‘I could never do maths at school’

An exploration of the ways in which an online intervention for parents can change the way they think and talk about mathematics and reduce the intergenerational transmission of Mathematics Anxiety.

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Abstract

Mathematics Anxiety is widespread and is believed to affect up to 20% of the population (Ashcraft and Ridley, 2005). Parents are the primary influencers of their children's attitudes and beliefs and if parents are anxious about mathematics, it is more likely that their children will be (Vanbinst, Bellon and Dowker, 2020; Soni and Kumari, 2017; Casad, Hale and Wachs, 2015; Ramirez *et al*., 2013). Children of highly anxious parents were found to have learnt significantly less mathematics in elementary school that those of less anxious parents (Schaeffer *et al*., 2018).

This study explored whether an hour-long, online intervention could guide parents to transmit more positive, less anxious attitudes to mathematics. In this study, an intervention, named Mathsbreak, was designed and trialled with a small number of participants (n=12). The design was informed by an initial research phase. It consisted of short video clips in which different professionals describe how they use primary-school mathematics in their jobs. It aimed to raise awareness of the utility value of mathematics and its widespread applications.

The intervention was evaluated immediately after participation and again several months later. Evaluations found that the course was positively received and effective in its aims of increasing awareness of the uses of mathematics and stimulating mathematical conversations with children. Parents remembered the key messages at both evaluation points and reported feeling more confident in supporting their children, more empowered to talk to the school about their children's mathematics, more motivated to try mathematical activities with their children and less likely to make negative statements about mathematics.

This research showed that an online intervention targeting utility value beliefs could be an effective tool in changing the attitudes transmitted by parents. The study makes a number of recommendations regarding parental engagement, homework and approaches to teaching mathematics.

Note on the Text

The term 'parent' is used throughout this thesis for clarity. It is intended to refer to parents, carers or any other adult involved in supporting a child at home.

Contents

Figures

Appendices

Chapter 1 – Introduction

1.1 Introduction

It is, in British culture, perfectly acceptable to say that you cannot do mathematics. This has been identified as a 'huge cultural and attitudinal barrier' to improving levels of numeracy (National Numeracy, 2019, p.10). It is an issue repeatedly raised by government-commissioned reports (Williams, 2008), newspapers (Walker, 2023; Barret, 2020; Jones, 2012) and mathematics campaigners (Seagull, 2022; Riley, 2018). All argue that an inability to do mathematics should not be seen as a badge of honour. Despite the fact that mathematics is ubiquitous in modern life, many people find it hard to see its relevance (National Numeracy and YouGov, 2022). Forty-five per cent of parents would feel prouder of a child who was very good at reading and writing compared with 20% who would feel prouder if they were very good with numbers (National Numeracy and YouGov, 2022). Actual levels of mathematical ability in the UK are concerning: only 22% of adults have the mathematics ability equivalent to a GCSE C Grade (National Numeracy, 2019). Fifty-seven per cent have particularly low numeracy skills, meaning their understanding of mathematics is at, or below, the level expected of an 11-year-old; this is below the OECD average (Pro Bono Economics, 2021). Despite these figures, only a third of British adults have any interest in improving their skills. Of those who said they did not wish to improve their skills, 56% thought they were already good enough and 37% could not see the benefit (National Numeracy and YouGov, 2022).

Negative attitudes towards mathematics among both adults and children have been documented in the education literature for decades (Larkin and Jorgensen, 2016; Brown, Brown and Bibby, 2008; Hodgen and Askew, 2007; Bibby, 2002). There is a widespread belief that mathematics ability is innate and that only some people will be successful in learning it (Boaler, 2009). There is also a growing awareness of Mathematics Anxiety (MA) and the fact that, for many people, a fear of mathematics is the biggest thing that is holding them back from gaining skills (National Numeracy, 2019). A recent report found 30% of school leavers (age 18–24) feel anxious about using mathematics and numbers (National Numeracy, 2023). This would suggest reducing negative attitudes and levels of MA in the population may be a first step to improving numerical competency.

This is a social justice as well as an educational issue; lack of number confidence is more likely to affect those from disadvantaged backgrounds and women (National Numeracy, 2023).

Too many adults are at risk of debt and exploitation as they lack the basic skills they need to navigate an increasingly complex financial environment (Barrett, 2022; Halfon, 2022; McGuinness, 2022). One in two adults were unable to pass a financial literacy test run by the OECD, putting the UK well below France, Norway and Canada (Halfon, 2022). A poll of 4000 adults published by the Centre for Social Justice revealed that almost half of individuals — 46% — who suffered financial problems said poor money-management skills contributed to their difficulties (Halfon, 2022). Those from ethnic minorities and those in the most deprived neighbourhoods are least likely to be financially literate and, again, women are less likely to be financially literate than men (Jenkins, 2021).

Having outlined the extent of the problem that needs to be tackled, I will in the following paragraphs lay out my argument for focussing this research on attitudes towards mathematics rather than mathematical skills. I will then explain my rationale for devising an intervention for parents rather than young people themselves. Following that, I will explain the decision making that led to a brief, online, social psychological intervention. I will conclude this chapter with an outline of the thesis itself.

1.2 The Rationale for an Online, Social Psychological Intervention for Parents

1.2.1 The Decision to Focus on Attitudes and Beliefs

Attitudes can be defined as 'external expressions of emotion and reflect people's values, expectations, and feelings toward things' (Cui, Zhang and Leung, 2021). A resounding theme in the reports on poor numeracy levels referenced above is the key role attitudes to mathematics play. This is encapsulated in the title of National Numeracy's Autumn Report (2019) *Building a Numerate Nation: Confidence, Belief and Skills.* The report emphasises that:

> we now have clear evidence of the importance of both confidence with numbers and what is known as a 'growth mindset'; the belief that you can improve is the biggest single factor in determining actual improvement. (National Numeracy, 2019)

Instead, it is thought that MA, the opposite of confidence and self-belief, may affect 20% of the population (Ashcraft and Ridley, 2005). It is characterised by feelings of apprehension, tension or discomfort and is experienced by many individuals when performing mathematics or in a mathematical context (Richardson and Suinn, 1972). It is predominately emotional but is associated with cognitive difficulties performing mathematical tasks (Carey *et al.*, 2019) and leads to avoidance of situations in which a person has to engage with mathematics. It does not, however, exclusively affect people with low mathematical skills. Seventy-seven per cent of children with high MA were normal to high achievers (Devine *et* *al.*, 2018). MA matters, even when children are apparently successful, because these negative feelings can result in an avoidance of mathematics as soon as it is no longer compulsory. Definitions, models, causes and remediations of MA will be discussed in detail in the following chapter, which deals with theoretical models. At this point, it is enough to note that it correlates negatively with enjoyment of mathematics, self confidence in mathematics, motivation to learn mathematics and views about the usefulness of mathematics (Ashcraft, 2019).

1.2.2 The Decision to Target Parents

The primary influencers of the attitudes and beliefs of young children are their parents. MA has been found in children as young as 6 years old (Carey *et al.*, 2019) and fears about mathematics and the consequences of failing have been found in children in the first grade of school (Szczygieł and Pieronkiewicz, 2022). These children appear to be arriving at school predisposed to be anxious about a subject they have almost no experience of. It would therefore seem likely that the atmosphere around mathematics at home is contributing to their fears. Alongside this, parental involvement in learning has been shown to have clear links with positive social and academic outcomes for children (Vukovic, Roberts and Green Wright, 2013; Cooper *et al.*, 2010; Yan and Lin, 2005). Intervening through parents is not, however, without complication. One review of interventions aimed at engaging parents with supporting mathematics concluded that there was little evidence that they were an effective solution to underachievement and 'may do more harm than good' (Huat See and Gorard, 2015, p.260).

There are a number of reasons why involving parents in supporting mathematics learning itself may be challenging. These are discussed in detail in Chapter 3, but to summarise briefly: parents report low levels of confidence in supporting their children with mathematics; this is commonly attributed to the changes in the mathematics curriculum and the way mathematics is now taught (Jay, Rose and Simmons, 2018; Muir, 2012; Winter *et al*., 2004). There is a lack of understanding of what should be expected at different ages (Muir, 2012; Cannon and Ginsburg, 2008), a fear of confusing children with older methods (Jay, Rose and Simmons, 2018; Winter *et al*., 2009) and uncertainty over involving children in the mathematics of daily living (Rose, Jay and Simmons, 2014; Sonnenschein *et al.*, 2012). There may also be a negative impact from increased involvement; for example, the transfer of parental anxiety may be more likely when a highly anxious parent helps with homework (Maloney *et al.*, 2015; Hill and Tyson, 2009). Mathematics-anxious parents are also more likely to behave in a controlling or inflexible rather than a supportive way when helping with homework. This risks further undermining children's confidence and creating an unconstructive spiral (Oh, Barger and Pomerantz, 2022). Jay, Rose and Simmons (2018) highlight a paradox in the literature,

> whereby correlational studies of parental involvement in education show uniformly positive effects on pupil attainment, but efforts by schools to increase levels of parental involvement tend to have either no effect or a negative effect on attainment in mathematics. (p.2)

Other researchers challenge the notion that increased parental involvement is self-evidently positive, arguing that there are many complex social factors at play that schools do not take account of in their policies (Lareau and Shumar, 1996). The tension is therefore clear: parents have a critical influence on their child's attitudes to mathematics; however, encouraging parents to be more involved in their child's learning may increase levels of stress, risk damaging relationships with the school and within families, exacerbate parents' own MA and result in increased transmission of negative attitudes.

Jeynes (2010), in a meta-analysis of the impact of parent involvement in US elementary schools, also found a strong relationship between parental involvement and academic outcomes. However, he found that it was not the teaching of skills but the 'subtle aspects' of parental involvement which had the most impact. He argued that it was not particular actions, such as checking homework or attending school functions, that made the difference but 'variables that reflected a general atmosphere of involvement produced the strongest results', such as parental expectations and parenting style. This, he argued, 'may create an educationally oriented ambience, which establishes an understanding of a certain level of support and standards in the child's mind' (Jeynes, 2010, p.40). A number of studies have also shown that 'academic socialisation', which 'encompasses the variety of parental beliefs and behaviours that influence children's school-related development', is fundamentally important (Taylor, Clayton and Rowley, 2004, p.163). For example,

> [Across social and ethnic groups] a common factor is the tendency of adolescents to do well in school when their parents express high expectations for school achievement and conduct warm, nurturing and frequent interactions with them. (Yan and Lin, 2005, p.124)

It is argued that a positive atmosphere around mathematics in the home environment has a more positive effect on both motivation and success than direct support with mathematics tasks (Elliot and Bachman, 2018; Hyde *et al*., 2017; Hill and Tyson, 2009). Jeynes (2010) himself asked whether these more 'subtle aspects' of parental involvement could be taught, whether an intervention that targeted them could be effective (p.111). This research will attempt to answer that question. The focus on attitudes and beliefs rather than asking parents to support mathematical skills will, it is hoped, circumvent some of the difficulties and sources of tension outlined above.

In terms of outcome, the ideal result of changing the beliefs held by parents would be the naissance of a 'competence cycle' (Leung, 2006 cited in Mok, 2020), where parents who are confident in mathematics bring up children who are confident in mathematics. This competence cycle has been identified in families of East Asian heritage across the world. Not only do students from East Asian countries top the international mathematics league tables with their TIMMS (Trends in International Mathematics and Science) and PISA (Programme for International Student Assessment) scores (Crehan, 2018; Jerrim, 2015) but, as a group, East Asians tend to be highly successful in whichever education system they find themselves (Mok, 2020; Gibbs *et al*., 2017; Jerrim, 2015). Currently, ethnic Chinese pupils have the highest average A level scores of all groups in the UK (Department for Education, 2022a) and 75% of ethnic Chinese children on free school meals achieved the expected standard in mathematics aged 11 compared to 44% of white British children on free school meals (Ofsted, 2021). Critically, mathematics is viewed in East Asian cultures as a skill which can be learnt (Crehan, 2018; Mok, 2020). The details of this approach to education, and what can be learnt from it, are discussed in detail in Section 3.4.2.4 with a particular focus on the intergenerational transmission of attitudes and beliefs.

1.2.3 The Choice of a Brief, Social Psychological Intervention

The arguments in the paragraphs above suggest that attitudes and beliefs are a valuable focus for an intervention and that targeting the way parents socialise children around mathematics could be an effective way to instigate change. This led to the consideration of a social psychological intervention. These interventions target thoughts, feelings and beliefs rather than academic skills or content (Yeager and Walton, 2011). They seek to change people's subjective experience, their perceptions or 'construals' of themselves and their place in their social world rather than their objective environment (Wilson, 2006). They are often brief and target a single, keystone belief (Paunesku *et al*., 2015), for example, the explanations people give themselves for poor performance. The aim of a social psychological intervention is to instigate a positive, self-reinforcing change in behaviour. There are numerous examples in the literature of these interventions being used in education to positive effect; a single activity having ‘a striking effect on achievement and attainment gaps, even over months and years’ (Yeager and Walton, 2011, p.268).

Examples of social psychological interventions include one consisting of a single writing assignment about personal values, given to US seventh graders and designed to counter the stereotype threat experienced by minority students, which has been credited with reducing the racial achievement gap by 40% (Cohen *et al*., 2006). Another, aimed at students transitioning to college, provided students with a narrative that any social adversity they experienced was common to all and short lived, rather than evidence that they did not belong. This short activity, although delivered to all students, was credited with improving the grades of African American students over three years and halving the racial achievement gap (Walton and Cohen, 2011). A third, where college students were guided to write letters to younger students emphasising that intelligence was malleable and therefore current difficulties were surmountable with hard work, had a significant positive effect on the college students’ own grades and reported enjoyment of college. As with the previous two examples, the impact was higher in students from African American backgrounds; this may have been because a belief in the malleability of intelligence reduced the impact of the stereotype threat which can impact the performance of black students (Aronson, Fried and Good, 2002).

Many metaphors have been used to describe these interventions – they are a new lens to view the world, a catalyst or the first spark in a chain reaction (Cohen and Garcia, 2014). Their advocates are also very clear that they are not magic (Yeager and Walton, 2011) or a ‘one-time shot in the arm’ (Cohen and Garcia, 2014, p.16). Whilst they have been shown to have an extraordinary power in specific situations, there are a number of caveats to consider. Firstly, they are highly dependent on context: they are only powerful if they both remove a specific, critical psychological barrier to learning and trigger self-reinforcing processes (Yeager and Walton, 2011). This means that all the other elements to support success must be in place alongside them; an intervention to improve a student’s self-confidence will only work if it is accompanied by effective instruction. To take the analogy of a light switch, the flicking of the switch viewed in isolation is powerful, but it only works if the rest of the electrical infrastructure is in place (Cohen *et al*., 2006). Secondly, these interventions depend on being psychologically precise in their understanding of how people construe themselves and their social world (Walton, 2014) and accurate in understanding the barriers they face. Thirdly, they need to be delivered in a ‘psychologically wise’ way that ‘delivers the treatment message effectively without generating problematic side effects like stigmatizing recipients’ (Yeager, Walton and Cohen, 2013, p.62); they may therefore need to be delivered to all students rather than specific vulnerable groups. This delivery may need to be subtle or even 'stealthy' (Yeager, Walton and Cohen, 2013) to avoid being experienced as controlling. For example, students in the final example above gained an understanding of the malleability of intelligence in the context of supporting younger students, not by being directly told (Aronson, Fried and Good, 2002). Finally, interventions need to be delivered early, to prevent a negative recursive process from gaining momentum (Cohen and Garcia, 2014).

One of the key issues with the viability of these interventions is their scalability: whether they can be adapted from small, bespoke, researcher-led programmes to delivery on a larger scale by non-experts. Yeager *et al*. (2016) report a successful attempt to scale up an online, two-session mindset intervention for 3000+ students entering high school; Broda *et al*. (2018) found an online growth-mindset intervention for first-year college students improved the GPA of Latinx students but not white or African American students; Fink *et al*. (2018) found a three-part online growth-mindset intervention increased the exam scores for first-year Chemistry undergraduates, particularly those from minority groups; Boaler *et al*. (2018) report that a massive open online course (MOOC) specifically targeting mindsets in mathematics had a significant positive impact on students' beliefs, engagement and standardised scores. In contrast, McCabe, Kane-Gerard and Friedman-Wheeler (2020) found no impact from a three-part online growth-mindset intervention for first-year students based on TED talks and, in a large-scale meta-analysis of mindset interventions involving over 300 studies, Sisk *et al*. (2018) found no significant effect size and suggested that intervention budgets should be spent elsewhere.

Whilst the evidence for the impact of social psychological interventions is not conclusive, it was my judgement that there was enough evidence of their potential impact in this situation to be worthy of exploration. The belief that mathematics ability is a fixed trait combined with widespread MA leading to the avoidance of mathematics represent 'construals' that could be overcome. There are already many resources in place for parents to support their children with mathematics, within and beyond schools, and the removal of these psychological barriers might allow parents to access them, and thus there is a potential to trigger a self-reinforcing, positive spiral towards increased confidence and positivity towards mathematics.

1.2.4 The Choice to Create an Online Intervention

The early stages of this research coincided with the Covid-19 pandemic, school closures and national lockdowns. This effectively curtailed any debate over a face-to-face or an online intervention. That is not to say that an online intervention was not a possible eventual outcome without this. Online interventions have many merits for busy parents: they are accessible without the need for childcare and they can be fitted around family schedules. Parents of primary-school children, as a demographic, are 99% likely to own a smart phone (Statista, 2022), meaning that few would be excluded by the use of this medium. Online interventions are also more likely to be scalable at low cost.

Taking all these elements together, this research was designed to answer the following questions.

1.3 Research Question

What are the effects of a brief, social psychological intervention on the beliefs, attitudes and opinions parents hold about mathematics and the way they talk about it to their children?

Research Sub-questions

1. What beliefs, attitudes and opinions do parents hold regarding mathematics learning?
2. What are parents' experiences of supporting their child with mathematics and what, if any, barriers do they face?
3. How do parents' opinions, attitudes and beliefs about mathematics affect the way they approach mathematics with their children?
4. What is the effect of parents' participation in a short online intervention on attitudes and opinions and the way they talk about mathematics to their children? Is this effect sustained over time?
5. Is the format of the intervention enjoyable, accessible and scalable?

These questions informed the form and direction of the study and the extent to which they were answered will be returned to in later chapters – see Sections 5.6 and 7.8. This research took place in England between 2020 and 2022. The following paragraphs provide a brief outline of the major current policy and contextual influences on mathematics teaching and the involvement of parents in the previous two decades.

1.4 Policy and Major Report Context

The main influence over how mathematics is taught in primary schools in England resides with the Department for Education (DfE) and the Office for Standards in Education (Ofsted). The National Curriculum for Mathematics (Department for Education, 2013) states in its introduction that mathematics is 'essential to everyday life, critical to science, technology and engineering and necessary for financial literacy and most forms of employment' (p.3). However, there is no further mention of the application of mathematics in the document. Similarly, the introduction states the importance of 'a sense of enjoyment and curiosity about the subject' (p.3) but makes no further mention of attitudes to mathematics. The non-statutory Mathematics Guidance for KS1 and 2 in England, which is read alongside the National Curriculum (Department for Education, 2020), is made up entirely of teaching objects, curriculum examples and assessment questions and makes no mention of applications of mathematics, attitudes toward it or MA.

1.4.1 The Ofsted Research Review

In the Ofsted Research Review: Mathematics (Ofsted, 2021) there is an acknowledgement of the fact that mathematics is seen as the preserve of 'naturals' (p.4); there is, however, no mention here of growth mindsets, prevailing social attitudes or relevance, but simply that it is the school's role to 'help pupils gain enjoyment through a growing self-confidence in their ability' (p.4). There is a brief discussion of anxiety, but it is conceptualised only as the result of weak skills, failure and frustration: 'It is not the nature of the subject but the failure to acquire knowledge that is at the root of the anxiety pathway' (p.11). Anxiety is to be resolved by a 'proficiency-first' approach and by closing the gaps with other learners. The review does acknowledge that some children may arrive at school predisposed to be anxious, a fact which effectively undermines the report's own assertion that it is solely the result of underachievement. Again, the proposed solution is that 'teachers ensure that anxious pupils acquire core mathematical knowledge' so that 'those pupils will begin to associate the subject with enjoyment and motivation' (p.11). Only one research paper is cited in support of this unidirectional view of MA (Ma and Xu, 2004); there is no mention of the active debate in the current literature about causes of MA or the existence of MA in high-achieving students (Devine *et al.*, 2018). This would suggest Ofsted has a definite agenda in regard to views of MA, which it is using the Research Review to propound. The validity and agenda of the Research Review have been challenged elsewhere (Association of Teachers of Mathematics and Mathematical Association, 2021; Association of Mathematics Education Teachers, 2021). This discussion of this approach to MA is returned to in Chapter 2 (see Section 2.1.1).

1.4.2 Primary Assessment Policy

In terms of assessment policy, the attainment of pupils in mathematics in primary schools is measured by Standard Assessment Tests (SATs) in Years 2 and 6, when children are 7 and 11 respectively. The Year 2 tests, which are scheduled to become optional in 2023, rely heavily on informal teacher assessment. The Year 6 tests, however, are externally marked, formal test papers; there are two for mathematics, lasting 45 minutes each. These high-stakes tests have a considerable influence over how mathematics is taught and the aspects of mathematics that are prioritised across the primary school; there is an inevitable focus on teaching to the test, often resulting in a curriculum heavy in abstract calculations:

> An unintended consequence of a strong focus on standards achieved in tests is a loss of vision of what primary mathematics is all about. Teachers feel under pressure to 'get a level', so want professional development that helps in the short term. (ACME report quoted in Williams, 2008)

A more recent introduction into the primary-school assessment calendar is the multiplication tables check (MTC). Disrupted by Covid-19, this will be introduced for all Year 4 children (8- and 9-year-olds) in 2023. This involves an online test of 25 multiplication questions up to 12x12; calculations appear on a screen with six seconds for each answer. The rationale for the introduction of this assessment is that fluency in recalling these facts is 'essential for future success in mathematics' (Standards and Testing Agency, 2022). This is significant for MA research as many studies have found that timed tests are a particular trigger for the onset of MA (Hunt and Sandhu, 2017) and that a disproportionate focus on fact recall can be detrimental to both conceptual development and understanding (Boaler, Williams and Confer, 2015). There is no acknowledgement in policy or in the documents associated with the MTC that time pressure can create anxiety in some children. In fact, the research review discussed above (Ofsted, 2021) argues that 'pupils benefit from timed practice of knowledge that should be easily recalled such as maths facts' (p.27) and that 'competitive maths games are, for example, more effective for learning and retention than non-competitive games' (p.28). Current government policy is therefore advocating a very specific view of mathematics learning and learners; this is stated without acknowledgement that many of its tenets are highly contested in the literature.

1.4.3 Maths Hubs

In terms of organisational structure, a key influence on the teaching of mathematics in schools are the Maths Hubs. These hubs are concerned with the professional development of mathematics teachers and are funded by the DfE. They are managed through the National

Centre for Excellence in the Teaching of Mathematics which itself is funded by Mathematics Education Innovation, a charity committed to improving mathematics education for all. All state schools are connected to a Maths Hub; the first 32 hubs were announced in 2014 and a further 8 in 2020. These have a Teaching for Mastery ideology and also run the China–England Mathematics Teacher Exchange Programme (Boylan *et al*., 2019). The continued expansions of these hubs underline the government's commitment to the Teaching for Mastery ideology.

1.4.4 Financial Education Policy

In terms of the application of mathematics and economic wellbeing, financial education has been on the school curriculum since 2014 but appears to have little time or resources allocated to it (Barrett, 2022; FT editorial board, 2021). There are no specific requirements for primary schools, and in secondary, financial education is expected to be delivered through existing mathematics and PSHE curricula. In this, the UK is 'something of an outlier' as the majority of OECD countries do include financial literacy in their primary curricula (Jay *et al*., 2022, p.6). The UK Strategy for Financial Wellbeing 2020–2030 (Money and Pensions Service, 2020) states in its aims that 2 million more children and young people will get a meaningful financial education; this would take the number from 4.8 million to 6.8 million. The bar for this 'meaningful' financial education is minimal and is measured by the answers to the following survey question:

> [Pupils] recall financial education at school they considered useful AND/OR
>
> Their parents gave them regular money, set rules about money and gave them responsibility for spending decisions. (Money and Pensions Service, 2020)

There is, however, evidence that teaching young children explicit financial knowledge is unlikely to be effective in shaping or changing behaviour unless it is embedded in real-life situations. Modelling by parents and other significant adults is far more likely to be influential (Whitebread and Bingham, 2013). If parents themselves lack confidence discussing numbers, and specifically money, as the discussion in Section 1.1 suggests is common, then they may avoid such conversations and leave children to the influence of other sources, such as peers or social media (Darbyshire, 2021; FT editorial board, 2021).

1.4.5 Policy on Parental Involvement

The importance of involving parents in their child's mathematical development has been emphasised in reports and policies for decades. The *Independent Review of Mathematics Teaching in Early Years Settings and Primary* (Williams, 2008), which was quoted above, had as one of its key questions for review 'How should parents and families best be helped to support young children's mathematical development?' (p.2) and makes repeated reference to the importance of their influence as a child's 'first and most enduring educator' (p.69). However, Williams notes that 'The United Kingdom is still one of the few advanced nations where it is socially acceptable – fashionable even – to profess an inability to cope with the subject' and that 'a parent expressing such sentiments can hardly be conducive to a learning environment at home in which mathematics is seen by children as an essential and rewarding part of their everyday lives' (p.5). He emphasises that something must be done to reverse the 'widely accepted can't do attitude' (p 71.) to mathematics in the UK.

> If parents believe they cannot understand mathematics, they have little incentive to act or to persevere in the face of difficulties with their children's learning, and they are unlikely to pass on a positive attitude. (Williams, 2008)

The review also mentions the barriers parents face understanding the new methods children are taught and that it is important for schools to address this by bringing parents up to date with teaching methods and also to

> recognise the wealth of mathematical knowledge that children pick up outside the classroom and help children make links between in school and out of school mathematics. (p.70)

He concludes with a call for attitudes towards mathematics to be at the heart of schools' involvement of parents:

> There is an opportunity here for schools to work together with parents to dispel myths about the mystery of mathematics and give both children and parents a good grounding and positive attitude to this subject. (Williams, 2008, p.72)

Education White Papers are policy documents produced by UK governments to set out their proposals for future legislation. Produced under the New Labour government (1997–2010), the *Excellence in Schools* White Paper makes explicit mention of the importance of involving families in literacy, numeracy and changing attitudes to education. It also advocates providing learning opportunities for the whole family (p.53). *Every Child Matters* (HMS0, 2003) brought policy on parenting and family support under the umbrella of the DfE, alongside policy on education. There are extensive proposals for support for parents, better communication with schools and family learning opportunities. (p.41). *Higher Standards, Better schools for all* (DfES, 2005) continues the theme of maintaining parental engagement and also empowering parents to 'drive up' standards. The foreword by the education secretary refers to parental engagement as one of three core aims of the White Paper:

> Put parents at the centre of our thinking – giving them greater choice and active engagement in their child's learning and how schools are run. (p.5)

The paper continues with a promise of funding for schools to run information sessions and advice on homework (p.71) and also specific resources for parents to help their children learn at home (p.67).

