduction in self-reported MA for half of the cases where initial self-reported MA was high. This study, therefore, presents some evidence towards the effectiveness of using the principles of Johnston-Wilder et al.'s (2020) toolkit, as a whole-class approach, to support primary school children with MA.

5.3 Research Question Two: What are the perceptions of key stakeholders (teachers, teaching assistants, and children) regarding the implementation of a whole-class mathematical resilience intervention, including the use of the Growth Zone Model (GZM)?

The purpose of this research question was to explore the perceptions of the staff and children who participated in this research. It was felt that relying solely on quantitative methods to examine the outcomes might limit the findings, and due to the exploratory nature of this study, understanding how the intervention was received would be valuable. This was also important because phase one of the study only focused on six children; however, the intervention was delivered universally in this Year 4 classroom. Therefore, this research question aimed to deepen the understanding of whether implementing a whole-class MR intervention in a primary school classroom was perceived as effective for supporting children with MA. Furthermore, as part of the QUAN→qual sequential explanatory design, phase two aimed to build on phase one's findings.

The analysis of the data, from interviews with the six focus children and the staff who facilitated the intervention, revealed five key themes:

- Desire to Implement
- Reflections on Teaching and Learning Culture
- Supports Communication and Timely Response to Needs
- Regulation Supports Behaviour for Learning
- Ease of Implementation

5.3.1 A Desire to Implement the Mathematics Resilience Intervention

The qualitative phase of this study revealed that both staff and children viewed the intervention as a positive experience, and they hoped that its application could extend more broadly across the school. Staff felt that adopting the intervention as a whole-school approach would be an appropriate next step. This aligns with the view that school leadership should and can play a role in facilitating a whole-school ethos that supports both staff and children with MA (Horne, 2022). Staff discussed the hope that other colleagues would recognise the benefits of the intervention and respond to it positively, which aligns with the view that a factor influencing the success of a whole-school approach is staff compatibility. That is, the intervention needs to align with staff beliefs in order for it to be implemented successfully (Ward, 2023). A shared vision within a school learning community is important when implementing new initiatives (Toikka & Tarnanen, 2024). Therefore, this would need to be a key consideration when introducing this intervention across a school.

Additionally, staff held the view that the intervention should be introduced to children earlier than proposed here; they felt that it should be introduced in Year 1 (equivalent to children aged 5 to 6 years). This is in line with the research that suggests children as young as four years old can experience MA (Petronzi et al., 2017). This research set out to explore how an MR intervention could be introduced earlier, and these reflections support the view that early intervention is seen as important.

In reference to the Growth Zone Model (GZM), it was felt to have the potential to be effective across a broader range of subjects. This suggests that staff and children viewed the GZM as viable in the classroom and beneficial in the context of mathematics, which aligns with the suggestion made that a practical GZM has been helpful in the classroom (Johnston-Wilder & Moreton, 2018). The context in which this research was conducted focused on children's experiences of MA, which is why the intervention was confined to mathematics. In addition, Johnston-Wilder et al. (2020) developed the toolkit to support the specific development of MR to support mathematical safeguarding and reduce experiences of MA. However, staff and children perceive that this tool could also be useful in other subjects that could also elicit experiences of discomfort or anxiety.

5.3.2 A Teaching and Learning Culture for Mathematics

Across the qualitative data, a range of deeper reflections on teaching and learning culture in the maths classroom emerged. This aligns with the finding that factors in the classroom learning environment are related to children's experiences of MA (O'Hara et al., 2022). Staff and children's comments indicated that the intervention supported staff in reflecting on their teaching and learning culture. This includes promoting an environment where mistakes are accepted as part of the learning process, fostering understanding and awareness of emotions, and acknowledging that all learners may find math challenging. Overall, staff perceived these factors as contributing to a safer learning environment, which is in line with the view of Johnston-Wilder et al. (2020), who suggested that the use of the toolkit principles can safeguard against MA.

Concerning the existing literature, staff and children's comments appeared to reflect a learning culture that promotes a growth mindset, a belief that anyone can learn mathematics (Dweck et al., 1995; Dweck & Leggett, 1988), and the understanding that struggle in mathematics is a universal experience (Kooken et al., 2016). Both *growth* and *struggle* are components of MR (Ishak et al., 2020; Kooken et al., 2013). Therefore, this could suggest that the intervention promoted reflection on these specific components. This is in line with the existing research, which found that an intervention that includes elements of *struggle* and a *growth mindset* helped to support a reduction in MA (See Section 2.6.6; Cropp, 2017; Samuel et al., 2023; Talaoc, 2019).

There was also reflection on the intervention's impact on encouraging peer-to-peer support, which relates to the finding that peer support has a positive impact on children's MA (Cropp, 2017; Zhuo et al., 2025). Therefore, facilitating a culture that supports connection and support between peers could also help to explain the findings in phase one. This relates to the finding that greater perception of peer support is associated with reductions in MA (Zhuo et al., 2025).

Overall, the perception that the intervention had led to reflections on teaching and learning culture in this study was in line with the findings from Johnston-Wilder and Moreton's (2018) research. They interviewed teaching staff after their participation in a workgroup that supported teachers in becoming familiar with the concepts of MR, and found that introducing teachers to the concept of MR had led to changes in their teaching practices.

5.3.3 A Tool to Facilitate Teacher-Student Communication and Subsequent Support

Another key perception was that the intervention supported effective communication between staff and children through the use of a visual tool. The GZM resource helped staff identify and respond more promptly to support children who expressed discomfort during maths lessons. In this way, the tool appears to have functioned in a manner similar to Assessment for Learning (Afl). AfL refers to classroom assessment practices that provide feedback to inform teaching instruction (Wiliam, 2011), typically focusing on academic progress. However, the GZM may offer a mechanism to combine AfL with an assessment of emotional well-being. It was highlighted that when learners placed themselves in the 'red zone', this provided staff with immediate, actionable feedback, which communicated that the child felt uncomfortable because they perceived the learning as beyond their ability. In turn, this encouraged staff to provide reassurance or adapt the learning task. The GZM, therefore, appears to extend the principle of AfL by capturing both the affective and academic domains of learning.

While the study intended to focus on the affective domain of mathematics, it appears that using the GZM also organically led to academic support. This is in line with the idea that when a learner is presented with a task they cannot access, this causes the learner to feel a level of discomfort, including a rise in anxiety (Johnston-Wilder et al., 2020). These reflections relate to the findings from Zhuo et al. (2025), who found that children who perceive they have a high level of teaching support are more likely to move from higher to lower levels of MA. Therefore, to help explain the reductions in MA in phase one, we could suggest that one mechanism underlying the intervention's effect was that the GZM tool enabled teachers to more effectively adapt their teaching to target learning at the appropriate level, reducing the time in which a child's MA can escalate and increasing children's perceptions of teacher support.

5.3.4 Mathematical Resilience Intervention Supports Regulation and Behaviour For Learning

The intervention was also perceived to support children in enhancing their emotional regulation, resulting in improved behaviour for learning in mathematics. This aligns with the idea that learners who have developed MR are more adept at handling setbacks and uncomfortable emotions, which can lead to avoidance and anxiety, allowing them to stay engaged in learning (Kooken et al., 2016). Staff and children's reflections suggested that the intervention benefited children's emotional regulation, task engagement, and readiness to learn in maths. The introduction of the relaxation response (Benson, 2000) and breathing exercises appeared to be a key facilitator for this. In line with previous research, teaching children strategies for self-regulation, such as mindfulness and breathing exercises, has been shown to support a reduction in children's MA (Passolunghi et al., 2020; Samuel et al., 2023).

The view was also held that following the introduction of the intervention, less avoidant behaviours were observed. In line with the literature, avoidance of maths is said to exist along a behavioural continuum of MA such that greater avoidance (as opposed to pursuit of the subject) is reflective of higher MA (Andrews & Brown, 2015; Olango, 2016; Pizzie & Kraemer, 2017) (See Section 2.3.1). Olango (2016) suggests that avoidance sits within a reinforcing cycle of MA, where anxiety, failure and avoidance interact cyclically. In this way, staff's reflection on the reduction of avoidance could suggest that this factor played a role in a reduction in MA. It is also a possibility that this reduction in avoidance led to fewer experiences of failure, which, according to Olango (2016), would also build confidence and reduce anxiety. Whilst phase one of this study did not evaluate learning outcomes or experiences of success in maths, this appears to be worth investigating and will be discussed in the implications for future research.

5.3.5 Intervention Feasibility

The final theme presented was that the intervention was easy to implement. It was regarded as efficient and simple to execute, primarily due to the straightforward nature of the resources and their accessibility for all children. When considering the feasibility of this intervention in a mainstream classroom, it is valuable to note that the facilitators felt that it did not place a high demand on their time or effort. This suggests that the intervention did not significantly impact teacher workload, which may also contribute to their continued desire to implement it. This is important to consider when one of the main reasons for deviations from intervention adherence is time restrictions (Carroll et al., 2007) and with teacher workload being a concern for the Department for Education (DfE) (2018). In addition, teaching unions have emphasised the need to take workload into account before implementing interventions (NASUWT, 2020).

The simplicity of the intervention may have supported it to be delivered with high fidelity as "research suggests that simple but specific interventions are more likely to be implemented with high fidelity than overly complex or vague ones," (Carroll et al., 2007, p.

5). Furthermore, staff reported that they had to make no adaptations to the intervention to ensure its accessibility for all children in their classroom, despite a large proportion of the class having an identified SEND need. This suggests that the tool serves as an inclusive resource for a wide range of learners. With the SEND Code of Practice (DfE, 2015) placing a focus on inclusive practice and the removal of barriers to learning, it is positive that the intervention was perceived as inclusive and, in phase one, showed positive outcomes for one child with an identified SEND need.

The discussion points above suggest that staff and children generally perceived the whole-class MR intervention as effective and were pleased with the outcomes. Despite generally positive feedback from staff and children regarding the MR intervention, some areas for development were noted. However, these were not referred to in the analysis as they were referenced relatively less and were suggestions for practical improvement of the resource rather than being viewed as an obstacle to the implementation of the intervention as a whole. These aspects were perceived as opportunities for development, with staff expressing a willingness to adapt and enhance the resources for future implementation. The areas identified for development included practical challenges of using pegs or paperclips on the GZM and changes to the design of the model, including the emojis.

5.3.6 Conclusions

To conclude, the findings from phase two support the idea that the intervention was effectively implemented in a manner that improved children's experiences of MA. This may help to explain why we were able to accept the experimental hypothesis (introduction of the intervention led to a reduction in self-reported MA) for half of the focus children in phase one. However, it also highlights that the intervention may have had broader implications than were evaluated during the first phase of the study. Avoidance, mathematical success, peer-to-peer support, teacher-child interaction, and classroom environment all seem to be factors that may have also been impacted by the delivery and implementation of this intervention. Further exploration of the intervention's impact would be beneficial and raises questions for further research.

5.4 Strengths and Limitations of the Current Study

This section of the discussion will focus on the strengths and limitations of each phase of the current study, as well as broader considerations, including recruitment and overall design.

This study employed a mixed-methods design to explore the effectiveness of a whole-class mathematical resilience (MR) intervention for supporting children's mathematics anxiety (MA). Despite criticism of the approach, such that qualitative and quantitative methods appear to have juxtaposing epistemologies, the potential benefits of a mixed methods design are argued to outweigh this 'incompatibility thesis' (Robson & McCartan, 2016). This methodological approach could be considered a strength, as the qualitative component provided deeper insights into perceptions concerning the intervention's application within the study's context, while the quantitative aspect allowed for an investigation of its impact on children's MA. However, it is essential to consider the reliability and validity of the quantitative, 'QUAN', part of this sequential explanatory study, as well as the trustworthiness of the findings from the qualitative, 'qual', phase. Tables outlining these considerations and the steps taken to address threats to reliability, validity, and trustworthiness can be found in Section 3.10. Some further considerations relating to both phases of the study are also addressed below.

5.4.1 Recruitment and Sampling

The recruitment phase of this study proceeded efficiently due to prior indications of interest in supporting MA expressed by a leadership team from one school, which they communicated to their link Educational Psychologist (EP). After an initial recruitment email was disseminated to this school, they confirmed their willingness to participate in the research, negating the necessity for additional recruitment strategies. The staff involved in this research demonstrated significant interest in the project and maintained engagement throughout.

One consideration for Educational Psychologists (EPs) is ‘staff readiness’ before they can support the implementation of an intervention (Moir, 2018). It is important to acknowledge that the school was very open to receiving support, which facilitated their engagement with the intervention. Consequently, the results may not be generalisable in the context of a school that exhibits less openness to change in practices surrounding MA. Considering Lewin’s (1948) change model, whereby an organisation needs to ‘unfreeze’ before change can be implemented, as a system, this school appeared to be at a stage ready for the change to be implemented. Comparatively, in another setting, there could have been greater resistance, which may have produced different outcomes.

In their most recent Ofsted report (2022), it stated that mathematics is well taught across the school. Inspectors identified the mathematics curriculum, including in the early years, as an area of strength. With the learning environment identified as a key factor associated with MA (O’Hara et al., 2022), there is potential that the school’s environment was more conducive to success (reductions in MA) due to its recognised strength in teaching mathematics.

Parental Engagement and Consent. The research school found it challenging to engage parents and obtain all thirty-four consent forms. Notably, no parents attended the information session offered to them regarding the research. The school wanted to implement the intervention as part of their universal offer for all children, aside from their involvement with the research. With the view that it would be unethical to withhold the whole-class intervention from those without consent, where parental consent was not obtainable, children were not removed from receiving the intervention, which was being implemented as a whole cohort intervention by staff. However, those without written consent had their data destroyed. The rationale for asking all children to complete the repeated measures was to ensure that all children felt included.

Focus Children. The children identified as focus cases were chosen based on their initial self-reported MA scores. These children were deemed to exhibit the highest levels of anxiety towards mathematics within their class. It was noted that these children represented a broad range of maths learners: two were working at the expected level for their age, two were working towards it, and two were working below. In addition, half of the learners had an identified SEND need, and half received a differentiated maths curriculum in a small group setting. The gender distribution was also equitable. Half of the children were White British, two were Black British, and one child was recorded as of mixed ethnic heritage. It became apparent that children with the highest levels of self-reported MA did not constitute a homogeneous group. The class teacher reflected that the focus children were broadly representative of the entire cohort. In the context of this study, these observations support the view that MA does not discriminate based on maths attainment, a finding consistent with existing literature (Devine et al., 2018; Zhang et al., 2019). Additionally, in this case, other factors such as SEND or gender did not appear to be related to higher self-reports of MA in the case of these focus children.

Half of the focus children were White British, consistent with overall class demographics. However, Black British children were overrepresented (two out of six, 33% of the focus group vs. 15% of the cohort), while no Asian or Asian British children appeared among the focus group despite comprising approximately 25% of the cohort. This pattern invites reflection on the role ethnicity plays in experiences of MA in this context of the study and highlights the complex intersectionality between the factors that can influence children's lived experiences of MA.

Dowker et al. (2016) suggest that cultural or ethnic factors may shape both students' willingness to report mathematics anxiety and how that anxiety affects their performance, highlighting a possible limitation to a self-report measure of MA in this context. Harris and Graham (2024) unpack further nuances, discussing how ethnicity, MA, and performance, including students' perceptions of the same ethnic representation in their class, interact. Although not within the scope of this study to explore this complex relationship in further detail, it is relevant to highlight here that the cultural representation across the focus children is skewed, and this finding is worth acknowledging to underscore the complexity of the intertwining factors that may be impacting MA. Of the focus children for whom the intervention was suggested to have a positive impact on MA, two were Black British and one was White British.

All focus children's first language was English and they were attending a single faith school located in the East Midlands. This has implications for the external validity and transferability of the study; nevertheless, due to its exploratory nature, the study focused on exploring the effectiveness of the intervention specifically in this setting with these focus children. It should also be noted that parental consent was not obtained for nine children across the cohort, and they were consequently excluded from data collection. This omission may have influenced the focus group's composition and thus the interpretation of these patterns.

5.4.2 Phase One Research Design

Phase one used single-case experiments adopting an AB design to evaluate the impact of the whole-class MR intervention on the MA of six children with initially high reported levels of MA. The researcher justified this design in Section 3.7, arguing that it was the most appropriate methodology, given the consideration of possible barriers to implementing other research methods, such as a Randomised Controlled Trial (RCT) or quasi-experimental design.

Quasi-experimental designs provide an alternative approach to RCTs when the idea of random assignment to conditions is not possible, whilst enabling real-world research to maintain some experimental control (Robson & McCartan, 2016). However, these designs are not considered to be true experiments, and there are several quasi-experimental designs to be avoided (Robson & McCartan, 2016). Quasi-experimental designs are susceptible to confounding variables as intervention and control groups differ in ways beyond the intervention itself and the researcher's control (Cohen et al., 2017).

Considering the research question, the intervention could have been implemented in one classroom, with a neighbouring classroom serving as a control group; however, no two classrooms are the same. A pre-test, post-test, non-equivalent group design would have allowed for comparison (Cohen et al., 2017; Robson & McCartan, 2016). However, the interpretation of results would prove challenging due to the inevitable presence of confounding variables, which can arise in education, such as differences in teaching styles, student characteristics, or classroom dynamics. As discussed in the literature review, inappropriate teaching methods and environmental factors, such as teacher education level and classroom culture, are factors found to influence MA (Kour & Rafaqi, 2024; O'Hara et al., 2022). Hence, it was concluded that implementing a quasi-experimental design would not be suitable due to the number of extraneous variables that would be uncontrollable across classrooms which could affect children's MA.

5.4.3 AB Single Case Experimental Design (SCED)

AB designs have been criticised for insufficient experimental control and possible risks to internal validity, particularly due to the lack of replication of the intervention phase in the design (Kratochwill et al., 2010; Robson & McCartan, 2016). Despite the researcher requesting that no new interventions be started, it cannot be assumed that no other changes to practice occurred across the study. While the class teacher was asked to identify any events that may have impacted the focus children throughout the study, the researcher cannot be certain that other events impacting participants' levels of MA occurred outside the context of the intervention. This concerns the threat of history (see Table 3. 3) which has implications for the internal validity of the study and makes it challenging to draw inferences from the design. However, due to the ethical considerations surrounding withdrawing the intervention, which was hypothesised to have a positive effect on anxiety, it was deemed that a withdrawal phase would not have been appropriate. Conducting a multiple baseline design was also unfeasible as the intervention was delivered at a whole-class level.

The benefit of implementing an AB design is its high internal validity, which allowed for a thorough evaluation of the changes over time following the intervention's introduction to establish a point of change. This was deemed essential due to the exploratory nature of the study. The researcher acknowledges that, time permitting, it may have been beneficial to have collected follow-up measures. However, since the staff continued implementing the intervention following their participation in the study, no natural evaluation following a withdrawal would have been possible.

Baseline phase. A limitation to the internal validity of this study was the lack of stability in the baseline phase for four of the six focus cases (Kratochwill & Levin, 2014; Lanovaz & Primiani, 2023). Due to a one-week delay in collecting repeated measures associated with school factors, the baseline phase was already reduced from five to four weeks. Consequently, it was not possible to wait for stability to be achieved in all cases. However, a minimum of three baseline data points is suggested, which for all of the focus cases was achieved (Kazdin, 2011). Potential explanations for the observed downward trend in the baseline phase are discussed in more detail in Section 5.2.3.

Missing Data Points. Due to pupil absence and teacher autonomy in gathering the measures, some weekly repeated measures were missing. This was particularly evident in the intervention phase, as constraints in the school timetable and teacher absence (from the third to the sixth of December) resulted in three weeks during phase B when the repeated measures could not be administered. Despite this, all focus cases had at least eight data points for this phase, which is above the minimum recommendation of three (Kazdin, 2011). There were also natural breaks across the phases due to school term times. However, it was not possible to adjust this in a real-world setting. It is important to note that data points were connected between the missing weeks of the repeated measures to support the visual analysis of those measures.

The decision was made to extend the intervention phase, which included administering the principles of the toolkit, including the GZM, into the new term after the Christmas break. This was motivated by the researcher's aim to gather a minimum of ten weeks of data, along with the class teacher's intention to integrate the intervention into their standard practice following its introduction.

5.4.4 Measures

As outlined in Section 3.7.7, the measures demonstrated high to acceptable internal consistency, supporting their reliability for use. Piloting of the measures was also completed. The class teacher, who conducted this pilot, provided a written response to the pilot, which can be found in Appendix I. Based on the teacher's feedback, no adaptations were made to the wording or length of the measures. However, their response indicated that the pictorial scale was challenging for the children to conceptualise; therefore, it was replaced with smiley face emojis. This was considered an easier option and in their development of the scale, Baker (2020) noted that all children chose the smiley face pictorial scale when given the option. Smiley faces have been widely used for child self-report measures (Yahaya & Abdul Salam, 2008).