However, the emphasis shifted under the Conservative government (2015–present). The language no longer mentions collaboration or involvement but instead emphasises dissemination of information and parents being able to 'hold schools to account' and 'demand' change. In the White Paper *Educational Excellence Everywhere* (Department for Education, 2016), the emphasis is on parental choice, information for parents, clear complaint procedures and having the 'information they need to challenge schools' (p.65). The most recent White Paper, *Opportunities for All: Strong Schools with Great Teachers for your Child* (Department for Education, 2022b), also makes repeated reference to the importance of parents. However, this is mostly in terms of the need to keep them informed and updated, particularly if their child is falling behind.

In summary, despite the explicit recommendations of the Williams report (2008), the New Labour White Papers (DfES, 2005; HMS0, 2003) and extensive academic research into the importance of attitudes to mathematics and the potential role for parents, current policy makes scant mention of them. In fact, many of the recent government positions, such as the unidirectional view of MA and the introduction of the timed MTC, actively contradict the recommendations given.

1.5 My Own Position

Another important aspect of context in this research is my own position: my 'self' as the researcher. I conduct this research as a teacher, a parent and a researcher. I have spent more than 15 years teaching primary-aged children in different schools, different cities and different socio-economic environments. I have also spent a number of years teaching and training teachers in Asia and can thus look at our own social and educational cultures with the slight detachment which comes from having experienced other ways of being. I am also now the parent of a primary-aged child and was, alongside many of the participants in this study, homeschooling during the Covid-19 pandemic. I am confident in mathematics, have spent a lot of time engaging my daughter with mathematics and would fit the profile of 'joyful' parents described in Section 5.3.2. This aspect of my identity has significant bearing on the research and the implications of it will be returned to in more detail in Section 4.5.

My interest in MA originated in research for a master's degree in education (Fieldhouse, 2014). As part of a case study investigating the deterioration in the mathematical performance of girls in one primary school with high levels of economic deprivation, I uncovered high levels of anxiety about mathematics. I felt strongly that mathematical understanding, financial literacy and opportunities in STEM fields should be available to all, regardless of gender or social class. It appeared, in this context, that the negative attitudes and fixed mindset prevalent in society were disproportionately impacting working-class girls.

When I arrived at the other side of the school gate as my own daughter started school, I was surprised by how few parents engaged with the small mathematical tasks the school sent home. This was within a parent group with high levels of engagement with reading, spelling and project work. Conversations with other parents revealed a fear of not knowing what to do and a concern about causing confusion, despite the fact this was infant school mathematics. In this context, I witnessed parents demonstrating high levels of anxiety when asked to participate in simple mathematical games in school workshops. I also overheard many conversations between parents and their young children which risked perpetuating anxiety about mathematics and the belief that mathematical ability was something you were born with. I became interested in what could be done to directly target these limiting attitudes and beliefs, with the aim of reducing the extent to which they were passed on. This research is the culmination of these ideas.

1.6 Research Paradigm

The experiences of individual parents are at the centre of this research and their perspectives were explored, in detail, throughout. The research was therefore situated in an idiographic paradigm where the individual is viewed as unique and complex. The knowledge which was created in this study came from the interactions of the researcher with the individual participants; there was not one truth to be sought but many possible interactions and many possible interpretations of them. This epistemological position influenced multiple aspects of the study, for example the qualitative methodology, the extended interviews and open ended questionnaires and the choice of reflexive thematic analysis to analyse the data (Braun and Clarke, 2006). Within this paradigm, the 'I' of the researcher is important and it is acknowledged that the values I hold, the decisions I made and the relationships I built inevitably influenced both data and interpretation. This subjectivity will be explored throughout the study through reflexive accounts, detailed descriptions and transparent documentation of decisions. The epistemological position and the approach to reflexivity taken in the study will be discussed in detail in Sections 4.2 and 4.5.

1.7 The Phases of This Research Study

This research has three phases, which are represented in the funnel model in Figure 1. In the first phase data was gathered to inform the design of an intervention. As discussed earlier, social psychological interventions are highly dependent on context, making this a critical element of the design process. This first phase involved extended interviews with 18 parents about their experiences of supporting their children with mathematics. Alongside this, data was collected from a systematic literature review, which generated more than 200 journal articles. This was supplemented by an analysis of previous relevant interventions and consideration of theories of intergenerational learning. Analysis of the data from the first phase informed the second phase, devising and trialling the intervention. The third phase involved evaluating this intervention. This evaluation consisted of a questionnaire on completion and a further questionnaire five months later to explore parents' reactions to the intervention and any changes in behaviour they believed had stemmed from it. This evaluation had a longitudinal element to capture whether any changes in behaviour had been sustained over time.

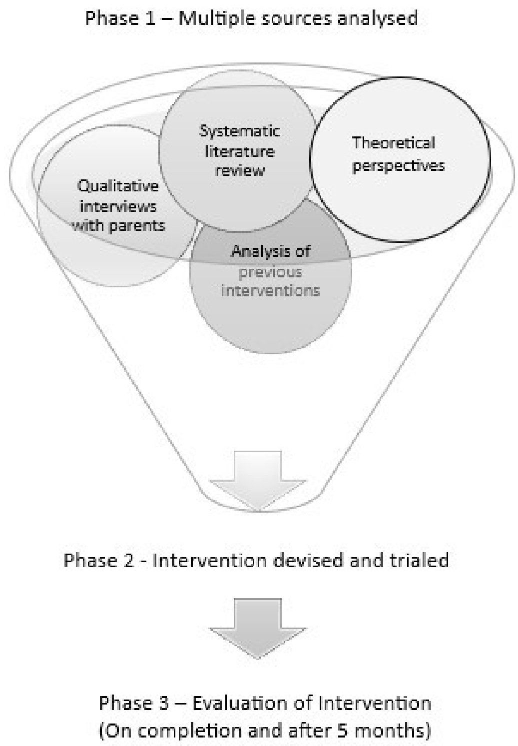


Figure 1 Diagram of the phases of the study

1.8 Summary of Following Chapters

The chapters which follow will detail the different phases of this research. In Chapter 2, the theoretical models on which the study is based are introduced: firstly, those related to MA itself; secondly, those related to the transmission of attitudes from one generation to another, namely Bandura's Social Learning (1971, 1977) and Self-Efficacy (1997) theories and Eccles *et al.*'s (1983) Expectancy Value Theory of Achievement Motivation.

In Chapter 3 there is a systematic review of the research literature related to parental engagement in mathematics and also an analysis of previous relevant interventions. Lessons from this literature and from previous interventions are used to inform the design of the intervention.

In Chapter 4, the research paradigm, methodology and research methods of the study are described in detail. This chapter also includes sections on recruitment of participants and ethical approach.

In Chapter 5, the context and purpose of the research interviews are described and they are analysed using reflexive thematic analysis. The themes drawn from the data are elaborated and discussed in the context of informing a novel intervention. The findings related to the first three sub-questions are discussed.

In Chapter 6, the rationale for the purpose, content and design of the intervention is discussed and the result of this, an intervention for parents named Mathsbreak, is described.

In Chapter 7, the method of evaluation is described and the rationale for methodological decisions discussed. The findings are analysed and discussed in terms of the remaining research sub-questions.

In Chapter 8, the study is discussed and evaluated as a whole, including its strengths and limitations, and conclusions are drawn. An argument is made for its contribution to knowledge and recommendations are made for practice and policy.

Chapter 2 – Theoretical Perspectives

This chapter contains the theoretical underpinnings of this study. The discussion of theoretical models is placed at this early point in the thesis as it informs the treatment of literature which follows, the analysis of the data and the content of the intervention. Two distinct areas of relevant theory are discussed below: those related to Mathematics Anxiety (MA) itself and those related to the transmission of attitudes more generally from one generation to another. Firstly, definitions and explanations of MA in the literature will be explored and the debate over how it is caused outlined. The model of MA adopted for this study will then be presented. A clear conceptualisation of MA is critical as Mathsbreak, the intervention created during the course of this study, is intended to reduce its transmission. In the subsequent section, theoretical models of transmission will be discussed in order to examine the mechanisms by which attitudes and beliefs are transmitted from one generation to another. Mathsbreak was intended to influence this transmission of attitudes. It is therefore essential that it was constructed with a clear understanding of the mechanisms of transmission in mind.

2.1 Mathematics Anxiety – Definitions and Explanations

MA is a specific form of emotional difficulty with mathematics. It is defined as 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 and Suinn, 1972, p.551)

Whilst there are different ways to measure MA, there is no doubt that it is prevalent. It is believed to affect up to 20% of the population (Ashcraft and Ridley, 2005). Across OECD countries, up to 33% of the 15-year-olds who took PISA tests reported getting very nervous when solving mathematics problems (Chang *et al.*, 2017). Around 25% of '4-year college' students and about 80% of community college students in the US report moderate to high anxiety about mathematics (Ramirez, Shaw and Maloney, 2018). MA has been identified in all age groups and recent research has focussed on measuring MA in increasingly young children (Lu *et al.*, 2021; Petronzi *et al.*, 2019; Jameson, 2014). MA is more than a dislike of mathematics. It can evoke the physiological responses associated with other forms of anxiety, such as a racing heart and sweaty palms (Jameson, Dierenfeld and Ybarra, 2022) or even the experience of pain (Lyons and Beilock, 2012), and is thought to operate in a similar way to a phobia (Hembree, 1990). At least two distinct dimensions of MA have been described –

mathematics-learning and mathematics-testing anxiety (Dowker, 2019; Carey *et al.*, 2017; Caviola *et al.*, 2017; Hill *et al.*, 2016). There is a strong correlation between MA and achievement (Namkung, Peng and Lin, 2019; Zhang, Zhao and Kong, 2019; Carey *et al.*, 2016; Hembree, 1990), however, the directionality of this relationship is highly contested in the literature. This directionality is a key issue for those intending to remediate MA or prevent it developing. The arguments of this debate are outlined below, followed by a wider discussion of models of MA.

2.1.1 The Deficit Account

The correlation between mathematics performance and MA has led some to theorise that it is a deficit of skills which is responsible. The term 'deficit account' was first used by Hembree (1990); it is also referred to as the 'reduced competency account' (Ashcraft, 2019). The essence of this account is that weaker mathematics skills lead to poorer learning and performance and subsequently to a learner experiencing MA. This is a highly contested explanation for MA but important to consider here in detail as this is the only cause of MA acknowledged by the recent Ofsted Research Review (Ofsted, 2021). This makes it likely to have a significant influence on the approach taken in English schools.

The key evidence for the deficit account is a longitudinal study by Ma and Xu (2004). Using data from 3000 high-school students over 6 years, they found that prior low mathematics achievement caused high levels of MA, but that previously high MA did not cause low mathematics achievement. This finding is qualified slightly by gender: boys with previously low mathematics achievement were more likely to develop anxiety later. However, girls experienced this only in year groups with school transitions. Anxiety was more stable over time for girls. The conclusions drawn from this paper were that the most effective means to prevent MA in boys is to improve their mathematics achievement. For girls, it is more important to prevent the anxiety taking hold, as once it has developed it is more likely to last as a stable trait.

Although the Ma and Xu (2004) paper has been cited as evidence for the exclusive adoption of the deficit model (Ofsted, 2021), the authors themselves draw more nuanced conclusions. Alongside arguing that getting mathematics achievement right in the early years of high school can prevent MA, they call for programmes that help students cope with the frustrations of learning mathematics; teachers to pay attention to both the 'cognitive and affective wellbeing of students' (p.177); and 'user friendly' mathematics curricula emphasising problem-solving, hands-on activities and cooperative learning. They recognise that mathematics tests are not ‘pure’ methods of measuring mathematics achievement as MA can supress performance (p.177) and that Hembree’s (1990) exploration of the use of cognitive behavioural interventions to reduce anxiety is valid and worthy of further investigation.

Hembree, writing 14 years earlier, acknowledged that ‘higher achievement in maths consistently accompanies reduction in MA’ but did not support the deficit model:

> There is no compelling evidence that poor performance causes mathematics anxiety. The constructs relations with IQ and ability seem small and special work to enhance students’ competence failed to reduce their anxiety levels. (1990, p.44)

Hembree’s view is supported by Devine *et al*. (2018), who found, in a study with 1757 primary-school children, that the majority of children (77%) with high MA had typical or high mathematics performance. They also found that children with developmental dyscalculia – serious difficulties with mathematical performance – were twice as likely to be anxious than those without. They argue that these are two separate difficulties and that interventions for MA should be fundamentally different to interventions designed to support weak development of numerical skills.

More recently, it has been argued that individuals with MA have deficits in the very basic building blocks of mathematical skills, such as recognising the magnitude of numbers (Núñez-Peña and Suárez-Pellicioni, 2014; Maloney, Ansari and Fugelsang, 2011). It has been hypothesised that these skill deficits lead to difficult early experiences of mathematics learning and therefore anxiety develops. Chang *et al.* (2017) report on a study using fMRI scanning, which found that low and high mathematics-anxious people use areas of their brains differently when performing simple calculations, possibly employing fewer automatic processes and therefore calculating less efficiently. Taken together, all of these findings point to a far more complex relationship between anxiety and mathematics performance than one simply causing the other. This bidirectional relationship is supported by the meta-analysis conducted by Namkung *et al*. (2019). They argue that interventions should focus on both remediating skills and reducing MA, rather than one or the other.

2.1.2 The Disruption Account

A related explanation for the relationship between MA and performance is the ‘disruption account’ (Ramirez, Shaw and Maloney, 2018). According to this model, MA disrupts cognitive processing and therefore masks true ability; this results in an individual’s scores on proficiency tests being an underestimate of their ability. This has been described as an ‘affective drop in performance’ (Ashcraft and Moore, 2009 p.197). One hypothesis for this, which has considerable support in the literature, is that MA compromises the functioning of the working memory, reduces its capacity and thus affects performance (Szczygieł, 2021; Passolunghi *et al*., 2019; Witt, 2012; Ashcraft and Krause, 2007). It has been found that mathematical tasks which require use of the working memory, such as carrying, are particularly vulnerable to disruption (Ashcraft and Moore, 2009; Ashcraft and Kirk, 2001). It is thought that ruminating thoughts and preoccupation with anxiety take up valuable cognitive resources and inhibit performance (Ramirez, Shaw and Maloney, 2018). This would suggest that students with lower working memory capacity would have their mathematics performance impacted most when experiencing MA. In fact, the opposite has been found. Ramirez *et al*. (2013) found that children with higher working memory capacity, who presumably relied on this capacity more for calculation, had more suppressed performance when anxiety was triggered. Witt (2012) found that, in mathematics-anxious children, this disruption to working memory was triggered simply by being asked to process digits as opposed to letters, with no calculation required. Ashcraft and Moore (2009) found this deterioration in performance was more pronounced under timed, high-stakes conditions, which raises questions over the validity of traditional testing to assess proficiency. This supports the finding of Faust *et al*. (1996) that individuals with higher MA were just as able to answer problems accurately when in an untimed, unpressured situation. Also, intervention studies focussed on alleviating MA that did not have any mathematics component have resulted in improved performance (Sheffield and Hunt, 2006; Hembree, 1990). These studies would add weight to the argument that the relationship can act in the opposite direction, namely MA causes poor performance rather than poor performance causing MA.

2.1.3 The Avoidance Account

Another explanation for the correlation of MA with weaker mathematics skills is the ‘avoidance account’ (Ashcraft, 2002; Hembree, 1990). This account proposes that individuals who experience MA avoid mathematical situations – whether that is avoiding practising, avoiding homework or taking fewer elective mathematics courses:

> [Individuals with MA] are exposed to less math in school and apparently learn less of what they are exposed to; as a result, they show lower achievement as measured by standardised tests. (Ashcraft, 2002, p.182)

As anxiety tends to be persistent, cumulative knowledge gaps arise as the result of repeated avoidance, and these become increasingly difficult to overcome (Lu *et al*., 2021). A negative spiral of skills deficit, avoidance and worsening skills then ensues (Ramirez, Shaw and Maloney, 2018).

2.1.4 Mathematics Anxiety as a Personality Trait

The explanations for MA in the literature are wider than this specific debate over the relationship between MA and performance. Early MA researchers considered whether the origins of MA were rooted in personality (Dreger and Aiken, 1957). They investigated whether individuals with MA had a disposition towards anxiety and questioned whether it was a separate construct to both test and general anxiety. Hembree (1990) found that MA did have a relationship to both and 'like test anxiety, mathematics anxiety seems to be a learned condition more behavioural than cognitive in nature' (p.45). Despite the overlap, Hembree (1990) acknowledged them to be separate constructs, a view supported by Hill *et al*. (2016). Similarly, Caviola *et al*. (2022) consider MA to be a discrete condition, but one that shares risk factors with both test and general anxiety. They argue that these conditions may contribute to the development of MA. A genetic element to MA has also been identified (Wang *et al*., 2014). Their identical-twin study found that 40% of the differences in MA between the children could be caused be a genetic predisposition and the remainder by child-specific environmental factors, such as negative experiences with mathematics. This would suggest that some individuals are disposed towards some forms of anxiety but that this does not offer a full explanation.

2.1.5 The Interpretation Account

A further, emerging account is the 'interpretation account'. According to this model, advocated by Ramirez, Shaw and Maloney (2018), a person's susceptibility to MA is influenced by how they interpret, or appraise, their prior experiences of mathematics learning. They cite a study by Meece, Wigfield and Eccles (1990) that found students' perception of their own ability, rather than their actual performance, influenced achievement the following year. Ramirez, Shaw and Maloney (2018) argue that this explains why children with maladaptive appraisals, who attribute poor performance to lack of ability, develop greater levels of MA. This explanation overlaps with Dweck's account of the positive effect of holding an incremental or growth mindset (Dweck, 2012):

> Those who attribute their poor performance to lower ability may be at greater risk for developing MA than those who attribute it to lower effort or acknowledge that mistakes are routine when learning math. (Ashcraft, 2019, p.15)

Ramirez *et al*. (2016) suggest that children as young as 6 year old can be trained to use cognitive reappraisal techniques to, in effect, change their interpretation of their experience and thus regulate their emotions. This, they argue, could be an effective intervention to reduce MA.

2.1.6 The Socio-cultural Account

To widen the discussion beyond the individual, there is a large body of literature dedicated to the social and cultural influences that can predispose a learner to MA. Numerous researchers have described the impact that family, teachers and social attitudes have on attitudes towards mathematics. I will gather these here under the term 'socio-cultural account'. Parental attitudes, beliefs and expectations have a significant impact on children's attainment and attitudes (Elliott and Bachman, 2018; Gunderson *et al.*, 2012). Parental MA has been found to impact children's MA (Vanbinst, Bellon and Dowker, 2020; Soni and Kumari, 2017; Casad, Hale and Wachs, 2015; Ramirez *et al.*, 2013). Children's MA was found to be significantly associated with their mother's MA and also with the educational level of both parents (Vanbinst, Bellon and Dowker, 2020). The mechanisms of this transmission are discussed further in Section 3.4.1. The recent Cambridge University report 'Understanding Mathematics Anxiety' concluded that tackling anxiety and belief systems in parents and teachers 'might be the first step to helping their children or students' (Carey *et al*., 2019, p.4).

Gender stereotypical beliefs, for example that boys are more suited to mathematical learning than girls, also affect mathematical attainment (Gunderson *et al.*, 2012; Jacobs, 1991a). Stereotype threat, when an individual's performance is impaired if they believe a group with which they identify is less capable, may be responsible for the higher levels of MA found in girls than boys (Carey *et al*., 2019; Hill *et al*., 2016; Casad, Hale and Wachs, 2015; Maloney and Beilock, 2012). It has been found that even subconsciously held stereotypical beliefs have a negative impact on very young children (Galdi, Cadinu and Tomasetto, 2014). In addition to this are the negative but pervasive social beliefs about mathematics discussed in the Introduction: that mathematics is inherently difficult, natural talent is more important than effort and what is learnt in mathematics has little relevance to the world beyond the classroom. In an unexpected finding, Stoet *et al*. (2016) found greater gender differences in MA in more developed countries, with the exception of the Nordic countries. Although relatively more mothers worked in STEM fields in developed countries, parents on average valued mathematical competence more in their sons (see Section 3.4.2.3 for further discussion of gender and MA).

Teachers also exert a significant influence on students' experience of and attitudes towards mathematics. Many people cite negative experiences with mathematics teachers as the reason they disliked, avoided or became anxious about the subject. These experiences include hostile reactions to errors, prioritising rote learning over understanding, overreliance on text books, increasingly challenging curricula and impatience with students who cannot keep up (Petronzi *et al*., 2019; Vinson, 2001). Such teaching practises may be a result of the teacher's own lack of confidence in mathematics (Ramirez, Shaw and Maloney, 2018; Vinson, 2001). Beilock *et al*. (2010) demonstrate how female teachers with MA passed on both gender-stereotyped ability beliefs and lower mathematics performance to their first- and second-grade female pupils. This finding is concerning as MA is prevalent among primary trainee teachers (Hembree, 1990; Kelly and Tomhave, 1985). Ramirez *et al*. (2018) found that the achievement of older students, in their study, ninth grade, can also be negatively impacted by teachers with MA. They hypothesise that their teachers, despite often being mathematics specialists, may teach in a more controlled manner which does not build student autonomy or problem solving. Through these approaches, they communicate a belief that only some students can be good at mathematics. The students then perceive their teacher to have lower expectations of them.

The multi-faceted and interrelated explanations for MA discussed above demonstrate that it does not have a single cause. Nor is there a simple relationship between MA and mathematics attainment. Ashcraft (2019) argues that all the explanatory models above have credible evidence behind them and, far from being mutually exclusive, form complementary interpretations of a complex phenomenon. Rubinsten *et al*. (2018) devised the developmental, dynamic and bio-psycho-social model of MA (see Figure 2) to show the interrelation of all these factors. This model demonstrates how within-child factors, such as neuro-cognitive and genetic predispositions and socio-cultural factors – such as parenting style and environment – interact to cause or protect against MA. This model emphasises the bidirectional relationship where environmental factors influence, and are influenced by, an individual's own traits. It maps out the potential positive and negative impacts of all of these factors on an individual's physiological, emotional, educational, attitudinal and behavioural responses. These are presented as continuous rather than binary states, analogous to mixing desk sliders rather than switches. I find this a persuasive representation of MA, particularly as it captures the potential variation in impact of different stimuli on different people at different times. It is this model that will underpin the understanding of MA in this study.

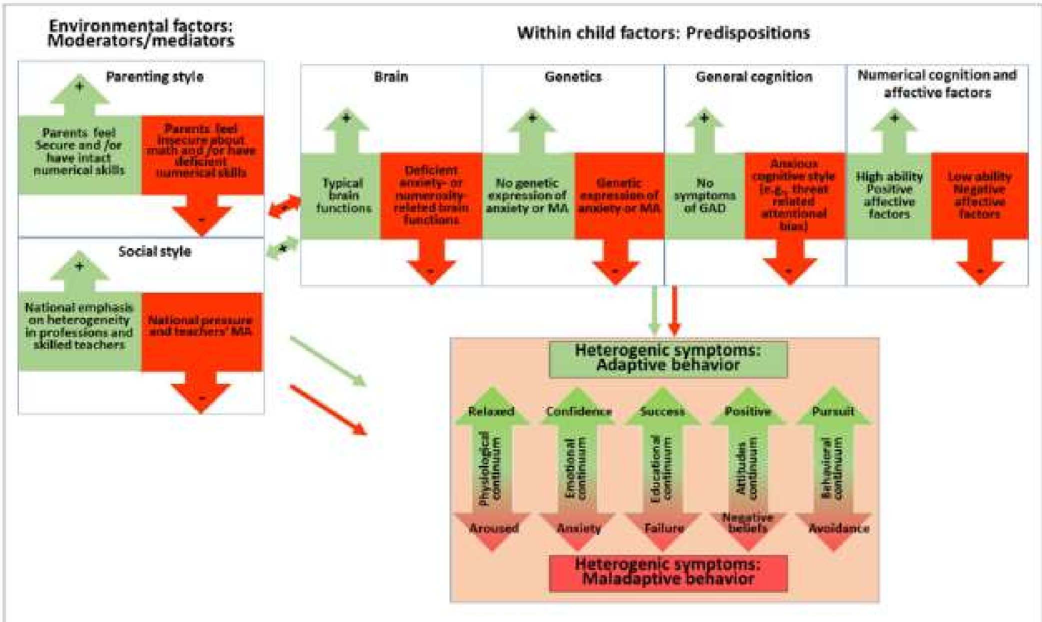


Figure 2 The developmental, dynamic bio-psycho-social model of MA (Rubinsten et al., 2018, p.2). Licenced under CC BY 4.0

2.2 Theories of Intergenerational Transmission of Attitudes and Beliefs

Social and cultural factors, including parents, which contribute to MA are important elements of the model in Figure 2. The discussion of MA above outlines the problem which Mathsbreak was intended to ameliorate. It aimed to do this by reducing the transmission of MA from parents to children. I will now move on to *how* it will achieve this. In the sections below I will explore theoretical models for the intergenerational transmission of attitudes. The theorists discussed below, Albert Bandura and Jacquelynn Eccles, were key influences on the design of the Mathsbreak intervention as they detail the mechanisms by which attitudes are transmitted.

2.2.1 Albert Bandura: Social Learning Theory and Self-Efficacy Theory.

> Most of the behaviours that people display are learned, either deliberately or inadvertently, through the influence of example. (Bandura, 1971, p.5)

Bandura's Social Learning (1971, 1977) and Self-Efficacy (1997) theories provide valuable insight into how MA is transmitted across generations. According to Social Learning Theory later renamed Social Cognitive Theory (SCT), behaviour is the result of interaction between personal, social and environmental factors. It states that people have the capacity to learn from observing others as well as from direct experience. Particularly relevant to the transmission of anxiety is the process of 'vicarious conditioning' (Bandura, 1971), where an emotional reaction is learnt by observing the reactions of others, particularly those who are emotionally close, such as parents. A sense of self-efficacy can be built from both direct experiences of success and from watching others experience success. However, it can also be diminished vicariously and watching someone else fail can instil doubt about the observer's own likelihood of success. For example, observing a parent avoid or react negatively to a mathematical task could damage a child's faith in their own mathematical ability. Bandura (1971) argues that this vicarious conditioning could be used in a therapeutic manner by deliberately exposing the child to positive models in order to lose fears and develop favourable attitudes. The Mathsbreak intervention aims to reduce the unintentional negative vicarious conditioning parents were providing and proactively increase positive role modelling.

Bandura's theories about self-efficacy also provided a useful framework for the intervention. He defined self-efficacy as 'the belief in one's capabilities to organize and execute the courses of action required to manage prospective situations' (Bandura, 1977a, p.193). High emotional arousal, such as a state of anxiety, can diminish efficacy, which could result in a spiral of anxiety and reduced self-efficacy. Bandura (1997) identifies four sources of self-efficacy: *enactive mastery experiences*, which include both successful and unsuccessful previous endeavours; *vicarious experiences*, including the observation of others and comparison of oneself with peers; *verbal persuasion*, or realistic, positive expressions of faith in one's capability by others; and *affective states*, or moods. Interventions based on SCT and self-efficacy have been widely used in health education to positive effect, from encouraging healthy eating in Mexico to promoting exercise to autistic teenagers in the US (Healy and Marchand, 2020; Zacarías *et al.*, 2019). For further examples of interventions based on SCT see Bíró *et al*. (2017), DiIorio, McCarty and Denzmore (2006), Ghoreishi *et al*. (2019), Najimi and Ghaffari (2013) and Zacarías *et al*. (2019). These studies highlight the importance of increasing both knowledge and skill to enact the desired changes (Zacarías *et al.*, 2019; Najimi and Ghaffari, 2013) and seeing others like oneself performing the behaviour (DiIorio, McCarty and Denzmore, 2006). Self-efficacy, outcome expectations and personal goals were found to be significant mediators of behaviour change in several studies (Ghoreishi *et al.*, 2019; Zacarías *et al.*, 2019; DiIorio, McCarty and Denzmore, 2006).

The intervention in this study focussed on three of Bandura's four sources of self-efficacy, described above, to empower parents to increase their child's feelings of self-efficacy:

vicarious experiences – demonstrating how to model positive attitudes to mathematics; *verbal persuasion* – showing how to communicate faith in a child's ability to learn; and *affective states* – showing how to create a positive atmosphere or mood around mathematical tasks. The hope was that these behaviours would create memories of positive mathematics learning and thus support the fourth source of self-efficacy, *enactive mastery experiences.* Exactly how these elements were mapped onto the intervention design will be discussed in more detail in Section 6.1.

The self-efficacy parents feel towards supporting their children is fundamental to their creation of an environment in which children's own self-efficacy can be cultivated. Bandura *et al*. (1996) argue that the educational aspirations parents hold for their children and their belief in their own efficacy to support them are both highly influential factors. Strong aspirations and parental self-efficacy beliefs act in a number of ways: they lead parents to construct an environment conducive to learning, to act as strong advocates for their children in the educational system and, probably most significantly, to enhance their children's own sense of self-efficacy and aspirations. Furthermore, Bandura *et al*. (1996) argue, high academic aspiration and strong parental self-efficacy is transmitted to teachers and affects the expectations they in turn hold towards the child. Parental valuing of education, the 'vision parents hold for their children' (Bandura *et al*., 1996, p.1219), can play a key role in a child's success, even if parents do not have the socio-economic or intellectual resources to enact support themselves.

The Mathsbreak intervention sought to increase parents' own sense of self-efficacy towards supporting their children. It did this by both increasing their knowledge of the importance of the 'subtle aspects of parental involvement' (Jeynes, 2010), such as an educationally supportive atmosphere, and aiding the development of skills to enact this. It provided reassurance that high levels of mathematical understanding were not necessary to support a child, explored uses of mathematics in situations that should be familiar to parents, gave concrete examples of how to handle difficulties with mathematics homework, and provided resources with links to further relevant information. It was hoped that, through these strategies, the intervention would enable small positive experiences of mathematics, which would encourage further actions and thus a positive spiral of behaviour change.

2.2.2 Jacquelynn Eccles: Expectancy Value Theory, the Model of Achievement and Performance and the Parent Socialisation Model

A second, complementary theory, the Expectancy Value Theory of achievement motivation (Eccles *et al.*, 1983), influenced the structure and content of the intervention. Similar to Bandura's theorising of self-efficacy above, this theory is relevant to both the child's and the parent's motivation. It can be summarised by the following two models: the motivation of the child themselves in Eccles *et al.'s* Motivational Model of Achievement and Performance (Wigfield *et al*., 2006, p.938) (Figure 3) and the mechanisms by which parents influence this motivation in Eccles' Parent Socialisation Model (Wigfield *et al*., 2006, p.969) (Figure 4). These models show the social psychological influences on choice and persistence. A child's achievement-related choices are directly influenced by their expectations of success in a task and the value they place on it. There are multiple influences on both expectations and task value. These can be individual, such as perceptions of competence, perceptions of task difficulty, goals, memories and interpretations of experience. They can also be social, such as the beliefs and attitudes of key adults and the child's perception of these beliefs. There are also wider cultural influences, such as cultural and gender-role stereotypes and the child's perception of the relevance of these.

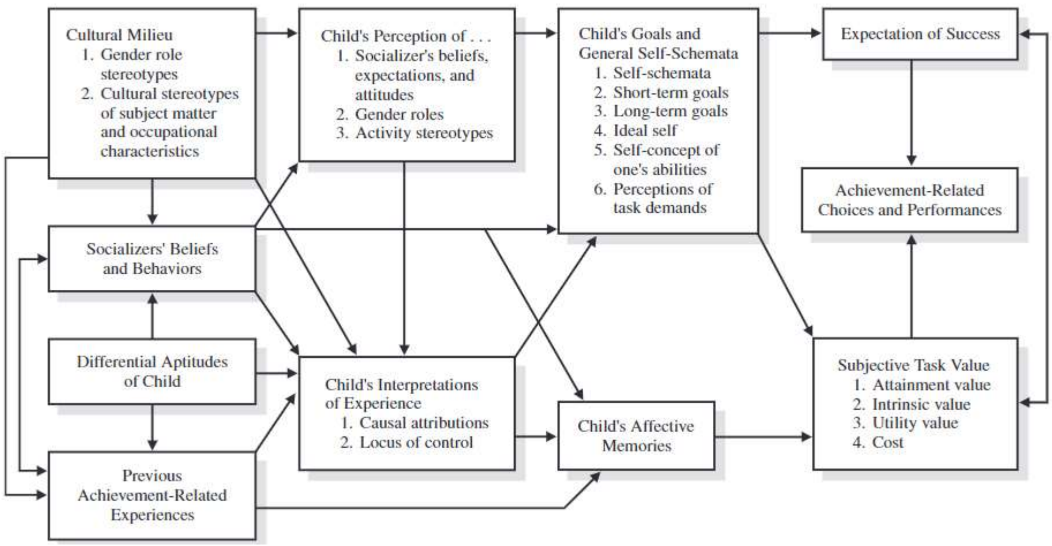


Figure 3 Eccles et al's *Motivational Model of Achievement Performance and Choice*

The importance of both 'expectation of success' and 'valuing a task' formed the basis of the key, repeating message to parents in the Mathsbreak course:

> When you are learning something, there are two things that really matter. You need to believe you will be successful, and you need to believe it will be useful to you. (Mathsbreak)

The idea that success is attainable for all is linked with the idea of a growth mindset (Dweck, 2012) (see Chapter 3 for further discussion). The core content of the videos, showing the use of mathematics in different professions, was intended to underline its value or usefulness. Muenks *et al*. (2018) argue that a child's view of their own competence in an area becomes increasingly stable over time; this stability may make it more difficult to influence negative expectancy beliefs as children get older. This would support the need to intervene as early as possible in a child's development.

The Mathsbreak intervention aimed to act through the medium of parents rather than directly through the children themselves. This was underpinned by the theoretical understanding that children's motivation is significantly influenced by the adults around them. The mechanism by which parents influence children's motivation is outlined in the Parent Socialisation Model in Figure 4 (Wigfield *et al*., 2006, p.969). This model demonstrates how a parent's general beliefs, behaviours, values and gender stereotypes interact with their beliefs about, and expectations for, their own child. These interactions create parenting behaviours, such as use of time, provision of resources, encouragement to participate in activities and explicit value training, which influence the child's world view, their perception of themselves, the extent they value tasks, expectations of success and choice of activity. In this way, beliefs about the value of an activity are passed from parent to child.

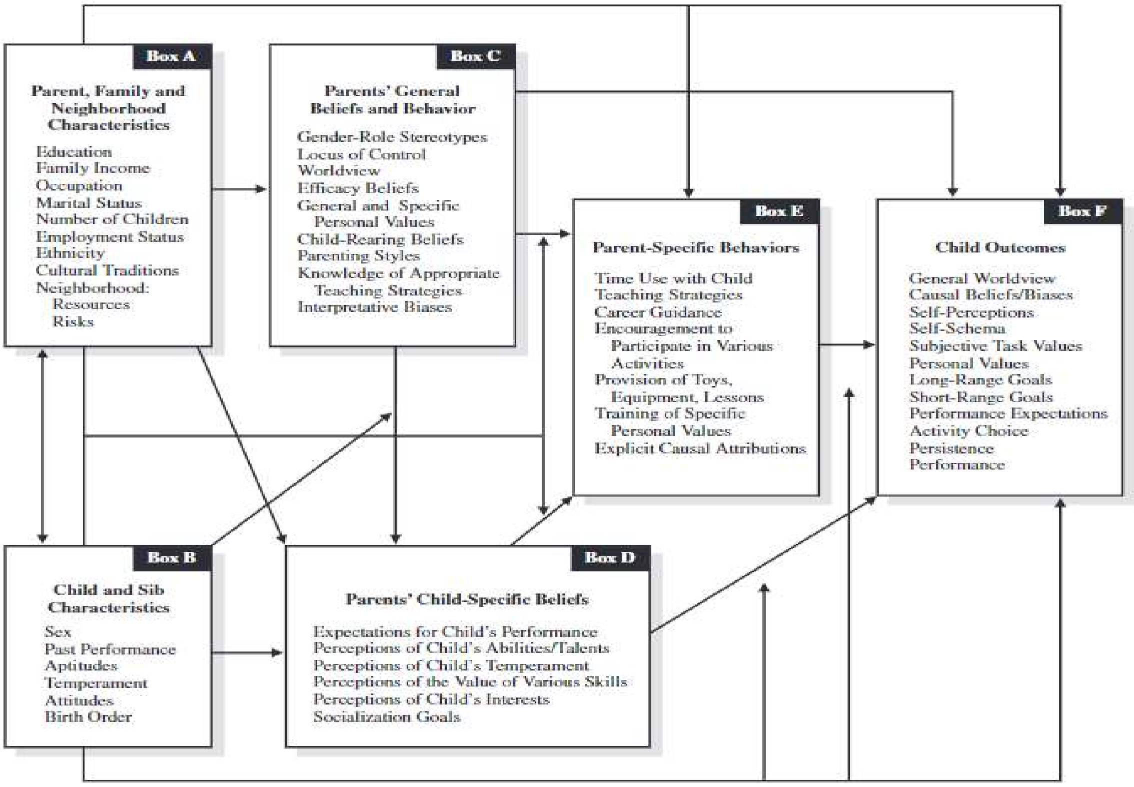


Figure 4 Eccles' Parent Socialisation Model

According to this model, the choice to expend effort in mathematical activities, and persist in the face of difficulties, depends on perceiving it as valuable and believing success is possible. The Mathsbreak intervention was underpinned by the premise, drawn from this model, that if parents believe that mathematics will be valuable for their child, believe that their child can be successful and also understand the power of the beliefs and attitudes they transmit, then they are more likely to create an effective motivational environment.

The powerful influence that parents have on children's developing expectancy beliefs and motivation have been widely documented. For example, Eccles *et al*. (1983) found that parents' beliefs about their children's mathematics abilities had a stronger influence on the child than their own past performance. The gender stereotypes held by parents are an important element in the Parent Socialisation Model; they interact with the sex of their child to influence beliefs about ability. These beliefs influence the child's own expectancy of success (Jacobs and Eccles, 1992; Jacobs, 1991). This has been confirmed by various studies. Girls, on average, perceived their mothers to have lower ability beliefs for them in mathematics, which led to a lower intrinsic valuing of mathematics and thus fewer mathematics-related career plans (Lazarides and Watt, 2017). A more detailed discussion of the influence of gender on attitudes to mathematics is contained below in Section 3.4.2.3.

Both the Expectancy Value models (Wigfield *et al.*, 2006; Eccles *et al.*, 1983) and Self-Efficacy Theory (Bandura 1997) allow the potential for a positive spiral. In both these, an increase in perceived competence can result in an increase in how much an activity is valued. Jacobs *et al*. (2002) found that changes in competence beliefs predicted changes in the valuing of an activity.

2.3 The Role of Theory in the Intervention Design

The conception of MA and the theoretical models of intergenerational transmission of attitudes described above lay the foundations for the intervention design, specifically, informing the choice to act through parents. The bio-psycho-social model of MA (Rubinsten *et al*., 2018) underlines the fundamental role parents play in their children's relationship with mathematics. Bandura's description of the power of vicarious conditioning in forming children's fear of mathematics and, conversely, the power of using this therapeutically is addressed explicitly. The intervention seeks to support the self-efficacy of children to succeed in mathematics by building the self-efficacy of parents to support them. The emphasis on expectations of success and valuing an activity, informed by Eccles *et al.'s* Motivational Model of Achievement and Performance (Wigfield *et al*., 2006, p.938) was central to the choice of focus on the utility value of mathematics. These connections are discussed in more detail in Chapter 6.

The following chapter contains a systematic review of the research literature related to parents and mathematics. This review, along with the empirical data gained from interviews with parents, informed the content of the intervention.

Chapter 3 – Literature Review

3.1 Overview of the Literature Review

This literature review was conducted to inform my understanding of the beliefs, attitudes and opinions parents hold regarding mathematics learning. Through it, I examined how these beliefs, attitudes and opinions affected parents' approach to doing mathematics with their children and any barriers they encountered. Through this review, combined with both the empirical data from interviews with parents (see Chapter 5) and the theories of Mathematics Anxiety (MA) and intergenerational transmission of attitudes (see Chapter 2), I sought to answer the following three research sub-questions, introduced in Section 1.3:

1. What beliefs, attitudes and opinions do parents hold regarding mathematics learning?
2. What are parents' experiences of supporting their child with mathematics and what, if any, barriers do they face?
3. How do parents' opinions, attitudes and beliefs about mathematics affect the way they approach mathematics with their children?

Analysis of data from these three sources informed the creation of the Mathsbreak intervention (see Chapter 6).

This literature review begins with details of the search strategies, then considers the impact of parents on preschool and then school-aged children. Following that is a discussion of the multiple barriers parents face when supporting their child with mathematics, starting with barriers within the individual and moving out to barriers within society as a whole. Then, as a point of comparison, the approach to mathematics taken in other cultures, particularly in East Asian culture, is discussed. The final part consists of an analysis of other relevant interventions in order to understand what can be learnt from them and applied to this context.

3.2 Systematic Search Strategy

A systematic search for literature was conducted using Scopus, JSTOR and the following EBSCO host search engines: British Education Index; Education Research Complete; APA PsychArticles and APA PsychInfo. These search engines were chosen for their range of peer-reviewed Education and Psychology journals. The searches included those articles with terms related to mathematics and parent or family in the title, with the additional references to anxiety-, attitude- or belief-related terms in the abstract (see Appendix 2 for exact search terms and results). The search was limited to peer-reviewed journals between 2000 and 2021. The start date of 2000 was chosen as it marked the introduction of the National

Curriculum (DfEE, 1999) and thus a change in teaching approaches; this date also provided two clear decades of literature. The titles were manually screened to remove irrelevant articles; for example, articles that included irrelevant uses of the term 'family', such as family physician were removed, as were which articles focussed on areas outside the focus of this research, such as pre-service teacher training. The searches were run three times, in February 2021 (152 unique articles), December 2021 (15 unique articles) and January 2023 (31 unique articles) This gave a total of 198 articles. Full details of all searches can be found in Appendix 2. The systematic search articles were supplemented in the review by other relevant articles which I came across when reading. Figure 5 shows the distribution of the articles across the time period, showing an increasing interest in this subject over the past five years.

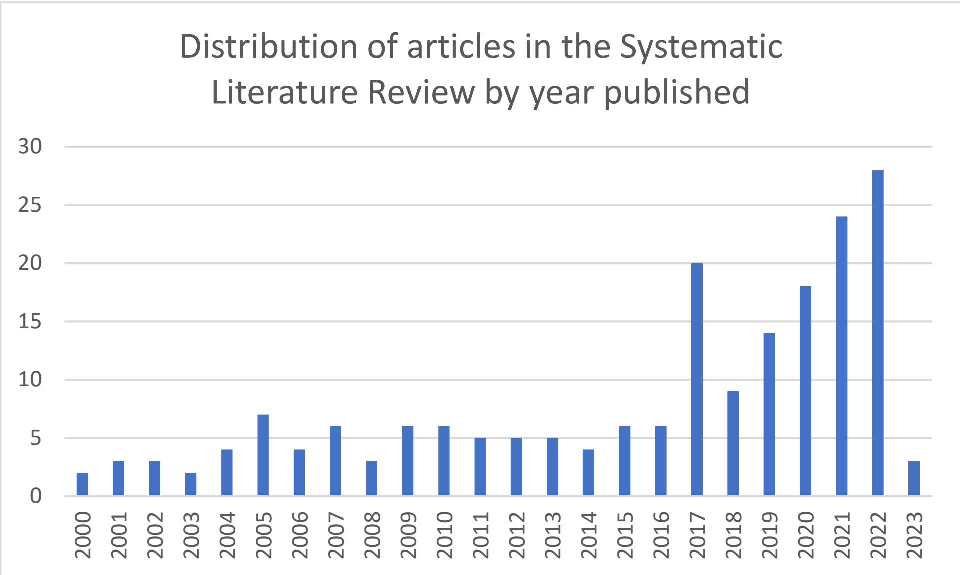


Figure 5 Distribution of articles in the systematic literature review by year published.

3.3 How Do Parents' Beliefs, Attitudes and Opinions Impact Their Children's Mathematical Experiences?

The research literature shows an increasing interest in the impact of children's experiences at home on their mathematics performance and their enjoyment of mathematics. Children's home experiences are inevitably shaped by the activities and resources provided by parents and carers and the conversations they engage in. Parents actions are, in turn, influenced by their own views of mathematics, their beliefs about their child and their understanding of their role. The mechanisms for the transmissions of attitudes were discussed in detail in Chapter 2 in relation to the theories of Bandura (1977, 1997) and Eccles (Eccles *et al.*, 1983) and the bio-psycho-social model of MA (Rubinsten *et al.*, 2018). This review of the literature will begin with a discussion of children's experiences of mathematics in the years before they start school, often referred to as the home numeracy environment, and then their experiences of homework once they start formal schooling.

3.3.1 How Does the Home Numeracy Environment Affect Transmission of Attitudes?

The term 'home numeracy environment' (HNE) refers to the mathematical experiences parents provide in early childhood. LeFevre *et al*. (2010) differentiate home numeracy activities into direct mathematical teaching, such as counting or naming shapes, and indirect activities involving mathematics, such as games, cooking or craft. Dowker (2021) argues that the definition of HNE should be expanded to include 'parental attitudes to mathematics and in particular, parental emotional reactions to mathematics, in particular mathematics anxiety' (p.1) as this emotional climate will inevitably affect children's experience of mathematics activities. It is this expanded definition of the HNE, including experiences, attitudes and emotional reactions, which is adopted in this study.

Children arrive at school with considerable variation in their early numeracy knowledge. This implies considerable variation in the experiences children have in their preschool years. Many studies have shown a positive relationship between the HNE and the mathematical performance of children in the first years of school (DeFlorio and Beliakoff, 2015; Lefevre *et al.*, 2009; Melhuish *et al.*, 2008). Other studies have also found that home numeracy experiences have an ongoing positive impact into later years (Dunst *et al.*, 2017). For example, Cui, Zhang and Leung (2021) found that parental involvement in learning and their attitudes to education in early childhood had a significant positive effect on children's achievement. Zippert and Rittle-Johnson (2020) found only limited association between parent involvement and later achievement and Missall *et al*. (2015) found none at all. Exploring the differences in parent beliefs, rather than activities, may be key to understanding this inconsistency (Douglas, Zippert and Rittle-Johnson, 2021; Dowker, 2021; Missall *et al.*, 2015). Dowker (2021) suggests that negative or anxious parental attitudes may interact with home numeracy activities to create early negative emotional associations with mathematics. Missall *et al*. (2015) call for examination of the broader environment and the quality of interactions rather than specific activities. Silver, Elliott and Libertus (2021) found that parents who held stronger beliefs in the importance of mathematics were more likely to engage in mathematical activities with their children. From a synthesis of the literature, Douglas, Zippert and Rittle-Johnson (2021) created a model which demonstrated the impact that parents' numeracy beliefs have on the frequency and quality of the support they give.

They divide these beliefs into three areas: child-specific beliefs, such as their understanding of their child's interest and ability; general beliefs about, for example, the importance of home support; and parent-specific beliefs, including their own expectations, abilities, interest and anxiety. The impact of these beliefs will be returned to in Section 3.4.1.

3.3.2 Homework

Once children start school, the main site for explicit mathematical engagement between parents and children is homework. Greater parent engagement in children's homework is widely believed to have a positive impact on attainment (Sheldon and Epstein, 2005; Yan and Lin, 2005; Sheldon, 2003; Hoover-Dempsey *et al.*, 2001). However, in reality the impact is more nuanced. In a synthesis of research, Patall, Cooper and Robinson (2008) found that the overall effect of parent involvement on achievement was small and highly dependent on variables such as type of homework, age of students, type of involvement and whether parents received any training. Involvement with homework can include many different behaviours: from providing space to interacting with teachers; from general oversight to engagement in learning strategies (Hoover-Dempsey *et al.*, 2001). The most effective way for schools to approach homework and include parents is widely debated in the literature and is returned to throughout the discussion of previous interventions in Section 3.5.

In terms of ways to support homework, Patall, Cooper and Robinson (2008) found the most effective strategy was for parents to set rules around where and when homework was to be done and clearly communicate expectations. They hypothesise that this is effective as it increases the time spent on homework and contributes to a climate where academic success is valued and expected. This would represent one of the 'subtle aspects' of parenting discussed in Section 1.2.2. Whilst there are certainly positive effects, there are also potential negative consequences to increasing parental involvement in homework. For example, when a mathematics-anxious parent helps with homework this can create a greater risk of both transmitting anxiety to their children and suppressing attainment (Retanal *et al.*, 2021; DiStefano *et al.*, 2020; Maloney *et al.*, 2015). Also, parents who are anxious can approach homework in a more controlling or inflexible way, which risks undermining a child's motivation and self-efficacy (Pomerantz, Moorman and Litwack, 2007). Parents who intervene too much between the child and the school can also undermine attainment (Barnes and Johnson, 2018) and homework can also cause distress and family strain (Lange and Meaney, 2011). As discussed above in the context of the HNE, it is the type and quality of parental involvement in homework – the 'how, whom and why' (Pomerantz, Moorman and Litwack, 2007) – that matter as these result in different types of academic socialisation.

3.4 What Barriers Do Parents Face in Creating a Positive Mathematical Environment

The literature elucidates multiple barriers which prevent parents from creating a mathematical environment at home that enables positive academic socialisation and productive support for learning. These barriers are discussed below, beginning with a focus on the attitudes and beliefs of the individual parent and then widening the lens to include socially situated barriers such as socio-economic status (SES), ethnicity and gender.

3.4.1 Barriers Located within the Individual Parent

3.4.1.1 Parent's Own Attitudes to Mathematics, Including Mathematics Anxiety

If parents are anxious about mathematics, it is more likely that their children will be (Vanbinst *et al.*, 2020; Soni and Kumari, 2017; Casad, Hale and Wachs, 2015; Ramirez *et al.*, 2013). Parent MA is associated with more negative attitudes regarding mathematics (Schaeffer *et al.*, 2018; Soni and Kumari, 2017) and parents' attitudes to mathematics significantly predict students' attitudes to mathematics (Mohr-Schroeder *et al.*, 2017). The more positive a parent's attitude to mathematics, the less MA is displayed by their children (Choi and Han, 2020). Parents who have negative feelings towards mathematics or who openly acknowledge their own mathematics deficiencies are more likely to have children with similar attitudes (Usher, 2009). In a meta-analysis, Choi and Han (2020) found a significant correlation between parental attitudes to mathematics and student MA and that this was strongest in the youngest students. However, they also found that only one parent needed to have a positive attitude to mathematics to reduce a student's MA.

A relationship between parents' MA and children's mathematics performance has been found among elementary, middle and high school students (Berkowitz *et al.*, 2015; Casad Hale and Wachs, 2015; Maloney *et al.*, 2015; Soni and Kumari, 2017). For example, children of highly anxious parents were found to have learnt significantly less mathematics in elementary school that those of less anxious parents (Schaeffer *et al.*, 2018). There may be a gendered element to this association: Vanbinst *et al.* (2020) found children's MA to be significantly associated with their mother's MA but less so with their father's MA. One plausible explanation for this is the larger role mothers are likely to play in supporting their children's learning. There are multiple candidates for the mechanism through which parent attitudes affect children's performance in mathematics. One is that a parent expressing positive attitudes stimulates a child's interest in mathematics and this affects their behaviour and attitude (Cui, Zhang and Leung, 2021). Another, that the attitudes held by parents influence their involvement with their child's learning, which in turn influences attainment (Cui *et al*., 2021; Dowker, 2021), for example, higher levels of MA are related to lower levels of school involvement (Kiss and Vukovic, 2021). Another possibility is that, for highly anxious parents, interactions around mathematics may be fraught and stressful, which could lead children to develop negative associations with mathematics (Dowker, 2021; DiStefano *et al.*, 2020). Parents who are anxious about mathematics may also express attitudes that reduce children's motivation, for example, asserting that mathematics is not useful (Maloney *et al.*, 2015). Maloney *et al.*'s (2015) finding that the risk of transmission of MA was increased only when mathematics-anxious parents helped with homework implies that the transmission is behaviourally driven rather than genetic. The mechanisms of transmission may act differently in different ethnic groups: Der-Karabetian (2004) found that mothers' attitudes were the most important factor in determining the success of African American middle school students, but parental expectation of success was by far the strongest predictor for European American and Latino American students.

Silver *et al.* (2021) found that there was not a simple linear relationship between parental MA and children's mathematics abilities. They argue instead that MA amplifies the effects of mathematics beliefs, meaning that parents with high anxiety, who believed mathematics was particularly important, had children who performed better than parents with low anxiety who also believed mathematics was important. Szczygieł (2020) found that the relationship between MA in parents and children's achievement varied across grades and genders, for example, that MA in mothers predicted the achievement of third-grade learners but not first- or second-grade learners and that this was not mediated through higher levels of anxiety in children. Fathers' MA, however, appeared to be associated with an increase in anxiety in first graders, particularly girls. So, although exact mechanisms are debated, taken together these studies provide clear evidence that children's attitudes and achievement in mathematics are influenced by the attitudes towards it held by their parents.