The measures taken were child self-report measures, which raises potential limitations regarding participant bias. Staff were asked to ensure that children understood there were no right or wrong answers to the questions. However, children were aware of their participation in the study, which had the potential to influence their responses. Additionally, staff reflected that they felt some children did not always consider their answers carefully. They also had some concerns that some children did not always fully understand what was being asked of them, which contradicts the findings of the pilot testing.

The variability present in David's data significantly complicated the interpretation of his findings. David is a child with an identified SEND need, specifically Attention Deficit Hyperactivity Disorder (ADHD). The researcher has questions about the accuracy with which he completed the repeated measures. It was noted that on some of his measures, he had diagonally circled the scale, which may indicate a lack of reliability across his data. In relation to this, the researcher also noted in their interview with David that he found it challenging to remain focused on the questions, and at times it proved difficult to interpret his answers, which is reflective of the information provided by school staff about David's needs. This could be indicative of why there was such variability in his self-report measures. Therefore, though the experimental hypothesis was rejected for David, these observations suggest that his SCED needs to be interpreted cautiously.

5.4.5 Visual and Statistical Analyses of SCED Data

To support the reliability of the analyses of the findings in phase one of the research, both visual and statistical analyses were used (Wendt & and Rindskopf, 2020). Moderate inter-rater agreement was also found based on a visual analysis check that was conducted by a colleague familiar with visual interpretations of SCEDs (see Section 4.2.10). Tau-U analysis was also used in the analysis of the SCED to help support the understanding of the visual graphs (Fingerhut et al., 2021).

The researcher could have produced a weighted average of the Tau-U findings to determine an overall effect size by combining the results for each case. When conducted, the analysis revealed a significant finding (τ = -0.34, z = -2.31, p = 0.02*), suggesting a significant overall effect of the intervention across phases with a trend towards improvement in self-reported MA. However, paired with visual analysis of the data, it was concluded that combining these statistics into a weighted average would be inappropriate due to the acceptance of the null hypothesis in three instances; thus, this finding is likely to have been susceptible to a type one error (Robson & McCartan, 2016).

5.4.6 Intervention

The nature of this study was exploratory as this was the first time, to the researcher's knowledge, that the principles of Johnston-Wilder et al., (2020) toolkit have been evaluated as a whole-class intervention in a primary school paired with staff training received through an Educational Psychology (EP) service. The resources were developed by the researcher and piloted, as outlined in Section 3.6.1. They were deemed suitable for delivery in the context of Year 4.

Determining intervention fidelity requires that the critical components or key features of the intervention be defined (O'Donnell, 2008). However, in this study, these components were not yet firmly established, as they were intended to be adaptable based on feedback from the participants. At this stage, the intervention procedure is outlined as follows: one staff training session, one whole-class MR intervention session delivered by the class teacher, and daily use of a practical GZM tool in maths lessons along with proactive staff response and embedding of the toolkit principles.

This whole-class intervention is in the initial stages of development, and therefore, the research aims to review its effectiveness and make adjustments in light of the findings; thus, at this stage, the ‘program design’ is not fixed. However, a fidelity check was implemented to observe how the GZM was being employed based on the training the school staff received and if it was in line with the researcher's intentions (See Section 3.6.2). The following was noted: the teacher and teaching assistant encouraged the use of the model, all children had access to their own copy, it was explicitly referred to during the lesson, and children were actively using it. The qualitative phase of the study also enabled the researcher to explore how the intervention had been implemented. As per the researcher's intentions, children’s use of GZM was responded to proactively, which both staff and children reported. Asking children in the semi-structured interview if they could explain the principles of the GZM also aimed to ensure that the concepts had been conveyed correctly.

It was noted that the staff training session appeared sufficient for staff to grasp the concepts shared, whilst an opportunity for staff supervision sessions was made available, they were not taken up. Though Io (2023) found that staff coaching from EPs to support their approach to MA was received well, the staff who facilitated the intervention did not feel that follow-up support after the training was required in this instance. However, it was noted in the interviews that children had difficulty recalling specific content introduced in the initial intervention session. This suggests that for some children, the initial session was not sufficient to support long-term retention of some of the psychoeducational aspects of the toolkit. Staff members recognised this gap and responded by revisiting the session content which is reflective of the staff training that suggested staff should actively respond to children’s use of the GZM by revisiting concepts from the toolkit. This raises questions for consideration around the specific duration, frequency and timing of intervention components, referred to as ‘dosage’, which may have influenced the effectiveness and retention of learning outcomes.

It is also important to note that, whilst all of the children received the initial intervention session in the context of their mainstream class, the application of the GZM tool was delivered across two groups, as nine children received a differentiated maths curriculum taught by one of the class’s teaching assistants. This raises the potential for individual differences in how the staff responded to the use of the GZM in practice. However, observations were carried out by the researcher in both contexts to ensure that the GZM tool was being applied in practice as intended, as discussed in Section 3.6.2. In the qualitative phase of the study, the participating children were also prompted to explain the concept of the GZM to ensure their comprehension. The interviews revealed that every child could articulate the model's core principles, indicating they were utilising the tool appropriately. Notably, Aisha offered the most sophisticated explanation, potentially shedding light on the success of her findings in phase one.

5.4.7 Consideration of Qualitative Interviews

Since the researcher conducted the interviews, which involved discussing the implementation of the intervention, participants may have been influenced by participant bias (Robson & McCartan, 2016). Participants might have aimed to portray the results positively, to strengthen the view that the intervention was successful. However, the decision not to record the interviews was made in the hope of alleviating any potential influences on factors such as participant openness, caused by the use of recording equipment (Nordstrom, 2015; Seale et al., 2004).

Field notes may introduce inaccuracies in transcripts that cannot be corroborated with post-interview recordings. To mitigate researcher bias and address concerns about credibility, the researcher documented all contextually relevant comments from both staff and child interviews. However, field notes are a non-standardised form of data collection, inherently shaped by the researcher's selective attention and interpretive lens, which may introduce bias. The field notes were captured using a laptop during the staff focus group, allowing the researcher to record much of the discussion verbatim. Although audio recording was considered, as discussed in section 3.8.3, it was not implemented.

In contrast, children's views were documented in full via individual worksheets, ensuring a complete and accurate record of their verbal responses. Given the nature of this method, no textual data were lost or paraphrased in transcription.

In the context of this study, where comparatively less weight was placed on the qualitative phase, the field notes successfully captured an overview of perceptions of the whole-class intervention, leading to five overarching themes. Using audio recordings would have allowed for the capture of greater nuance in the data; however, as part of this QUAN-qual sequential design, field notes were deemed appropriate for this exploratory study.

Children's Semi-Structured Interviews. By gathering children's voices and considering their perceptions of the intervention, this study recognises the value of each child's individual experiences (Murray, 2019). Following the initial analysis of the SCED data, it was noted that the data sets exhibited heterogeneity, indicating a variation in children's responses to the intervention. Therefore, it was decided that individual interviews would be selected over a focus group.

Participant bias may have been less likely among the children, as they met with the researcher only after the intervention had been delivered and were unaware of the researcher's involvement in creating the resources. However, this may have elicited some anxiety in the children as they were interviewed by an unfamiliar adult, which could have impacted how freely they felt able to respond. It was noted that the children's answers were relatively brief, which may reflect a reluctance to share their views openly and therefore presents a risk to the credibility of the findings. However, one cannot assume that the children did not express all of the opinions they wished to share.

The semi-structured interviews were complemented with a worksheet-style response form in which the researcher recorded the children's answers in front of them for transparency. Efforts were made to ensure that the questions were accessible to the children, and their perceptions were gathered simply by asking what they thought worked well and what they thought did not work well about the intervention. Before these interviews were completed, it was decided not to share the interview outline with school staff to prevent them from preparing children, which could have caused response bias.

While the initial semi-structured interview could have functioned as a pilot (Robson & McCartan, 2016), no adaptations were made following its implementation. As a result, the question concerning children's understanding of mathematical resilience, which some found difficult to answer, remained in subsequent interviews. Positioning the question on mathematical resilience at the very start of the interview may have impacted children's confidence, as it potentially could have felt testing or evaluative of their knowledge; relocating it later in the sequence could have fostered deeper reflections by allowing children to ease into the conversation. In retrospect, revising the interview schedule after the initial session may have improved clarity and supported children's confidence. The decision not to adapt the structure introduces a methodological limitation by potentially reducing the accessibility or depth of some of the children's responses.

Staff Focus Group. The potential for group dynamics to influence the focus group should be acknowledged, as it has implications for the credibility of the findings. Acknowledging potential power imbalances within the data collection process is important, both between the researcher and participants and among participants themselves. As the staff work closely together, the relationships between them and possible power dynamics could have affected their contributions (Ayrton, 2019; Robson & McCartan, 2016). The hierarchical dynamics within the focus group between teaching assistants (TA) and the class teacher, who was also a leader of mathematics, may have shaped what individuals felt comfortable sharing. Asymmetries between the TAs and the teacher's role could have influenced participants' willingness to express opposing views or critique the intervention openly. Additionally, the researcher's role as a trainee EP may have unintentionally affected participants' responses through perceived evaluative pressure or professional positioning. Therefore, perceived power dynamics may potentially impact the authenticity and comprehensiveness of focus group data, as contributions could be influenced or understated due to perceived hierarchical structures within the group setting (Robson & McCartan, 2016). While it was generally perceived during the focus group that each staff member had an equal opportunity to contribute, it remains challenging for the researcher to ascertain whether the influence of group dynamics shaped some viewpoints. The observation that all staff expressed similar perspectives might suggest the presence of bias; alternatively, it could reflect a genuinely shared perception of the intervention.

5.4.8 Researcher Role and Reflexivity

The perspectives, beliefs, and experiences of researchers can influence the research process and the interpretation of findings. The research was carried out through a lens of critical realism, with the researcher highlighting a real-world problem, mathematics anxiety (MA) in primary schools, and attempting to suggest a way to create a positive change (Kozhevnikov & Vincent, 2019). The researcher recognises that their background as a primary school teacher has likely shaped their views on the research topic. Their aspiration to identify a solution to the noted issue may also have affected their interpretation and the confirmability of the findings. For example, using Reflexive Thematic Analysis (RTA), which is completed only by the researcher, means that the themes identified have been influenced by the researcher's perspectives. However, the use of methodological triangulation, integrating quantitative and qualitative data, was hoped to counter this threat to validity (Robson & McCartan, 2016).

5.5 Implications of the Findings

5.5.1 Implications for Future Research

Based on the researcher's review of the literature, this study appears to be one of the first to explore and quantitatively investigate whole-class approaches to early intervention for supporting mathematical anxiety (MA) in primary school children in the UK. With the findings indicating a reduction in MA for some children, further research into this area would be beneficial to support the development of the intervention or make adaptations to the methodological approach used here. Future researchers may wish to conduct a larger-scale study across a range of schools to understand the application of this approach in other contexts. It is also worth considering that introducing the intervention described here with a younger cohort of children could be beneficial. Therefore, any of the research suggestions below could be explored with a younger age range. However, this may require the development of suitable measures for young children to accurately assess MA or decide on another measure of MA (e.g., avoidance).

In the current study, the qualitative phase alluded to the perception that the intervention had an impact on the factors of *growth* and *struggle* for children in the classroom. However, there did not appear to be reflections on the other component of MR, which is a belief that maths is valuable (*value*). During phase one of this study, a measure of self-report MR was gathered as a triangulation measure. Self-reported MR was calculated by combining scores across these three factors (*growth*, *struggle* and *value*). It was not within the scope of this study to conduct further analysis of these components at the individual level. However, it appears relevant to explore the possibility that the intervention did not have as much of an impact on children's beliefs about the *value* of maths. The rationale for this research would be to identify which components of MR are facilitated by the implementation of this intervention, which could inform the development of the intervention components and staff training to ensure all three areas of MR are addressed.

The current study used self-report measures of MA to evaluate the intervention's impact. However, acknowledging that self-reported MA may naturally fluctuate, an alternative investigation could be to explore children's views before and after the introduction of the intervention. This could use deductive methods of analysis to explore qualitative data that looks explicitly for predetermined themes suggested to be linked to MA. This could include looking for the concepts of a growth mindset, the value of the subject and a belief that anybody can find maths difficult, to draw conclusions about their level of mathematical resilience.

The perception of school staff that this intervention may have led to a reduction of avoidance behaviours in maths lessons indicates that further research would be beneficial to support this finding. Avoidance is one of the factors within Olango's (2016) cycle of mathematics anxiety, with anxiety and failure being the two other components. It would therefore be of interest to use measures of avoidance and experiences of failure in maths to see if this effect is captured.

During the discussion of the findings, it was interpreted that, based on the findings of Zhuo et al., (2025), some of the reduction in MA seen across the study could be associated with the perception that peer and teacher support increased. Given the view that the intervention may have influenced these perceptions, it would be worthwhile to explore them in further detail to help understand the mechanisms of the intervention and accurately support its implementation moving forward.

Finally, Johnston-Wilder et al. (2020) suggest that employing the strategies in their toolkit can enhance student attainment and self-efficacy. Due to the exploratory nature of the study and its scope, these outcomes were not evaluated as part of the current research. Based on the positive perceptions held of the intervention in this context, it would be worthwhile to extend the research to understand its effect on learning and success in mathematics.

5.5.2 Implications for Educational Settings including Schools

The study has several practical implications for schools and educational providers. The findings emphasise the importance of recognising and addressing mathematics anxiety (MA) as a widespread issue, not limited to specific attainment levels or demographic groups. It therefore calls for educators and school staff to have knowledge of MA, know how to identify it, and feel prepared to support children who may experience it. As discussed by Horne (2022), the researcher suggests that this warrants a whole-school approach whereby school leadership should explicitly recognise MA as a barrier to learning, allocate time in staff meetings to discuss MA and include MA reduction strategies within school development plans.

MA has been identified early in children's formal education (Maloney & Beilock, 2012; Petronzi et al., 2017). This study highlights the critical role practitioners could play in early years and primary settings. Practitioners should be aware of MA and the factors which influence its early development. Practitioners should also engage in reflective practice to understand how their own attitudes and classroom dynamics shape MA. Consequently, the researcher calls for enhanced professional learning for early years and primary educators to strengthen their universal provision for supporting MA; embedding practical tools and psychoeducational approaches, including the mathematical resilience (MR) intervention presented here, to identify and address MA from the very start of formal education.

As a formative assessment tool, the Growth Zone Model (GZM) (Johnston-Wilder et al., 2013), offers a practical way to capture children's emotional comfort alongside their mathematical understanding. This study demonstrated how the GZM facilitated the early identification and communication of MA, enabling timely support for children in mathematics. In addition, as highlighted by school staff in the context of this study, the whole-class intervention has the potential to lead to deeper reflections from staff about their teaching practice and enhance insight into the needs of their children in their classroom.

The staff training and intervention, which incorporated Johnston-Wilder et al.'s (2020) toolkit, were straightforward to implement and highly valued by the participants in this research, who expressed a keen interest in extending its application across subjects and year groups. These findings demonstrate the viability and practicality of adopting this toolkit for schools seeking to enhance their staff's knowledge base around MA. However, given the finding that school staff possess limited knowledge of MA (Io, 2023), the researcher recommends that its successful integration be supported by formal training or coaching from a knowledgeable professional.

5.5.3 Implications for Educational Psychologists' Practice

As highlighted in the literature review, there is currently a limited evidence base to support the use of universal approaches to support MA in UK primary schools, particularly concerning the evaluation of these methods using quantitative methods. With the majority of research papers identified for review (Section 2.6.6) being conducted outside of the UK or with secondary-aged children, this study aims to contribute to our understanding of how Educational Psychologists (EPs) could support primary schools at a systemic level to understand and support MA from the earliest years.

Some emerging evidence from both phases points to positive outcomes, including improvements in children's experiences of mathematics anxiety, associated with the whole-class intervention. EPs could, therefore, conduct further research that builds upon the evidence base to substantiate this finding and inform practice. It seems important to explore the efficacy of whole-class MR interventions across a broader range of settings and in earlier years to determine if they could be effective more widely. EPs could use this evidence to contribute to guidance and policy for the teaching and learning of mathematics through a lens of psychological theory. With the principles of Johnston-Wilder et al.'s (2020) toolkit being underpinned by psychoeducation, EPs appear well placed to do so.

Despite MA being a concern and early intervention being deemed as important (Ramirez et al., 2018), the finding that school staff have limited knowledge of the phenomenon positions EPs as pivotal in educating schools to inform their understanding (Io, 2023). This study emphasises the role of EPs in initiating discussions with school staff regarding the potential influence of MA on children in their schools. It appears important to promote MR tools, such as the application of the Growth Zone Model (GZM), which could assist staff in becoming more aware of when and who experiences MA. In phase two, it was found that the use of the GZM prompted a shift in educators' perceptions of their students. It encouraged them to challenge their assumptions about children who may be silently grappling with uncomfortable emotions or difficulties in mathematics. Thus, the study underscores the responsibility of EPs in collaborating with schools to inform staff of the importance of the role of the affective domain in maths on children's engagement with the subject. This is in line with the view that EPs can bridge the distance between the evidence base and real-world practice (Campbell & Green, 2022). Considering the five core functions of EP practice, this appears to be possible through staff training, consultation, and exploring the possibility that MA could be a hypothesis in their casework (Scottish Executive, 2002). Discussions with staff could include promoting early intervention and assessment of MA, as well as working with staff to support their awareness of and beliefs about MA.

The role of EPs seems to be branching away from individual casework, moving towards more systemic ways of working, with effective collaboration being established through the relationships EPs have built and their familiarity with the specific contexts and cultures of their schools (Moir, 2018). Regarding working systemically to support the implementation of interventions, the EP role is said to include discussing intervention options, preparing staff for change, evaluating the implementation of interventions, and promoting effective practices (Moir, 2018). Staff involved in this research felt that a whole-school approach to MA would be beneficial, which raises an opportunity for EPs to work collaboratively with schools at a systemic level. EPs could work with leadership teams to unpick the impact of MA in their setting and develop an appropriate response or intervention to meet their school's needs. This appears particularly important given the view that leadership are key to facilitating an ethos which responds effectively to MA for both their children and staff (Horne, 2022).

5.6 Researcher's Final Reflections

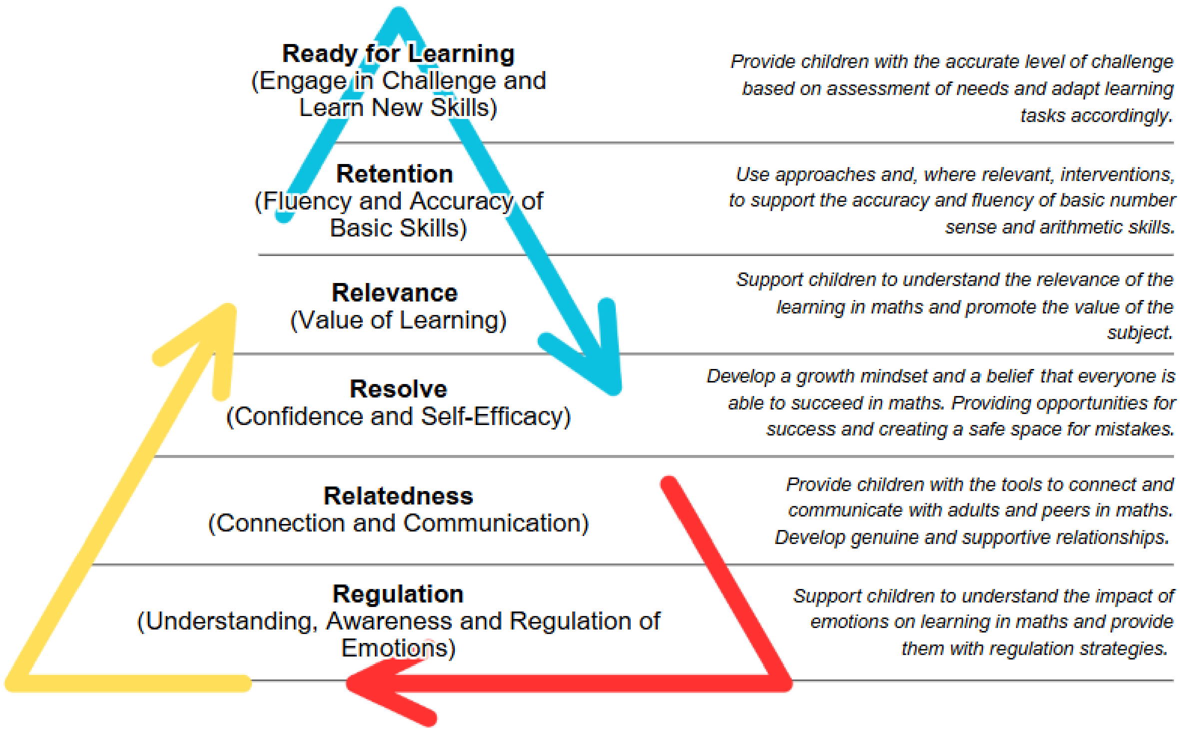
The current study employed a mixed-methods approach to explore the impact of introducing a mathematical resilience (MR) intervention in UK primary schools. I hope the findings will contribute to the evidence base in a way that raises awareness of MA in schools and will encourage other education professionals to consider whether promoting MR through an intervention such as this could support their learners.