3.4.1.2 Parent's Self-Efficacy and Expectations of Their Children's Success

One factor which can facilitate or hinder how parents support their children's mathematics is their own self-efficacy in this area. Self-efficacy is defined by Bandura (1977) as an individual's belief in their ability to perform in a specific situation and or accomplish a task. If parents feel a strong sense of efficacy, meaning that they feel that their actions can have a positive impact on their children's educational development, they are more likely to get involved (Cui, Zhang and Leung, 2021; Liu and Leighton, 2021). Parents with low levels of mathematical understanding themselves are less likely to feel efficacious in helping their children. Children's MA is significantly associated with the educational level of both parents (Vanbinst *et al*., 2020). Particularly low levels of self-efficacy can lead to learned helplessness, where people behave as if they cannot change unpleasant outcomes, even if they did in fact have the capacity to avoid them (Goodall and Johnston-Wilder, 2015). Learned helplessness in parents can be a significant barrier to them supporting their children in mathematics, as exemplified in a case study by Goodall and Johnston-Wilder 2015). In support of this, a contrasting study with a large data set found that mothers with an external locus of control, or the general belief that external factors such as fate, luck or other people influence what happens to them, had children who scored more poorly on mathematics tests than children of mothers with an internal locus of control (Golding *et al.*, 2019). Self-efficacy, either in a specific domain such as mathematics or more generally, is malleable and can be improved through interventions that build resilience, such as coaching (Golding *et al.*, 2019; Goodall and Johnston-Wilder, 2015). A school environment perceived by parents as welcoming and specific invitations to action from teachers can also lead to a stronger sense of self-efficacy in parents (Liu and Leighton, 2021).

Another important factor is the beliefs parents themselves hold about their children's mathematical ability. Parents' belief in their child's ability contributes directly to their children's high performance (Aunola *et al.*, 2003); parents with high expectations for success had children who held more positive attitudes towards mathematics as well as more confidence to learn difficult mathematics in the future (Silver, Elliott and Libertus, 2021). Mothers' early beliefs about a child's ability have been found to influence young adults' career choices (Bleeker and Jacobs, 2004). Even with adolescents, parents who rate their children's mathematics competence higher have children who perform better in mathematics and, perhaps surprisingly at this age, parent beliefs have a greater influence than teachers' beliefs (Putnick *et al.*, 2020). These beliefs, attitudes and expectations act together: a study involving African American students found that parents who expected success in school, believed people can learn to be good at mathematics, and checked homework more frequently increased their child's likelihood of being on an engineering-career trajectory (Barnes and Johnson, 2018). Conversely, parents who see mathematics as difficult and believe their children are not very good have children who mirror those views (Aunola *et al.*, 2003).

In terms of the mechanisms by which expectations act, holding high expectations can influence children's achievement in mathematics by reducing their MA (Vukovic, Roberts and Green Wright, 2013) and can even mitigate the impact of parents' own MA (Kiss and Vukovic, 2021). Also, it is possible that parents who believe in their children's abilities in mathematics provide more challenging tasks and more opportunities for their children to practise mathematics-related problem-solving skills (Aunola *et al.*, 2003). Even if students perceive their parents and teachers to be overestimating their ability, this has a positive impact on students' intrinsic task values over time. Conversely, if students perceive parents and teachers to underestimate their ability, this damages their intrinsic motivation. This overestimation does have limits however: if parents' hold unrealistically high expectations or become too pushy, the impact on student performance is negative (Gniewosz and Watt, 2017). This may be because excessive parental aspiration can lead to over-involvement and control, leading to increased anxiety and decreased self-efficacy in children (Murayama *et al.*, 2016). Parents' beliefs about their children's competence are not formed in isolation; they are inevitably influenced by their children's previous performance, which can create self-perpetuating, cumulative spirals, either positively or negatively (Aunola *et al.*, 2003).

3.4.1.3 Parents' Beliefs about Their Role

Another factor which impacts parents' ability to support their children effectively is their beliefs about the role they should play in their child's mathematical learning. Numerous studies have found that parents did not have specific expectations when engaging in mathematics with their preschool children (Cannon and Ginsburg, 2008) and assumed they should focus more on reading and emergent literacy skills (Keating, Harmon and Arnold, 2022; Sonnenschein, Metzger and Thompson, 2016). Linking with the discussion of self-efficacy above, parents who are confident in their ability to help children succeed may cultivate strong beliefs about their role and responsibility in their children's mathematics achievement (Liu and Leighton, 2021). Parents' construction of their role in children's mathematical learning can be impacted by gender, income, education levels and ethnicity (Wilder, 2017). The impact of the potential barriers to supporting mathematics created by social factors such as these are returned to in Section 3.4.2.

3.4.1.4 Parenting Style

Parenting style is also mentioned in the literature as an influence on both mathematical attainment and attitudes. Parenting style has been defined as a 'constellation of attitudes toward the child that are communicated to the child and that, taken together, create an emotional climate' (Macmull and Ashkenazi, 2019, p.2). There are three main parenting styles defined in the literature: authoritative, authoritarian and permissive. Authoritative parents follow logic and have boundaries but emphasise rewards and offer a high degree of parental support and willingness to understand the perspective of the child. They encourage dialogue and share reasoning for decisions with their children. Authoritarian parents are more dictatorial, have a more absolute set of standards and are perceived as not being particularly warm or affectionate. Permissive parents demand little from their children, set flexible boundaries and perceive themselves as a resource for their child rather than an individual in charge of shaping current and future behaviour (summarised from Macmull and Ashkenazi, 2019). In Macmull and Ashkenazi's (2019) study, the authoritarian parenting style predicted higher levels of MA in children and also reduced self-efficacy. The authoritative style was also associated with MA, but this was compensated for by the creation of high levels of self-efficacy, which mitigated the impact of MA on attainment. The permissive parenting style was associated with the least MA but was associated with high levels of irresponsibility, immaturity and lack of interest in education, and this negatively impacted attainment. Parenting that is controlling, places pressure on achievement or is intrusive has a negative impact (Buff, Reusser and Dinkelmann, 2017; Daches Cohen and Rubinsten, 2017; Dinkelmann and Buff, 2016). A study involving Taiwanese students found that a home culture which promoted self-efficacy mediated success and that over-involvement, in terms of direct instruction, had an indirect negative effect as it undermined self-efficacy (Kung and Lee, 2016). Parenting which provided structure and was perceived to value the learning predicted enjoyment of learning in children (Buff, Reusser and Dinkelmann, 2017). Emotionally responsive parenting in the first year of schooling supports the development of effortful control, defined as the ability to regulate attention, behaviour and emotion, and this in turn leads to higher levels of mathematics achievement (Swanson *et al.*, 2014). The most effective parenting practices can vary according to context: McGee and Spencer (2015), in a study of the characteristics of parents of high-achieving black college students, found that common themes were acting as role models and mentors, advocating for their children, fostering self-efficacy and emotional perseverance and coaching their children to advocate for themselves.

These parenting styles provided inspiration and also acted as a protective factor against stress and discouragement and may be particularly powerful in an education system perceived as hostile. These studies demonstrate, in a number of ways, that approaches to parenting itself, not just mathematics, have an impact on attitudes and achievement.

3.4.1.5 Beliefs about the Value of Mathematics

The beliefs parents hold about the value of mathematics influence how they approach it with their children. In a study with low-income parents of preschoolers, parents rated mathematics as significantly less important than reading (Keating, Harmon and Arnold, 2022), which replicates the findings of Cannon and Ginsburg (2008) discussed above. As mentioned above, Silver *et al.* (2021) found that strong beliefs about the importance of mathematics predicted children who arrived in school with stronger mathematical skills. The impact of the value parents place on particular subjects has been shown to remain as children get older:

> If the parents believe that a particular subject is important, their adolescent children tend to perform better in that subject. It could be that the more value their parents place on a particular subject, the more efforts the high school students put into that subject area, resulting in better grades. (Hong *et al.*, 2010, p.434)

This is consistent with Eccles' expectancy value theory (Eccles *et al.*, 1983), discussed in Section 2.2.2, which states that a person will be more motivated in a task if they expect to succeed and value the outcome. An intervention designed to increase communication between parents and adolescents about the utility value (UV) of mathematics and science, which is discussed further in Section 3.5.4, found that increasing such conversations increased the number of STEM high-school courses students took (Harackiewicz *et al.*, 2012). However, high family valuing of mathematics can have different effects depending on a child's sense of self-efficacy. Coming from a family which values mathematics is likely to increase a child's interest and motivation but also potentially increase their anxiety about succeeding. In a child with a high sense of self-efficacy, the overall impact is positive. However, in a child with low self-efficacy, the anxiety provoked can outweigh the positive effect of interest and motivation (Boehme, Preckel and Goetz, 2017).

There is also debate over the directionality of this relationship between parental value beliefs and children's achievement. Hong *et al.* (2010) found that parents' mathematical values led to an increase in high-school students' achievements, even after controlling for previous achievement. In contrast, other studies found influence in the opposite direction and that children's previous achievement instead predicted parents' valuing of mathematics (Bleeker and Jacobs, 2004; Tiedmann, 2000). The influence of parental valuing of subjects may also be affected by a child's gender. For example, Lee *et al.* (2020) found Korean parents' beliefs predicted their son's interest in a STEM career but not their daughters. They hypothesise that for male-dominated domains like STEM, girls may need a wider range of socialisers to shape their values, not just parents. The mechanisms by which parental valuing of mathematic translates to behaviour may also be influenced by culture: Cui *et al.* (2021) found that, in Singapore, when parents highly value mathematics and science they will concentrate on cultivating intrinsic motivation and interest, whereas in Hong Kong parents focus on the instrumental value of mathematics and science in gaining access to higher education. Despite the nuances of these studies, the overall findings suggest that having parents who hold the belief that mathematics is valuable is a positive factor for children's learning.

3.4.1.6 Beliefs about How Mathematics Is Learnt

The beliefs parents hold about how mathematics is learnt and who can be successful also impact their children. In terms of how children learn mathematical skills, a number of studies have discussed the need to educate parents about the benefits of informal, play-based learning (Sonnenschein, Metzger and Thompson, 2016; Kyle, McIntyre and Moore, 2001). Sonnenschein and Sun (2017) also found that the parents in their study were not aware that observing them engaging in mathematical activities themselves was valuable for children's learning.

Beyond the practicalities of how skills are learnt is a more critical belief as to whether everyone can do well in mathematics, or whether ability is innate:

> One of the most damaging [myths] is the idea that some people are born with a 'math brain' and some are not, and that high achievement is only available to some students. (Boaler *et al.*, 2018, p.1)

Usher (2009) documented this fixed entity 'either you have it or you don't in math' (p.310) view of ability in her study. Szczygieł (2021) also found that highly mathematics-anxious parents and teachers can cause children's low mathematics achievement due to the beliefs they present about learning mathematics, particularly the belief in needing special mathematical abilities to be able succeed. This 'myth of the math person' is transmitted culturally and has been found on clothing, television shows and films (Anderson, Boaler and Dieckmann, 2018, p.2). Boaler (2009) attributes the widespread MA in the UK, US and elsewhere to this idea that only some people can be successful in mathematics. This idea is discussed as part of the interpretation account of MA in Section 2.1.5. A number of the interventions discussed in Section 3.5 focus on countering this myth by promoting a growth mindset. When students shift to a growth mindset and believe that their intelligence is malleable, their achievement increases (Boaler *et al.*, 2018). It is clear, therefore, that holding an innate-ability belief about mathematics is a barrier to passing motivating beliefs to children.

3.4.1.7 Beliefs about the Nature of Mathematics

If parents believe that mathematics is a narrow subject, with right and wrong answers, they are less likely to be able see, or show their children, its applications in everyday life. Boaler (2016) contrasts a traditional, narrow view of mathematics 'producing short answers to narrow questions under pressure' (p.21) with the many creative, complex applications mathematics has. She argues that the gulf between the narrow, limited version of mathematics presented in schools and the real mathematics done by mathematicians is one of the reasons for the widespread dislike of and anxiety about mathematics:

> [Students] rarely think they are in maths classrooms to appreciate the beauty of mathematics, to ask deep questions, to explore the rich set of connections that make up the subject or even learn about the applications of mathematics. (p.21)

Similarly, in a study on homeschooling, Reaburn (2021) makes a connection between a fixed view of mathematics ability and an emphasis on traditional teaching:

> In contrast, teachers who believe that mathematics is a way of looking at the world will encourage their students to engage in problem solving and let students explore solutions for themselves. These teachers also tend to believe that mathematics is creative and that mathematics ability is amenable to change. (p.608)

The same study also found that parents who were more confident supporting mathematics were more likely to see mathematics as a creative subject.

3.4.2 Beyond the Individual – Social Barriers to Transmitting Positive Attitudes

Many of the barriers to creating an environment supportive to mathematics learning identified in the literature were not located in the individual but were the result of larger societal factors. In this section the impact of low incomes, gender and ethnicity are discussed.

3.4.2.1 Socio-economic Status

Children growing up in families with lower incomes emerge from school with substantially lower levels of educational attainment than their wealthier peers and this gap grows particularly fast during primary-school years (Goodman *et al.*, 2010). In considering the impact of SES on parents' mathematical interactions with their children the following definition is used, with the acknowledgement that different studies will themselves have applied different definitions:

> Socioeconomic status is a social construct that encompasses parents' education level, income and financial security, occupational prestige as well as quality of life attributes such as societal opportunities and privileges, and perceptions of social status and class. (American Psychological Association, 2017 quoted in Douglas, Zippert and Rittle-Johnson, 2021, p.6)

A study commissioned by the Joseph Rowntree Foundation, using large, longitudinal data sets – the Millennium Cohort Study of 18,000 children and the Avon Longitudinal Study of Parents of 14,000 mothers – found that factors relating to parents accounted for 49% of the difference in the attainment of the richest and the poorest pupils aged 11 (Goodman *et al.*, 2010). These factors are complex and intertwined, and many, such as parents' own educational history or family size, cannot be influenced by an intervention. However, the study found that 12% of the difference can be explained by attitudes and behaviours even after prior attainment had been controlled for; these attitudes and behaviours could be malleable.

Parents with higher SES tend to engage in more mathematics with their children than parents with lower SES (Douglas, Zippert and Rittle-Johnson, 2021) and children from higher SES families tend to have more advanced number skills even before kindergarten (Elliott and Bachman, 2018). Children from lower SES families are likely to begin school with less developed mathematical knowledge (Elliott and Bachman, 2018; DeFlorio and Beliakoff, 2015). These differences are important because these gaps increase, rather than decrease, through a child's education (Keating, Harmon and Arnold, 2022) and early mathematics skills have been found to be predictive of later achievement across academic domains (Duncan *et al.*, 2007). There are reasons for these differences which are directly related to income: homes with fewer socio-economic resources are likely to have a less stimulating environment for learning (Hart, Ganley and Purpura, 2016; Goodman *et al.*, 2010); parents with fewer resources are likely to spend more time working and have less time to engage their children in activities (Lareau and Shumar, 1996) and therefore may not be able to enact their intention to engage their children in mathematical activities (Sonnenschein and Sun 2016); and higher levels of family stress may reduce parents' capacity to support their children's learning (Desforges and Abouchaar, 2003).

However, the precise pathways through which SES affects mathematical achievement are complex and subject to variability between families. The details of these pathways are debated in the literature (Østbø and Zachrisson, 2021; Elliott and Bachman, 2018; Pan *et al.*, 2018). Firstly, the differences in mathematical activity are related to parental beliefs, expectations and self-efficacy (see Section 3.4). This self-efficacy may also relate back to income and whether parents believe they can provide the necessary economic resources for their child to succeed (Hascoët, Giaconi and Jamain, 2021). Approaches to learning are also delineated by class: parents with higher SES tended to endorse approaches that engage the child's interest and make interactions enjoyable. These approaches tend to result in higher scores than those which focus solely on the learning of skills. More parents with lower SES endorsed the skills approach (Sonnenschein, Metzger and Thompson, 2016; Kyle, McIntyre and Moore, 2001). Higher SES parents may also be more willing to move away from traditional approaches and adapt to changes in educational philosophies (Pan *et al*., 2018). Parents with higher SES are more likely to expect developmental milestones and conceptual understanding at a younger age and may over, rather than under, estimate their child's ability (Pan *et al.*, 2018; Hart, Ganley and Purpura, 2016; DeFlorio and Beliakoff, 2015).

The relationships between parents and schools are also a significant influence; Lareau and Shumar (1996) describe discernible class differences in the way families approach relationships with school and the activities sent home from schools. They argue that universal calls to increase parents' participation in schooling are failing to acknowledge these differences and failing to consider the potential negative impacts. Parents with lower SES are less likely to be able to support their children in the ways expected by the schools due to limited educational skills, lack of flexibility in their working hours, limited economic resources, transportation difficulties and weaker social networks with other parents. These social networks are used extensively by middle-class parents to clarify tasks and refine knowledge of teachers and teacher practices. Lack of involvement due to these difficulties can be interpreted by schools as lack of motivation and thus damage the parent–school relationship further. Less educated, lower SES parents may also be more vulnerable to having their educational weaknesses exposed by supporting homework and therefore feel more defensive (Lareau and Shumar, 1996). There are also differences related to parents' perception of their role. Parents with lower SES were more likely to believe that school contributed more than home to numeracy development (DeFlorio and Beliakoff, 2015; Starkey and Klein, 2000). Alongside these difficulties, there is a very different power dynamic between parents from different backgrounds and schools. Parents with lower SES may feel less able to challenge the school and more concerned that the school is in a position to report them to child welfare authorities. This would suggest that schools, and any intervention to engage parents, would need to take account of the varying reactions and capacities of families with different SES.

3.4.2.2 Ethnicity

Ethnicity and cultural heritage also influence the mathematical support parents provide, their relationship with their child's school and the barriers they face. Academic socialisation may be very different in different cultures (Sonnenschein and Sun, 2017). The mathematical values and practices in the home may not be shared by the school; for example, measurement systems or calculation methods may differ from those of the parent's home culture (Crafter, 2012). The content and priorities of the mathematics curriculum may also be different to that in a parent's home country. Researching the attitudes of British Pakistani parents, de Abreu and Cline (2005) found differences in the levels of mathematical calculation expected at different ages: parents were comparing lessons with those of relatives in Pakistan and becoming frustrated with the British approach. De Abreu and Cline (2005) also found that parents had misunderstood elements of the school curriculum; for example, they believed calculators were being used in the UK as a substitute for learning calculation, and they did not have the social networks to correct this misunderstanding. Pakistani families within this study took different approaches to supporting their children in the British system. Some were concerned that use of Urdu terms for mathematical concepts would confuse children, and therefore delegated support to cousins and older siblings to teach in English. Others, however, felt that mathematics was the same in any language and so meanings could be shared. There were accounts of children themselves compartmentalising the mathematics of home and school to meet dual expectations, with the potential risk of confusion:

> I can do it both ways so when I'm at school I do it the school way, and when I'm at home I do it the home way. (de Abreu and Cline, 2005, p.707)

Parents from ethnic minorities, who may not have been educated in the UK, must navigate an unfamiliar system, possibly in a second language and also translate the cultural messages they are receiving. Crafter (2012) gives the example of a Bangladeshi mother who understood the English in a parent consultation but failed to interpret the 'teacher talk' – the couching of difficulties in positive discourse that must then be interpreted. She therefore left with the belief her son was doing 'fine' in mathematics when he was actually working well below his peers.

Ethnic minority parents may also have different understandings of their role in relation to the school. In the US, research with Latino families found that many parents construed their role as providing general support to their children but felt that becoming directly engaged in their learning could be seen as disrespectful to teachers (Whitaker and Hoover-Dempsey, 2013). These beliefs risk being interpreted by the schools as lack of interest. The funds of knowledge and practices that these families do have are not always noticed or recognised by the dominant culture (Beltrán-Grimm, 2022; Yan and Lin, 2005); this topic is returned to in Section 3.5.2 in the discussion of interventions which disrupt a dominant cultural view of mathematical knowledge. All of these difficulties, which may be compounded by the impact of low SES discussed above, create barriers to parents engaging effectively with their children's mathematics.

3.4.2.3 Gender

There is considerable discussion in the literature over how child's and the parent's gender interact to affect the transmission of attitudes to mathematics. Gender is a key element of Eccles' Parent Socialisation Model (Jacobs, 1991), discussed in Section 2.2.2. The argument, returned to throughout the 20 years of literature surveyed, is that the gender-stereotyped attitudes to mathematics that exist in society are transmitted to children through the behaviours and attitudes of the adults around them. These subtly influence their self-efficacy and attainment. Gender stereotyping, in this context, is the belief that certain domains of learning are inherently male or female. There is considerable evidence that the belief that mathematics is a male domain persists, despite the changes in societal attitude to the roles of men and women and the increasingly equal attainment of girls. These beliefs are not necessarily consciously held or directly transmitted but are transferred through subtle differences in interaction, expectations for success, types of praise, ways of helping, activities provided and assessment of a child's ability.

In the early years, differences have been found in the way parents interact mathematically with their babies, toddlers and preschoolers. Parents of 10- to 18-month-old babies were found to use more mathematics references over time with boys than girls (Leech *et al*., 2021). Parents used more complex and frequent special language with preschool boys (Levine *et al.,* 2012) and report engaging in more mathematics-related activities with them (Hart, Ganley and Purpura, 2016). Mothers offer girls more unsolicited help with mathematics homework and leave boys to work more independently, possibly because they believed girls need more help (Lindberg, Hyde and Hirsch, 2008). Parents, in a study by Uscianowski *et al*. (2020), posed more complex mathematics questions to preschool sons than daughters. They also used more number talk with preschool boys during non-mathematics related activity, but not during explicitly mathematics activity (Thippana *et al.*, 2020). This is an important finding as it differentiates what parents do when they are consciously 'doing maths' and when they are not and it is unconscious behaviour that appears to have most impact. The difference in number talk matters, both in terms of content and transmission of attitudes, as the amount a child hears in toddler and preschool years relates to later mathematical achievement (Thippana *et al.*, 2020) and differences in interaction style may give subtle messages about expectations for mathematical competence (Leech *et al*., 2021).

It is not entirely clear why these gendered differences in parent behaviour exist. It could be due to gender-stereotypical beliefs, or that parents are picking up on perceived intrinsic interest in their child (Keating, Harmon and Arnold, 2022). It is clear, however, that children as young as five have gendered beliefs about mathematics (del Río *et al.*, 2019) and are vulnerable to stereotype threat. Making gender salient was found to disrupt girls' mathematics performance as early as 5 years old and across the range of actual mathematical attainment (Galdi, Cadinu and Tomasetto, 2014). Interestingly, the performance of girls in this study whose mothers strongly rejected the stereotype did not decrease under stereotype threat. Several studies suggest that the strongest influence on children's attitudes comes from same gender parents, particularly mothers and female teachers on girls (Gladstone *et al*., 2018; Casad, Hale and Wachs, 2015; Gunderson *et al*., 2012).

For parents of school-aged children, holding gender-stereotypical beliefs was found to reduce a mother's involvement with her daughters' mathematics, but not her sons' (Denner *et al*., 2018). Many studies have demonstrated that parents and teachers underestimate mathematical ability in girls and, when they are successful, attribute that success to hard work rather than ability (McCoy, Byrne and O'Connor, 2021; Rozek *et al*., 2015; Gunderson *et al*., 2012; Räty and Kärkkäinen, 2011; Jacobs *et al*., 2004; Leedy, LaLonde and Runk, 2003; Tiedemann, 2000). This is important because children's perception of their own ability mirrors their parents' regardless of how they are actually doing in mathematics (Frome and Eccles, 1998). A mother's perception of a child's ability was found to be both directly and indirectly related to children's self-perceptions and career choices 12 years later (Bleeker and Jacobs, 2004). This is particularly true for girls, and the researchers hypothesise that the effect is due to the impact of their mother's beliefs on a child's developing perceptions of their own competence. Lindberg, Hyde and Hirsch (2008) did not find a difference in how mothers rated their sons' and daughters' ability but found mothers perceived the mathematics itself to be more difficult when working with girls. There also appear to be differences in the messages adults give boys and girls over whether intelligence is stable or malleable. For example, the types of praise teachers and parents more frequently give boys may be more likely to lead to a growth mindset (Gunderson *et al*., 2012).

Mathematics gender stereotypes held by teachers, parents and important others are linked to higher MA in children (Hembree, 1990). Higher levels of MA are recorded in women and girls (see Section 2.1.6) and children's MA is significantly associated with their mothers' MA (Vanbinst, Bellon and Dowker, 2020). Girls taught by teachers with higher levels of MA achieved less at the end of the year, even after controlling for achievement at the start (Casad, Hale and Wachs, 2015). The additional risk is that girls may interpret this anxiety as appropriate female behaviour and internalise it (Gunderson *et al*., 2012). In school-aged children themselves, endorsement of gender stereotypes predicted MA, mathematics self-efficacy and attainment in both girls and boys (Casad, Hale and Wachs, 2015).

Self-concept, an individual's beliefs in their own competence in a given activity, can predict achievement (del Río *et al.*, 2021) and has also been found to be a highly gendered construct. Girls in many countries have a significantly lower mathematical self-concept than boys by fourth grade, despite the narrowing or closing of the mathematical achievement gap (Mejía-Rodríguez, Luyten and Meelissen, 2021). Similarly, a Spanish study found male high-school students to have significantly higher self-concepts despite equal performance (Galende, Arrivillaga and Madariaga, 2020). Differences in self-concept may account for the differing numbers of boys and girls choosing STEM careers despite similar academic success (Mejía-Rodríguez, Luyten and Meelissen, 2021). One study found that fathers' UV beliefs impacted their daughters' end of year grades more than their sons' (Gladstone *et al.*, 2018).

The extensive literature on this subject clearly shows that gender stereotypes and the resulting behaviours and attitudes in parents and teachers do present barriers to girls' mathematics achievement. However, this can be viewed in a more positive light as these beliefs and attitudes could be malleable, therefore interventions and awareness raising could have a significant impact.

3.4.2.4 Comparison with East Asian Culture

There are, within the literature, repeated references to a group of students who do routinely succeed in mathematics, those of East Asian heritage. As mentioned in Section 1.2.2, students from Shanghai, Hong Kong, Taiwan and Singapore top the international league tables represented by TIMMS and PISA scores (Crehan, 2018; Jerrim, 2015). Their advantage moves beyond specific education systems: students of East Asian descent outperform their peers in whichever country they are educated in (Gibbs *et al*., 2017; Jerrim, 2015; Mok, 2020). This advantage appears early, between 2 and 4 years old (Sun, 2011) and, in the USA, Asian American children exhibit stronger mathematics and reading skills than white children at school entry (Gibbs *et al.*, 2017a). This suggests that the early childhood environment created by East Asian parents is key.