I was initially hesitant regarding the successful implementation of the intervention, considering the whole-class approach. Nevertheless, the enthusiasm received from the staff and school leadership made the process of conducting this research both enjoyable and relatively smooth. This has prompted me to contemplate the impact of conducting research with a school that had an "open-door" and the influence of fostering positive relationships, which could enhance the apparent effectiveness of interventions when they are approached with complete dedication.

Conducting this research has led me to reflect that school staff's understanding, beliefs and approach to MA is essential when considering trying to reduce children's experiences of MA. The study has prompted me to consider developing a framework for building resilience in mathematics that incorporates the affective domain. It is proposed that such a framework or flow diagram could help teachers reflect on their teaching and learning culture, as well as how they respond to learners in math, based on the findings of this research. Reflecting on other psychological models, such as the instructional hierarchy (Haring et al., 1978) and Dr Bruce Perry's 3Rs (Regulate, Relate and Reason), and combined with the findings of the current study, I have proposed a model which intertwines them into a model for the teaching and learning of mathematics. I have presented this model in Figure 5. 1 with the view that the intervention implemented here predominantly focused on *regulation, relatedness* and *resolve* through the development of children's understanding and awareness of emotions in maths, fostering of peer and teacher support, and reflections on the teaching and learning culture. I am open to critique of the model and support in identifying and exploring relevant evidence-based approaches for each stage. Whilst it is represented as a hierarchy, it is acknowledged that this is not fixed and therefore, it is surrounded by arrows to indicate that at any stage, a learner may need to return to earlier stages of the model.

Figure 5. 1

6Rs of Building Resilience and Readiness to Learn in Mathematics



Note. A proposed model for building resilience and readiness to learn in mathematics

5.7 Dissemination

The Local Authority, where the TEP was on a bursary placement, has shown an interest in the TEPs future dissemination of the findings following the study's completion. The study findings will also be shared with the participating school including parents, carers and the participating children. During a discussion with the class teacher at the research school, it was shared that the intervention may be implemented across the setting in which the researcher would likely be asked to engage.

The researcher contacted Sue Johnston-Wilder, the author of the mathematical resilience toolkit, to discuss the concept of this study. The researcher appreciates Johnston-Wilder et al.'s, (2020) expertise in creating the toolkit and developing the GZM, and plans to share the findings with the authors.

5.8 Conclusion

The current study explored the implementation of a whole-class mathematical resilience intervention as an early intervention in primary schools to tackle mathematics anxiety. This intervention applied the principles of Johnston-Wilder et al.'s (2020) toolkit in which the authors had recognised that more research into its efficacy would be beneficial. The aim of this study was to contribute to the evidence base for the application of these tools in UK primary schools.

Based on the findings of phase one of this study, it was concluded that for children with initially high scores on a self-report measure of MA, the implementation of the intervention had a positive impact on MA in half of the focus cases. In the other cases, it was challenging to establish if any reductions in MA were related to the effects of the intervention due to an observed decrease in MA before the intervention's implementation or because of significant variability in the data.

Phase two of the study highlighted that the overall perception of staff and children was that the intervention's implementation had been successful in the classroom, with a positive impact on children's ability to communicate their needs, staff's ability to respond quickly to these, and children's regulation and behaviour for learning. Engagement in the intervention was also seen to lead to deeper reflections on the teaching and learning culture of the classroom. In addition, it was felt that the intervention was easy to implement, and it was hoped, in the context of this research, that the intervention could be implemented at a whole-school level.

5.8.1 Unique Contribution

The development of mathematical resilience (MR) in children has been argued to be crucial for enhancing mathematical well-being and mitigating mathematics anxiety (MA) (Johnston-Wilder et al., 2021). The literature review conducted in Chapter 2 of this research concluded that, of the studies identified for review, where an intervention had been implemented to reduce MA by promoting aspects of MR, an overall reduction in self-reported MA was observed (Cropp, 2017; Passolunghi et al., 2020; Samuel et al., 2023; Talaoc, 2019). However, all of these studies were conducted outside of the UK, and children with identified Special Educational Needs and Disability (SEND) were either excluded or not taken into account in the analysis. It was concluded that due to the heterogeneity of the studies, the scarcity of early intervention research in primary schools, and the lack of inclusion of children with identified SEND, this study would provide a unique contribution by exploring the impact of such an intervention universally in mainstream classrooms in UK primary schools.

This research aims to add to the evidence base of MR building approaches using Johnston-Wilder et al.'s (2020) toolkit, including the practical use of the Growth Zone Model (GZM). The study has found some evidence for a relationship between the application of the toolkit in a mainstream classroom and a reduction in children's MA. The findings add to the existing evidence base for promoting MR in mathematics and illustrate some effectiveness of using the tools, including the GZM, at a whole-class level in the context of a UK primary school.

Whilst the author recognises that the generalisability of these findings may be limited due to the small-scale nature of this study, it has added to the limited evidence base for the use of universal MA interventions in primary schools. It also has implications for EP practice and future research, building on the current understanding of how we can support children and young people with MA.

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Zhuo, X., Wang, Y., Xu, Y., Feng, H., Liu, C., Wang, Y., & Si, J. (2025). How students' math anxiety profiles change in primary school: The roles of teacher support, peer support and math attitudes. *British Journal of Educational Psychology*. https://doi.org/10.1111/bjep.12758

Appendices

Appendix A

Screening of Systematic Reviews

References screened from the systematic reviews of mathematics anxiety interventions; review of inclusion criteria and subsequent exclusion of reports

Systematic Review	Reference	Category	Reason for exclusion
Sammallahti et al., (2023)	Akeb-urai et al. (2020)	Emotion	Intervention design
	Akeb-urai et al. (2020) Group 2	Emotion	Intervention design
	Bander et al. (1982) Group 2	Emotion	Intervention design
	Collingwood & Dewey (2018)*	Emotion	Intervention design
	Ford et al. (2012)	Emotion	Measures
	Gregor (2005)	Emotion	Measures
	Hines et al. (2016)	Emotion	Intervention design
	Huang & Mayer (2016)	Emotion	Age of sample
	Huang & Mayer (2019)	Emotion	Age of sample
	Jamieson et al. (2016)	Emotion	Age of sample
	Khng (2017)	Emotion	Measures
	Kostka & Wilson (1986)	Emotion	Age of sample
	Mavilidi et al. (2020)	Emotion	Measures
	Mesghina & Richland (2020)	Emotion	*Included*
	Passolunghi et al. (2020)*	Emotion	*Included*

	Ramos Salazar (2019)	Emotion	Age of sample
	Samuel & Warner (2021)	Emotion	Age of sample
	Schneider & Nevid (1993)	Emotion	Age of sample
	Shobe et al. (2005)	Emotion	Age of sample
	Skryabina et al. (2016)	Emotion	Measures
	Stocker & Gallagher (2019)	Emotion	Age of sample
	Suinn & Richardson (1971)	Emotion	Age of sample
	Tassell et al. (2020)	Emotion	Participants
	Thompson et al. (2016)	Emotion	Measures
	Vance & Watson (1994) Group 2	Emotion	Age of sample
	Zettle (2003)	Emotion	Age of sample
Balt et al.,(2022)	Asanjarani and Zarebahramabadi (2021)	CBI	Intervention design
	Asikhia and Mohangi (2015)	CBI	Intervention design
	Brandenberger and Moser (2018)	CBI	*Included*
	Collingwood and Dewey (2018)*	CBI	Intervention design
	Hines et al. (2016)	CBI	Intervention design
	Kamann and Wong (1993)	CBI	Intervention design
	Karimi and Venkatesan (2009)	CBI	Intervention design
	Kim et al. (2017)	CBI	*Included*
	LaGue et al. (2019)	CBI	Intervention design
	Passolunghi et al. (2020)*	CBI	*Included*
	Ruark (2021)	CBI	Intervention design
	Ruff and Boes (2014)	CBI	Intervention design

	Sheffield and Hunt (2006)	CBI	Intervention design
	Singh (2016)	CBI	Intervention design

***Duplicates**

Appendix B

Studies Implementing Universal Approaches

Summary of studies applying universal approaches across two systematic reviews

Systematic Review	Reference	Sample	Design	Intervention	Main findings
Balt et al. (2022)	Brandenberger and Moser (2018)	N = 348 Adolescence (13-17 years)	Quasi-experimental (pre and post)	Combined workshops for students and teachers. The content included emotions, motivation, learning goals, cooperative learning, and feedback.	Lower MA scores following workshops but also in control group. Intervention group reported “higher joy of learning” than the control group and a group without teachers present.
	Kim et al. (2017)	n = 138 Adolescence (13–17 years)	Quasi-experimental (pre and post)	An embodied agent with instructional guidance and anxiety-treating messages (electronic intervention)	Both groups reported reduced MA and increased math performance

Sammallahti et al. (2023)	Mesghina & Richland (2020)	N = 250 Children (10 – 12 years)	Mixed methods, control group	Expressive writing	Expressive writing increased anxiety in all children
	Passolunghi et al. (2020)	N = 224 Children (9 years)	Quasi-experimental (pre and post)	Mathematics anxiety training (vs. Math strategy training)	MA training led to a reduction in MA but no effect on mathematics achievement

Appendix C

Review of Abstracts

Review of abstracts and subsequent exclusion of reports

Reference	Title	Year	Reason for exclusion
Adler (2024)	A Longitudinal Examination Of The Relations Between Motivation, Math Achievement, And STEM Career Aspirations Among Black Students.	2024	Intervention
Apostolidu (2023)	Breaking Through The Fear: Exploring The Mathematical Resilience Toolkit With Anxious FE Students	2023	Included for assessment of eligibility
Aydin (2022)	Profiles Of Academically Resilient Students: An Examination On Timss Mathematics Data.	2022	Intervention
Buckley (2023)	Reframing Anxiety And Uncertainty In The Mathematics Classroom	2023	Included for assessment of eligibility.
Caleon (2021)	Examining The Phenomenon Of Resilience In Schools: Development, Validation, And Application Of The School Resilience Scale.	2021	Intervention
Cassidy (2016)	The Academic Resilience Scale (ARS-30): A New Multidimensional Construct Measure.	2016	Study design
Chen (2019)	Effect Of Mobile Augmented Reality On Learning Performance, Motivation, And Math Anxiety In A Math Course.	2019	Intervention
Cline (2015)	Why Does Mathematics Make So Many People Fearful?	2015	Type of research paper

Cropp (2017)	Using Peer Mentoring To Reduce Mathematical Anxiety	2017	Included for assessment of eligibility.
Darin (2022)	Does Mathematical Resilience Address Mathematics Anxiety? A Measurement Validation Study For High School Students	2022	Included for assessment of eligibility.
Dowker (2016)	Mathematics Anxiety: What Have We Learned In 60 Years?	2016	Study design
Doz (2024)	The Interplay Between Ego-Resiliency, Math Anxiety And Working Memory In Math Achievement.	2024	Included for assessment of eligibility.
Eligio (2017)	Understanding Emotions In Mathematical Thinking And Learning.	2017	Study design
Goodall (2017)	The Emotions Experienced While Learning Mathematics At Home.	2017	Intervention
Griggs (2013)	The Responsive Classroom Approach And Fifth Grade Students' Math And Science Anxiety And Self-Efficacy.	2013	Intervention
Guzman (2021)	Psychometric Properties Of The Revised Child Mathematics Anxiety Questionnaire (CMAQ-R) For Spanish Speaking Children.	2021	Study design
Guzman (2023)	Effect Of Parents' Mathematics Anxiety And Home Numeracy Activities On Young Children's Math Performance-Anxiety Relationship.	2023	Study design
Hanin (2019)	Emotional And Motivational Relationship Of Elementary Students To Mathematical Problem-Solving: A	2019	Study design

	Person-Centered Approach.		
Hunt (2017)	Mental Arithmetic Performance, Physiological Reactivity And Mathematics Anxiety Amongst U.K. Primary School Children.	2017	Study design
Hunt (2022)	Appraisals Of Previous Math Experiences Play An Important Role In Math Anxiety.	2022	Included for assessment of eligibility.
Johansson (2023)	A Modeling Approach To Identify Academically Resilient Students: Evidence From Pirls 2016.	2023	Intervention
Johnston-Wilder (2013)	Developing Coaches For Mathematical Resilience	2013	Study design
Johnston-Wilder (2014)	Developing Coaches For Mathematical Resilience: Level 2	2014	Included for assessment of eligibility.
Johnston-Wilder (2015)	Developing Peer Coaching For Mathematical Resilience In Post-16 Students Who Are Encountering Mathematics In Other Subjects	2015	Included for assessment of eligibility.
Johnston-Wilder (2015)	Developing Mathematical Resilience In School-Students Who Have Experienced Repeated Failure	2015	Included for assessment of eligibility.
Johnston-Wilder (2016)	Developing Teaching For Mathematical Resilience In Further Education	2016	Included for assessment of eligibility.
Johnston-Wilder (2017)	Developing Teaching For Mathematical Resilience In Further Education: Development And Evaluation Of A 4-Day Course	2017	Included for assessment of eligibility.

Johnston-Wilder (2018)	Developing Mathematical-Resilience-Promoting Practices In Teachers	2018	Included for assessment of eligibility.
Kooken (2016)	Development And Validation Of The Mathematical Resilience Scale	2016	Study design
Kuldas (2015)	Malaysian Adolescent Students' Needs For Enhancing Thinking Skills, Counteracting Risk Factors And Demonstrating Academic Resilience.	2015	Intervention
Lee (2017)	The Construct Of Mathematical Resilience.	2017	Study design
Lee (2022)	Agency And Fidelity In Primary Teachers' Efforts To Develop Mathematical Resilience	2022	Included for assessment of eligibility.
Lee (2024)	Remembering Learning Mathematics - We Can Run But We Can't Hide	2024	Study design
Liu (2020)	Chinese Adolescents' Belief In A Just World And Academic Resilience: The Mediating Role Of Perceived Academic Competence.	2020	Intervention
Lovelace (2023)	Does Mathematical Resilience Address Mathematics Anxiety? A Measurement Validation Study For High School Students.	2023	Included for assessment of eligibility.
Lugalia (2013)	The Role Of Ict In Developing Mathematical Resilience In Learners	2013	Included for assessment of eligibility.
Luttenberger (2018)	Spotlight On Math Anxiety.	2018	Study design
Mutaf-Yildiz (2020)	Probing The Relationship Between Home Numeracy And Children's Mathematical Skills: A Systematic Review.	2020	Intervention

Öztürk (2022)	Middle School Students' Mathematical Resilience And Perceptions Of Mathematics: A Cluster Analysis Approach	2022	Study design
Passolunghi (2020)	Math Anxiety And Math Achievement: The Effects Of Emotional And Math Strategy Training.	2020	Included for assessment of eligibility.
Pieronkiewicz (2020)	How Can Parents And Elementary School Teachers Promote Resilience In Young Children Through Mathematical Conversations?	2020	Included for assessment of eligibility.
Pulungan (2022)	Mathematical Resilience: How Students Survived In Learning Mathematics Online During The COVID-19 Pandemic	2022	Study design
Ricketts (2017)	Development And Validation Of A Scale To Measure Academic Resilience In Mathematics.	2017	Study design
Ryan (2024)	Connectedness Within The Statistics Classroom.	2024	Intervention
Salvo-Garrido (2020)	Resilient Students In The Area Of Mathematics: Examining Protective And Risk Factors In An Emerging Country.	2020	Study design
Samuel (2023)	'I Can Math, Too!': Reducing Math Anxiety In STEM-Related Courses Using A Combined Mindfulness And Growth Mindset Approach (MAGMA) In The Classroom	2023	Included for assessment of eligibility.
Sandilos (2020)	English Learners' Achievement In Mathematics And Science: Examining The Role Of Self-Efficacy.	2020	Intervention

Sandoval-Hernandez (2016)	Factors And Conditions Promoting Academic Resilience: A TIMSS-Based Analysis Of Five Asian Education Systems.	2016	Intervention
Sedat (2024)	A Moderated Mediation Analysis On The Relationship Between Metacognition And Mathematical Resilience Of Gifted Students	2024	Study design
Shen (2016)	The Relation Between College Students' Academic Mindsets And Their Persistence During Math Problem Solving.	2016	Study design
Suarez-Pellicioni (2021)	Neurocognitive Mechanisms Explaining The Role Of Math Attitudes In Predicting Children's Improvement In Multiplication Skill.	2021	Study design
Szczygiel (2020)	When Does Math Anxiety In Parents And Teachers Predict Math Anxiety And Math Achievement In Elementary School Children? The Role Of Gender And Grade Year.	2020	Intervention
Talaoc (2020)	Attending To The Affective Domain: Mathematics In A Suburban Community College.	2020	Included for assessment of eligibility.
Throndsen (2022)	Does Mathematics Anxiety Moderate The Effect Of Problem Difficulty On Cognitive Effort?	2022	Intervention
Weissgerber (2022)	The Interplay Of Math Anxiety And Math Competence For Later Performance.	2022	Intervention

Appendix D

Assessment for Eligibility

Full paper accessed and assessed for eligibility

Research paper	**Eligible (Y/N)**	**Assessment**
Apostolidu, M., & Johnston-Wilder, S. (2023). Breaking through the fear: exploring the mathematical resilience toolkit with anxious FE students. *Research in Post-Compulsory Education*, *28*(2), 330–347. https://doi-org.nottingham.idm.oclc.org/10.1080/13596748.2023.2206704	N	2. Study design The study did not reflect upon a MR intervention's impact on mathematics anxiety
Buckley, S., Sullivan, P. Reframing anxiety and uncertainty in the mathematics classroom. *Math Ed Res J* **35** (Suppl 1), 157–170 (2023). https://doi-org.nottingham.idm.oclc.org/10.1007/s13394-021-00393-8	N	2. Study design The study did not reflect upon a MR intervention's impact on mathematics anxiety
~~Darin (2022). *Does Mathematical Resilience Address Mathematics Anxiety? A Measurement Validation Study for High School Students* (Doctoral dissertation, California State University, Sacramento).~~ See Lovelace (2022)	~~Y~~	*Duplicate – Author's name is incorrect*
Cropp, I. (2017). Using peer mentoring to reduce mathematical anxiety. *Research Papers in Education*, *32*(4), 481–500. https://doi-org.nottingham.idm.oclc.org/10.1080/02671522.2017.1318808	Y	

Doz, E., Cuder, A., Pellizzoni, S. *et al.* The interplay between ego-resiliency, math anxiety and working memory in math achievement. *Psychological Research* (2024). https://doi-org.nottingham.idm.oclc.org/10.1007/s00426-024-01995-0	N	1. Intervention The study explores the role of ego-resiliency on attainment as opposed to MR
Hunt, T. E., & Maloney, E. A. (2022). Appraisals of previous math experiences play an important role in math anxiety. *Annals of the New York Academy of Sciences*, *1515*(1), 143-154.	Y	
Johnston-Wilder, S., Lee, C., Garton, E., & Brindley, J. (2014). Developing coaches for mathematical resilience: Level 2. *CERI2014 Proceedings*, 4457-4465.	N	3. Type of research paper Conference paper. Unclear as to whether the article is peer reviewed
Johnston-Wilder, S., Lee, C., Brindley, J., & Garton, E. (2015). Developing peer coaching for mathematical resilience in post-16 students who are encountering mathematics in other subjects. *ICERI2015 Proceedings*.	N	3. Type of research paper Conference paper. Unclear as to whether the article is peer reviewed
Johnston-Wilder, S., Lee, C., Brindley, J., & Garton, E. (2015). Developing mathematical resilience in school-students who have experienced repeated failure.	N	3. Type of research paper Conference paper. Unclear

		as to whether the article is peer reviewed
Johnston-Wilder, S., Pardoe, S., Almehrz, H., Evans, B., Marsh, J., & Richards, S. (2016). Developing teaching for mathematical resilience in further education. *ICERI2016 Proceedings*, 3019-3028.	N	3. Type of research paper Conference paper. Unclear as to whether the article is peer reviewed
Johnston-Wilder, S., Pardoe, S., Marsh, J., Almehrz, H., Evans, B., & Richards, S. (2017). Developing teaching for mathematical resilience in further education: Development and evaluation of a 4-day course. ICERI2017 Proceedings.	N	3. Type of research paper Conference paper. Unclear as to whether the article is peer reviewed
Johnston-Wilder, S., & Moreton, J. (2018). Developing mathematical-resilience-promoting practices in teachers. In *ICERI2018 Proceedings* (pp. 8228-8237). IATED.	N	3. Type of research paper Conference paper. Unclear as to whether the article is peer reviewed
Lee, C., & Ward-Penny, R. (2021). Agency and fidelity in primary teachers' efforts to develop mathematical resilience. *Teacher Development*, *26*(1), 75–93. https://doi-org.nottingham.idm.oclc.org/10.1080/13664530.2021.2006768	N	2. Study design Does not reflect on the impact of MR

		intervention on MA
Lovelace, D. R. (2022). *Does Mathematical Resilience Address Mathematics Anxiety? A Measurement Validation Study for High School Students* (Doctoral dissertation, California State University, Sacramento).	Y	
Lugalia, M., Johnston-Wilder, S., & Goodall, J. (2013). The role of ICT in developing mathematical resilience in learners. In *INTED2013 Proceedings* (pp. 4096-4105). IATED.	N	3. Type of research paper Conference paper. Unclear as to whether the article is peer reviewed
Passolunghi, M. C., De Vita, C., & Pellizzoni, S. (2020). Math anxiety and math achievement: The effects of emotional and math strategy training. *Developmental science*, *23*(6), e12964.	Y	
Pieronkiewicz, B., & Szczygieł, M. (2019). How can parents and elementary school teachers promote resilience in young children through mathematical conversations? *Early Child Development and Care*, *190*(10), 1604–1618. https://doi-org.nottingham.idm.oclc.org/10.1080/03004430.2019.1647189	Y	
Samuel, T. S., Buttet, S., & Warner, J. (2022). "I Can Math, Too!": Reducing Math Anxiety in STEM-Related Courses Using a Combined Mindfulness and Growth Mindset Approach (MAGMA) in the Classroom. *Community College Journal of Research and Practice*, *47*(10), 613–626. https://doi-org.nottingham.idm.oclc.org/10.1080/10668926.2022.2050843	Y	*Does not refer to MR specifically but applies 'Growth Mindset' and mindfulness approach which are both*

		elements of the toolkit which is said to promote MR. *(Published online 2022)*
Talaoc, J. J. (2019). *Attending to the affective domain: Mathematics in a suburban community college* (Doctoral dissertation, California State University, Los Angeles).	Y	

Appendix E

Preliminary synthesis

Summary of studies included for review

Author/s (Year of publication) and Title	Location and setting	Participants	Study Design	Summary	Outcome measures	Findings
Cropp (2017)	England, UK Secondary school	5 female students (Aged 11 – 15 years) Peer mentors (Total unknown) (Aged 16 – 17 years)	Case study design	The study explored if peer mentors could help reduce mathematical anxiety. Five female students, aged 11 to 15, who were labelled by their teachers as mathematically anxious, were paired with female peer mentors, aged 16 to 17, to take part in four intervention. The mentors' role was to provide support and demonstrate strategies for overcoming challenges, to enhance the students' mathematical resilience and decrease their mathematical anxiety. Intervention:	<u>Qualitative</u>: Data was collected using semi-structured interviews. This was supplemented with pre and post questionnaires and feedback sheets collected at the end of each peer mentoring session.	<u>Qualitative:</u> Three out of four participants reported reduced MA and all participants were said to express a positive attitude about the peer mentoring. The findings suggested that MA improved after the peer mentoring intervention, though this increased for one student. This was argued to possibly be due to an increased awareness of their anxiety.

Author/s (Year of publication) and Title	Location and setting	Participants	Study Design	Summary	Outcome measures	Findings
				Peer mentors were instructed to model a positive attitude to getting stuck, model how to seek out resources before asking for help and told to allow their students to take their time.		
Hunt & Maloney (2022)	UK Online	308 adult participants (229 females, 76 males) Mean age = 27.56 years 92% of participants were based in the UK People with dyscalculia	Survey	The study surveyed adult participants online to assess self-reported measures of: 1. math anxiety 2. mathematical resilience 3. math attitudes 4. appraisal of previous math experiences.	Quantitative: 'Appraisals of Previous Mathematics Experiences Scale' was used to assess an appraisal of their previous maths experiences. This scale was devised specifically for the study and comprised on 24-items. 'Mathematics Anxiety Scale-UK' is a 23-item self-report measure to assess an	Quantitative: The data was analysed using a series of Pearson's bivariate correlations and mediation analyses. All variables were found to be related. Math anxiety was significantly and negatively related to mathematical resilience.

Author/s (Year of publication) and Title	Location and setting	Participants	Study Design	Summary	Outcome measures	Findings
		were excluded from the study			individuals mathematics anxiety. 'Mathematical Resilience Scale' was used to measure an individuals mathematical resilience as well as their growth mindset beliefs. 'Attitudes Towards Mathematics Scale' was used to assess an individuals attitudes toward mathematics.	
(Lovelace, 2022)	United States American High School, private and religiously affiliated	1, 057 young people Grades 9 – 12	Cross-sectional survey design	In this study, a mathematical resilience scale was tested. The research aimed to determine if mathematical resilience could be assessed based on students' attitudes towards math, their perspective on overcoming challenges in learning math, and their belief in their ability to improve their mathematical understanding; *value, struggle* and *growth*. Additionally, the study investigated whether mathematical resilience could help address negative attitudes	<u>Quantitative</u>: Mathematical Resilience Scale (Kooken et al., 2016) Mathematics Anxiety Scale (Betz, 1978)	<u>Quantitative</u>: Hypotheses were tested using a full structural equation model. The study that factors of mathematical resilience (growth, struggle and value) correlate negatively with mathematics anxiety. MR as a combined construct of all three factors had a significant negative correlation with measures of mathematics anxiety.

Author/s (Year of publication) and Title	Location and setting	Participants	Study Design	Summary	Outcome measures	Findings
				towards math. The study also tested relationships between mathematical resilience, mathematics anxiety, and outcomes.		The pupils beliefs about the value of math and their growth mindset in math also correlate significantly and negatively with adverse feelings about math.
(Passolunghi et al., 2020)	Italy School-based	224 children (116 female, 108 male) 9 years Native Italian speakers	Pretest-posttest quasi-experimental design	This study administered two different training programmes to primary school aged children. The delivered MA training (worked on recongising and coping with feelings association with MA) and Math strategy training (worked on calculation strategies). They also had a third group receiving Control training. The researchers evaluated the impact of these training methods on anxiety, MA and math achievement. <u>Intervention</u>: Sessions 1 – 2: Knowledge and recognition of emotions – asked to complete activities to help them recognise different emotions including states of arousal	<u>Quantitative</u>: The Revised Children's Manifest Anxiety Scale—Second Edition (RCMAS- 2; Reynolds, Richmond, Sella, Scozzari, & Di Pietro, 2012) The Abbreviated Math Anxiety Scale (AMAS; Caviola, Primi, Chiesi, & Mammarella, 2017; Hopko, Mahadevan, Bare, & Hunt, 2003) Mathematical ability was evaluated using the MATM3 test (from Amoretti, Bazzini, Pesci, & Reggiani, 2007)	<u>Quantitative</u>: Quantitative findings were analysed using a multivariate analysis of covariance (MANCOVA). The study's results found that MA training resulted in a reduction in MA. It did not appear to impact on math performance. Math strategy training also resulted in a reduction of MA but also saw improvement in math achievement.

Author/s (Year of publication) and Title	Location and setting	Participants	Study Design	Summary	Outcome measures	Findings
				Sessions 3 – 4: Activities to show the importance of math in the real world and the effect of the subject on people's emotions in school. Sessions 5,6 and 7: Introduced strategies to support the reduction of MA; deep breathing, visualisation, and reframing negative thoughts (based on CBT). Session 8: Recap		
(Samuel et al., 2023)	United States Community College	157 students (81 female, 76 male) Mean age = 18 years, 7 months STEM students	Mixed methods (pretest-posttest quasi-experimental design)	The study explored the impact of a mindfulness and growth mindset approach (MAGMA) on reducing math anxiety. They delivered the MAGMA approach training to teaching staff who then delivered the MAGMA intervention for a US semester. Intervention: Videos to illustrate concepts of mindfulness and a growth mindset were shown to the	Quantitative: The brief Abbreviated Math Anxiety Scale (AMAS; Hopko et al., 2003) A 34-item revised Math Self-Efficacy Scale (MSES; Betz & Hackett, 1983). Qualitative: The researchers conducted both student and instructor	Quantitative: Within-groups analysis was conducted with a paired samples t-test and the nonparametric Wilcoxon signed-ranked test. Results indicated that the group receiving the MAGMA intervention, in comparison to a control group, saw a considerable decline in math anxiety scores.

Author/s (Year of publication) and Title	Location and setting	Participants	Study Design	Summary	Outcome measures	Findings
				participants. At the start of each lesson, participants were encouraged to take part in a guided breathing exercise. Teachers then encouraged students to say aloud growth mindset statements. Teachers were also encouraged to remind students of the relaxation strategies and growth mindset beliefs throughout their lessons. They were also instructed to reframe fixed mindset statements.	(teacher) focus groups. They completed semi-structured interview. Students were asked to reflect on their math anxiety and self-efficacy over the course of the semester. Instructors were asked to reflect on the effectiveness of the intervention for their students.	Paired samples t-test showed that in the intervention condition females' math anxiety scores decreased significantly at post-test. However, there was no significant difference found for males. . <u>Qualitative</u>: The themes which came from the student focus groups were '*deep breathing reduces maths anxiety and helps to persist', 'mindfulness is helpful outside of class*' and '*saying growth mindset affirmations gave them confidence'*. The themes which came from the focus groups with instructors were '*importance of routine for implementing the MAGMA intervention', 'importance of mindfulness for*

Author/s (Year of publication) and Title	Location and setting	Participants	Study Design	Summary	Outcome measures	Findings
						both students' and instructors' benefit', and *'importance of growth mindset affirmations and student enthusiasm'.*
(Talaoc, 2019)	United States Community College	134 students (84 female, 43 male) 12 students (interviewed) Mean age = 24.36 (18 – 59 years old)	Mixed methods	The study sought to analyse the relationships between mathematical anxiety, mathematical resilience, and mathematical performance. The impact of an affective domain intervention on mathematical anxiety and mathematical resilience were also explored. The study comprised of both survey findings and semi-structured interviews at follow-up. Affective domain interventions were embedded within the initial pre-test survey. Intervention: ADIs targeted growth mindset, productive struggle, and personal future value.	Quantitative: A 36-item survey was designed to capture mathematical anxiety and mathematical resilience. This included the: Mathematical Resilience Scale (MRS) (Kooken et al., 2016) Abbreviated Mathematical Anxiety Scale (AMAS) (Hopko, Mahadevan, Bare, & Hunt, 2003) Qualitative: A semi-structured interview with questions designed to	Quantitative: Paired samples t-tests were carried out to analyse the data. The study found a significant increase in mathematical resilience (MRS) scores and a significant decrease in mathematics anxiety (AMAS) scores between pre and post survey. Qualitative: Data was analysed using a prefigured coding scheme. The themes which came from the interviews were ' *Mathematical Anxiety and Its Impact*', ' *Practices that promote mathematical*

Author/s (Year of publication) and Title	Location and setting	Participants	Study Design	Summary	Outcome measures	Findings
					explore students' perceptions of mathematics, instructional practices, and their current class. Classroom observations were also carried out to complement the qualitative data.	*resilience'* and '*Curriculum and instructional practices that impact student success'*. Their findings suggested that students felt practices which promoted a value of maths, having a growth mindset, and a belief that struggle is productive helped to build mathematical resilience. They also reported that affective domain interventions are beneficial.

Appendix F

Study Appraisals

Study Appraisals Using the MMAT Quality Appraisal Tool

Author/s (Year of publication)	Study design	Methodological quality criteria	Response				Quality score (% of quality criteria met)
			Yes	No	Can't tell	Comments	
(Cropp, 2017)	Screening questions	S1. Are there clear research questions?	✓				***** (100%)
		S2. Do the collected data allow to address the research questions?	✓				
	Qualitative	1.1. Is the qualitative approach appropriate to answer the research question?	✓				
		1.2. Are the qualitative data collection methods adequate to address the research question?	✓				
		1.3. Are the findings adequately derived from the data?	✓				
		1.4. Is the interpretation of results sufficiently substantiated by data?	✓				
		1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?	✓				
(Hunt & Maloney, 2022)	Screening questions	S1. Are there clear research questions?	✓			.	**** (80%)
		S2. Do the collected data allow to address the research questions?	✓				
	Quantitative descriptive	4.1. Is the sampling strategy relevant to address the research question?	✓				
		4.2. Is the sample representative of the target population?	✓				
		4.3. Are the measurements appropriate?	✓				
		4.4. Is the risk of nonresponse bias low?		✗		The majority of participants were female students or graduates. This was an opportunistic sample through advertisement on social media at a UK university and therefore there is scope for	

						nonresponse bias from different populations.	
		4.5. Is the statistical analysis appropriate to answer the research question?	✓				
Lovelace (2022)	Screening questions	S1. Are there clear research questions?	✓				**** (60%)
		S2. Do the collected data allow to address the research questions?	✓				
	Quantitative descriptive	4.1. Is the sampling strategy relevant to address the research question?	✓				
		4.2. Is the sample representative of the target population?		✗		Limitations recognise the sample population is impacted by the demographics of the setting where the study took place	
		4.3. Are the measurements appropriate?	✓				
		4.4. Is the risk of nonresponse bias low?		✗		Missing data in the data set appears in a pattern and some consecutive sequences of responses are missing for some participants.	
		4.5. Is the statistical analysis appropriate to answer the research question?	✓				
(Passolunghi et al., 2020)	Screening questions	S1. Are there clear research questions?	✓				***** (100%)
		S2. Do the collected data allow to address the research questions?	✓				
	Quantitative non-randomised	3.1. Are the participants representative of the target population?	✓				
		3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	✓				
		3.3. Are there complete outcome data?	✓				
		3.4. Are the confounders accounted for in the design and analysis?	✓			The study refers to the investigation of the differences between groups at pre-testing.	

		3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	✓				
(Samuel et al., 2023)	Screening questions	S1. Are there clear research questions?	✓				** (20%)
		S2. Do the collected data allow to address the research questions?	✓				
	Mixed Methods	5.1. Is there an adequate rationale for using a mixed methods design to address the research question?	✓				
		5.2 Are the different components of the study effectively integrated to answer the research question?	✓			Addressed in discussion.	
		5.3 Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	✓				
		5.4 Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	✓				
		5.5 Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	✗				
	Qualitative non-randomised	3.1. Are the participants representative of the target population?	✓				
		3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	✓				
		3.3. Are there complete outcome data?	✗			69% response rate due to incomplete survey data	
		3.4. Are the confounders accounted for in the design and analysis?			✗	No evidence that confounding variables other than gender have been considered	
		3.5. During the study period, is the intervention administered (or exposure occurred) as intended?			✗	2 classes were excluded from the study due to lack of student participation and refusal to complete post-test measures. No mention of intervention fidelity.	
	Qualitative	1.1. Is the qualitative approach appropriate to answer the research question?	✓				
		1.2. Are the qualitative data collection methods adequate to address the research question?	✓				
		1.3. Are the findings adequately derived from the data?	✓				

		1.4. Is the interpretation of results sufficiently substantiated by data?			✗	One quote is provided for each theme for a single student	
		1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?	✓				
(Talaoc, 2019)	Screening questions	S1. Are there clear research questions?	✓				
		S2. Do the collected data allow to address the research questions?	✓				
	Mixed methods	5.1. Is there an adequate rationale for using a mixed methods design to address the research question?	✓				
		5.2 Are the different components of the study effectively integrated to answer the research question?	✓				
		5.3 Are the outputs of the integration of qualitative and quantitative components adequately interpreted?	✓			Themes and transcript coding.	**** (80%)
		5.4 Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	✓			Sufficient use of quotes to support themes.	
		5.5 Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	✓				
	Qualitative non-randomised	3.1. Are the participants representative of the target population?	✓				
		3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	✓				
		3.3. Are there complete outcome data?	✓				
		3.4. Are the confounders accounted for in the design and analysis?	✓				
		3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	✗			Unable to conduct quasi-experimental design (with control) due to changes in the setting	
	Qualitative	1.1. Is the qualitative approach appropriate to answer the research question?	✓				
		1.2. Are the qualitative data collection methods adequate to address the research question?	✓				
		1.3. Are the findings adequately derived from the data?	✓				
		1.4. Is the interpretation of results sufficiently substantiated by data?	✓				

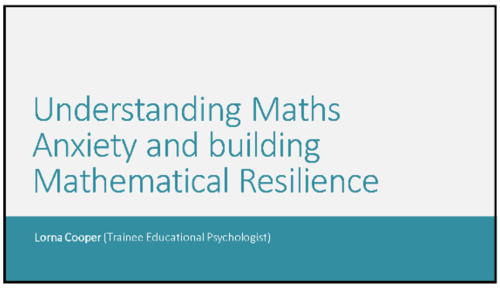
		1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?	✓			There is cross-validation of quantitative and qualitative findings	

✓ = indicates that criteria were met, ✗ = indicates that criteria were not met or cannot tell,

= indicates that questions were not considered

Appendix G

Training Slides for School Staff



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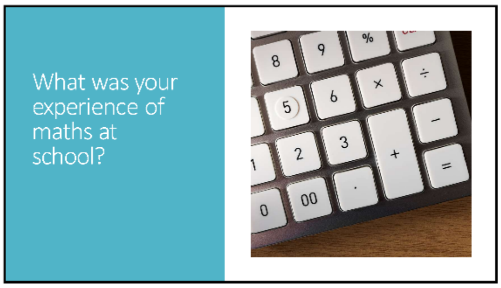

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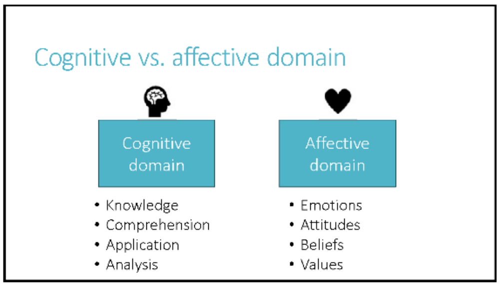

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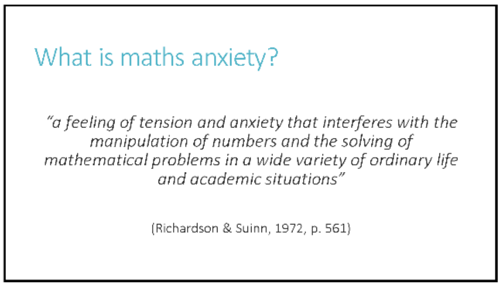

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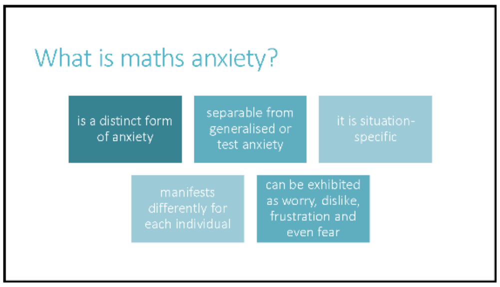

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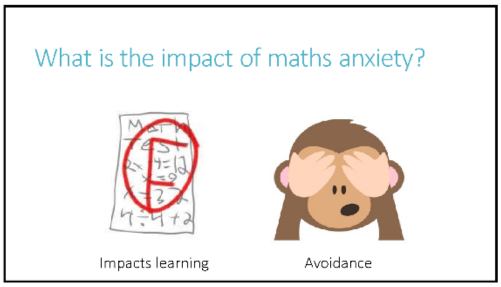

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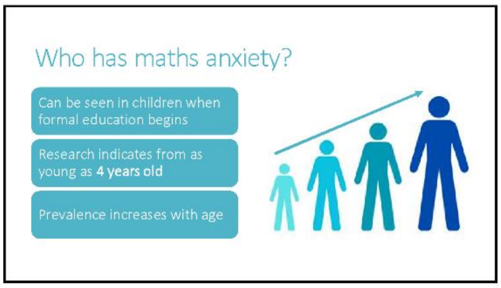

Who has maths anxiety?
Can be seen in children when formal education begins
Research indicates from as young as 4 years old
Prevalence increases with age