There is debate in the literature over the particular features of parenting and culture that lead to this educational success. Relatively high SES has been cited, but Chinese and Vietnamese parents have lower socio-economic resources compared to other Asian groups but still have high levels of academic success (Gibbs *et al*., 2017). The prevalence of out-of-school tutoring in these communities may also contribute (Gibbs *et al*., 2017; Jerrim, 2015). Most interestingly for this study, Gibbs *et al*. (2017) make a distinction between the 'tangible behaviours' of parenting, often seen as evidence of parental involvement, such as attending school events, volunteering at school or visiting libraries, and the 'abstract ideals', or the beliefs and expectations they have about schooling. East Asian parents have 'high levels of abstract ideals but low levels of tangible behaviours' (Gibbs *et al*., 2017, p.319); they expect their child to perform well, place a high value on academic achievement and communicate that expectation to their children (Cao, Bishop and Forgasz, 2007).

To examine these abstract ideals further, it is necessary to consider cultural beliefs about learning in general and learning mathematics specifically. The Confucian ideal of learning, as a moral quest for self-improvement, influences Chinese parents and children (Mok, 2020; Gibbs *et al*., 2017; Li, 2004):

> Learning does not privilege anyone, and neither does it discriminate against anyone. Everyone is capable of seeking and achieving knowledge regardless of one's inborn capacity and social circumstances. (Crehan, 2018, p.159)

A study comparing the views of learning of US and Chinese preschoolers found that American children valued ability, task attempting and strategy, whereas Chinese children valued qualities of diligence, persistence and concentration and they also associated learning with personal virtue (Li, 2004). East Asian children have higher levels of intrinsic motivation compared to their Australian peers and are more likely to believe they can succeed if they work hard (Jerrim, 2015). These examples suggest that the East Asian educational culture is primed to foster a growth mindset. It also appears that this cultural view of learning creates a strong sense of self-efficacy in parents themselves. Bandura *et al*. (1996) argue that parents who have a high sense of parenting efficacy 'select and construct environments conducive to their children's development and serve as strong advocates on their behalf' (p.1216); these parents are able to persist and succeed in a child-centred task despite significant social stress, socio-economic setback or other barriers. East Asian families appear to successfully create environments that promote learning and normalise high levels of academic success and they are doing this well before a child starts school (Gibbs *et al.*, 2017a).

In terms of beliefs about how mathematics is learnt, Chinese parents view it as a skill which can be taught with effort and willpower (Crehan, 2018; Mok, 2020) and attribute failure to lack of effort (Hess, McDevitt and Chang, 1987). American parents were more likely to cite innate ability, genetics and even luck in mathematical success (Stevenson and Stigler, 1994; Hess, McDevitt and Chang, 1987). American students viewed mathematics learning as ‘a rapid insight rather than lengthy struggle’ (Stevenson and Stigler, 1992, p.105), whereas Chinese students saw deep learning as a process of thinking, reflection and practice. These beliefs about mathematics, coupled with the fact that many parents have been successful themselves and are able to help their children, have created a ‘Competence Cycle’ (Leung, 2006 cited in Mok, 2020):

> None of [these Chinese] parents show any fear or negative emotions towards mathematics and they do not avoid, but rather offer help in their children’s mathematics … none of the children show any negative emotions towards mathematics. (Mok, 2020, p.82)

Interestingly, the ‘right or wrong’ nature of mathematics, previously cited as a contributory factor to MA, appears to have the reverse effect in an East Asian context. Here it is described as a low-risk subject; there is no ambiguity, so if you do the work, you can pass the exam (Mok, 2020). This belief in mathematics as a skill which can be taught, without cultural context to misunderstand or misinterpret, is perhaps particularly appealing for an immigrant family. The value placed by East Asian parents on mathematics resounds strongly through all the research studies. This may be pragmatic; mathematics is a gateway skill to selective schooling and university entrance as well as success within society (Mok, 2020). The value placed on mathematics is evidenced in the willingness of East Asian parents to spend time and money on resources and private tutoring.

3.5 Analysis of Previous Interventions

In this part of the literature review, reports of relevant interventions have been collected and analysed to draw out strengths, limitations, theoretical framing and key features in order to inform a novel intervention. Twenty-six separate interventions have been included here; the same intervention may, however, be the focus of more than one journal article. For the purposes of this discussion, they have been grouped into five broad areas. This grouping has been done according to their intention rather than their mode of delivery, theoretical framework or target audience:

- Group 1 – Those that aim to improve parents' understanding of, and interest in, the school mathematics curriculum.
- Group 2 – Those that aim to increase focus on the mathematics of daily life and seek to disrupt a school-centred view of mathematics.
- Group 3 – Those that seek to engage parents in mathematical conversations with their children at home, a subset of which focus on the HNE of preschool children.
- Group 4 – Those that seek to promote positive beliefs about mathematics and to emphasise its usefulness, often referred to as UV.
- Group 5 – Those that aim to reduce anxiety though relaxation and mindfulness.

3.5.1 Group 1 – Improving Parents' Understanding of and Engagement with the School Mathematics Curriculum

These interventions are discussed in two subsets. The first set has a focus on improving the experience and efficacy of mathematics homework or engaging parents in class projects, and the second set used variations on a workshop format to explicitly teach parents how to support their children.

The first set of interventions aimed to improve both the cognitive and emotional experience of homework by engaging parents more fully and facilitating positive, enjoyable interactions (Williams and Williams, 2021; Docherty *et al*., 2018; Panaoura, 2017; Mousoulides, 2013; Van Voorhis, 2011). Homework is an attractive focal point for intervention as it is already a familiar routine connecting schools and homes. These interventions drew on Social Cognitive Theory (Bandura, 1971) and Communities of Practice (Wenger, 1998), as

> during the completion of homework children engage in academic and social communities of practice where the resources and beliefs of their parents come into play. (Landers, 2013, p.375)

In terms of the format of the interventions, Van Voorhis (2011) in the Teachers Involve Parents in Schoolwork programme offered weekly interactive tasks, complete with prompts for parents and opportunity for them to provide feedback. This extended study involved 153 third- and fourth-grade US students over two years. In Williams and Williams (2021) open-ended, problem-solving tasks, with real-life mathematics contexts, were sent home once a week for 20 weeks to 14 classes across multiple English schools. This intervention included a changeover session each week when children's homework was shared with the class and a new task set. This ensured knowledge, in terms of different solutions, travelled from home to school as well as from school to home. Docherty *et al*. (2018), Mousoulides (2013) and

Panaoura (2017) harnessed the new technologies of virtual learning environments, Twitter and Facebook to deliver their interventions. Docherty *et al*. (2018) used a digital learning journal for a single-class intervention with Scottish 6-year-olds. On this platform, videos, photographs and descriptions of children's mathematics learning in school were shared and parents were invited to upload images of their child participating in the suggested activities at home. Panaoura (2017), working with fifth-grade children in Cyprus, posted twice weekly mathematics problems to a closed Facebook group for five weeks for children to solve. Their parents were encouraged to post photos, videos and comments related to working on the tasks with their children. Mousoulides (2013), also in Cyprus, involved parents in an inquiry-based learning project with sixth-grade students. Using Twitter to communicate, parents supported the children to solve an extended real-world problem in the context of a water shortage in Cyprus. This principally involved class time (three hours over five weeks) and reversed the usual direction of knowledge transfer by inviting parents to contribute home knowledge to a school-based task.

Clarity of both task and parental role were priorities in all of these interventions. Time and resources were invested in instructions and also modelling of behaviour, approaches and dispositions. For example, Williams and Williams (2021) included a parent information session, emphasising the benefits of showing curiosity, persistence and flexibility and allowing the child to lead the interaction. Panaoura (2017) began the intervention with four hours of online training for parents, which included explanations of the value of problem-solving skills and how to develop them, explanations of the mathematics curriculum, video excerpts and example scripts for supporting children. All were attempting to navigate the tensions that can result from confusion over a parent's role or doubts about mathematical knowledge. Clarity of information was also considered to 'level the playing field for more families' by ensuring all had the background knowledge they needed (Van Voorhis, 2011, p.33). Panaoura (2017) explicitly framed the parents' role in terms of attitudes and dispositions rather than being a 'second teacher' of mathematical skills (Panaoura, 2017, p.44). All of these interventions were costly in terms of teacher and researcher time and therefore difficult to replicate at any scale in their current forms. For example, Docherty *et al*. (2018) had the support of four educational psychologists and high levels of teacher participation in uploading classroom videos and tasks.

In terms of success, there was substantial anecdotal data that the homework formats were popular with both parents and children and that they resulted in positive interactions, better connection between home and school knowledge and increased parental understanding of school mathematics. The interventions also

> raised awareness of the mathematics knowledge parents often use unthinkingly in everyday situations and how natural it is to talk about mathematical problems. (Williams and Williams, 2021, p.224)

However, across all these studies, the evidence for direct gains in mathematical achievement is small, particularly considering the time-consuming nature of the interventions. It is possible that changes in parental beliefs could make significant differences to mathematical interactions over time, but this has not been evidenced; there were no longitudinal evaluations to assess whether the increase in positive interactions was sustained beyond the intervention.

The second set of interventions in this group used variations on a workshop format to explicitly teach parents how to support their children (Knapp *et al*., 2017; Westenskow *et al*. 2015; Kritzer and Pagliaro, 2013; Starkey and Klein, 2000). As with Docherty *et al*. (2018) and Panaoura (2017) above, these studies created communities of learners and valued the interactions between participants. Their theoretical frameworks included the Funds of Knowledge socio-cultural theory (Moll *et al.*, 1992), which foregrounds the knowledge that parents already hold, and Social Mediation Theory (Bodrova and Leong, 2007), which roots learning in social interactions.

The first two of these interventions both involved sequences of eight workshops in areas of economic disadvantage in the US: the Maths and Parent Partners project worked with children from fourth to eighth grade and their parents (Knapp *et al*., 2017) and an intervention with Headstart families worked with preschool children and their parents (Starkey and Klein, 2000). Both of these aimed to reduce the SES-related differences in informal mathematical knowledge that children possess on entering kindergarten and in accessing the school curriculum. The workshops in both interventions focussed on building knowledge of mathematics topics and pedagogical skills to support children: valuing children's strategies, listening and using manipulatives. Kritzer and Pagliaro (2013) report another comparable intervention with parents of young deaf or hard-of-hearing children. It consisted of five days of workshops and an online platform where interactions were facilitated in between sessions. It involved six families with a preschool child. The workshops covered explicit mathematical content, how it could be integrated into daily routines and how it could be made accessible to a deaf child. Parents were asked to post specific videos of their interactions with their child, for example, bedtime or 'out in the world'. Researchers then interacted with the parents online, providing feedback and prompting discussion. There was opportunity for interaction with other parents and the creation of a community through the online discussion board. Westenskow *et al*. (2015) report an intervention which was neither interactive homework nor direct parental coaching but had similar objectives. It allowed parents to observe their fifth-grade child's participation in ten weeks of individual tutoring. The aim of the intervention was to evaluate parents' responses to the mathematics, the instructional strategies, their own child's responses and whether this learning was transferred to interactions outside of the sessions and enabled them to better support their child.

In terms of the impact of these workshops, Knapp *et al*. (2017) found gains in both parent 'Mathematical Knowledge for Teaching' and children's mathematical scores. Starkey and Klein (2000) found significant improvements in the children's post-test scores across all areas of mathematics. They found parents

> willing and able to support this important area of their children's development once they were provided with the training to do so. (p.676)

Kritzer and Pagliaro (2013) cite qualitative data from analysing extensive video extracts and parental interviews suggesting the intervention had a positive impact on parents' awareness of appropriate mathematics and how to mediate it to their children. Westenskow *et al*. (2015) elicited positive qualitative feedback regarding attitudes and planned changes of approach when supporting homework. One reported outcome was an increased expectation that their child could learn mathematics, a potentially important finding according to Expectancy Value theory (Eccles *et al*., 1983). However, none of these studies were followed up longitudinally to see if the early gains were maintained. These interventions were also highly demanding in terms of budget and time: Starkey and Klein (2000), for example, provided transportation, childcare for younger children and regular communication to promote attendance.

The key learning points, taken from this group of studies as a whole, are firstly that it is essential to give detailed, clear instructions for parents. These should include both what they should do and the aims of the activities. Secondly, that it is important to spend time structuring and guiding parental interaction, for example, providing example scripts of the role they could play and prompts about how to manage the interaction. Thirdly, that there is a distinct benefit to using real-life contexts that harness and value parents' existing knowledge. The use of these elements reduced anxiety and created positive spirals of motivation, as children became enthused and drew their parents in. Finally, there is a potential value in creating communities of learners, interacting with and supporting each other.

3.5.2 Group 2 – Disrupting the Foregrounding of School Knowledge

This group of interventions were intended to disrupt the notion that knowledge must come from school to home, foregrounding instead the knowledge that parents already have (Jay, Rose and Simmons, 2017; Civil, Bratton and Quintos, 2005; Winter *et al*., 2004; Kyle, McIntyre and Moore, 2001). They are framed by the concept of Funds of Knowledge, the 'historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and wellbeing' (Moll *et al.*, 1992) and also theories of Deconstruction and Différance (Derrida, 1978, 1981, 1982) and Critical Pedagogy (Freire, 1972).

In terms of format most, but not all, of these interventions took the form of workshops. The Home School Knowledge Exchange project, reported by both Winter *et al*. (2004) and Feiler *et al*. (2006), was based on the premise that

> both parents and teachers have knowledge that is relevant to enhancing children's learning, but that this knowledge is often poorly communicated and under-utilised. (Winter *et al.*, 2009)

In this intervention in two multicultural UK cities, classes of Year 4 and 5 children in four schools were involved in a diverse range of activities that drew home and school together. Whilst both parents and teachers appeared more comfortable with the school to home transmission of knowledge, attempts were made to explore how home to school sharing could be facilitated. One positive example of this included sending a camera home so parents and children could take photos, then inviting parents into school to support writing about them. This was successful as the parents knew the provenance of the pictures and could meaningfully contribute to the task. There was no data on children's attainment from the project but qualitative descriptions led to the conclusion that parents did want to be involved, to an extent that surprised the schools, but that one size did not fit all for parent involvement.

Also in the UK, Jay, Rose and Simmons (2017) focussed on a parent-centred approach to mathematics. Their approach was intended to be even more disruptive to the existing home to school flow of mathematical information. Informed by the Derridean theory of Deconstruction and Différance (Derrida, 1978, 1981, 1982), it aimed to restructure how both mathematics and parental involvement are viewed. Jay, Rose and Simmons (2017) argue that many of the difficulties and anxieties parents faced with mathematical engagement were exacerbated by the unfamiliar methods and uncertain parameters of the school mathematics curriculum. They suggest that parents' difficulties in reconciling school mathematics with their everyday experiences could account for some of the difficulties in the home/school relationship

> when schools continue to attempt to engage parents using methods and activities that experience and research evidence have shown can be alienating and counterproductive. (p.225)

They also argue that parents were not recognising the mathematics that they did engage in. Their intervention involved four one-hour workshops with parents of 7–9-year-old children. The workshops aimed to 'decentre' mathematics from school to everyday contexts: mathematics *in* activity, not mathematics *as* activity (Stevens, 2013). They found that some parents struggled to think beyond the parameters of school mathematics – seeing everyday mathematics as 'the discussion of school maths in out-of-school contexts' (Jay, Rose and Simmons, 2017, p.223). Other parents, however, found the concept of everyday mathematics liberating and inspiring. As the authors acknowledge, their evidence of changes in conversations at home rely on parents' self-report. This was both an exploratory study and a high-intensity intervention, reaching a limited number of parents in four schools in a city. There was again no longitudinal element to the study to see if the increased awareness of mathematics continued over time.

Civil, Bratton and Quintos (2005) report an intervention to improve mathematical skills among parents in an economically deprived, mostly Latino community in the US. Framed by theories of Critical Pedagogy (Friere, 1972) and Funds of Knowledge (Moll *et al.*, 1992), this aimed to disrupt even further the home–school relationship and address the issues of power between parents and school. It particularly focussed on changing the schools' perceptions of parents from minority communities. It trained Latino parents in mathematics content and also as mathematical activists, enabling them to teach groups of other parents and take an active role in advocating for their communities in school. Whilst there are no reported outcomes of this intervention, it does contribute to the discussion of power dynamics and the direction of knowledge transfer. Belief in the value of the mathematics the parents already know has a history in the literature. Kyle, McIntyre and Moore (2001) describe a small-scale intervention, also framed by Funds of Knowledge (Moll *et al.*, 1992), in which teachers spent time at home with families, gaining an understanding of the mathematics they did use and the contexts they found meaningful, and then integrated this knowledge back into mathematics teaching in the classroom.

The key learning points from these interventions are, firstly, the extent of time, flexibility and openness that it takes to seek out and foreground home knowledge in school, but that this could be a potentially rich area to unlock. Secondly, parents may care deeply about their children's progress in school, but through lack of confidence, time or cultural knowledge may not demonstrate this concern in the way schools expect. Thirdly, parents may not be able to envisage means of interaction beyond the ones they are familiar with, so the responsibility to suggest and trial innovative ideas should be taken by the school. Finally, parents are not a homogenous group; even within communities with a common language, the needs, expectations and experiences of education can be very different. As with the previous group of interventions, these were all demanding in terms of researcher, teacher and parent time and only involved a small number of classes. However, they can be viewed as useful exploratory investigations into the parent/school relationship which could inform an intervention of a more scalable form.

3.5.3 Group 3 – Facilitating Mathematical Conversations in the Home

This group of interventions sought to engage parents in mathematical conversations with their children beyond the confines of the school curriculum (Linder and Emerson, 2019; Paz, 2019; Schaeffer *et al.*, 2018; Muccio, Kuwahara-Fujita and Otsuji, 2014). These interventions intended, through stories, play or conversational tasks, to structure a relaxed and unpressured interaction between parent and child, devoid of negative connotations. As with the interventions above, they draw on the Funds of Knowledge theoretical framing (Moll *et al.*, 1992) and also Ecological Systems (Bronfenbrenner, 1986) and Expectancy Value theory (Eccles *et al.*, 1983).

Paz (2019) reports a study, in an economically deprived area of Chile, which prompted parents, by text message, to do short, simple activities with their teenagers. These activities only took a few minutes and did not require any specific mathematical knowledge; examples include discussing the largest container they had ever filled with water and estimating the distance between two local places. This content was then integrated into the next mathematics lesson. The format was designed to resolve some of the barriers to parent participation, such as time, uncertainty and lack of mathematical knowledge. Parents also received another message prompting them in a positive interaction with their child, such as telling them how proud they were for their efforts in mathematics. This intervention, conducted with 420 students from ninth and tenth grade, was found to improve the mathematical achievement of participating students, compared to a control, at both three and nine months after the intervention. As there was no explicit additional mathematics teaching involved, the researcher hypothesised that the improved grades were driven either by bringing real-world contexts into the classroom and thus increasing engagement and perceived value in the work – its UV – or from an improved mindset from time spent engaging with parents and receiving their support. This study makes reference to Ecological Systems Theory (Bronfenbrenner, 1995), where the interaction creates both social bonding and mutual development.

Schaeffer *et al*. (2018) investigated whether providing parents of first-grade children with a mathematics app which 'promoted parent-child engagement in structured math interactions' (p.1788) could break the connection between parental MA and children's achievement, an aim particularly relevant to my study. This was a large-scale randomised controlled trial intervention involving 587 children across 40 classrooms in the US. This intervention was effective in that the mathematics performance over time of the group using the app did not correlate with their parents' level of MA, but it did in the control group. This was a longitudinal study and demonstrated a disassociation between parental MA and the child's mathematics performance two years later, even when app use had declined. Interestingly, the intervention did not reduce parents' own MA. Schaeffer *et al*. (2018) hypothesise that the lasting impact of this intervention was due to the changes it created in the parents' expectations for their children's ability to learn in mathematics and the value they place on mathematics, which is in line with Expectancy Value Theory (Eccles *et al.*, 1983).

There are also many interventions described in the literature which aim to improve the HNE for preschool children, usually by sending resources into the home to be played with (see Section 3.3.1 for discussion of the HNE). For example, in a small-scale but comprehensive intervention framed by Ecological Systems Theory (Bronfenbrenner, 1995), Linder and Emerson (2019) sent home packs of maths activities to parents of preschool children. They used analysis of pre- and post-intervention videos of parents playing with their child to measure impact, unlike many studies which relied on parents' own reports of behaviour change. They found that the mathematics packs, accompanied by very detailed instructions and suggested scripts for open-ended questioning and exploration, did engage families and result in a breadth of play across different areas of mathematics. However, although there was a dramatic increase in mathematical interactions in the post-intervention video, tenfold in some cases, these interactions had returned to being mostly number based, such as asking children to count things in a way that was unrelated to the task in hand. Parents appeared to need the continued scaffold of the activities to integrate shape, measure, pattern and sorting into their play. Post-intervention interviews did reveal shifts in parent beliefs about mathematics and about their role; specifically, a realisation that they should not show children their own negative feelings about mathematics but should model enthusiasm and interest. The manner of interactions had also changed by the post-intervention video – parents were no longer standing over their children and directing them, but were down at their level encouraging them to explore. Similarly, the Ohana Maths project in Hawai'i (Muccio, Kuwahara-Fujita and Otsuji, 2014), based on the Funds of Knowledge perspective (Moll *et al*., 1992), provided parents with backpacks of mathematics activities for their toddlers and preschoolers. These were specifically tailored to be culturally appropriate to Hawaiian family lifestyle. No data on impact was cited, but there were interesting comments from feedback that parents wanted more, rather than less, detail of how to use, adapt and time the activities, which reflects the parent's dependence on the activity scripts in Linder and Emerson (2019).

The key learning points from this group of interventions are that attitudes and beliefs may be more easily altered than knowledge and skills: parents appear to embrace the importance of mathematics and adjust the manner in which they interact but still find it hard to transfer activities into different contexts without being guided. The request for more, rather than fewer, instructions is a common theme across many of these studies. Integrating mathematical talk and play does not appear to become instinctive; it remains a conscious activity that benefits from structures, examples and reminders. The interventions by Paz (2019) and Schaeffer *et al*. (2018) stand out, in that they are delivered in a digital format and therefore have the potential to be scalable. They also, significantly, demonstrate a positive effect beyond the duration of the intervention itself.

3.5.4 Group 4 – Utility Value Interventions

This set of interventions focussed specifically on promoting the purpose and utility of mathematical learning, rather than the content of the mathematics curriculum. These were larger-scale studies, with more formal evaluations over longer time periods, which targeted students' beliefs that the courses they were taking would be useful to them in the future. They were framed mainly by Expectancy Value Theory and the Parent Socialisation Model (Eccles *et al.*, 1983) and also by Rogoff's theorising about the social context of development (Rogoff, 1990).

The first of these studies is the only one to work directly through parents. The impact parents can have on the UV their adolescent places on STEM subjects was examined in a two-phase study, conducted with high-school students in the US (Hyde *et al.*, 2017; Harackiewicz *et al.*, 2012). These explored whether influencing the discussion mothers have with their children could increase the child's STEM-course choices. This is an example of a social psychological intervention that was delivered, indirectly, through the family, rather than directly to its target audience. It is based on the premise that, by

> having intimate knowledge of their children's specific interests and history, parents may be uniquely qualified to help them appreciate the relevance of mathematics and science to their lives. (Harackiewicz *et al*., 2012, p.904)

In the initial piece of exploratory research (Hyde *et al.*, 2017), the researchers analysed the answers that 130 mothers of ninth-grade children gave to a hypothetical statement that specific science or mathematics topics were a waste of time. They found that mothers who made either frequent, or elaborated, personal connections between their child and a STEM course were associated with higher course interest and perceived UV in their child a year later, and actual course taking three years later. From this study, an intervention was devised to facilitate and increase the effectiveness of these conversations (Harackiewicz *et al.*, 2012). Two brochures were sent to parents and access was given to a website, all highlighting the usefulness of STEM courses. Parents were invited to share these resources with their children and were given advice how to do so. It was found that students from families who received the materials took significantly more mathematics and science classes than students in the control group. The effect was mediated by the levels of the mother's education, which has been previously identified as a primary predictor of STEM course taking (Melhuish *et al.*, 2008). The intervention had the greatest impact on students with less educated parents and the smallest impact on the children of postgraduate-educated parents, although this may be because they were choosing these courses anyway. This is an example of the Robin Hood effect of social psychological interventions (Häfner *et al*., 2017): they offer more to the students with fewer family resources to draw on.

Rozek *et al*. (2015) analysed the impact of gender on the data from the same study and found that it was most effective in increasing STEM course taking for high-achieving daughters and low-achieving sons. Low-achieving daughters were not helped by the intervention, but low-achieving sons were. Previous research has shown that parents have exaggerated expectations for success in STEM for their sons, and diminished expectations for their daughters (Eccles *et al*., 1993; Yee and Eccles, 1988). Rozek *et al*. (2015) suggest that this bias may explain the differential in impact of the intervention; parents will deem all boys, even those with poor prior performance, capable of succeeding. For girls, however, their previous low grades may create low expectations for both parent and child, which negate the benefits of the UV intervention. This hypothesis is in line with previous research that suggests UV interventions are less effective for those with low expectancy of success (Durik and Harackiewicz, 2007).

The following studies also involve the use of UV interventions, although these are not mediated through parents. They are instead conducted directly with college or high-school students. One such intervention involved asking German ninth-grade students to either write about the relevance of mathematics to their own lives or to evaluate quotations by young adults regarding the importance of mathematics to their lives. Each class received a 90-minute standardised relevance presentation followed by two short reinforcement activities to be completed at home. A team of researchers (Brisson *et al*., 2017; Häfner *et al*., 2017; Gaspard *et al*., 2015) analysed the large data set, comprising of nearly 2000 students, to evaluate the impact on students' competence beliefs, effort and standardised test scores. Impact was assessed after six weeks and again after five months.

The task which involved evaluating the quotations was found to be the more effective than the self-generated essay task on measures of self-concept, homework self-efficacy, teacher-rated effort and test scores at the five-month point. The essay condition did not have statistically significant outcomes on most of these measures. This was thought to be because students may not have been able, by themselves, to generate the same number and range of connections. These findings would suggest that a relevance intervention would benefit from being highly structured and containing concrete examples. The researchers attributed the positive effect of this study to including a confidence reinforcement to emphasise to students that mathematics achievement can be improved by effort; providing examples about the utility of mathematics and asking students to actively apply the relevance to themselves (Brisson *et al*., 2017). Again, these interventions were found to have a greater benefit to female students. Explanations for this included the role modelling by the female researchers and the use of the medium of writing, which may have appealed more to girls. Also, although a balance of male- and female-domain examples of the usefulness of mathematics were included, the female-type domains may be more likely to be new information and therefore more salient to girls. These factors would need more investigation. Häfner *et al*. (2017) examined the same data for evidence of the impact of a family's motivational resources. They found that the relevance interventions were especially valuable for students whose parents had lower UV and family interest in mathematics. This difference was found even within a relatively homogenous sample of predominantly middle-class, Caucasian, German 14-year-olds from an academically selective school. It would be interesting to investigate whether the differential effect is true in a more diverse social sample.