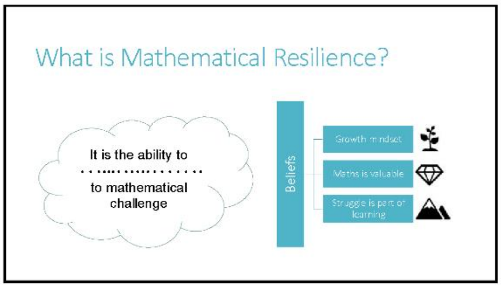
7


Explaining Anxiety to children
FIGHT
FREEZE
FLIGHT

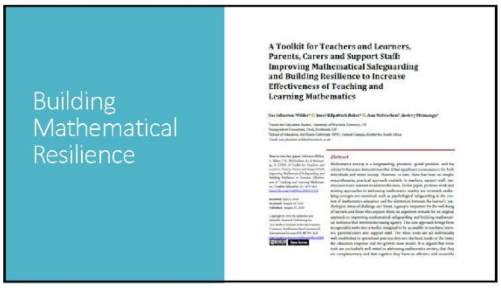
8


Mathematical Resilience

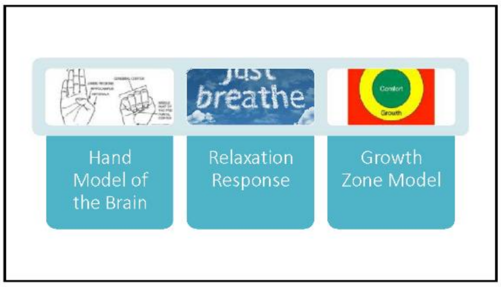
9


What is Mathematical Resilience?
It is the ability to
....
to mathematical challenge
Beliefs
Growth mindset
Maths is valuable
Struggle is part of learning

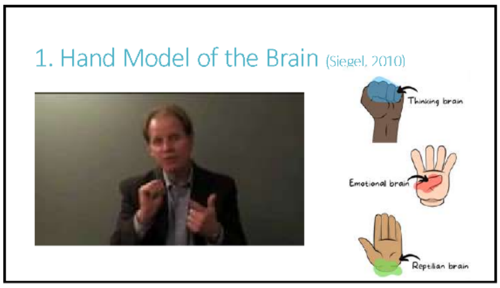
10


Building Mathematical Resilience
A Toolkit for Teachers and Learners, Parents, Carers and Support Staff: Improving Mathematical Safeguarding and Building Resilience to Increase Effectiveness of Teaching and Learning Mathematics

11


breathe
Hand Model of the Brain
Relaxation Response
Growth Zone Model

12



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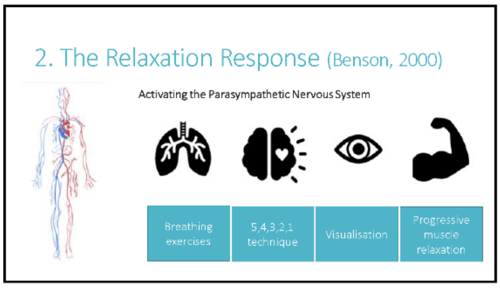

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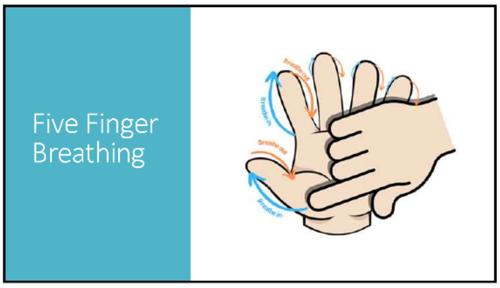

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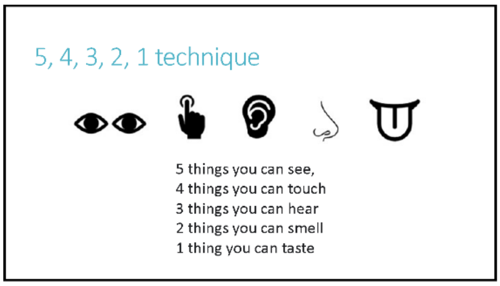

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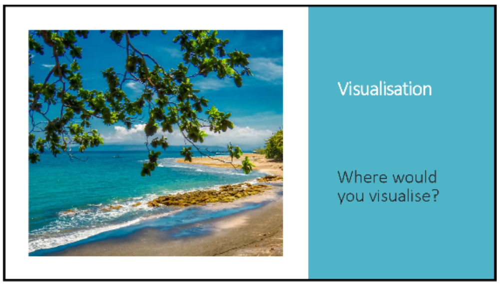

18

Progressive Muscle Relaxation

19

"When arousal is too high, a child's performance deteriorates, and they experience physical and emotional distress. Mastery experiences are less likely, and the child is vulnerable to repeated failure in their efforts to complete daily tasks. The result is that their **self-confidence is undermined** and their **ability to cope with adversity is reduced**. In contrast, if we can maintain a child's arousal in the middle part of the range, they are more likely to perform at their best, to have mastery experiences and to feel capable and competent when faced with adversity. So, in order to **promote resilience in children we need to understand the relationship between arousal and performance**, and to implement strategies to maintain optimum levels of arousal."

(Pearce, 2011)

20

3. The Growth Zone Model

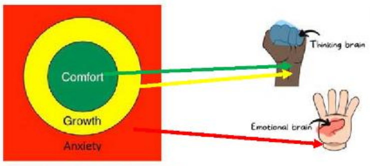

Figure 2. Growth zone model (Johnston-Wilder et al., 2013).

21

Comfort Zone	Learning/Growth Zone	Anxious/Uncomfortable Zone
Comfortable Relaxed Confident	Challenge Some discomfort	Threatened /Scared Stressed/Angry Hopeless
• Working on a familiar task • Can complete task independently	• New learning happens • Mistakes are made • Require support	• No learning takes place • Learning is not within the learners perceived reach

22

A metaphor for the model

23

Growth Zone

Teachers

- Allow time for mistakes
- Allow for collaborative working
- Give time for questions

Children

- Underline unfamiliar words
- Access resources
- Talk to a peer
- Ask the teacher questions

24

Uncomfortable Zone

Teachers

- Coregulate
- Review the task
- Adaptive teaching

25

Using GZM in practice

Using a hard copy of the GZM and counters to enable year 5 pupils to show which zone they were currently in. A teacher reported:

initially … it was always the red and I can't do it, I can't do it, I don't understand it, this is too much too hard … and slowly just from the little steps we were doing, so it might be using the resources, explaining the vocabulary… offering strategies to support each other so how can we help each other? … her counter slowly got into the [orange] … she will always now ask for the challenge. (p. 8232)

(Johnston-Wilder & Moreton, 2018)

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Child voice

Because I was really stuck on what to do, and … I just had no idea and I was really confused, and so then I realised that I felt like I was about to go into brain freeze, and then I did the breathing … it really helped … when my brain freezes, I now know how to get it back, and be able to carry on with my work.

27

Introducing the toolkit to your class

28

Thank you!

Questions?

29

Appendix H

Overview of Mathematical Resilience Lesson Plan for Year 4

Objective:

Students will understand the concept of mathematical resilience, recognise emotional responses to math challenges, and learn strategies to manage these emotions.

Lesson Outline:

1. Introduction

- Discuss the idea of mathematical resilience.
- Pose the essential questions:
  - What is mathematical resilience?
  - Why do some people feel uncomfortable with math?
  - How can we manage these emotions?

2. Emotional Awareness Activity

- Have students write down as many emotions as they can (one per post-it note).
- Discuss:
  - Are these emotions comfortable or uncomfortable?
  - What physical reactions might accompany these emotions?
- Link this to how students may feel in math class.

3. Hand Brain Model

- Introduce the Hand Brain Model:
  - Thinking Brain vs. Emotional Brain vs. Reptile Brain.
  - Explain "flipping our lid"—how panic/anxiety affects learning.

4. Coping Strategies/Relaxation Response

- Teach relaxation techniques e.g.,:
  - Five Finger Breathing
  - Guided breathing exercise
- Explain how relaxation helps our Thinking Brain regulate ready for learning.

5. Growth Zone Model

- Introduce the Comfort Zone, Growth Zone, and Uncomfortable Zone.
- Have students indicate where they feel during math lessons.
- Discuss how being in the Growth Zone means learning is happening! It means that we are being challenged but within our ability to do so.

6. Reflection & Discussion

- “Tell your partner one thing you learned today.”
- Whole-class discussion: How can we apply these strategies in future math lessons?

Follow-up:

- Informal check-ins on emotions and zones during future lessons.
- Student reflections on coping strategies used in math challenges.
- Revisit the principles of the toolkit pro-actively.

Appendix I

Teacher's email response to the pilot

I have gone through the pilot stuff that you sent me with children in my class. They had some very interesting feedback!

1. Show three or four of Year 4 children the Growth Zone Model scale and ask if they think a counter or white board pen dot would be best.

- Children said that they would probably lose their counter so wouldn't want to use one.
- Children said that they wouldn't mind using a whiteboard pen but were worried about what would happen if they didn't have one or if it had run out.
- One child suggested using a small wooden pen with initials or name so they wouldn't get lost and the children really liked that idea. They said they would feel happy with a peg because they could keep the Growth Zone Model and the peg together and we would all know which one belonged to us. They liked the idea of having something that they own and don't have to share.

---

2. Read out the statements I have attached to this email to your class. All I would need is for the statements to be read out to your current Year 4s and for you to ask them if they understand them. Could you also time how long it takes for you to read the statements. If there are any statements they don't understand, can you highlight these/or make some notes and then we will can back together to discuss.

1.

1. Having to complete a worksheet by yourself.
2. Thinking about a maths test the day before you take it.
3. Watching the teacher work out a maths problem on the board.
4. Taking a maths test.
5. Being given maths homework with lots of difficult questions that you have to hand in the next day.
6. Listening to the teacher talk for a long time in maths.
7. Listening to another child in your class explain a maths problem.
8. Finding out you are going to have a surprise maths quiz when you start your maths lesson.
9. Starting a new topic in maths.

<u>How long did it take you to read these statements to your class?</u>

3-4 minutes

<u>Were there any questions they did not understand? (Please number)</u>

7-Children thought that a child would be teaching them how to solve a problem rather than us having a discussion. I mentioned using talk partners and cold calling as more of a discussion of a problem and they understood that more. This might be context specific.

<u>Any other comments:</u>

-Children already started to have some reactions to the statements about tests and homework!

2.

1. Maths will help me when I grow up
2. If you can't do maths now, you will never be able to
3. Everyone finds maths tricky sometimes
4. I will need maths when I grow up
5. Children who are good at maths find some of the questions tricky
6. You can't change whether you are good or bad at maths
7. Everyone gets things wrong sometimes when they are doing maths
8. Maths will help me
9. People who are good at maths might not get all the answers right
10. Some people can't learn maths
11. Only clever people can do maths
12. People in my class sometimes find maths tricky

<u>How long did it take you to read these statements to your class?</u>

3-4 minutes.

<u>Were there any questions they did not understand? (Please number)</u>

10-Children talked about what might happen if you had a disability, were a baby or if you had speech and language difficulties. They wanted to talk about how different people learn and what type of maths you could learn of you had a special educational need.

<u>Any other comments:</u>

3. I have attached a PPT slide of a 5-point scale. I would like to know if the children understand the concept of scaling something to 5 using the thumbs. If you could put the scale up for your class to see and ask them questions like, ‘Broccoli is nice’ or ‘Pizza is yummy’. Then, could you ask them to give each statement a score out of 5 (using two, one or no thumbs up/down)?

- It took longer than I expected to get the children to understand the 5 point scale. The children were concerned that they would forget what the open hands meant and associated it with not understanding something rather than feeling neutral about it. They suggested 'middle thumbs up' (thumb halfway between up and down).

- A couple of children kept comparing the images to numbers eg 'so this is like 1 out of 5'. But said that they would get used to using the thumbs system.

Appendix J

Intervention Pilot Feedback

Table 3. 5

Pilot Feedback

Positive features	Areas for development
• It is good that the correct vocabulary is used e.g., 'mathematical resilience' as the children need to know this. • The adapted version of the Growth Zone Model into a linear scale will work. Year 4 children will understand that it is the same and will also find it easier to use. • Children are familiar with a similar concept - the Zones of Regulation – which will help them to understand the Growth Zone Model. • The session is easy to slot in. It is good in terms of teacher workload. • Introducing this session and the concepts will be really beneficial for children with maths anxiety. • Feel that it would take approximately 30 minutes to deliver.	• The learning outcomes could be referred to as 'Questions for Learning' (QfL). Each statement would be a question the children could answer at the end of the session e.g., I can… • Add the word resilience to the vocabulary check at the start of the session • Change 'reptile' to reptile brain on the vocabulary slide • A copy of the GZM scale could be put on the first slide of each maths lesson under the 'Question for Learning' to remind children and draw attention to it. • Teachers should use the language (comfort, growth, uncomfortable zone) as opposed to the colours of the zones so that children do not get confused between the Zones of Regulation and the Growth Zone Model. • Children could put a whiteboard pen dot to indicate where they are on the model rather than using counters. This will account for children losing the counters and less distracting.

Note. This table summarises the feedback from the class teacher who took part in the intervention pilot

Appendix K

Recruitment Email

My name is Lorna Cooper and I am a Trainee Educational Psychologist on placement with [Psychology Service] as part of my doctoral training programme at the University of Nottingham.

As part of my training, I am undertaking a research project to **evaluate the impact of a whole-class intervention, designed to build children's mathematical resilience, on mathematics anxiety.**

Why are you receiving this email?

- I am seeking to **recruit schools in […] City** who would like to be involved in this research project.
- I am looking to recruit **class teachers** of **Year 4** children to deliver a whole-class mathematical resilience intervention.

Research aim:

- Explore the impact of implementing a mathematical resilience intervention on children's maths anxiety.
- Explore the children's perceptions of a mathematical resilience intervention.
- Explore class teachers' perceptions of a mathematical resilience intervention.
- Enhance teachers' understanding of mathematical resilience and the impact of maths anxiety in the classroom.
- Be part of adding to the limited body of UK research on whole-class approaches to developing mathematically resilient learners.

How will this benefit participating schools?

- Access to training on strategies designed to build mathematical resilience.
- Opportunity to use research to inform school provision based on teacher and pupil perspectives.
- Access to research findings through attending a meeting or receiving a summary sheet.

	School staff **Led by Lorna Cooper**	**Sharing information**	Information about the project will be shared with key staff who are to be involved in the study. (e.g., Year 4 teacher, maths lead, SLT)	Lorna Cooper will visit the setting or set up a Teams call and meet with key staff to share the project overview.
ASAP following staff information session	Parents Led by Lorna Cooper	**Parent drop-in session**	Information about the project will be shared with parents of the children who are	Lorna Cooper will visit the setting and meet with

September			to be involved in the study. Provide an opportunity for parents to ask the researcher questions.	parents to share the project overview. **Parental consent will be sought at this drop-in session**. School to provide a space for parent drop-in.
September 2024	Class Teacher	**Gather child consent**	An overview of the project will be shared with the whole class receiving the intervention.	Children will be made aware of their right to withdraw and will provide their consent to take part.
September/ October 2024 **≥ 5 weeks**	Children	**Baseline measures**	Children will complete a measure of maths anxiety on a weekly basis. Children will complete a resilience scale twice.	To be discussed with the class teacher.
September/ October 2024	Delivered to Class Teacher and Teaching Assistants Led by Lorna Cooper.	**Introduction to Mathematical Resilience Tools and Psychoeducation**	A 1.5 hour session to introduce psychoeducation and strategies to build children's mathematical resilience.	Face-to-face session. School to provide a space for this training.
October/ December 2024 **10 weeks**	Class Teacher	**Application of training**	A commitment to implementing a specific classroom strategy over a 10-week period. This involves embedding and applying the tools introduced in maths lessons. A physical resource will also be used.	Teachers will be provided with resources and have the opportunity to access weekly supervision from Lorna Cooper to support them.
October/ December 2024 **10 weeks**	Focus children	**Repeated measures**	Children will complete a measure of maths anxiety on a	To be discussed with

			weekly basis. Children will complete a resilience scale 4 times over 15 weeks.	the class teacher.
January 2024 Post 10 weeks	Class Teacher and Children	**Focus group (children)**	The six focus children will be used to gather the children's perceptions of the whole-class strategies. Both closed and open-ended questions will be used to explore children's perspectives post-intervention	Lorna Cooper will visit the setting.
January 2024 Post 10 weeks		**Focus group (school staff)**	A focus group with the class teacher and teaching assistants will gain their views on how successful they felt the delivery of the intervention was and any changes they have observed as a result.	Lorna Cooper will visit the setting
January/ February 2024 **Follow-up**	School staff Led by Lorna Cooper	**Debrief and information sharing**	Summary of the intervention outcomes and next steps in the research will be shared with participating schools.	

Appendix L

Staff Consent Form and Information Sheet

School Staff Information Sheet

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

School of Psychology

Information Sheet

Title of Project: Evaluating the Impact of a Whole-Class Strategy, Designed to Build Children's Mathematical Resilience, on Maths Anxiety in UK Primary Schools: A Mixed-Methods Approach

Ethics Approval Number: S1613

Researcher: Lorna Cooper

Supervisor: Dr. Victoria Lewis

Contact Details: lorna.cooper@nottingham.ac.uk

victoria.lewis@nottingham.ac.uk

This is an invitation to take part in a research study around the development of **mathematical resilience**. The study aims to explore the impact of a whole-class intervention in supporting children to understand and manage anxious or uncomfortable feelings specific to mathematics.

Before you decide that you wish to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

Why is this research being carried out?

It has been suggested that early intervention, to prevent or reduce maths anxiety, is crucial to long term outcomes[1], until now little attention has been paid to the investigation of whole-class interventions which aim to do so in UK primary schools.

This research aims to support the development of an intervention which can be delivered to all children to support them to become mathematically resilient. The hope is that this research will demonstrate the benefits of equipping all children with strategies to support them manage uncomfortable feelings in mathematics.

If your you participate, you will:

- Receive training in using a whole class strategy which centres on building mathematical resilience delivered by the researcher.
- Receive the electronic resources to equip you to implement the strategy.

[1] (Petronzi et al., 2017)

- Implement the strategy over the course of 10-weeks with the aim to support your class to manage uncomfortable feelings in maths.
   - *You are asked to encourage and respond to your class in applying the strategies in your maths lessons.*
- Support your class to complete measures of maths anxiety and mathematical resilience.
- Following the intervention, you will asked to take part in a short interview to give you opportunity to share your views on the intervention.

Participation in this study is totally voluntary and you are under no obligation to take part. You are free to withdraw at any point before or during the study. All data collected will be kept confidential and used for research purposes only. It will be stored in compliance with the Data Protection Act.

If you have any questions or concerns please don't hesitate to ask now. We can also be contacted after your participation at the above address.

If you have any complaints about the study, please contact:
Stephen Jackson (Chair of Ethics Committee)
stephen.jackson@nottingham.ac.uk

School Staff Consent Form

School of Psychology

Consent Form

Title of Project: **Evaluating the Impact of a Whole-Class Strategy, Designed to Build Children's Mathematical Resilience, on Maths Anxiety in UK Primary Schools: A Mixed-Methods Approach**

Ethics Approval Number or Taught Project Archive Number: S1613

Researcher: Lorna Cooper [e-mail] lorna.cooper@nottingham.ac.uk

Supervisor: Dr. Victoria Lewis [e-mail] victoria.lewis@nottingham.ac.uk

The participant should answer these questions independently:

- Have you read and understood the Information Sheet? YES/NO
- Have you had the opportunity to ask questions about the study? YES/NO
- Have all your questions been answered satisfactorily (if applicable)? YES/NO
- Do you understand that you are free to withdraw from the study? YES/NO

  (at any time and without giving a reason)
- I give permission for my data from this study to be shared with other researchers provided that my anonymity is completely protected. YES/NO

- Do you agree to take part in the study? YES/NO

____________________________________ __________________________

Print name

Date

____

Signature

Appendix M

Parent Consent Form and Information Sheet

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Parent Information Sheet

Title of Project Evaluating the Impact of a Whole-Class Strategy, Designed to Build Children's Mathematical Resilience, on Maths Anxiety in UK Primary Schools: A Mixed-Methods Approach

Ethics Approval Number: S1613

Researcher: Lorna Cooper

Supervisor: Dr. Victoria Lewis

Contact Details: lorna.cooper@nottingham.ac.uk   victoria.lewis@nottingham.ac.uk

Dear Parents and Guardians,

We are writing to inform you about an important initiative our school is undertaking to alleviate maths anxiety among our students. To combat this issue, we are excited to participate in a research study aimed at developing mathematical resilience in our children.

This study will help us understand better the factors contributing to maths anxiety and implementstrategies that foster a more positive learning environment for all.

We invite you to attend an information chat on **Thursday, 19th September, from 15:00 to 15:15.** This session will provide an opportunity for you to learn more about the study and ask any questions regarding the consent form. Your involvement is crucial in supporting our students' journeys in overcoming obstacles in their learning. Please could you read the information below and sign the consent form, which has been handed out as a hard copy to your child, as soon as possible.

Thank you for your continued support. We look forward to seeing you at the information chat.

This is an invitation to allow your child to take part in a research study around the development of mathematical resilience. The study aims to evaluate the impact of a whole-class mathematical resilience intervention in supporting children to understand and manage anxious or uncomfortable feelings specific to mathematics.

Before you decide that you wish for your child to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

Why is this research being carried out?

It has been suggested that early intervention, to prevent or reduce maths anxiety, is crucial to long term outcomes[2], until now little attention has been paid to the investigation of whole-class interventions which aim to do so in UK primary schools.

This research aims to support the development of an approach which can be used universally with primary school children to support them in becoming mathematically resilient. The hope is that this research will demonstrate the benefits of equipping all children with strategies to support them manage uncomfortable feelings in mathematics.

If your child participates, they will:

- Complete a questionnaire which will look at their experience of maths anxiety
- Receive an input from their class teacher which introduces them to a strategy to support them manage uncomfortable feelings in maths.
    - *The initial session will last between 45-60 minutes and the strategies taught will continue then to be embedded in their typical maths lessons.*
- Complete measures of maths anxiety and mathematical resilience over the course of 13 weeks.
- Your child may be selected to take part in a focus group. You will be contacted to seek additional consent if so.

Participation in this study is totally voluntary and your child is under no obligation to take part. You or your child is free to withdraw at any point before or during the study. All data collected will be kept confidential and used for research purposes only. It will be stored in compliance with the Data Protection Act.

If you have any questions or concerns please don't hesitate to ask now. We can also be contacted after your participation at the above address.

If you have any complaints about the study, please contact:
Stephen Jackson (Chair of Ethics Committee)
stephen.jackson@nottingham.ac.uk

[2] (Petronzi et al., 2017)

Parental Consent Form

Title of Project **Evaluating the Impact of a Whole-Class Strategy, Designed to Build Children's Mathematical Resilience, on Maths Anxiety in UK Primary Schools: A Mixed-Methods Approach**

Ethics Approval Number or Taught Project Archive Number: S1613

Researcher: Lorna Cooper, lorna.cooper@nottingham.ac.uk

Supervisor: Dr. Victoria Lewis, victoria.lewis@nottingham.ac.uk

The participant should answer these questions independently:

- Have you read and understood the Information Sheet? YES/NO
- Have you had the opportunity to ask questions about the study? YES/NO
- Have all your questions been answered satisfactorily (if applicable)? YES/NO
- Do you understand that you are free to withdraw your consent from the study? YES/NO (at any time and without giving a reason)
- I give permission for my child's data from this study to be shared with other researchers provided that their anonymity is completely protected. YES/NO
- Do you agree for your child take part in the study? YES/NO

Parental Permission

By signing this document, you are agreeing to allow your child, - ________________________[name], to be part of the study titled '**Evaluating the Impact of a Whole-Class Strategy, Designed to Build Children's Mathematical Resilience, on Maths Anxiety in UK Primary Schools: A Mixed-Methods Approach**.'

Your child's participation in this study is completely voluntary. If you allow your child to be part of the study, you may change your mind and withdraw your approval at any time. Your child may choose not to be part of the study, even if you agree, and may refuse to answer the questionnaires or stop participating at any time.

You will be given a copy of this document for your records and one copy will be kept with the study records. Be sure that the questions you have asked about the study have been answered and that you understand what your child will be asked to do. You may contact the researcher if you think of a question later.

I give my permission for my child [_____________________]to participate in this study.

____ ____________________

Signature Date

<u>Supplementary consent</u>

<u>Thank you!</u> *We would like to thank your child for their initial participation in the intervention in class.* *We are now asking them to share their thoughts and feedback on the strategies they used.*

By signing this document, you agree to allow your child, ________________________[name], take part in a brief **10-minute discussion** with the researcher. The discussion will allow them to share their views on the mathematical resilience strategies introduced to them in class. Their views will be recorded anonymously.

Your child's participation in this study is completely voluntary. If you allow your child to be part of the study, you may change your mind and withdraw your approval at any time. Your child may choose not to be part of the study, even if you agree, and may refuse to answer the questionnaires or stop participating at any time.

You will be given a copy of this document for your records and one copy will be kept with the study records. Be sure that the questions you have asked about the study have been answered and that you understand what your child will be asked to do. You may contact the researcher if you think of a question later.

I give my permission for my child [_____________________]to participate in this study.

____ ____________________

Signature Date

Appendix N

Children's Information Sheet

Hi there!

My name is Lorna and I study at the University of Nottingham. I want to do some research to look at how schools could help children (just like you!) to feel better in their maths lessons.

I would like to know if you would be interested in taking part in this research. To take part you will:

- Take part in one lesson about feeling more confident in maths
- Your whole class will try a new strategy in maths lessons to help you all tell your teacher how you are feeling

You might:

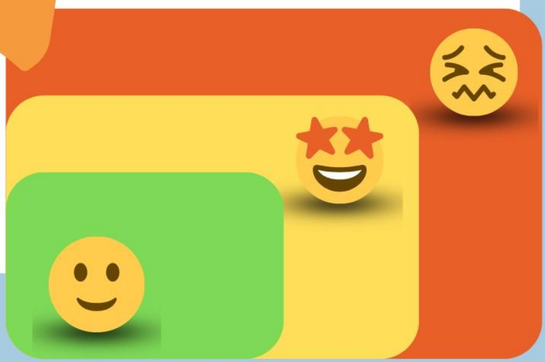
- Answer a questionnaire to see how you feel about maths every week
- Tell me what you thought about the strategy and if it helped you

I will then use your answers to help me see if what you did was helpful! Your name won't be used and you can choose not to take part at anytime.

If you agree to take part, your teacher will help you to do the questionnaires and give you a code to keep your name a secret.

Thanks!

What you will use looks a bit like this!



Appendix O

Staff Focus Group Interview Questions

1. WWW: What Worked Well? (Facilitators)
    a. *What went well in terms of the use of the Growth Zone Model?*

2. EBI: Even Better If?/What Didn't Work Well? (Barriers)
    a. *Would you have made any changes to how it was used?*

3. How did you respond when children used the GZM to indicate they were in the 'uncomfortable/panic' zone?

4. Do you feel the intervention has had an impact on your class? If yes, how?

5. Did the session have any impact on your own thoughts and feelings surrounding maths?

6. Would you recommend the toolkit or Growth Zone Model to other teaching staff? Why?

Appendix P

Children's Semi-Structured Interview Worksheet

1. Can you tell me what you have learnt about mathematical resilience?

2. What is the Growth Zone Model?

3. Thinking about the things you have been taught about mathematical resilience and using the GZM scale…

What worked well? 😊	What didn't work well? It would be even better if? ☹

4. What would you tell another child in school who feels anxious or worried about maths?

Appendix Q

Ethics Approval

The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

School of Psychology
The University of Nottingham
University Park
Nottingham
NG7 2RD

tel: +44 (0)115 846 7403 or (0)115 951 4344

SJ/tp

Ref: S1613

Thursday 30th May 2024

Dear Lorna Cooper & Victoria Lewis

Ethics Committee Review

Thank you for submitting an account of your proposed research 'Evaluating the Impact of a Whole-Class Strategy, Designed to Build Children's Mathematical Resilience, on Maths Anxiety in UK Primary Schools: A Mixed-Methods Approach'

That proposal has now been reviewed and we are pleased to tell you it has met with the Committee's approval.

However:
Please note the following comments from our reviewers.

Reviewer One:

- Add the ethics approval number to recruitment email.
- Check the children's assent for each activity, and clarify the approximate duration for each activity.
- State how many staff will be involved in the interview, where and how long the activity will take.

Independently of the Ethics Committee procedures, supervisors also have responsibilities for the risk assessment of projects as detailed in the safety pages of the University web site. Ethics Committee approval does not alter, replace, or remove those responsibilities, nor does it certify that they have been met.
Yours sincerely

Professor Stephen Jackson
Chair, Ethics Committee

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

School of Psychology
The University of Nottingham
University Park
Nottingham
NG7 2RD

tel: +44 (0)115 846 7403 or (0)115 951 4344

Thursday 10th October 2024

Ref: S1645 Chair Approval Minor Amendments

Dear Victoria Lewis and Lorna Cooper

Your name and contact details:- Lorna Cooper (Trainee Educational Psychologist)
Today's date:- 25th September 2024
Title of the new project:- N/A
Are you an undergraduate, postgraduate or staff? Postgraduate

Details of the previous study:
Applicant: Lorna Cooper (Trainee Educational Psychologist)
Title: Evaluating the Impact of a Whole Class Strategy, Designed to Build Children's Mathematical Resilience, on Maths Anxiety in UK Primary Schools: A Mixed-Methods Approach'
Date of approval: 30th May 2024
Reference number (if known): S1613
As Chair of the Ethics Committee I have considered your request and I am happy to grant approval for the following changes:

List of significant changes in the proposed study. This list should include any changes which could potentially impact on ethical risks of the work e.g., moving from student participants to vulnerable adults; use of sensitive stimulus materials; changes in remuneration or consent procedures:

- 1. Where written parental consent has not been able to be obtained, children will not be removed from receiving the intervention. However, any data they produce will not be collected.
- 2. To ensure that all children feel included, all children will complete outcome measures. However, those without written consent will have their data destroyed. Measures are to be completed on paper and school staff will be asked to follow their school's procedure for disposing of documents.

Final responsibility for ethical conduct of your research rests with you or your supervisor. The Codes of Practice setting out these responsibilities have been published by the British Psychological Society and the University Research Ethics Committee. If you have any concerns whatever during the conduct of your research then you should consult those Codes of Practice.

Independently of the Ethics Committee procedures, supervisors also have responsibilities for the risk assessment of projects as detailed in the safety pages of the University web site. Ethics Committee approval does not alter, replace, or remove those responsibilities, nor does it certify that they have been met.
Yours sincerely,

Appendix R

Ethical Considerations

Table 3. 6

Ethical Considerations

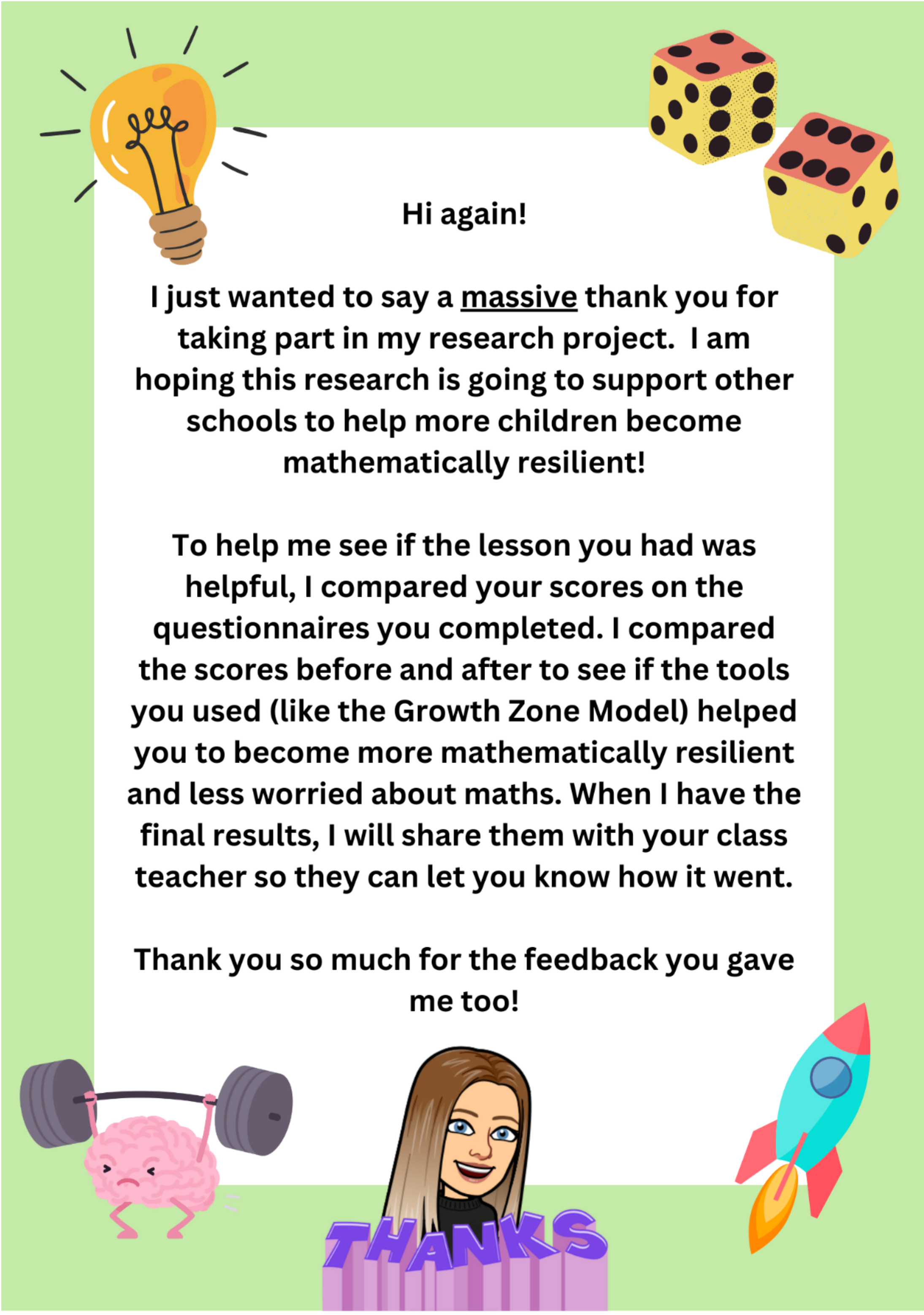
Principle	Considerations	Action Taken
Risk "*Potential physical or psychological harm, discomfort or stress to human participants that a research project may generate*," (Oates et al., 2021, p. 10)	Ensuring actions are taken to avoid inflicting harm or causing risk to participants Procedures likely to change participants' mood are carefully considered Extended testing or repeated sessions with the same participant	An adult was available during the completion of repeated measures if children required support. A pleasant follow-up activity (e.g., a game or outdoor break) was provided after completing measures to mitigate possible negative mood impacts. Measures were piloted with Year 4 children to evaluate their accessibility and duration. If completion time exceeded reasonable limits or caused discomfort, children were advised to stop. A debriefing sheet was shared with children following the completion of the study. (see Appendix S) Audio recordings were not conducted. A summary of the findings will be shared with the school and parents in writing.
Consent "*Researchers should ensure that every person from whom data are gathered for the*	Assuring valid and informed consent from all participants is provided	Parents/carers received an information sheet explaining the research aims.

purposes of research consents freely and voluntarily to participation, having been given sufficient information to enable them to make an informed choice," (Oates et al., 2021, p. 12)	Information regarding the purpose, nature, and any expected consequences of participating in the research is provided	Adapted information sheets were shared with children in an age-appropriate format. Parental consent was obtained through signed consent forms, and children were also made aware of their rights and could indicate their preference not to use their data. A parental information session was organised (though not attended) to communicate the research aims. Staff and stakeholders were engaged in discussions to clarify the research purpose and expectations.
Confidentiality *"Participants in psychological research have a right to expect that information they provide will be treated confidentially and, if published, will not be identifiable as theirs,"* (Oates et al., 2021, p. 21)	Details that could identify participants are removed Records and data are processed and stored confidentially to prevent the disclosure of participant information Information is maintained in a confidential manner	Pseudonyms were used for focus children. The research school was not named, and demographic information was kept minimal to protect anonymity. Electronic data was stored securely behind a password Unique codes were assigned to participants by teachers to ensure anonymity. Data withdrawal requests would be handled through these codes to maintain confidentiality. All data was appropriately anonymised, and interviews with the children were conducted individually. A privacy notice was appended to the information sheet for school staff and parents (Appendix T).
Respect *"Value the dignity and worth of all persons, with sensitivity to the dynamics of perceived*	Unfair, prejudiced, or discriminatory practice	Care was taken to ensure no child was unfairly singled out during the intervention. Due to a lack of parental engagement, a resubmission for ethics approval was

authority or influence over persons and peoples and with particular regard to people's rights," (BPS, 2021, p. 6)	Power dynamics where research is conducted with individuals with an unequal relationship Procedures from which participants might not feel free to withdraw at any point or may regret taking part in	completed. It was agreed that all children would receive the whole-class intervention as part of the school's universal offer. However, their data would be destroyed if parents/carers did not fill in the consent form. All children took part in the same activities, except for the interviews of the focus children. The dual roles of the researcher were separated to avoid conflicts. Research days were distinct from TEP duties, and the researcher avoided working in a school they were professionally linked with to maintain objectivity and reduce undue influence. Participants were informed of their right to withdraw at any time. For children, this included measures to indicate withdrawal, such as circling a sad face on the measures. The offer of weekly supervision sessions with teaching staff created opportunities to discuss concerns and reconsider participation, ensuring staff could freely express discomfort or doubts.

Appendix S

Debrief Letter for Children



Hi again!

I just wanted to say a <u>massive</u> thank you for taking part in my research project. I am hoping this research is going to support other schools to help more children become mathematically resilient!

To help me see if the lesson you had was helpful, I compared your scores on the questionnaires you completed. I compared the scores before and after to see if the tools you used (like the Growth Zone Model) helped you to become more mathematically resilient and less worried about maths. When I have the final results, I will share them with your class teacher so they can let you know how it went.

Thank you so much for the feedback you gave me too!

Appendix T

Privacy Notice

Privacy Notice

The University of Nottingham, University Park, Nottingham, NG7 2RD (0115 951 5151), is committed to protecting your personal data and informing you of your rights in relation to that data.

The University of Nottingham is registered as a Data Controller under the Data Protection Act 2018 (registration No. Z5654762).

One of the University's responsibilities as a data controller is to be transparent in our processing of your personal data and to tell you about the different ways in which we collect and use your personal data. The University will process your personal data in accordance with the UK data protection legislation and this privacy notice is issued in accordance with the UK GDPR Articles 13 and 14.

We may update our Privacy Notices at any time. The current version of all of our Privacy Notices can be found below, and we encourage you to check back here regularly to review any changes.

The Data Protection Officer

The University has appointed a Data Protection Officer. Their postal address is: Data Protection Officer, B16 Lenton Hurst, University of Nottingham, University Park, Nottingham NG7 2RD They can be emailed at dpo@nottingham.ac.uk and telephoned on (0115) 748 7179.

What information do we hold?

We hold a range of personal data about you and/or your child, some of which you may provide to us directly and some of which we may receive from third parties. This includes gender, age, and attainment.

How do we use it and why?

We only process data for specified purposes and if it is justified in accordance with data protection law. The purpose of this processing is: for academic research and aiding understanding in a growing research area. This processing is justified because: it is required to allow the researcher to carry out a detailed analysis for research purposes.

The legal basis for this processing is: Public Task

Where we use Public Task as the legal basis for processing, the consequences of not providing the University with your personal data are: exclusion of data gathered from the sample including questionnaire results.

How long do we keep your data?

The University will only keep your personal data for as long as necessary to fulfil the purposes for which we collected it. To determine the appropriate retention period for personal data, we consider the amount, nature, and sensitivity of the personal data, the potential risk of harm from unauthorised use or disclosure of your personal data, the purposes for which we process your personal data and whether we can achieve those purposes through other means, and the applicable legal requirements. We retain your data for: 10 years.

Your rights as a data subject

You have a number of rights under UK GDPR. Further information about these rights and how to invoke them can be found on our website here: https://www.nottingham.ac.uk/utilities/privacy/privacy.aspx

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Where can I get more information?

Please contact the researcher, Lorna Cooper: lorna.cooper@nottingham.ac.uk if you have any questions or wish to request deletion of your personal data.

If you have any questions about this privacy notice or how your data is processed, please contact the data protection team: dpo@nottingham.ac.uk

This privacy notice is reviewed regularly and we will alert you to any changes we might make.

Appendix U

Characteristic for Visual Analysis

Table 4. 15

Characteristics for Visual Analysis.

Characteristic	**Process of Analysis**
Central Tendency (Level + Mean Level Change)	The mean value for both phases is determined. The mean level change is then reported as the difference between the means (Lane & Gast, 2014). Mean scores for all cases are reported in Table 4.3, and score changes of more than one score unit are highlighted in **bold.** A broadened median (BMed) is also calculated to account for extreme scores in the data set, which may influence the calculation of the mean (Morley, 2017). This is presented visually for each case.
Variability	The reported range and standard deviation for each phase illustrate how the data varies from the mean in each dataset (Kratochwill et al., 2010). Range data is reported in Table 4.3. Range lines are also presented graphically.
Trend	Linear trend lines for the data points in each phase are presented graphically using Excel® for Microsoft 365 MSO (Version 2502). The direction of the trend is then reported as either deteriorating or improving and accelerating or decelerating (Lane & Gast, 2014). The *spilt-middle method* is also used, which is more resistant to the influence of outliers (Morley, 2017). The *split-middle method* plots a trend line based on the median level of each half of a phase's data set. The difference between trend lines will be calculated using their linear equations (y=mx+c) as a basis for comparison. Trend refers to the slope (m) of the line of best fit and the magnitude of change is reported as the absolute difference between slopes.
Overlap Region	The amount of overlapping data points across phases is considered (Kratochwill et al., 2010). The percentage of overlapping data points is reported for each case.