Another pair of interrelated UV interventions were carried out with US college psychology students. These examined the frequency with which students connected course material with their lives (Hullean *et al*., 2017). This was conducted by the same team of researchers as the parent-mediated study above (Harackiewicz *et al.*, 2012) and followed the same pattern. The first part was an exploratory study, which was conducted with 97 students. This found that those who reported making frequent connections between the course material and their lives showed higher expectancy, UV and interest in the course. The second study, conducted with 357 students, involved a sequence of prompts to engage, which were presented through an existing online teaching platform. There were two levels of intervention in this double-blind randomised trial. The first condition prompted students to compose a short essay regarding the relevance of the psychology material studied to their own lives. The second condition gave the same essay prompt and in addition asked them to make a specific intention of when and where they would think further about making connections with the course material. This sequence was repeated with another set of prompts towards the end of the semester. This study was designed to understand the mechanism by which increasing perceived UV subsequently increases interest and performance, particularly as it has been noted that the effects are not the same for everyone (Durik *et al*., 2015; Harackiewicz *et al*., 2014). The intervention was found to show positive effects for low performers and null effects for high performers. It proved particularly beneficial for male students who had performed poorly on the first exam. Analysis of the data found, to the researcher's surprise, that the intervention increased the low-achieving students' outcomes by increasing their expectancies of success rather than the perceived UV of the subject. The prompts to make a plan to make connections later, did not have a significant impact. The authors believe this may have been because an online prompt did not activate enough behavioural commitment or because, when unsupported, the connections students made between the course and their lives were of poor quality.

Woolley *et al*. (2013) evaluated a lengthier and more structured programme called CareerStart – an intervention designed to show the relevance of lessons to middle-grade students in the US. It consisted of ten pre-planned lessons for each grade, for each core subject, which connected the content to its use in the world of work. It was tested using a Cluster Randomised Controlled Trial, with seven classes participating in the programme, and was delivered to the same students for three years. CareerStart was found to have a significant effect on student mathematics achievement, as measured by their eighth-grade standardised test scores. The theory of change, which appears to have been supported by the findings, was that perceiving lessons as relevant to their future would increase students' cognitive and emotional engagement, and thus their behavioural engagement, which would lead to higher achievement outcomes. This has many features in common with the interventions above; specifically, it provides precise examples and supports students to make connections between the subject and their lives.

The final intervention included here is a massive open online course (MOOC) devised by Boaler *et al*. (2018). Also targeted directly at high-school students, it is relevant here as it aimed to improve mathematics achievement by operating on beliefs and attitudes, including UV. It also achieved a scalable, online delivery beyond that of the interventions discussed above. Informed by Growth Mindset Theory (Dweck, 2012), it aimed to change students' ideas about their own potential and challenge unhelpful, limiting myths. It was also brief, consisting of six 15-minute online sessions. It promoted the following beliefs:

- Everyone can learn mathematics to high levels.
- Mistakes, challenges and struggle are the best times for brain growth.
- Depth of thinking is more important than speed.
- Mathematics is a creative and beautiful subject.
- Good strategies for learning mathematics include talking and drawing.
- Mathematics is all around us in life and is important. (Boaler *et al.*, 2018, p.2)

This was evaluated by randomised controlled trial, with just over 1000 US students from sixth to eighth grade. The MOOC intervention was found to have a significant positive impact on participants' achievement in mathematics, beliefs about mathematics and engagement, as rated by their teachers. Whilst there were clearly technical difficulties with online access and gaps in both the student engagement and achievement data reported by schools, the authors argue that the data they analysed is sufficient to show significant gains among the intervention cohort. The study provides evidence of the link between changes in students' beliefs and changes in their learning outcomes. There is, however, no evidence of whether the reported gains are sustained over time. Whilst the article does not mention Expectancy Value Theory (Eccles *et al.*, 1983) explicitly, its design is aligned with it – increasing students' expectation of success in mathematics and their belief in its value.

The key point to take from these studies is that increasing the perceived UV and relevance of a subject can have a positive effect on motivation and attainment. However, to be effective, interventions of this type need to be highly structured, with concrete examples, to enable participants to make effective connections between themselves and the subject. Interventions of this type may be particularly effective for those students with lower family motivational resources. Also, the Harackiewicz *et al*. (2012) study demonstrates that UV is an area that parents could valuably contribute to; they are ideally placed to communicate the relevance of mathematics to their children's lives, and in fact relevance may be a better site for intervention than enjoyment or competence:

> In essence, it may be easier for parents to demonstrate the utility value of academic pursuits than to help their children find those pursuits interesting. For example, even if parents cannot convince their child that mathematics is enjoyable (Intrinsic value) or that he or she is good at mathematics (Expectancy), they can discuss how useful mathematics is for careers in engineering or computer science and for gaining college admission. (Harackiewicz *et al.*, 2012, p.900)

Importantly, the success of an intervention based on UV would not rely on developing parents' mathematical or teaching skills, which is time consuming and costly, but rather on applying their experience of the world and their knowledge of their child to make meaningful connections. The format of these interventions, either online or with standardised materials, also means they have potential to be replicated at scale. These examples are, with the exception of Woolley *et al*. (2013), also brief in nature.

3.5.5 Group 5 – Mindset Interventions

A final group of interventions were targeted directly at reducing MA through techniques such as relaxation or mindfulness. Zenner *et al.* (2014) conducted a systematic review and meta-analysis of 24 general mindfulness-based interventions in schools and found them to have a significant positive effect on cognitive performance and on the psychological measures of stress, coping and resilience. Brunyé *et al*. (2013) found that participating in a focussed breathing activity just before a mathematics test improved the performance of highly mathematics-anxious undergraduates by 9%, bringing them close to the performance of those without MA. Similarly, in another study with undergraduates (Sharp *et al.*, 2000), a few minutes of guided relaxation at the start of each class was found to reduce anxiety and increase performance on a problem-solving task by around 30%. Karimi and Venkatesan (2009) also found a significant improvement in mathematics performance in high-school students in Iran following an intensive cognitive behavioural group therapy intervention, which was delivered in fifteen 90-minute sessions by two psychologists. Whilst these results suggest that this approach could be effective in reducing parents' and children's anxiety, there are a number of logistical issues taking this out of consideration for this study. Firstly, the time commitment is considerable. Secondly, these interventions are, in these examples, aimed at participants who are engaged in mathematics courses themselves, as school or college students, rather than parents supporting children. There may however be tools or techniques from this approach that would be valuable for parents, such as calming techniques for themselves, or their children, when mathematics work becomes stressful.

3.6 What Does This Mean for a Novel Intervention?

To draw this analysis together, the key learning points for designing an intervention appear to be:

- Detail and clarity are of fundamental importance; any intervention would need to be highly structured, with lots of concrete examples, scripts for parents to draw on and resources to support them.
- The tone of the interaction between parents and children is more important than mathematical knowledge or materials. Time would need to be invested in developing parents' understanding of this and demonstrating the importance of their role in modelling values and attitudes.
- Real-life contexts are likely be more accessible to parents and less anxiety provoking. However, parents may not be aware of the mathematics that they are doing in their daily lives. They may find it hard to think of examples of mathematics beyond the school mathematics curriculum.
- Parents may be more anxious and unsure of their role than teachers and researchers realise.
- There may be benefits to creating a community of practice around an intervention.
- Attitudes and beliefs may be an easier target than mathematical knowledge or teaching skills and require a less intensive intervention.
- The UV of mathematics appears a promising focus.
- Online platforms have potential for an accessible, scalable intervention.
- It may be possible to create positive and sustainable changes in attitudes and beliefs within a brief intervention.

This review of the literature, including the analysis of the barriers parents face when supporting mathematics and the key learning points from previous interventions listed above, was used to inform the creation of a novel intervention. This review also informed the questions asked in the interviews (Section 4.2.4.1) and the analysis of the data collected from them (Section 5.2). The design of the intervention itself is be discussed in Chapter 6.

Chapter 4 – Methodology

4.1 Overview of the Study

This study set out to design and create an online social psychological intervention for parents and then evaluate it. The intervention aimed to reduce the intergenerational transmission of Mathematics Anxiety (MA) by encouraging changes in the beliefs parents held about mathematics and thus the interactions they had with their children. The study consisted of three distinct phases (see Figure 1). In the first phase, data was collected and collated from multiple sources in order to inform the design of the intervention; these included qualitative interviews with parents, a systematic review of the literature and an analysis of previous interventions. In the second phase, the intervention was created, participants were recruited and the intervention was trialled. In the third phase, the intervention was evaluated. There were two main sources of data used in the evaluation: qualitative survey data regarding participants' views of their experiences and quantitative usage data generated by the online platform. Participants completed these surveys at the end of the intervention and again several months later. This longitudinal element was important for capturing the durability of any behaviour changes initiated by the intervention.

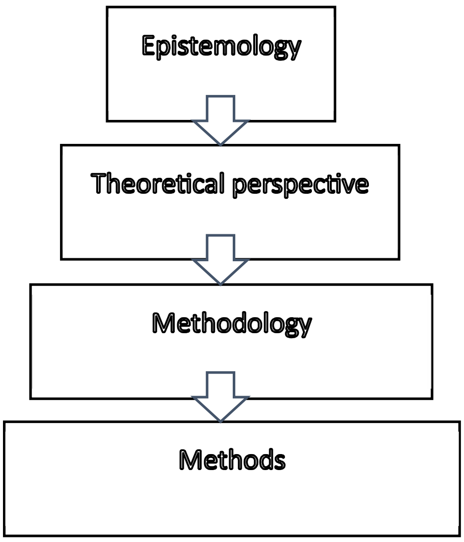
This study crossed boundaries of methodological definitions between evaluation and intervention and these methodologies will be discussed in Section 4.2.3. It was, in the main, a qualitative study: the largest proportion of the data came from semi-structured interviews and open-ended survey questions. There is a small element of quantitative data, including the analytic data recorded by the website showing how people engaged with the course. However, whilst this quantitative data does add a further dimension to the qualitative data and triangulates the engagement reported by participants, it is not analysed using statistical methods and it does not contribute an equal amount to the study. It does not, therefore, reach the definition of mixed methods research set by Creswell (2022). He stated that mixed methods research should 'combine statistical trends (quantitative data) with stories and personal experiences (qualitative data)', that they should contribute equal value to the research and the integration 'should provide insight beyond what can be learnt from the qualitative and quantitative data' (p.2). This remains, therefore, in essence a qualitative study.

This chapter will begin by situating the study on its epistemological foundations and outline the paradigms and theoretical perspectives which led to the research choices outlined above. Following that, the rationale for the methodologies, methods and recruitment of participants will be discussed. Finally, the ethical stance of the study, the approach to validity taken and the need for reflexivity on the part of the researcher will be explored.

4.2 Research Paradigm

A paradigm is defined here as 'a contextual framework which provides the overarching theoretical basis for undertaking research' (O'Reilly and Kiyimba, 2015, p.1). It is a basic set of beliefs held by the researcher and guiding their actions (Guba, 1990, p.1). This research, into the individual experiences of parents, stemmed from an idiographic paradigm. Within this, the individual is viewed as unique and complex rather than an example of a predefined general case. This research takes an emic or inductive approach, starting from the perspectives and words of the participants. For this reason, the research began with an exploration of participants' perspectives through semi-structured interviews with open questions. It did not begin with a hypothesis, to be proven or disproven, but set out more openly to understand the participants' experiences of doing mathematics with their children and, subsequently, their views of engaging with the intervention. Although the participants are tentatively grouped into personas, as a way of understanding how parents with different dispositions towards mathematics reacted to the intervention, there is no attempt to draw broad generalisations from the data. Instead, it is an exploration of the experiences of individuals.

In the following section I have adopted the structure suggested by Crotty (1998) to describe the research paradigm and will define and outline the relationships between epistemology, theoretical perspective, methodology and methods below (p.4 Figure 1).



4.2.1 Epistemology

> Epistemology is concerned with providing a philosophical grounding for deciding what kinds of knowledge are possible and how we can ensure that they are both adequate and legitimate. (Maynard, 1994, p.10)

The epistemology of this research is influenced by constructivism. It is underpinned by the belief that knowledge is neither discovered objectively from an external reality, nor produced subjectively by an individual, independent of reality. Knowledge is created in the course of an interaction:

> There is not objective truth waiting for us to discover it. Truth, or meaning, comes into existence in and out of our engagement with the realities of the world. There is not meaning without a mind. Meaning is not discovered but constructed. (Crotty, 1998, p.8–9)

In a constructivist epistemology, knowledge is relative. There is not one truth but the possibility of a plurality of truths associated with different constructions of reality (Blaikie, 1993). The research interviews were socially constructed activities: both the participants and the researcher conceptualised and interpreted their own actions and experiences and the actions of others. Different people in a society experience and understand the same objective reality in different ways and have individual reasons for their actions (Alharahsheh and Pius, 2020; Bhattacherjee, 2012); this research was interested in how the participants understood their reality and explained their own actions.

This epistemological position influenced all aspects of the study, for example, the choice of a qualitative methodology, the use of open-ended questioning in both interview and questionnaires and the employment of reflexive thematic analysis to analyse the data. Data from interviews, for example, was understood to be constructed in the relationship between interviewer and interviewee. It was treated with the awareness that 'with another interviewer a different interaction may be created and different knowledge produced' (Brinkman and Kvale, 2018, p.14). This is not to say that the knowledge constructed is not valid; this epistemology does not allow for the existence of ‘pure’ data, unaffected by the context. The impact of the researcher on the data collected is inevitable; the importance of reflexivity and transparency in this regard is discussed in Section 4.5. This epistemological position also influenced the structure of the study: the staggered design allowed the perspectives of the participants in the first phase to influence the development of the intervention in the second phase.

4.2.2 Theoretical Perspective

Theoretical perspective is defined by Crotty (1998) as the 'statement of the assumptions bought to the research task and reflected in the methodology as we understand and employ it'; it is also the researcher's 'view of the human world and the social life within that world' (p.7). This is a different use of the term 'theoretical perspective' to the one used in Chapter 2 in reference to the theorists whose work underpins the study. This study was built on an interpretative view of the world: individuals are viewed as having agency in the social world rather than simply reacting to the social structures around them. They think and choose how to act and attached meaning to what they do. According to Max Weber (1864–1920), the task of the sociologist is to understand or interpret what people do; he used the term *verstehen,* to understand, to describe this task (O'Reilly, 2009). The researcher has to make sense of, or interpret, what is observed. This interpretation is inevitably influenced by the researcher's own values and beliefs. Interpretivism produces, and values, 'culturally derived and historically situated interpretations of the social life-world' (Crotty, 1998, p.67):

> There can be no theory free observation or knowledge. The activities involved in constructing knowledge occur against the background of shared interpretations, practices and language; these occur within our historical, cultural and gendered ways of being. In short, as all social enquiry reflects the standpoint of the researcher, and all observation is theory-laden, it is impossible to produce theory-free knowledge. (Denzin and Lincoln 2000, p.872 in Blaikie, 1993)

This study does not, therefore, consist of pure description of the participants' subjective experience. Their experience was interpreted by me, the researcher, with my own history, perspective and assumptions. It was also interpreted in the light of my knowledge of educational theories, literature and previous interviews, which enabled me to place the descriptions into a wider context. Lareau defends this layer of researcher interpretation:

> It does not trouble me if my interpretations of the factors influencing their behaviour is different from their interpretation of their lives. Parents at Prescott and Colton schools cannot be expected to be aware of the class structure of which they are a part, nor of the influence of class on behaviour. (Lareau, 1996, p.225)

The interpretive perspective influenced the choices of both methodology and methods in this study. An evaluation methodology, with a small sample size, open-ended interviews and surveys, allowed the participants to explain their views and the reasoning behind their actions.

4.2.3 Methodology

In terms of methodology, this research was conceptualised as a sequence of evaluations with an intervention at its core. It involved an intervention in order to make a direct contribution to current practice:

> Rather than providing hypotheses about what should work, intervention studies provide evidence of what can work (given the particular circumstances of the study). By strengthening the reciprocal relationship between theory, research and practice, field interventions bolster practical validity arguments integrating psychological theories into the mainstream of educational practice. (Lazowski and Hulleman, 2016, p.626)

The use of evaluation methodology is consistent with the interpretivist perspective. This was not a formal intervention study, with a large number of participants, a control group and a precise measure of impact. It was instead concerned with exploring in more depth the experiences of small number of participants and their reflections on participation. It was intended to explore how the intervention could work for an individual in the context of their own life and beliefs. For this reason, interviews and open-ended survey questions were used to gain 'thick data' – detailed and dense descriptions of the cultural practices under study (Geertz, 1973).

4.2.3.1 Proactive Evaluation

The initial phase of the study was a 'proactive evaluation': an evaluation that takes place before a programme is designed, the aim of which is to 'provide findings to aid decision making about a new programme, one being developed from scratch' (Owen and Rogers, 1999, p.2). Proactive evaluations are intended to clarify the extent and nature of need, synthesize the known research and critically review other relevant programmes. Owen and Rogers (1999) argue that this stage of programme planning is essential as it avoids interventions being based on 'the intuition of program planners, long used practices or personal preferences' (p.4). It also ensures that interventions are finely tuned to the current context of the people they are intended to support; this is critical for the success of social psychological interventions (Yeager and Walton, 2011).

An assessment of need is fundamental to a proactive evaluation. In this context, Owen and Rogers (1999) consider it important to consider 'need' as a noun, as a gap between present and desired situations, rather than 'need' as a verb, as in 'what people need'. The later usage risks conflating needs with solutions. Need has also been defined as the

> measurable gap between two conditions – 'What is' (the current status or state) and 'what should be' (the desired status of state). (Altschuld and Kumar, 2012, p.4)

Roth refines this further to reflect different needs:

> Ideal state – actual = goal discrepancy
>
> Minimal satisfactory state – actual = essential discrepancy
>
> Desired – actual = want (desired discrepancy)
>
> Expected – actual = expectancy discrepancy. (1990, p.141)

The most relevant to this study is goal discrepancy. In the long term, the ideal state would be that children grew up in households with positive, confident attitudes to mathematics, enjoyed learning it, were motivated to succeed and in turn passed those attitudes on to their children; in other words, the creation of a competence cycle (Leung, 2006 cited in Mok, 2020). In the short term, an ideal state would be that parents were aware of the influence they had as role models, had positive mathematical conversations with their child and were able to point out the mathematics being used in the world around them. The purpose of the proactive evaluation was to establish as much as possible about the actual, current situation through empirical data and research. This was informed by 'a review of exemplary practice' (Owen and Rogers, 1999, p.4), in this case, the analysis of previous interventions in Section 3.5.

4.2.3.2 Outcome Evaluation

The final phase, after the intervention had been designed and completed by participants, was an 'outcome evaluation'. This was intended to explore how the people involved experienced the intervention and how they felt about it. The evaluation was a vehicle for further learning, both about the context and how the intervention was used in practice. There has been discussion in the literature over why social psychological interventions appear to work well for some participants and have minimal impact on others (Schwartz *et al.*, 2016) and the evaluation was intended to explore this question in this context. The Theory of Change which was drafted as part of the intervention design process (See Section 6.6.4) supported the structuring of the evaluation. The questions probed whether any of the initial changes of belief or behaviour had occurred, which in turn provided evidence that the theory was valid. This was not a formal impact evaluation: it did not attempt to quantify the extent to which the intervention 'worked'. It is instead a more open-ended exploration of how the programme was experienced by the participants.

In this way, it was influenced by Kushner's (2000) concept of Personalised Evaluation, with its call to invert the conventional relationship between the individual and the programme:

> rather than document the program and 'read' the lives of individuals in that context; to document the lives and work of people and to use that as a context within which to read the significance of programs. (p.11)

Although the evaluation questionnaires, discussed in detail in Chapter 7, do attempt to identify whether participants' attitudes and behaviours have changed as a result of the intervention, they do not attempt to quantify this but instead ask participants for their own examples and their reflections on the experience of participating. It foregrounds these experiences over any attempt to collect quantifiable data to show its success, as warned against by Kushner:

> The evaluators were so focussed on measuring the measurable that they failed to understand the nature of the relationships being built inside and around the program. (Kushner, 2017, p.8)

4.2.4 Methods

4.2.4.1 Interviews

In order to build a detailed picture of the context, extended, semi-structured interviews were chosen for the Phase 1 proactive evaluation. The purpose of these was to gain insight into parents' experiences, attitudes and beliefs; for this it was valuable to allow flexibility in the questions and subsequent conversation. It is acknowledged, as discussed above, that data obtained from interviews is subjective and context dependent; they are a social interpretive encounter, not merely a data collection exercise (Cohen, Manion and Morrison, 2007). The interviewer is not getting pure information or the untouched views of participants (Assuncao Folque, 2010) but knowledge constructed in the interaction between interviewer and interviewee (Savin-Baden and Howell Major, 2013; Brinkman and Kvale, 2007). People describe their experience according to the situation, their relationship with the interviewer, the perceived purpose of the interview and the image of themselves they wish to project. The questions asked, the reactions to answers and the rapport established will all have influenced the data obtained (Brinkman and Kvale, 2018; Savin-Baden and Howell Major, 2013). Interviews as a method, with their foregrounding of the experience and reflections of the individual, fit well within a constructivist and interpretivist paradigm. The context dependence of the data, as discussed in Section 4.2.1, is not seen to detract from its validity.

All interviews had the same four sections, but the individual questions within them varied slightly with the flow of conversation – the interview guide was treated as an outline with suggested questions, rather than a binding, sequenced structure (see Appendix 3 for an example transcript). The key sections were:

- Parents' own experiences of mathematics
- Experience of doing mathematics with their child
- Discussion of general statements about mathematics
- Discussion of potential intervention formats.

The questions were designed to address both the 'thematic content' – attitudes to mathematics – and the 'dynamic dimension' of the interview – maintaining the flow of conversation (Brinkman and Kvale, 2018). For example, the opening questions, regarding parents' own experience of mathematics, enabled all participants to speak at some length. This allowed a rapport to be established whilst also giving useful insights into levels of mathematical confidence and beliefs about mathematics. The second section focussed on working on mathematics with children; this was particularly pertinent as the interviews followed several months of homeschooling. I had a bank of questions, to use as needed, which were easy to answer, such as asking about the use of mathematics apps, cooking or board games. These were intended to serve as a pause or change of tack if the interviewee was finding the questions difficult. The third section was more abstract and explored more explicitly the beliefs about mathematics that were central to the study.

In terms of procedures, two pilot interviews were conducted with friends who had primary-aged children and identified themselves as anxious about mathematics. These pilots enabled me to test the technology, questions and timing and discuss the experiences of the interviews with participants afterwards. No significant changes were made to the protocol after the pilots. However, some additional questions were added as the interviews progressed, as interesting areas of discussion arose, for example, how parents found communication with their child's school around mathematics (see Appendix 4 for questions and amends). The key change, made after the first four interviews, was to replace the PowerPoint of statements with open-ended questions in order to generate more discussion. Replacing for example 'Boys tend to enjoy maths more than girls' with which I asked participants to agree or disagree, were replaced with open-ended question 'Have you come across any gender stereotypes around maths?' (see Appendix 5 for PowerPoint slides).

4.2.4.1.1 Video Interviewing

Video interviewing was overall a positive and productive experience. The conversations felt natural and rapport only slightly more difficult to establish than with an interview in person. Participants appeared relaxed, frank and willing to talk at length. The success of video interviewing was well documented during the Covid-19 pandemic. Tett (2020) records, for example, unexpected advantages in a study involved interviews with manual workers in Mumbai when the researchers exchanged an elaborate lab in a hotel for a mobile phone during lockdown; they found participants were more comfortable in their home environment, felt less pressure to dress or act formally to match the setting, appeared to feel more in control and freer to share their point of view. This may have parallels in this study, in that parents were in their own home rather than in their child's school. Interviewing in a school would have made it harder to separate the researcher from the school staff and may have invoked a more formal attitude and a desire to give what they perceived as the 'right' answers.

There are accounts in the literature, prior to the pandemic, in which researchers found video interviews to be effective. Seitz (2016) reports both researcher and participants feeling less nervous and less pressured when online. Krouwel, Jolly and Greenfield (2019) found video interviews produced a similar volume of data and similar breadth of codes to in-person interviews, with just slightly fewer statements per code. Upadhyay and Liplovich (2020) describe very positive experiences of interviewing young adults through video call, suggesting that this should be a 'viable first choice option rather than an alternative or secondary choice' (p.9). However, Adams-Hutcheson and Longhurst (2017) argue that the awkward or unknown social etiquette for video calls and the absence of familiar social rhythms that facilitate communication, such as sharing a cup of tea or interacting with a pet, are an obstacle to rapport. I would argue that the ubiquity of the media has made this less of an issue. It is possible that the pandemic brought us to such a point of familiarity with the technology that it does indeed go unnoticed and '[sinks] into the background' (Ash, 2013, p.20). Increased familiarity and regular use certainly meant that neither I nor my participants faced the technological obstacles discussed in most earlier articles on this subject (Mirick and Wladkowski, 2019; Seitz, 2016; Hanna, 2012; Sedgwick and Spiers, 2009).

I found, as reflected in the literature (Gray *et al*., 2020; Upadhyay and Lipkovich, 2020; Mirick and Wladkowski, 2019; Deakin and Wakefield, 2014), that the efficiency of the media was appealing to participants. They needed only to take half an hour out of their day and there was no travel involved or arrangements to make. I also found, as Mirick and Wladkowski (2019) did, that the ability to take part in the interview whilst caring for children enabled more people to participate. The shared experience of making arrangements around children's routines and speaking from our home environments, with their visual clues of family life (Mirick and Wladkowski, 2019), contributed to rapport.

As a researcher, I found being in my own space prior to the meeting helpful. I was in control of the environment in a way that would have been difficult in a school or public setting. I had my prompts and questions ready but 'off camera', which aided a more natural flow of conversation; I could glance down when necessary but was not shuffling papers. I found the software's recording facility easy to use, high quality and unobtrusive. There was an icon on the screen to show when I was recording, but there was no device on the table between us. I also found having a video recording helpful when transcribing the conversations as expressions and mannerisms aided interpretation of meaning.

4.2.4.2 Analysis of Interview Data

Silverman (2011) outlines three approaches to interpreting interview data. The first is positivist, where the answers represent 'facts' about the world, independent of the researcher or setting and where the interviewer's role is to extract information without contaminating it. The second is emotionalist, where interviews are seen as 'an authentic gaze into the soul of another' (p.179), providing an insight into participants' world views or emotions, and the interviewer's role is to create a rapport and an atmosphere 'conducive to open and undistorted communication' (Gubruim and Holstein, 2003, p.116). The third is constructivist, where participants 'construct aspects of reality in collaboration with the interviewer' (p.127) and the data is a product of the interaction and is inevitably impacted by the circumstances. It is from this third position, aligned with the constructivist epistemology described in Section 4.2.1, that I approached analysis of these interviews. Thus, the interviewees were not passive vessels waiting to be tapped (Braun and Clarke, 2006) but were instead responding to our social encounter. They were actively presenting an identity (Holstein and Gubrian, 1995), influenced by the cultural narrative that surrounded them and contemporary ways of talking about the topic (Braun and Clarke, 2006). They held many roles – mother, professional, teacher – that they may have assumed at different points in the interview (Gubrium and Holstein, 1997). The interviews needed, therefore, to be analysed within their context: in terms of the questions that elicited those particular responses, the relationship between interviewer and interviewee and the cultural narratives that are being accepted or rejected in the talk. Reflexive thematic analysis (Braun and Clarke, 2022) was used to analyse and identify themes in the data. The rationale for choosing reflexive thematic analysis and the process of using it is described in detail in Section 5.2.