Immediacy of Effect/Point of Change	The two adjacent data points between phases A and B were examined to determine if the effect is immediate. However, knowledge of the intervention influences how the point of change is interpreted if the effect is not expected to be seen immediately (Morley, 2017). In this study, where a visually apparent point of change is observed, this is discussed on a case-by-case basis.

Note. A table outlining the characteristics of the single case data that was analysed visually for Phase One of the study's findings, including a description of how this was implemented. These characteristics support the analysis of differences between phases of a SCED, enabling a judgment about the effects of the intervention. Time must be spent on ensuring quality graphical displays so that the data effectively communicates the findings; steps taken to ensure the quality of the visual data have been implemented from Morley (2017). The graphs omit weeks when data collection was interrupted by school holidays and link data points for individual weeks of child absence. This approach helped the researcher identify patterns within the dataset. The second figure for each case features four graphs generated with the Shiny SCDA program (De et al., 2020), illustrating mean level change, broadened median level change, split-middle trend lines, and range lines.

Appendix V

Demographic Information and Descriptive Statistics

	Aisha	David	Emily	Isabel	Ryan	Zachary
Gender	Female	Male	Female	Female	Male	Male
Class	Mainstream	Mainstream	Small Group	Mainstream	Mainstream	Small Group
Attainment	Towards	Towards	Below	Expected	Expected	Below
SEND	No	Yes	Yes	No	No	Yes
Mathematics Anxiety mAMAS						
Phase A (Baseline)						
Mean	36.67	24.75	23.00	37.25	17.75	22.00
Median	37.00	25.00	24.00	39.50	16.50	21.00
Range	1 (36-37)	13 (18-31)	20 (12-32)	10 (30-40)	16 (11-27)	10 (18-28)
Variance	0.33	30.92	70.67	23.58	52.92	18.67
Standard Deviation	0.58	5.56	8.41	4.86	7.27	4.32
Skewness	-1.73	-0.22	-0.65	-1.95	0.67	1.19
Phase B (Intervention)						
Mean	**28.50**	**21.50**	**18.80**	37.70	**12.30**	**16.20**
Median	26.50	23.50	19.00	40.00	12.50	16.50
Range	14 (22-36)	21 (9-30)	12 (14-26)	20 (23-43)	4 (10-14)	12 (10-22)
Variance	32.57	52.00	18.40	37.79	1.34	11.73
Standard Deviation	5.71	7.21	4.29	6.15	1.16	3.43
Skewness	0.29	-0.68	0.36	-1.73	-0.73	-0.15
Mathematical Resilience BCMRS						
Time 1 (Baseline)	1.68	2.75	3.52	3.18	2.20	3.33
Time 2 (Baseline)	-	4.62	3.75	3.00	5.33	4.02
Time 3 (Intervention)	4.17	3.38	4.00	4.02	5.67	6.00
Time 4 (Intervention)	3.12	4.50	3.38	5.75	5.80	4.83

Note. This table summarises the six focus children's demographic information and descriptive statistics. All data is provided to two decimal places.

Appendix W

Inter-rater Agreement Form

This table shows the characteristics which were employed to conduct a visual analysis of the graphs below:

Characteristic	Process of Analysis
Central Tendency (Level + Mean Level Change)	The mean value for both phases is calculated. The mean level change is subsequently reported as the difference between these means. A broadened median (BMed) is also calculated to address extreme scores in the data set that may affect the mean. This information is visually represented for each case.
Variability	The range and standard deviation for each phase demonstrate the variability of the data from the mean in each dataset. Graphical representations of the range lines are also provided.
Trend	Using Excel, linear trend lines for the data points in each phase are graphically illustrated. The trend's direction is reported as either deteriorating or improving, as well as accelerating or decelerating. Additionally, the split-middle method is utilised, which is less affected by outliers. The differences between trend lines will be calculated based on their linear equations (y=mx+c) for comparison purposes.
Overlap Region	The extent of overlapping data points between phases is taken into account. For each case, the percentage of these overlapping data points is documented.
Immediacy of Effect/Point of Change	The two neighbouring data points between phases A and B are marked to determine if the effect is immediate. Any visibly clear point of change is analysed individually.

Please could you kindly review each of the graphs, along with their corresponding visual analyses, and consider your response to the subsequent question:

"To what extent can you confirm that the child's scores on the modified Abbreviated Maths Anxiety Scale (mAMAS) exhibited improvement from the baseline to the intervention phase?"

For all measures and graphs, a **downward** trend signals improvement.

Please indicate your response on the rating scale from 1 (not at all convinced) to 5 (very certain) for each graph.

"To what extent can you confirm that the child's scores on the modified Abbreviated Maths Anxiety Scale (mAMAS) exhibited improvement from the baseline to the intervention phase?"					
	1 Not at all convinced	2 Unsure	3 It is possible	4 Reasonably certain	5 Very certain
Aisha					
David					
Emily					
Isabel					
Ryan					
Zachary					

Appendix X

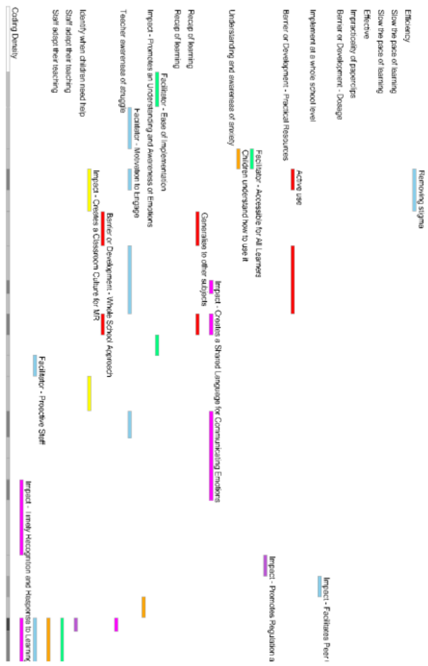
Staff Focus Group Transcript with Initial Coding Bands

¶1: **NVivo Transcript for Focus Group**
¶2: Thinking about the whole-class intervention strategy:
¶3:

1. ¶4: WWW: What Worked Well?

- ¶5: Growth chart has gone really well. It's a simple enough thing and they have taken it on (T)
- ¶6: It's the first thing they ask for and the peg (TA-MS)
- ¶7: That's the first thing and they have taken to it (TA-SG)
- ¶8: They know they can go back and change it at any point (TA-T)
- ¶9: They are happy to show me if it's on red (TA-SG)
- ¶10: It's taken away the awkwardness or stigma of "I can't do it" (TA-MS)
- ¶11: A few that have asked if we can take it into different lessons (TA-SG). It could work (T)
- ¶12: They use each individual colour as a scale itself and if they are really uncomfortable, they will put it right on the edge (T)
- ¶13: They use the 'I'm not going to flip my lid" from the presentation and they use that elsewhere too (TA-SG)
- ¶14: They are putting the thinking brain and emotional brain into other lessons (TA-SG)
- ¶15: It wasn't a distraction (TA-MS)
- ¶16: It's better than some of the other things we have been given (TA-MS)
- ¶17: Usually, it's a one-off type of chat and then it goes out of their mind, this is not just a quick chat and then forgotten. It's there in their book in lessons (T)
- ¶18: Mine tend to use it when they first come into school. Like they are telling me they are not in a good place to learn when they arrive. It's really useful to know they are using it as a mood indicator (TA-SG).
- ¶19: The children are using the language from the initial session. (T)
- ¶20: You can react quickly, and you can see it immediately. (SG-TA)
- ¶21: They usually just sit there. But now [child name] is now putting her hand up and asking for help (MS-TA)
- ¶22: It has empowered the children to ask for help (T)
- ¶23: They are taking ownership of their learning (T)
- ¶24: Children are recognising that everyone is in the same place (MS-TA)
- ¶25: Know that emotions are a normal part of learning (T)
- ¶26: Enables us to know there is a problem (T) and then we can adapt what we do (SG-TA)

1 / 6



1A

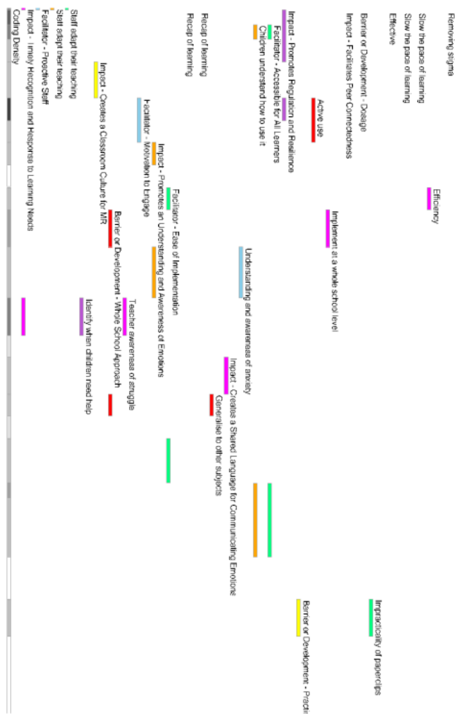
- ¶27: The breathing slide with the circle is the next slide after the starter question now. They know what they are going to be doing and how are they going to feel about the maths and relax into it. I find that helps (T)
- ¶28: Use it every day, the breathing slide (TA-MS). Incorporating the breathing techniques at the start of every lesson and it helps to add that visual
- ¶29: You find some of them using the hand thing (T) [5 finger breathing]
- ¶30: They do the hand thing when watching the session (TA-MS)
- ¶31: Helps children to understand the normality of feelings and life (T)
- ¶32: It's a life skill (TA-SG)
- ¶33: The session itself its not massively long (T)
- ¶34: As a school we need to embrace it in all classes. So when they get into Year 1 and they can do it. It will become a routine (TA-MS)
- ¶35: There's such a problem with anxiety in children on the whole and they need to be aware of it and understand it. My experience is that it has been a response of "you're just being silly get on with it."
- ¶36: Hard when you're on your own when they all have their hand up. This is a quick solution to seeing how they are (TA-MS)
- ¶37: It has had an impact (T)
- ¶38: The wording of it is better rather than using positive and negative, it's comfortable and uncomfortable (T)
- ¶39: I've taken that language (comfortable and uncomfortable) into other things (T)
- ¶40: I like the size of the scale it doesn't get in the way (TA-SG)
- ¶41: They don't really play with it that much (TA-MS)
- ¶42: They look after them (T)
- ¶43: We genuinely didn't have to explain more for children with learning needs or SEND. There's not lots of writing. There were lots of images and they could relate to it (T) Half the class are on the SEN register (T)
- ¶44: They did get it. [name] got it (TA-SG)

¶45:

2. ¶46: EBI: Even Better If: *Would you have made any changes?*

- ¶47: The amount of paper clips I've found. Have to have paper clips on our person at all times (T)
- ¶48: A lot of them are just going "yeah I'm here" (TA-SG)
- ¶49: Probably the ones that feel confident are just circling the same numbers on the measures (T)

2 / 6



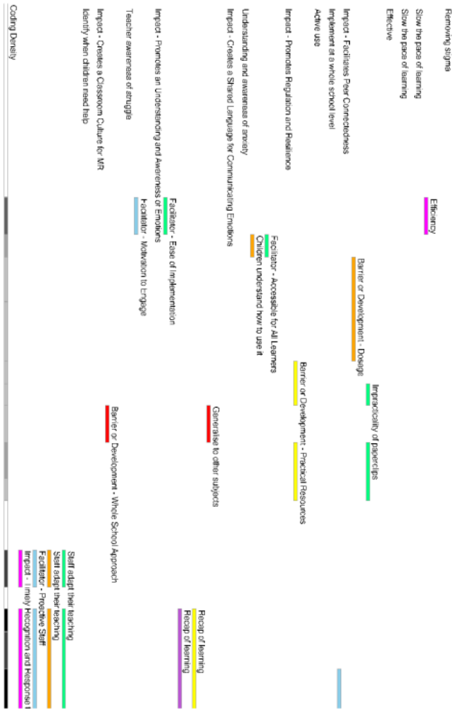
2A

- ¶50: Questionnaires they got into a habit and didn't think about them carefully every time. We could have read the questions out in a different order (MS-TA)
- ¶51: I could have stopped them and taken them through the questionnaires a bit more. But it's hard when you have the time pressures of school (T)
- ¶52: In an ideal world you wouldn't do questionnaires you'd just talk to them (SG-TA)
- ¶53: You don't know if they are understanding the questions on the measure but could have revisited it more (T)
- ¶54: I think I have done that less [revisiting the questions on the measures] (T)
- ¶55: Some of the children are not reading it [measures] properly they are just going.. bang, bang, bang (TA-MS)
- ¶56: *No, I wouldn't change the session. It was the right length and simple and engaging. (T)*
- ¶57: *The children understood and it was accessible to everyone (TA-SG)*
- ¶58: *I've revisited the session a couple of times (T)*
- ¶59: *It's useful revisiting it (TA-MS)*
- ¶60: Maybe I should have given them more opportunities to stop and reflect and move their GZM. But it's that "we've gotta get through this, we've got to get through this" (T)
- ¶61: Yeah, give them a few minutes to stop and change it (TA-MS)
- ¶62: The pegs keep falling apart. They don't work (TA-MS)
- ¶63: The paper clips are better to slide up and down but they fall off in their books (T)
- ¶64: If we were using them across the board in every lesson they could stay on the tables (T)
- ¶65: Next year, I was thinking about it in bed, I was preplanning. I'm going to get them and make some plastic sliders for the scales (TA-MS)
- ¶66: Needs to be a laminated piece of plastic that can slide up and down (TA-MS)

¶67:

3. ¶68: How did you respond when children used the GZM to indicate they were in the 'uncomfortable/panic' zone?

- ¶69: I think the first thing is to reassure them that if they are finding something tricky it's okay (T)
  - ¶70: You are good at that with [child name] (TA)
- ¶71: It's reassurance and recap quickly then (TA-SG)
- ¶72: Going over the last few things we did and yes, recapping the learning (TA-SG)
- ¶73: If you can see that a few of them are uncomfortable it might be that we stop the class and go through it again. I put the question up and go through it together (T) They like



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doing that it reaffirms that not everyone has got it right (TA-MS) It creates a conversation (T)

- ¶74: The uncomfortable panic zone is really helpful for me to see especially when I'm doing practical things. I can see them move it into the growth zone when we're doing practical things. It gives it meaning. I go back to the practical activity when they sit down and move it to the red zone when they are writing. (TA-SG)
- ¶75: I ask them what they don't understand and go through it with them (T)
- ¶76: It's like a brick wall if they don't have the foundation. They can't build on a foundation they haven't got. If they need it, they need it and do it at a slower pace (TA-MS).

¶77:

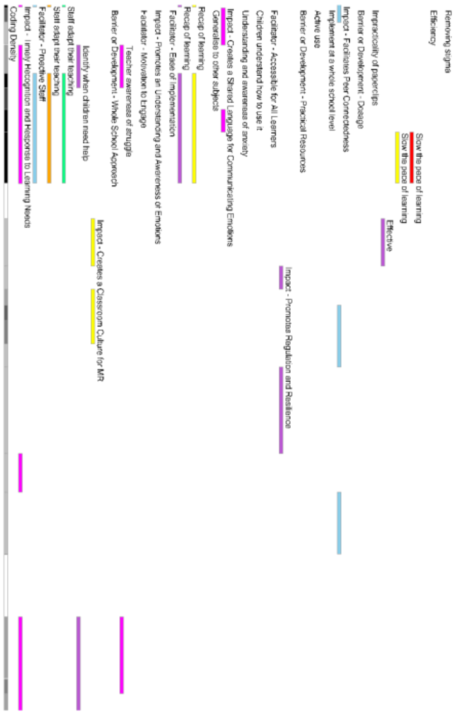
4. ¶78: Do you feel the intervention has had an impact on your class? If yes, how?

- ¶79: A positive yes (T)
- ¶80: Everything that was on the what went well (TA-SG)
- ¶81: They are a lot calmer and not fidgeting (TA-MS)
- ¶82: In terms of culture – I think you know we all want to have a culture that children are able to get things wrong in a safe environment and this has helped with that. Its helped children to help each other as well (T)
- ¶83: If they see that someone is on red, they will help them (TA-SG)
- ¶84: They are talking about the work more rather than about what happened last night (TA-MS)
- ¶85: They are not getting out of their seat and talking (TA-MS)
- ¶86: Yes, I think they aren't avoiding the work as much (T)
- ¶87: It could be that we know they feel uncomfortable. We can do something quite quickly to try to help and support (TA-SG)
- ¶88: They are supporting each other (TA-SG)
- ¶89: It's not just the teacher supporting them it's their peers. They talk it through together when one is on red (TA-MS)

¶90:

5. ¶91: Did the session have any impact on your own thoughts and feelings surrounding maths?

- ¶92: Those children that can portray themselves as confident, but they could be struggling. You wouldn't normally gravitate towards them as you think they've got it. (T)
- ¶93: There are times when those more confident children actually need help (TA-MS)
- ¶94: You can kind of almost see when you start a new concept, a lot of them will go red. And then over a few days, however long, it will gradually slip back into the growth zone.



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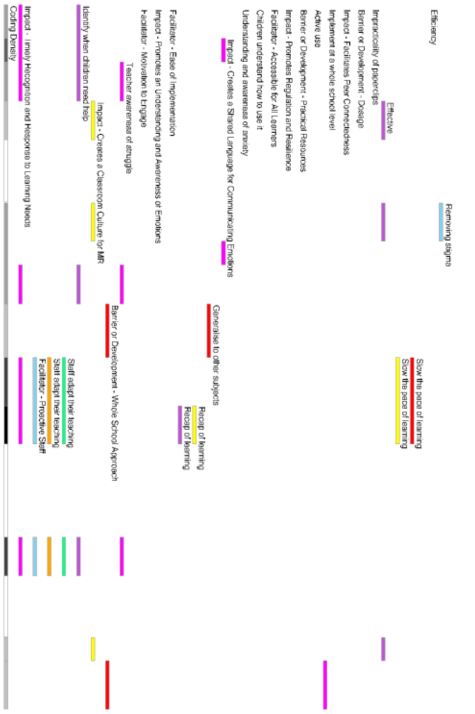
[child name] was one who can normally grasp things quickly, but wasn't grasping the bus stop method and slowly but surely her scale slipped back down to green after moving it to red initially. Once I had a chat with her, she felt better (T)

- ¶95: Normally you can't see it, when they don't get it, and children would try and work it out themselves (TA-MS)
- ¶96: When we spoke in the original discussion about maths, I now think, I think this would have helped me in school (T)
- ¶97: I feel a little bit more confident (TA-MS)
- ¶98: I was really scared in maths; I might have been terrified to put it on red. In the past, you would get ridiculed (TA-SG)
- ¶99: I just think of myself in this class now, this would help me. It has changed and we recognise mental health now (T)
- ¶100: It makes me more aware of how they are feeling (TA-SG)
- ¶101: You don't assume anymore. Like with [name] you would assume he could do it. But you don't do that anymore (TA-MS)
- ¶102: I'd be interested to think about it in other subjects because when I was at school I really struggled with art. The reality was so different to the image I had in my head, and I couldn't work out how to sort it (T)
- ¶103: Don't rush through it as much as more (TA-MS)
- ¶104: I don't feel under any pressure to rush the lessons at all (TA-SG)
- ¶105: This really helps with that, that if we need to go back over it, then we shouldn't rush (T)
- ¶106: Overall, we really need children to have a basic understanding of number sense and the things they are going to use (T)
- ¶107: Yes, we need to teach them the things they need like cooking, volume and area. I do hate maths that might be why. But [name] won't need algebra. We need to give them the maths skills for life (TA-MS)
- ¶108: You think about the top and bottom and how you can push or support. And it can be those middle kids that get lost. It's helped me to think about that differently (T)

¶109:

6. **¶110: Would you recommend the toolkit or Growth Zone Model to other teaching staff? Why?**

- ¶111: I would recommend the toolkit or GZM to other teaching staff (T)
- ¶112: It would be well worth doing a staff meeting on it (T)



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- ¶113: A PowerPoint is already done, and the scales don't take long to sort and then it's done (TA-MS)
- ¶114: It raises awareness of anxiety, and I think that needs to be done. Not just among kids but staff as well. It's a thing it exists and we need to be compassionate towards it and understand it (T)
- ¶115: I think the perception of some people, it's something I'm passionate about, children who are feeling anxiety can be dismissed as just playing up. What we need to do is move away from that as a profession and this sort of thing can help (T)
- ¶116: The class is such a complicated class and all the needs. I can't say that there is one child who has messed around or been silly. They have really seen it for the positive (TA-SG)
- ¶117: You need to role it out as a whole school from Year 1 (TA-MS)
- ¶118: The adults need to respond positively to it (TA-SG)
- ¶119: They don't even need their own individual GZM and you could blue tac it to the tables and anyone could use it even if they move lesson (TA-MS)
- ¶120: If you start it in year 1, you could start it, it's that simple (TA-SG)
- ¶121: It will just become automatic (TA-MS)
- ¶122: It could dwindle over time but will it eventually go into the background. I don't know (TA-MS)
- ¶123: It would be about embedding it in culture (T)
- ¶124: I would hope that what would happen would be that people would appreciate the positive effect that it has had (T).
- ¶125: A big fat yes! (T)
- ¶126: English would be another good one to test it on. You would see the flip side. Some kids are more confident in maths than English for example (TA-MS).