4.2.4.3 Analysis of Website Usage Data

The platform on which the course was hosted was able to track data to show how individual users interacted with the course. This included the number of times the course was accessed, which videos were viewed and for how long on each occasion. This cannot, of course, record whether the video was being actively watched in that time, but it can give an indication of the way the course was accessed and which videos were more or less appealing to participants. This data was considered in two ways. Firstly, on its own in order to consider the patterns of usage across the different elements of the course. Secondly, it was considered alongside the survey responses of each participant, to add another layer of understanding and an element of triangulation in exploring how they accessed the course.

4.2.4.4 Analysis of Evaluation Survey Data

The evaluation survey contained both qualitative, longer-answer questions and quantitative multiple-choice questions. The qualitative data was analysed, as above, using thematic analysis. The quantitative data was graphed in order to uncover patterns or trends. The process of analysis and findings are described in detail in Chapter 7.

4.3 Recruitment of Participants

Two sets of participants were recruited for this research. Firstly, parents with at least one primary-aged child were recruited to participate in 30-minute online interviews. Secondly, parents, again with at least one primary-aged child, were recruited to trial the intervention itself. These groups were recruited separately; however, there was some overlap as two parents who participated in the interviews also completed and evaluated the intervention.

4.3.1 Recruitment for Phase 1 Interviews

In Phase 1, the original plan was to recruit parents of primary-aged children who identified themselves as anxious about mathematics for interviews. This recruitment was intended to take place in-person, at events for parents in 3–5 local schools with diverse catchments. However, this phase of the research took place in the summer of 2020, between the two main periods of school closure caused by the Covid-19 pandemic. At this time, school entry was highly controlled and some year groups had not yet returned to school at all. It was the time of strict ‘bubbles’ to reduce contact between children, staggered starts to the school day and two-week isolation for anyone in contact with a case of Covid 19. In this context it was not possible to recruit through schools as originally planned or to arrange face-to-face interviews. A decision was made at this point to recruit and interview online.

There were several iterations of the recruitment strategy. The first, asking the original, local schools to send a flyer to parents by email, had very limited success (3 participants). Only two schools felt able to do this and the one school in which this led to participants being recruited placed the flyer in the body of a newsletter. The other school relied on parents clicking on a link through to a 'Mathematics Study you may be interested in'. This did not lead to any enquiries. I would imagine that parents who were anxious about mathematics did not click through; the parents who did were probably more confident and realised that the study was not aimed at them. This demonstrates the importance of controlling the message at all stages when recruiting.

The second, more successful strategy, was to use my social media network to recruit: Facebook and WhatsApp were used to circulate an advert with an embedded link to a website containing further details and a contact form. My contacts were asked to post this again on their own network and school groups (see Appendix 6 for recruitment materials). This method recruited 13 participants. The invitation was also extended at this point to any parent with a primary child, rather than specifically those who felt anxious. I hypothesised that admitting anxiety in an impersonal context may be proving a barrier. However, this did mean that not all participants found mathematics challenging; some in fact were very confident in mathematics, had experience of doing research or were simply interested. Two had their own agendas in that they wanted to express their dissatisfaction with their school's approach to mathematics. I could have screened potential interviewees before interview; however, it proved valuable to have a point of comparison between the behaviour and beliefs of parents who were more or less confident about mathematics.

There were several benefits to online recruitment. Firstly, participants were located across the UK rather than in one area. Secondly, it was clear to participants that there was no connection between me and their child's school. Thirdly, the interviews were logistically easy and time efficient for both parties. As discussed in Section 4.4.5, in all cases I offered an £8 book token as an incentive to participate in the research. This was certainly a factor in recruiting some of the participants and, I would argue, increased the socio-economic diversity of the sample. Using these methods, I recruited 16 parents and 2 further parents were referred to me directly. All were interviewed via video call for approximately 30 minutes.

Recruitment strategy	Interest expressed	Interviews conducted	Features to note
Flyer emailed by schools to parents.	5	3 (2 M, 1 F)	Schools controlled message accompanying flyer. Email given as contact. Specifically targeting less confident parents.
Social media advert with link to website	34	15 (1 M, 14 F)	£8 voucher offered. Click through to website to leave email. Open to any parent, not necessarily those less confident.
Word of mouth	n/a	2 (1 M, 1 F)	Parents who identified as being anxious about maths.

Figure 6. Summary of recruitment strategy for Phase 1

4.3.2 Recruitment for Phase 2 – the Intervention

The same method of online recruitment was used to recruit participants for the intervention (See Appendix 7). No compensation was offered for participation in the intervention, but a £10 voucher was offered for completion of the longitudinal evaluation survey.

Recruitment strategy	Interest expressed	Course started	Course completed	Evaluation on completion	Longitudinal evaluation
Social media advert with link to website M-Male F-Female	33 (28F 5M)	15 (13F 2M)	11 (10F 1M)	10 (9F 1M)	9 (8F 1M)
Participants from interviews approached by email	2 (2F)	2 (2F)	2 (2F)	2 (2F)	2 (2F)
Total	**35**	**17**	**13**	**12**	**11**
Percentage continuing from the previous stage	-	51%	76%	92%	92%

Figure 7. Summary of completion percentages for participants in the intervention

4.3.3 Sampling

A target sample size of 12–16 interviews was chosen. This was considered to provide enough data to explore research questions and expose the key themes (Brinkman and Kvale, 2018; Rowley, 2012; Guest, Bunce and Johnson, 2006) and was also a realistic number of interviews for one researcher to conduct, transcribe and analyse. The sample could be described as a convenience sample: a form of nonprobability sampling which selects participants that are readily accessible to the researcher (Lewis-Beck, Bryman and Futing Liao, 2004). Convenience sampling was undertaken with an awareness that it could not be considered a methodologically robust approach nor could it be used to represent a population. It is, however, defended in the literature in exploratory or pilot studies: it can be helpful in obtaining a range of attitudes and opinions and in identifying tentative hypotheses (Galloway, 2005), for testing out ideas (Gray, 2014) or for exploratory studies (Neuman, 2011). Any self-selected sample is likely to attract people with a particular interest in the topic, either positive or negative, and this would be the case online or in person.

The study was advertised until the target of 16 participants was reached. Two participants were subsequently referred to the researcher directly, as people who were anxious about mathematics and were interested in the study. These could be considered critical cases as they had an awareness of their own high levels of anxiety and were explicitly interested in participating because of this: Critical cases are those that can make a point dramatically or are, for whatever reason, particularly important (Patton, 1990 in Gray, 2014).

Although no specific demographic questions were asked before the interviews, conversation revealed diversity in terms of the participants' employment and geographical location; participants included a barrister, a lorry driver, a stay-at-home mother who grew up in care, a research biologist and a nurse. Locations included two cities in south-west England, a village in rural Wales, a small town in Scotland and a large town in south-east England. In terms of gender, the children who were mentioned included 13 girls and 12 boys, falling across the primary-age range. One clear imbalance was that of participant gender: 15 mothers and 3 fathers. There could be a number of reasons for this; the literature suggests women are more likely to acknowledge anxiety around mathematics (Flessati and Jamieson, 1991; Meece *et al.*, 1982; Betz, 1977) and also women are reported to have provided the majority of homeschooling during the closures (Topping, 2021; Ryan, 2020). From my own experience, I would suggest that mothers are more likely to engage with school-or child- related social media platforms. It may, therefore, have been useful to target recruitment at social media groups aimed at fathers.

4.4 Ethics

This research adhered to the British Educational Research Association (BERA) (2018) guidelines and received approval from the UWE ethics committee (see Appendix 8). An ethical approach cannot, however, be reduced to guidelines and checklists without risking the loss of genuine moral considerations (Gibbs and Costley, 2006; Sikes, 2006; Cohen *et al.*, 2007). Ethical considerations were reflected upon throughout the research and an 'ethic of care' employed (Gibbs and Costley, 2006); the impact of all research decisions on participants were explicitly considered. Each research method used had elements of ethical complexity, which will be discussed below.

4.4.1 Informed Consent

The BERA (2018) guidelines require that all participants are aided to understand the process they are involved in and that their consent is voluntary and informed. Participants in all phases of this research were provided, by email, with information about the study and information about how their data was to be used and stored (see Appendix 9). Participants were informed that they could withdraw at any time during the interview or intervention and that they could withdraw their data until a given date. All interview participants returned a consent form, which included an agreement for the interviews to be recorded. The details of this were confirmed verbally at the start of the interview. All participants of the intervention and evaluation surveys completed an online consent form (see Appendix 10 for consent forms).

4.4.2 Privacy and Storage of Data

BERA (2018) emphasises that the 'confidential and anonymous treatment of participants' data is considered the norm' (p.21). The research adhered to this, and also to the university's Handbook of Research Ethics. Recordings and transcripts of interviews were stored directly on the university OneDrive; the video-conferencing platform did not store a copy of the recording. No names or identifying features were included in the transcript. Instead, each speaker was given an identifying code, such as 1-F-Anx-1GY3 (Interview 1, Female, Anxious, daughter in Year 3), which also acted as a filename, and this was used during data analysis. Codes were replaced by pseudonyms for readability in the final account. Participants' contact details were stored in a password-protected Excel spreadsheet on the university OneDrive.

The intervention was created and hosted on 'Teachable'©, a platform for online courses. This platform stored participants' email addresses for the purpose of allowing access to the intervention. It also collected data about an individual's interaction with the course. Teachable© was chosen as it had policies which fully adhered to GDPR regulations (see Appendix 11) and did not make any direct contact with participants of courses hosted on its platform. The evaluation surveys were created using Qualtrics©, a secure platform approved by the university for survey research.

4.4.3 Ethics of Online Recruitment

> Social science is fundamental to a democratic society, and should be inclusive of different interests, values, funders, methods and perspectives. (BERA, 2018, p.4)

It was the intention of this research to be inclusive of all people who wished to participate. One concern expressed in the literature regarding online research is the exclusion of participants that lack access to the technology (Seitz, 2016; Madge and O'Connor, 2002). As both recruitment posts, the interviews and the intervention itself could be accessed with a smart phone, this was not a significant barrier to participation with my target population – 99% of this age group are likely to own a smart phone (Statista, 2022). It is true, however, that only parents who were active on social media would have seen the advertisements. It is possible that digital recruitment exacerbated the difficulty of recruiting less confident people or those who were unfamiliar with research. Reaching this group may have been easier if recruitment had taken place in person, in collaboration with trusted staff at individual schools.

4.4.4 Ethics of Online Interviews

In most regards, the ethics of interviewing online are not substantively different to interviewing in person. The three main areas of ethical complexity in an interview are informed consent, confidentiality and the consequences of the interview for the participant (Cohen, Manion and Morrison, 2007, p.382). The first two areas have been addressed above. The third, the consequences of the interview, are potentially significant both online and face to face. Firstly, in a research interview, the interviewer deliberately builds 'rapport' in order to facilitate relaxed communication. There is a danger that this may lead participants to disclose more than they intended and so feel uncomfortable or exposed. An unstructured interview may also include topics that were not anticipated by the participants. As they have 'consented' to the interview, participants may not feel able to refuse to answer certain questions. In order to mitigate these risks, the topics to be covered were summarised briefly at the beginning, participants were reminded that they could move on from any question they did not wish to answer and attention was paid to the demeanour of the interviewee to judge how comfortable they were and to move away from probing a topic if they appeared uncomfortable:

> The craft consists of calibrating social distances without making the subject feel like an insect under the microscope. (Brinkman and Kvale, 2018, p.10)

Participants may also have concerns over who will see their responses, so the confidential nature of the interview, the anonymisation process and the use of the transcripts was reiterated at the end. Participants were also reminded that they could withdraw their data at any time in the following week without needing to give a reason.

There were a few aspects which required further consideration in an online interview, for example, how the interviewer should respond if someone became distressed (Seitz, 2016; Sedgwick and Spiers, 2009). This was particularly pertinent as the interviewing was conducted during a period of lockdowns and social isolation. I had prepared a list of helpline numbers relevant to parenting and mental health. There were two occasions where the difficulty of offering sympathy or support online occurred: one participant appeared to be upset when mentioning she had lost her job, but it was hard to read the signals or know how to respond. Another revealed, before recording began, details of a family situation in which she clearly needed support. She was a local participant, and further conversation indicated she was engaged with a local, well-regarded family support team. This safeguarding-related disclosure would have created more of an ethical dilemma had I not been reassured that professionals were involved. Had she been in another area of the country I am uncertain what I could have done, beyond offering the helpline information, which would have felt inadequate.

Another issue that arose on two occasions involved parents unexpectedly drawing their children into the meeting – 'I'm talking to this lady about maths, come and tell her what you think about maths'. I felt ethically compromised in that the child was unaware of the nature of the call and that it was being recorded. Whilst the conversations demonstrated in real time the mindset issue I was uncovering, with comments such as 'It's tricky isn't it', 'You don't like maths. Do you?', 'It makes you upset doesn't it', I was uncomfortable discussing the child's mathematics attainment in front of the child. When arranging later interviews, I was more explicit about being out of earshot of children, although this did not prevent the same issue occurring again on one other occasion. Generally, in terms of privacy, most participants had the benefit of being alone at home, so no one could overhear.

In terms of access to research, virtual interviewing opens up the possibility of involvement to more people; for example, virtual interviewing allows more rural, less mobile and lower-income people to participate in research (Upadhyay and Lipkovich, 2020). The fact that the meeting could be joined on a phone or other device made the research accessible to those without a home computer (Gray *et al.*, 2020). It offered flexibility for a population that may be 'habitually left out of research' due to parenting responsibilities (Madge and O'Connor, 2002, p.96). Interestingly, in terms of power dynamics, it was repeatedly mentioned in the literature that participants felt more empowered to terminate the interviews if they became uncomfortable (Upadhyay and Lipkovich, 2020; Deakin and Wakefield, 2014): 'Power is reconfigured, whereby the participant can turn off, tune out or disengage' (Adams-Hutcheson and Longhurst, 2017, p.153).

4.4.5 Offering an Incentive

> Researchers' use of incentives to encourage participation should be commensurate with good sense, such that the level of incentive does not impinge on the free decision to participate. (BERA, 2018, p.19)

A decision was made to offer an £8 e-book token for participation in the interviews. At the approximate price for a child's book, this was considered a mild incentive and appropriate compensation for 30 minutes of time. It did also encourage participation from a wider demographic; the voucher was certainly a key motivation for several of the participants. I also offered a £10 voucher for completion of the final, longitudinal evaluation. I offered this directly to the 12 participants for whom I had complete data. This felt reasonable compensation for completing another survey, having already completed one before and after the course. It was effective in that I received 11 out of 12 final evaluations back within a two-week period.

4.4.6 Ensuring the Quality of the Research

> All educational researchers should aim to protect the integrity and reputation of educational research by ensuring that they conduct their research to the highest standards. (BERA, 2018, p.29)

There is debate among qualitative researchers over how the integrity of a piece of research can be assured. Lincoln and Guba (1985) defined a concept of 'trustworthiness', which was made up of 'credibility' – showing that the findings should be believed; 'transferability' – showing that the findings are applicable to other contexts; 'dependability' – demonstrating that the findings are consistent and could be repeated; and 'confirmability' – presenting evidence that the findings are based in the participants' responses and not the bias of the researcher. These characteristics, Schwandt (2007) argues, were designed to reflect the scientific conventions of internal validity, external validity, reliability and objectivity in order to demonstrate parity with more conventional quantitative research. Qualitative research is, however, inherently different in that reality is viewed as constructed and interpreted, therefore exact replication across different occasions or contexts could not be expected. The concepts of credibility or trustworthiness are themselves subjective and open to different interpretation; what appears credible to one reader may not do to another. This does not undermine the concept and this approach is consistent with the epistemology of this study (see Section 4.2).

Riessman, quoted in Silverman (1986), acknowledges the importance of the reader of the research in constructing trustworthiness; he argues that the presentation of the data should be 'persuasive, plausible, reasonable and convincing' and goes on to argue that:

> Persuasiveness is strengthened when the investigators' theoretical claims are supported with evidence from informants' accounts, negative cases are included and alternative interpretations are considered. (Silverman, 2011, p.351)

Fielding and Fielding (1986) give examples of the pitfalls to be avoided when producing trustworthy research. Firstly, anecdotalism, or selecting data to confirm preconceived ideas, and secondly the overweighting of dramatic data at the expense of more routine, but more indicative, examples This study sought to meet the high standards of integrity described by the quotations above; it set out to be trustworthy and persuasive while avoiding being anecdotal or sensationalist. To this end, the context of the collection of data was described in detail, using 'Thick Description' (Geertz, 1973), so that readers could make a judgement about relevance to their own situations. There was a prolonged engagement with participants and there was triangulation between several sources of data in both phases. Responses of participants are quoted at length to allow readers to engage with their voices and consider the plausibility of the conclusions drawn. The process of analysis was transparent and is described in detail and explicit connections were drawn between the data and any claims that were constructed from it. The greatest challenge to the trustworthiness of this research is that it was devised, conducted and evaluated by a single researcher. The risks that this entailed were countered in a number of ways: by 'careful scholarship' (Seale, 2004, p.409) and transparency; by regular 'peer debriefing' (Schwandt, Lincoln and Guba, 2007) with supervisors to develop, test and defend emerging ideas; and by engaging in reflexivity, which is described in Section 4.5.

4.5 Reflexivity

Reflexivity has been defined as the 'continual process of engaging with and articulating the place of the researcher and the context of the research' (Barrett, Kajamaa and Johnston, 2020, p.9). It represents a recognition that the researcher is inescapably part of the social world that they are researching (Hammersley and Atkinson, 1984, p.14). Qualitative researchers engage in reflexivity to analyse how their subjectivity has shaped their research; it is an acknowledgement that their perspective, their bias, is 'fundamentally intertwined with the research process' (Olmos-Vega *et al.*, 2022, p.1). In order to be reflexive, a researcher should 'acknowledge and disclose their own selves in the research' (Cohen, Manion and Morrison, 2007, p.171) and, most importantly, attempt to understand how this affects or influences it. Reflexivity involves a 'continuous process of questioning, examining, accepting and articulating our attitudes, assumptions, perspectives and roles' (Barrett, Kajamaa and Johnston, 2020, p.10). This subjectivity is not, in the paradigm of this research, seen as a deficit. Reflexivity is not an 'apology for the lack of objectivity'; impartial representation is 'neither possible nor desirable' (Olmos-Vega *et al.*, 2022, p.2). Instead, a reflexive approach recognises the inevitability of the researcher's influence on both context and participants and seeks to explore it:

> rather than engaging in futile attempts to eliminate the effects of the researcher, we should set about understanding them. (Hammersley and Atkinson, 1984, p.17)

The self of the researcher impacts all aspects of a study, from the initial motivation to the research to the paradigm in which it is situated; from the methodological choices to the rapport with the participants. It can be a real benefit; an insider position, for example, can give a profound understanding of particular phenomenon (Barrett, Kajamaa and Johnston, 2020, p.11) and enable access and support trust, but it can also lead to factors being taken for granted or left unexamined. Holliday argues that researchers should 'approach their own actions as strangers, holding everything up for scrutiny, accounting for every action' (2007, p.20). This self-conscious consideration of research decisions and researcher behaviour can reveal the influence of the researcher on the research.

Reflexivity has at its heart the positionality and social identity of the researcher. Researchers bring their own biographies to the situation and participants behave in a certain way in their presence (Cohen, Manion and Morrison, 2007, p.171). They also bring their identities, in terms, for example, of their class, gender, sexuality and race. These affect how the researcher sees and interprets the world, and also how the world sees and interprets them (Jacobson and Mustafa, 2019). Jacobson and Mustafa (2019) argue that identifying and disclosing an identity is a complex but necessary process for the qualitative researcher. It is complex because identities themselves are fluid and changing and are often abstract and intangible in nature. It is difficult to know which facets of our social identity are more influential in a particular time and place; the social political climate changes the salience of these aspects of ourselves. It is also difficult to ascertain exactly how social identities impact the subtle interactions of the research process.

My identity is intertwined with this research at every stage. The research subject originated in my experiences and interest; I recruited the participants and conducted the interviews; I wrote the scripts and spoke to the camera in the videos and I analysed the data from the evaluations. The participants reacted to me; how at ease they felt depended on how they saw themselves in relation to me or to what I represented to them. In some respects, I was an insider: I was a parent of a primary-school child and therefore shared an important characteristic with the participants. However, the participants, scattered across the country, were not within one community in any tangible sense. They were instead part of their own communities based, for example, around schools and locations to which I was an outsider.

Another important facet of my identity is that I am confident in mathematics. I did not struggle with school mathematics and I did not share the anxieties and confusion experienced by many of the participants when homeschooling their children. My family valued mathematics and believed there was an inherent logic to it that was accessible to anyone who applied themselves. My mother has a pragmatic approach to number and confidently manages both family and charity finances, taking pride in her mental arithmetic. My father was a structural engineer and has completed a degree in Quantum Physics in his retirement simply because it interested him. He drew my attention to patterns and equations and explanations rooted in physics, which were given with little allowance for my age. It was assumed that I would be successful in school mathematics and I was, continuing to study until A level. On reflection, this home numeracy environment has all the characteristics that contribute to success (see Section 3.3.2): it was broad, confident and positive with an underlying expectation of success.

I viewed this research, therefore, through a variety of lenses – parent, teacher, mother, researcher, insider, outsider. The ones elucidated above are the ones I am consciously aware of, but there will be others of which I am less explicitly aware. In order to keep this subjectivity at the forefront of my mind, I have reflected on how this positionality interacts with the conclusions I draw where this appears relevant.

4.6 Towards the Study Itself

This chapter has detailed the many layers of methodological consideration that went into the design of this study, from broad epistemologies to specific methods. The following chapter contains the analysis of the 18 interviews conducted with parents which will, along with the literature review and the theoretical perspectives, inform the creation of the intervention.

Chapter 5 – Analysis of the Interview Data

5.1 The Context and Purpose of the Interviews

This chapter contains the analysis of the semi-structured interviews from Phase 1 of the study. It is based on 18 interviews conducted with parents of primary-school children between June and September 2020. This analysis, along with the theoretical models (Chapter 2) and the literature review (Chapter 3), contributed to answering the first three research sub- questions, introduced in Section 1.3. Findings related to these questions will be returned to in Section 5.6.

1. What beliefs, attitudes and opinions do parents hold regarding mathematics learning?
2. What are parents' experiences of supporting their child with mathematics and what if any, barriers do they face?
3. How do parents' opinions, attitudes and beliefs about mathematics affect the way they approach mathematics with their children?

The original intention was to interview parents about their experiences of mathematics in a typical school year, with the assumption this would be mainly focussed on supporting homework. Due to the Covid-19 pandemic, however, most of these parents had homeschooled their children for around four months between March and July 2020 and were aware that schools could close again with little notice. This gave the discussions about supporting mathematics an immediacy and relevance that they may not otherwise have had. The children discussed in these interviews were in classes from Reception (4–5-year-olds) to Year 6 (10–11-year-olds). Some of the parents also had older or younger children, but all had at least one child in primary school. The purpose of these interviews was to explore how parents experienced mathematics with their children and the beliefs that underpinned their behaviour. The data was then analysed to draw out salient issues to inform the design of the intervention. As discussed in Section 1.2.3, social psychological interventions are dependent on context; to be effective they must remove a specific, critical psychological barrier to learning and trigger self-reinforcing processes (Yeager and Walton, 2011). Their design must, therefore, be based on a deep and current understanding of the context.

5.2 The Process of Thematic Coding and Analysis

The analysis contained in this chapter is organised in two parts, both of which are based on data from the full set of interviews. In the first part, parents with comparable approaches to mathematics are grouped into personas. The idea of personas originated in software design as a tool to understand the goals, motivations and behaviours of potential users (Cooper, 2004). The process used to create these and the rationale for it is discussed in Section 5.3. The second part of the analysis contains the thematic analysis (TA) of the same set of data. Both sets of analyses informed the creation of the intervention and this process is described in detail in Chapter 6.

The interviews were analysed using reflexive TA, as defined by Braun and Clarke (2022). Braun and Clarke situate TA firmly within a qualitative paradigm, arguing that reflexive TA works best when situated in a 'fully qualitative' set of research values (2022, p.7). These include an interest in process over cause and effect; a critical and questioning approach to knowledge; an understanding of nuance, complexity and even contradiction; and an ability to tolerate some degree of uncertainty. This is consistent with the constructivist epistemological positioning of this research, described in Section 4.2.

Coding itself is a subjective and interpretive process; theme development is inevitably influenced by the researcher's knowledge, experiences and attitudes. As Cresswell (2007) notes, 'interpretations of the data always incorporate the assumptions that the researcher brings to the topic' (p.83). In reflexive TA, researcher subjectivity is viewed as a valuable tool for analysis, rather than a 'problem to be managed, controlled or gotten rid of' (Braun and Clarke, 2022, p.8). Themes, for example, are not seen as emerging but are produced by the researcher through their engagement with the data, influenced by their prior knowledge, skills, values and experiences: 'Our assumptions always influence our research – it is not a case of *whether* they influence, but *how* they influence' (Braun and Clarke, 2022, p.18). The influences of my subjectivity as a researcher and the impact this inevitably had on my interpretation of the data are acknowledged and discussed where most relevant in this chapter.

5.2.1 The Coding Process

The reflexive TA was conducted in six phases, as detailed by Braun and Clarke (2022, pp.35–36):

Phase 1 – Familiarisation with the whole data set

Phase 2 – Coding

Phase 3 – Generation of initial themes

Phase 4 – Developing and reviewing themes

Phase 5 – Refining, defining and naming themes

Phase 6 – Writing up.

Firstly, the 18 participants were grouped into four personas (see Section 5.3) which reflected their dispositions and attitudes towards mathematics. This was done iteratively, by listening to and reading the transcripts several times in their entirety and placing together any participants with similar dispositions towards mathematics; this rereading was repeated until, by a process of constant comparison, all participants were placed in a group and that group appeared both internally consistent and different to the other groups. The number of groups had not been predetermined. The groups were then named and their common characteristics drawn out.