¶127:

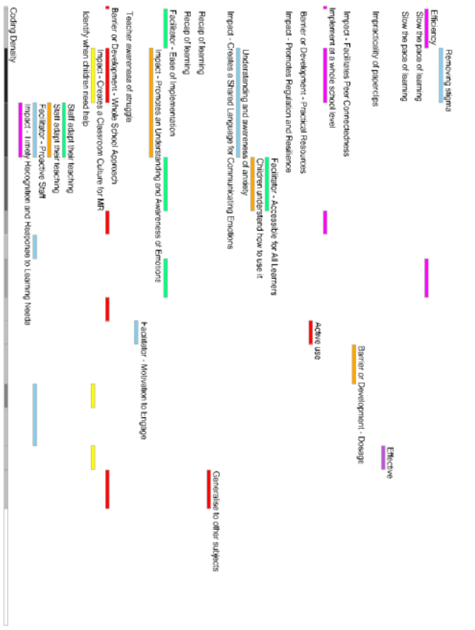
¶128:

¶129:

¶130:

¶131:

¶132:



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Appendix Y

Initial Theme Development

	Theme	Description	References
Impact	Fosters a Classroom Culture for Mathematical Resilience	The intervention appears to have had a positive impact on fostering a classroom culture that promotes mathematical resilience. This culture includes having a shared language for communicating emotions, promoting an understanding and awareness of emotions, facilitating regulation and promoting peer connectedness. Sub-theme(s): *Creates a Shared Language for Communicating Emotions, Promotes an Understanding and Awareness of Emotions, Facilitates Peer Connectedness, Promotes Regulation for Learning*	45
	Timely Recognition and Response to Learning Needs	The intervention helps teachers quickly identify when and where children need additional support, allowing staff to adjust their teaching in response to these needs.	44
Facilitators	Proactive Staff	Staff must be proactive in implementing and responding positively to the approach. This includes embedding it in their classroom culture and proactively responding to children's use of the GZM.	[illegible]
	Accessible for All Learners	The GZM is accessible for all children, including those with identified SEND needs. Once children understand its concept, they can describe and actively use the model in the classroom to communicate with their teacher.	14
	Ease of Implementation	School staff can easily implement the intervention. Children use the GZM appropriately in the classroom, and it does not cause a distraction.	11
	Motivation to Engage	Children are motivated to engage with the GZM and actively use the model in the classroom.	1[illegible]
Barriers and Areas for Development	Dosage	The dosage of the intervention is an area for development as the initial session delivered was perhaps not sufficient to ensure that children remembered and understood the concepts of MR. More time to revisit and reflect on the GZM would be beneficial.	1[illegible]
	Whole School Approach	The intervention is proposed as a strategy to be implemented throughout the entire school, starting in key stage one. Additionally, its applicability across various subjects has been emphasised, reflecting its versatility and the potential for expanding its application.	15

These were deep reflections on the how the interventions had facilitated conversation and change in culture. Reduce into to a theme about reflections on teaching and learning culture?

Communication aspect facilitates identification of need and response

Hoped for outcome? More about the desire to implement and their hopes for staff to engage.

These could be collapsed together? Accessibility makes it easy to implement?

This is rather a limitation to be discussed in discussion. Based on the fact the study is exploratory it suggests increased dosage.

Desire to implement which pairs with staff and pupil motivation to engage?

Appendix Z

Reflexive Thematic Analysis: Process and Summary Notes

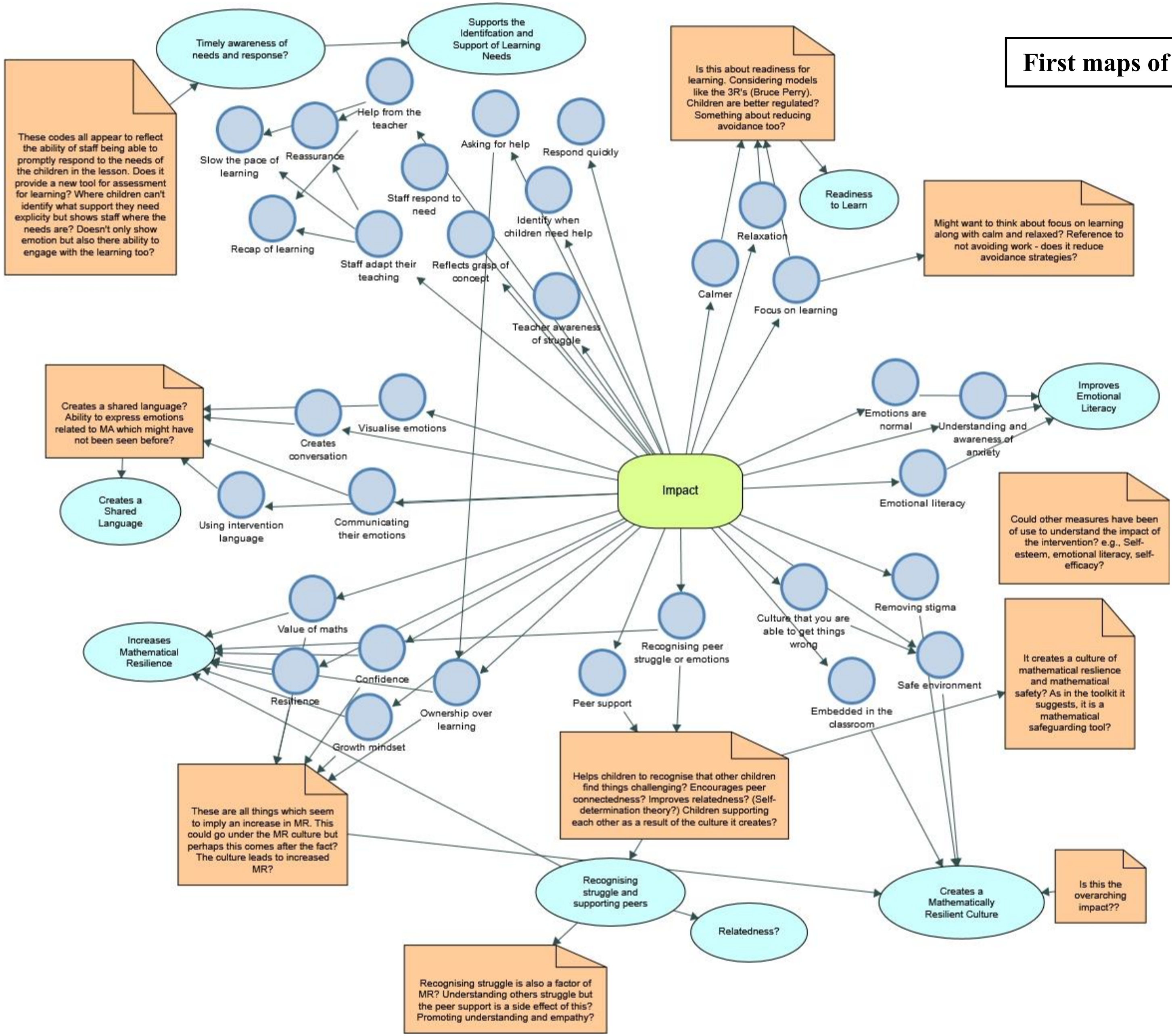
Stage	Process	Reflections	
1. Familiarisation	- Reviewing and reflection on the interview data - Verifying the focus group interview data for inaccuracies and typographical errors - Preparation of field notes from the focus group for NVivo - Transcribing the responses provided by children into a text document from hand written field notes	STAFF • Talk about the ease of its use and understandability – mention of SEND – not a barrier • Mention of it being the 'first thing' they look for – habit? Part of a routine? – Suggestion it needs to be earlier in school (Year 1) so it becomes routine • Children are asking/communicating they need help – empowerment is mentioned • Teachers are able to respond quickly to children needing help and they can communicate it • Recognition of emotions/anxiety/Mental health as normal– 'it's a life skill' – creating a safe environment for struggle? Children helping each other • Use of the language is valuable – creating a shared language? • Hasn't become a distraction • Session length was good for staff • Reassurance following recognition of struggle?	CHILDREN - Ability to tell the teacher how they feel and have this responded to - Teacher adapts the learning – makes it 'easier' or scaffolds e.g. 'groups' - Mention of feeling calmer - Mention of noticing that other peers can share how they feel/get the help they need - Adults can see how they feel - Reference to the breathing exercises - Children suggesting alteration to the zones/emojis – action research project? - Children saying they couldn't remember the session or what resilient means – intervention dosage needs looking at? - Noticing similar comments from children as were given by staff. - Even though children were interviewed individually, they provided similar responses. - Aisha's explanation of the model was the most developed and clear. Indicative of her outcomes? Or does this indicate her ability to engage

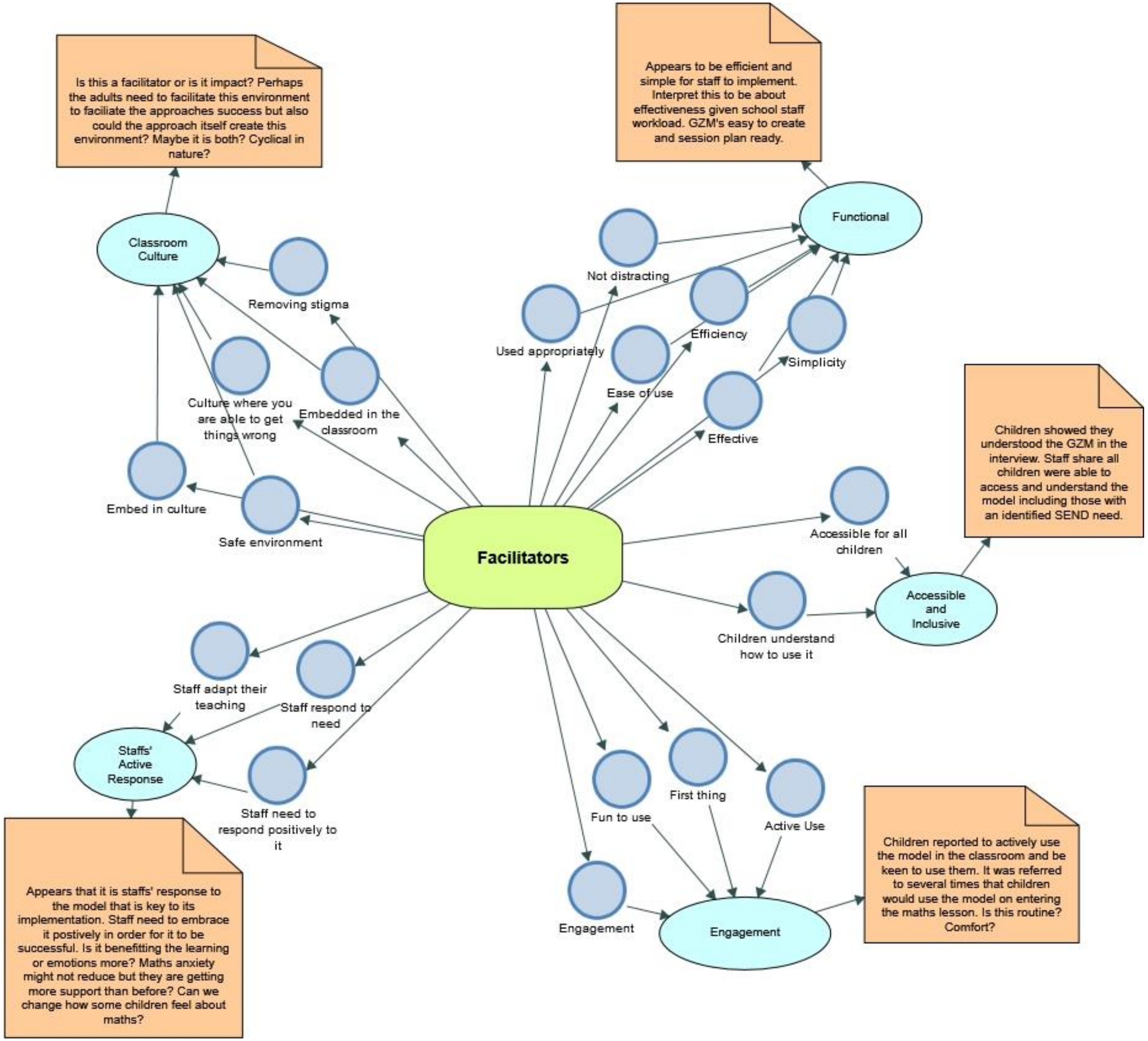
		• Recap of learning/teacher remodelling input - one of the key proactive responses • Recognition of struggle in maths is normal • Children are calmer • Focusing on the work/preventing avoidance? Avoidance indicates anxiety? Could looking at the amount/reduction in avoidance strategies be a measure of effectiveness? • Able to identify children struggling who once thought not to be – alternative form of Assessment for Learning? Assessment for Readiness? • Beneficial in other subjects • How can it be embedded in school culture? • Measures – some children not responding in the expected way- reflection on the reliability of the measures? Limitation • Need time to reflect on the GZM – pace of lessons? • Practical issues with pegs/paper clips.	with the measures accurately? Some children may have needed recap of the initial session/how to use the model. Or they found it difficult to understand what the measures were asking them?
2. Initial Coding	- Initial coding of data using NVivo.	- Their codes are complementary across the staff and child interviews – shared view	

	- Staff focus group data was coded first. - Child interviews coding after.	- Evident from children's responses that they understood the GZM but not what MR is – appears the initial session was not high enough dosage? How would this be looked at? Is this a limitation rather than a theme? - Lots of similar codes that could be brought together – create parent nodes - Organise codes into themes which could be under the over arching research question. The themes could be sorted into possible facilitators, possible barriers, impact and suggestions based on knowledge of the data and purpose of this phase? Facilitators also seem like impact? Perhaps better to have themes under one umbrella of the overall? Perceptions and then have five themes?
3. Identifying Themes	- Concept maps were used to help draw themes together on NVivo - Reflections in notes on the maps - Hierarchy chart - Reference quantities - Word clouds - Produced code report of qualitative quotes - Processes helped to support theme development	- Initial themes created for facilitators, barriers, impact and suggestions - Could this be minimised to: facilitators, suggestions for improvement (including barriers?), and impact – or just under overall perceptions? - Include a theme of 'suggestions for future use' under barriers? – It's not barriers, it's even better if? Are these just limitations? - Had to recode a second time due to a tech issue – initial codes kept and reflected on - After reviewing and looking at data deleted 'life skills', 'staff confidence'– they did not reflect these codes strongly enough - Codes with 1-3 references – perhaps not strong enough to make interpretations from? Delete themes with small amount of references
4. Reviewing Themes	- Reflection using post-it notes in considering themes and how they relate? Can they be reduced? - Further concept mapping was produced to review the themes and codes	- Some of the themes appear to be related. As in, one facilitates the other – e.g., creating a shared language for communicating emotions appears to be related to improved emotional literacy? Does the creation of the language support emotional literacy development or are these separate outcomes? Understanding of emotions seems different to communicating though because some children may have had the awareness but not had the ability to communicate how they felt? - Creates a classroom culture for mathematical resilience or reflections on it as such (overarching theme) it was felt the other themes were sub-themes which

		are the factors which facilitate this culture – but also about the reflections on culture? - This appears to be separate from the discussions around staff being able to identify learning needs promptly. Cognitive vs. affective? So whilst the intervention focused on the affective domain promoting reflecting on a culture for MR, it actually impacts the cognitive domain because it communicates their level of understanding and supports teachers' proactive response to learning needs.
5. Defining and Naming Themes		- A table of proposed themes – ten themes – split across three areas – - reduction of these themes into five main themes under the overarching RQ – collapsed themes that had overlapping meaning and renamed themes. - Nature of the QUAN-qual – need to be clear on the outcomes of this phase – what were the major views/perceptions of staff and children re the intervention – supported with theme reduction and clarity of the messages in the data

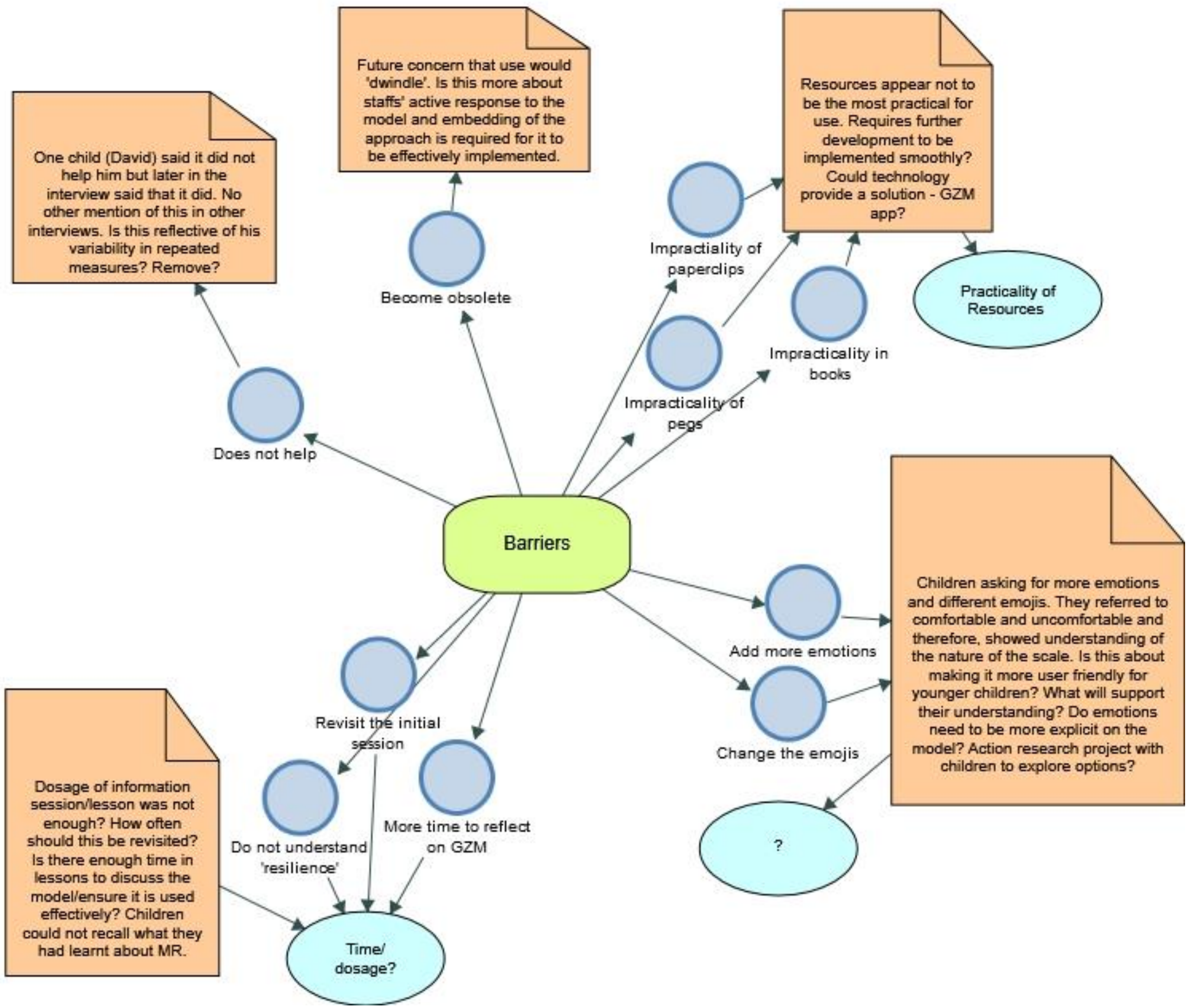
First maps of codes and reflections





- Is classroom culture in two parts? The approach creates the culture described, but the teacher is required to embed the approach as part of their classroom culture for it to be implemented effectively. Is this about the reflections they had on their classroom culture overall?

- Think functionality is possibly about the approach not adding to workload or classroom management – it does not add additional stress? Easy to implement?



- Are these barriers or suggestions for improvement? Could this feedback be used to refine the intervention or develop it instead of a theme itself?
- Are these all limitations rather than themes? Dosage is more about the development of the intervention going forward
- Referenced relatively less in comparison