For the TA, the interview transcripts were coded inductively, looking line by line at the transcribed texts in a reiterative cycle. Coded interviews were revisited at least three times to look for evidence of codes identified later. Once the interviews were all coded, these codes were reviewed, any overlapping or repetitive codes were merged and any disparate codes separated. The initial coding generated 52 distinct codes. Some of these were ‘in vivo’ codes, where words of the participants appeared to capture something interesting or represent an idea well, and were coded verbatim, such as ‘I can do the maths I have to do’ or ‘Maths kind of runs in the family’. Nvivo© was used to support the process of coding and analysis; this software allowed the data to be highlighted, collated and viewed in different ways. It allowed one fragment of data to be allocated to multiple codes if relevant. It also allowed the data to be viewed code by code or transcript by transcript. This flexibility enabled connections to be made and tracked across the data set and aided the consolidation of codes into themes.

There were many influences on the analysis of the data; the research questions and the interview schedules were formulated with knowledge of salient issues in the literature and the choice of codes was influenced in turn by the research questions and also the literature. In some cases, this connection is explicit: the data was actively searched for examples of concepts that had been ‘foreshadowed’ (Simons, 2009) as important, for example, barriers to supporting mathematics or beliefs about ability. This underlying research-based knowledge had multiple effects: on the one hand it meant I was tuned in to the possible themes that might arise; on the other hand, there was an inevitable risk that I would overweight the attention I paid to ideas I recognised or expected to find. To mitigate the possibility of confirmation bias, or the overweighting of expected data, the interviews were coded until all sections of the transcripts had been allocated to at least one code. It was hoped this methodical approach would ensure all elements of the data were examined.

5.3 Description of the Four Personas

The idea of personas, or imagined archetypal users, was introduced by Cooper (2004). He argued that testing technology with specific users in mind was an effective way of making the design more user friendly. Here, rather than being combined into fictionalised characters, interviewees were grouped. This allowed the similarities and differences between them to be drawn out and used to build pictures of the potential users. The intervention design was then considered in terms these different users, what they might need and how they might react to different elements. These personas were:

- Anxious – anxious, fearful, not confident in mathematics
  [based on interviews with Anna, Kaylee, Jackie, Gemma, Sadie, Jason]
- Joyful – joyful, playful, confident, mathematically able
  [based on interviews with Dawn, Daisy and Harriet]
- Pragmatic
  - mathematically able, pragmatic, less aware of emotional aspect
    [based on interviews with Maryam, Cora, Gail, Laura]
  - mathematically able, frustrated supporting children but aware of emotional aspect
    [based on interview with Mark]
- Coping – coping but not confident
  [based on interviews with Alice, Claire, Sadie, Stuart, Helen].

Below, each persona is described in more detail, with extracts from the participants interviews which exemplify their characteristics.

5.3.1 The Anxious Parents

These parents found mathematics at school difficult and alienating. They were placed in lower sets and often entered for foundation GCSE papers which limited their possible grade to a C, considered the lowest pass grade, or even below. They left school with a negative impression of both maths as a subject and their own ability to learn it. They felt they had little idea of the purpose of the mathematics they learnt at school. Their remembered emotions included 'struggling' [Gemma], 'hatred' [Kaylee] 'really really anxious and really frightened' [Jackie]. This negative legacy was recalled when working with their own children in mathematics:

> I remember the whole thing being pretty horrific for me. And that's what it brings back. Now you think, Oh God, I don't think I ever did that well. [Sadie]

Despite the fact that their children were still in primary school, they found the content of the mathematics homework difficult. Anna, who had a child in Year 4, recalled,

> but with fractions and equivalent fractions, I had no idea. You know, I just can't remember any of that stuff that we learned and, and I wasn't sure how they were teaching them.

Interactions during mathematics homework or lockdown learning were characterised by heightened emotions, conflict and rejection of help. Parents acknowledged that their own lack of confidence contributed to their lack of patience or frustration with their child:

> you know … just really struggling and we would both end up in tears, you know, worst days … I'd really bite because she just wasn't listening and that really pushed my buttons and probably the confidence thing as well you know, that I felt I couldn't do it. [Anna]

These parents found practical mathematics tasks far more engaging and experienced more success and enjoyment doing these. The most common example of successful activities involved measurement: measuring rooms, heights, how far you could jump and materials for a DT project. Mathematics in the workplace could be a challenge and some of these parents would do what they could to avoid it. In many cases, however, the parents had strategies to cope and given time and space could work out what was necessary for themselves. Calculating in front of people or with time pressure, and lack of belief in their own ability, were repeatedly mentioned as problems:

> But even at work, things like that. They might ask you mileages … And I have to sit down and work that out sometimes. I kind of, I fob them off by saying I can't do that now. I'll do that in a minute. And then after, find a quiet spot and sort it out. [Jason]

Interestingly, two of these parents had jobs which involved mathematics regularly. Gemma managed multi-million-pound budgets for a bank but felt 'it was never in her comfort zone'. Anna did book keeping but did not find it threatening as she worked alone and could take her time, although she did become flustered when asked for figures in meetings.

All these parents felt they could manage household expenses and family finances, that this was straightforward and 'just basic maths' [Gemma]. Mathematical activities mentioned in this category include paying bills, managing mortgages, saving for holidays, shopping, percentages, splitting bills and calculating debts. There was, however, a recurring theme that they were 'faking it', that somehow the mathematics they were doing was not valid, that by using available tools they were not doing it properly, that they were 'over reliant on a calculator' [Jackie] or just plugging things into a spreadsheet. This type of mathematics was considered so easy that the only requirement to do it successfully was not to be 'completely useless' [Claire]. Accounts of what they could do were often qualified with something they could not do:

> I can do adding, subtracting, dividing, multiplication. But I mean, I couldn't now do a lot. I could not write a long division. I couldn't do a long division. I can't remember formulas. [Jackie]

Interestingly, these views are reflected in a finding by National Numeracy that:

> many adults have such negative perceptions of themselves from mathematics as experienced at school, that what they can do, they see as 'common sense' or non-mathematics. Skills such as measurement or numerical calculations are taken for granted, because to recognise these as maths would contradict their self-image as unsuccessful maths learners. (2023, p.3)

However, within the accounts are numerous examples of resilience. Anna tried many different approaches to homeschooling mathematics with her 9-year-old, finally getting up early, working through materials and watching the videos first, so that she could confidently help her daughter later. Some parents bought books to help them [Sadie] or to inspire their children [Anna], worked through online courses [Jackie], asked for support from mathematics teachers and employed tutors [Gemma]. There were, however, continual doubts about their ability to support their children:

> But I don't know if I actually, I feel like I don't really have a role with them. I feel quite disconnected from that side of things. So the reading and writing absolutely fine. But I feel very disconnected from the Maths thing. [Gemma]

5.3.2 The Joyful Parents

These parents were, in many ways, the opposite. They were at ease with mathematics. They were confident, playful and eager to watch their child learn. Their descriptions of the mathematics they did with their children were full of delight and creativity:

> We've just started doing midnight maths where we just lay in bed, we're having a little cuddle. And basically, he'll pick a number. And it'll be 21 or something. And we'll come up with loads of sums where the answer is always 21. He gets to shout out the answer confidently and we have to like scratch our heads and think of all these sums to come up with 21. [Daisy]

There is much to be celebrated in that vignette: the mathematics was light hearted and fun and created connection. The worry of whether they were doing it 'right' that characterised the more anxious parents was notably absent. In another family, mathematics was integrated into the routine without particular fanfare:

> Recognising numbers on car registration numbers, keypads on computers, calculators, drawing them, writing them? Anything … counting the number of petals on a flower? The 12345 once I caught a fish alive is the one that she brushes her teeth to … She makes her own games up. She'll pick up a pack of cards and open it up and go, you can have this it's eight. I'll have this. It's a six and I win. Okay. Not quite sure how that matches but fair enough. [Harriet]

It is worth noting that Daisy and Harriet did have very young children, in Reception and Year 1, so they had not yet encountered regular school mathematics work. There was, however, a belief that these children are set up to succeed in mathematics. The parents believe a combination of their home lives and backgrounds gives them an advantage, that they come from 'mathematical famil[ies] … bought up in a world where things are counted' [Harriet], with grandparents who were engineers, doctors, book keepers, auditors, and that they, as parents, will be able to support their child to succeed:

> I think I'd quite like to steer them to carry on maths as well, because I think with their kind of backgrounds. I think they'd do well in it. [Daisy]

Their definition of this success is far more wide-ranging than that of the more anxious parents, who were focussed on a GCSE pass; the joyful parents mentioned finding 'numbers interesting and fascinating' [Dawn], gaining an understanding you can build on [Harriet] as well as strong mental arithmetic [Dawn]. These parents readily express their own enjoyment of mathematics:

> So, now my relationship with numbers and statistics is like, I love them. You know, and I see patterns in numbers that I just, you know, it kind of jumps out at me and something like Strava for logging runs. I love the fact there's all this data being gathered. [Dawn]

They could give examples of how mathematics could be visual and creative, in music, art, photography, nature or architecture. They confidently linked mathematics with different careers:

> And so if one of my children says yeah, I want to be an Arctic Explorer, I'm going to be like, yes, you know, go and study all the earth sciences, you know, carry on with your maths, carry on with your science. [Dawn]

There was among this group of parents an explicit awareness of the need for enjoyment, for exploration and for confidence, as Daisy said, for 'making maths cosy'. It is with this group of parents I would inevitably have been placed had I been a participant. The interviews flowed as there was a shared understanding and enjoyment of the mathematical anecdotes above. There was also none of the anxiety I sensed among some of the other parents that they might be asked to do some mathematics. Strikingly, however, the joyful parents also made numerous references to the innate or genetic nature of mathematics ability. In the light of these comments, I interrogated my own view, or the views I held before commencing this study. I think, perhaps, I did believe my preschool daughter to be naturally mathematical despite the knowledge that this 'ability' was the result of the environment she had grown up in and the carefully curated experiences she had had. This illustrates how hard it is to separate observable ability from context. The belief that mathematical ability is innate is a theme that will be returned to later in this chapter (see Section 5.5.4).

5.3.3 The Pragmatic Parents

In contrast, there is another group of parents who have been academically successful in mathematics but do not feel any affinity with it or enjoy doing it with their children. They are prepared to support their children and to buy the resources they need, but the pleasure or playfulness expressed by the more joyful parents is absent. For example, Maryam described working through a mathematics book with her 5-year-old:

> She needs to do it so she has to do it. So that's it … again I don't really think I'm inspiring a load of interest in her in any respect.

These parents did, however, feel confident asserting their views about mathematics education. They had a functional, utilitarian approach; children need to be able to do it as a life skill, for academic success and for future earnings. Frustration with the school's methods of teaching mathematics was a recurrent theme across this group. They prioritised calculation and felt that the school should focus more on accuracy and practice and getting the basics right, on 'literally just being able to calculate, being able to understand how numbers work, being able to multiply, subtract, divide and add' [Cora]:

> [the school are] trying to make it more creative, more enjoyable, more funky, but … they just need to do loads of sums until they've got it right. [Cora]

Their expectations for school mathematics were built on the type of learning they themselves experienced, in the UK and overseas. They would like text books and higher expectations, although interwoven in their descriptions of recreating this at home are descriptions of their child's resistance and frustration. There is, perhaps, less awareness of the importance of the emotional aspects of mathematics:

> we were doing a math book on Sunday. And basically, we ended up with a pencil going arrrrrrrrr [scribbling action]. [Cora]

> She works very, very hard at it, but gets very very frustrated [Cora]

There is also the desire to know exactly how the children are being taught, so that they can replicate it at home. New and varied methods are a source of frustration:

> There was one time I was tearing my hair out, because I just can't get him to understand something. You know, like, I don't know, 87 minus 59. It's like, I had to text the teacher and say, well, do you take 60 off? And then take another one off? Or do you round it up? Oh, no, we count up using the frog method. And when I told him it that way, said, Oh, yeah, I get it now. It's like, okay, great. If only I'd known. [Laura]

Again, mathematics ability was frequently referred to as innate; the idea that some people had 'a natural affinity' [Laura] was a particularly strong theme through these interviews. These parents seemed to hold the view that real talent in mathematics involved being good without effort, that the success they have had is somehow inferior, achieved by 'learning by rote' [Maryam] or having a good memory:

> I had to work to be good. I wasn't my friend who was just brilliant at it without trying. But I liked being in the top set. [Gail]

So, whilst able to support their children with content, this view of mathematics had implications for the messages that they were passing on and how they reacted to their children finding anything difficult. Reflecting on my own position, it was this group of parents I felt the least affinity with in that I disagreed with many of the views expressed. As a group these participants were also more assured and outspoken in their views, with none of the hesitancy and uncertainty expressed by the anxious or coping parents. I was therefore conscious of being open and encouraging during the interviews and not expressing judgement through my responses, making assumptions or engaging in discussion, but letting them speak at length and explain their views.

A variation on this persona was one parent who was reasonably confident in mathematics, aware of the value of emotional engagement, but unsure how to work productively with his children. He struggled to tackle strong resistance to mathematics in his children. He would like to inspire joy but felt ‘that ship has sailed’ [Mark]; his children, twin girls, resisted any attempt to open up their mathematical thinking:

> I've got one that's more emotional, and she will give up straightaway. The other one will try for a long time and be thinking about it very earnestly. But often, after 10 minutes of looking very serious and thinking about it, there's no answer. And no, she doesn't really want to ask for help, basically. Whereas the other one, just like gives up? I can't do it. You know, So, actually, they are different in that perspective. They both they're both completely the same in terms of hating the thought of maths.

Interestingly, even though this father had an A level in mathematics, he again never felt he ‘properly understood’, that he had passed by ‘cramming’ and felt himself to be the ‘least intelligent’ in his class. Despite having persevered with his own learning, he could not see how mathematics was useful to him in his career in marketing, beyond ‘calculator type maths’.

5.3.4 The Coping Parents

The final group of parents could be described as coping but not confident. These parents, generally but not always, had a poor experience of mathematics at school. Some became disheartened when also entered for GCSE papers which limited their grade; they described not seeing the point of mathematics and being disengaged. Now, however, as adults, they have realised its value, that it ‘is kind of the backbone and foundation to lots of things’[Sadie] and are keen for their children to succeed with it. This group of parents was well aware of the emotional aspect of mathematics learning; they listed their priorities for their children as feeling confident, not scared and not feeling like they are behind. A strong theme among these parents was their desire not to pass on negative feelings to their children, to ensure that fear of mathematics doesn’t ‘rub off’ [Claire] and even to be role models of mathematical confidence:

> So I did stand up about five years ago and say, I'll be the treasurer of scouts. So I had to do all the books. And I did it because I want to show my children that you can't be afraid of numbers, you just got to have a go. And they're just numbers at the end of the day. But I had that sense of dread. God, I've got to the books and I didn't like having to deal with all the numbers. I kind of a … it's not my comfort zone. [Helen]

Another mother (Alice) was planning to return to education to do GSCE Mathematics, in order to learn with her children, model the importance of mathematics and avoid sustaining gender stereotypes. There is repeated discussion among these parents of the need for mathematical resilience, that their children find errors or struggle really difficult. This reflects the findings by Silver *et al.* (2021), discussed in Section 3.4.1.1, that a belief in the importance of mathematics can motivate parents to take specific, positive actions with their children. They were aware of the importance of mindset but did not always have the tools or strategies to support it:

> The biggest challenge with her in terms of Maths, and again, this is with all work, just because she wants to be the best … so the difficulty with her is reassuring her that it's, it's okay to fail. And it's okay to not know and it's okay to have to learn and getting through she will get frustrated and crying, throw her work in the air, you know, because she really wants to be able to do it. [Stuart]

Whilst there were references to 'natural ability' scattered through these interviews this is a less salient theme. Having mathematical parents was seen as an advantage, but there was more mention of strong, effective teaching. These parents often attributed their own lack of success at school to poor teaching; the breakthroughs they did have were attributed to good teaching:

> I look at the kids now and how they're taught. And I think it's so different. And I think it's probably that that kind of gives them that advantage now, and I think yeah, I think looking back, that's kind of how and why I don't think I did ever do very well. [Sadie]

These four personas reveal the variety of dispositions and beliefs about mathematics that parents may bring to the intervention. The design process, described in Chapter 6, considered the intervention from each of their perspectives. These personas were also used in the evaluation of the intervention: the initial survey asked participants to allocate themselves to the persona that they felt best reflected them. Their responses after the course could then be considered in the light of their persona and analysed in groups.

5.4 Thematic Coding

Following the creation of the personas, the data set was considered as a whole. There were 52 initial codes and these were grouped into hierarchies of main and sub-themes. Gerunds were used at this stage of organisation. The use of gerunds, it is argued, allows the researcher 'to move forward analytically and identify actions and processes within the data' (Carmichael and Cunningham, 2017, p.63), to move beyond the words themselves to the actions they reveal. Examples of gerund codes include: Aspiring, Celebrating, Misunderstanding, Persevering, Struggling, Worrying, Avoiding. These themes were grouped again into five overarching themes which structure the analysis below: Emotion and Conflict; Confusion and Misunderstanding; Seeing and Valuing; Natural Ability; and, finally, Gender. The hierarchy of codes that formed 'Emotion and Conflict' are show in Figure 8, as an example.

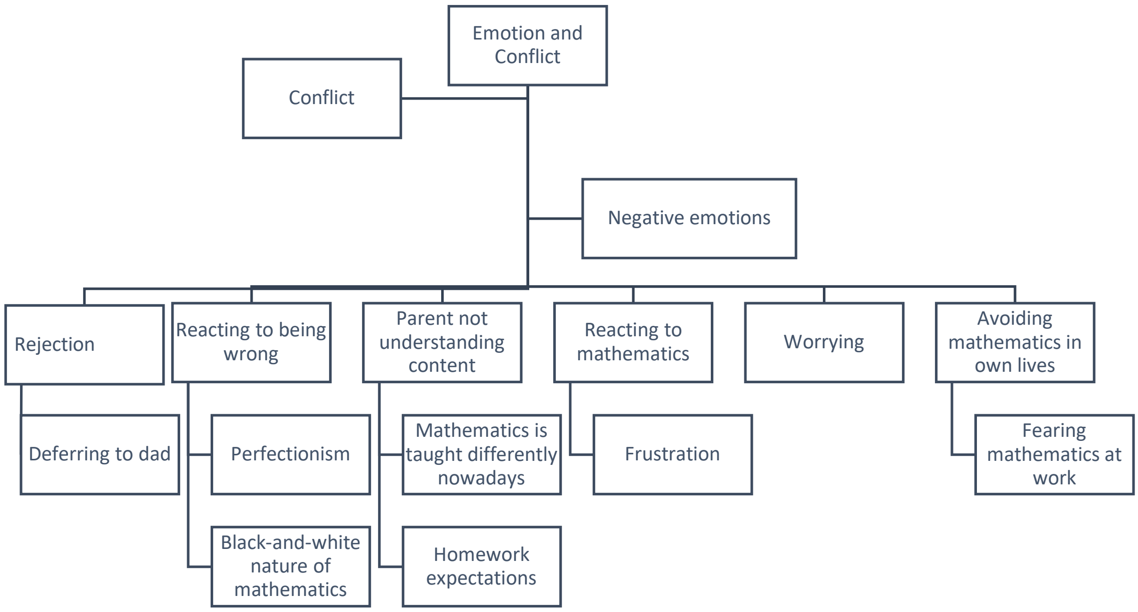


Figure 8 Coding tree for the Emotion and Conflict theme

Some codes were not embraced by the main themes and remained as stand-alone examples, for example, 'Remembering maths at school' stood alone as a code. Although elements of this could have been linked with emotion, the historic nature of the emotion did not fully fit with that theme. Some codes contributed to more than one theme; for example, 'parent not knowing content' was placed under 'misunderstanding' and also under 'conflict' as it was relevant to both themes. In Section 5.5, the themes are described, using excerpts from the transcripts to exemplify the points being made and allow the participants to speak for themselves.

5.5 Thematic Analysis

5.5.1 Theme 1 – Emotion and Conflict

Firstly, the intensity and range of the negative emotions which participants associated with mathematics stood out from the interviews, whether doing mathematics themselves or supporting their children. There were mentions, in order of prevalence, of frustration, anxiety, tears, fear, hatred, impatience, terror, horror, dread, resistance, fury, irritation, embarrassment, panic and boredom. These emotions were caused in a number of ways; for some, working with children brought back 'pretty horrific' [Sadie] experiences of school mathematics and this set the tone for the interaction with children. Parents also battled a range of emotions when having to do mathematics in their own lives; they felt very nervous if they had to perform any calculations in front of others and they employed a range of strategies to avoid or postpone doing mathematics at all:

> When I'm asked things in a meeting, I still think I can't do it. And it's that label you put on yourself like, I can't do that. And then when you do work it out when you've got time by yourself to do it. It's like, oh, yeah, that's, you know, that's that I can work that out. [Anna]

Doing mathematics with their children was the source of significant conflict, even for parents who were confident in mathematics. Whilst there were some accounts of playful or enjoyable interactions, these were very much in the minority and tended to focus around practical, open-ended activities such as measuring rooms. Parents gave multiple examples of heightened emotions and arguments. These were caused by disagreements over methods, confusion over the task, adult frustration at a child's inability to follow the instructions or apparent lack of concentration and child frustration that a parent could not explain what to do. In many cases the tensions led to parental help being rejected entirely:

> I think he's just decided that I'm no good at it. So there's no point in talking to me. So, during lockdown, he certainly flatly refused to let me have any input into his maths homework at all, even though we could have learned on YouTube together. He just flatly refused to have anything to do with me. [Gemma]

One repeated cause of conflict was a child's reaction to being wrong. There appeared to be something particular about mathematics, or more specifically the right or wrong nature of the calculations they were doing, that led to conflict in a way that other subjects did not. Children did not like to be wrong, and certainly did not like to be seen to be wrong, or even unsure, by a parent:

> My son, he does not like it if he gets something wrong, or if he finds it difficult, he will automatically sort of shy away from it … And I guess maths is something that actually does flag up that error. And that if you're doing a sum it's obvious, if you get it wrong, you've obviously got it wrong. [Dawn]

> There's something about having me explain something I think she doesn't she doesn't like to be seen to not be able to do something. She likes to be seen to be really good and really confident and asking for help in her eyes is admitting defeat. [Helen]

In the home environment, many children were described as being very resistant to challenge or taking risks. The volatile reaction to any struggle or error described by parents in these interviews rang very true with my own experience as a parent homeschooling in this period. Despite my knowledge of the subject, its pedagogy and child development, I could not prevent mathematics tasks from becoming emotionally fraught. The following quote came from the parent of a 5-year-old:

> my little boy … all the feedback we're getting back … is he's a real perfectionist. And, and he doesn't want to try things. And we definitely see that with him. He won't try it. He won't try you won't even know, put pen to paper until he can do it perfectly. [Daisy]

Parents appeared bemused by these reactions in such young learners and were unsure how best to react. The emotionality of doing mathematics in the home does not appear to be addressed by schools in their homework policies. Mathematics homework as a source of conflict is a repeated theme in the education literature (see Section 3.3.2) and there is evidence here of the risks of transmitting anxiety (Retanal *et al.*, 2021; DiStefano *et al.*, 2020; Maloney *et al.*, 2015), controlling or inflexible support (Pomerantz, Moorman and Litwack, 2007) and homework causing distress and family strain (Lange and Meaney, 2011).

5.5.2 Theme 2 – Confusion and Misunderstanding

Many of the interactions between parents, children and their schools were awash with misunderstanding, particularly about current methods, appropriate levels of difficulty and the school's expectations regarding homework. There was evidence that some parents had not accurately interpreted information from the school about their child's mathematics, either by not understanding educational parlance or taking at face value the veiled communication of 'teacher talk'. For example, Kaylee described an end-of-year report for a child who seemed, from discussion earlier in the interview, to be having significant difficulties with mathematics:

> It just has one bit that says that she's not doing too bad, basically in a nutshell. And she does need a little bit of support. And but they think, yeah, in a nutshell she's doing quite well. [Kaylee]

This example echoes almost exactly the example from the literature referred to in Section 3.4.2.2. In that case the parent was of a different ethnic background to the teacher, in this case a different class background; the failure of communication was the same (Crafter, 2012).

Changes in the methods that children are taught for calculations was a source of considerable anxiety and frustration among parents, whether they were confident in mathematics themselves or not. The less confident were worried they would not understand the methods or be able to help their child. The more confident were more likely to be frustrated as they did not see the point. Some of the frustration was a result of a child misusing a method or reverting to an inefficient method – drawing dots for a large division sum – and the parent assuming that the teacher expected that:

> That drives me nuts. It's like, why are you drawing out half a page of dots. Mummy it says 623. And I'm like, well you don't need to draw 623 dots. And we end up with a page of dots. No I have to draw the dots, the teacher said I have to draw the dots. [Cora]

In reality, drawing dots would be a strategy for initial learning with small numbers; a teacher is almost certain to have taught a more efficient method for larger numbers. This reluctance to move on from longhand strategies, in which they have been successful, to more efficient strategies is particularly common in both girls and anxious learners (Davis and Carr, 2002).

Several of the parents would have liked more specific information about the current learning the methods being used. One parent felt a text book would resolve these issues and make the learning trajectory clearer. There was also some confusion over what was expected in terms of homework; whilst some parents had a clear, weekly task such as using an app, or practising times tables, others reported being far less clear about what they should be doing than they were with spelling and reading tasks. There was also confusion over how much help they should be giving children with mathematics. On the one hand, it was hard to watch a child struggle and get frustrated; on the other hand, if a parent helped them they feared the teacher would think the child understood. This confusion over what schools expect is entirely consistent with findings in the literature: the interventions reviewed in Section 3.5 represent many attempts to bridge these gaps in communication between school and home and enable parents and teachers to work cohesively to support children’s learning. As the analysis of these interventions showed, this is complex and not easily achievable.

There were also widely disparate understandings of what was appropriate mathematics for different age groups. One father (Stuart) was impressed his 7-year-old could count in 2s – a skill expected in 5-year-olds, whereas another mother [Maryam] was expecting her 5-year-old to know all her times tables and work with numbers to 1000. This, again, echoes findings in the literature that there is a wide variance between parents’ expectations of their children at certain ages and that this is often dependent on the parents’ own educational levels (see Section 3.4.2.1).

5.5.3 Theme 3 – Seeing and Valuing

Mathematics, in these interviews, was mostly referred to in terms of school calculations. Other aspects of mathematics were barely mentioned. Several parents asserted that they did not use much mathematics in their adult lives, despite working in psychology, IT or digital marketing:

> I still couldn't really tell you how I'm really using [mathematics] greatly in my life, you know. And so I think that's a big thing. I mean, I think you've got to be able to see where it's going. [Maryam]

> And I think this is probably where it kind of goes wrong in math, isn't it? There's so much stuff that you learn even just thinking about GCSEs, you don't really see how that's relevant in your own life. And I think that's kind of why you sort of tune out in a way. [Sadie]

> You tend to especially tend to think of very much Maths as a purely academic qualification? Don't you do maths to be a math teacher or something? You don't tend to think of it as a means to an end to something else? [Laura]

However, parents who believed they did not engage with mathematics at all, beyond their child's homework, went on to describe how they managed the household budgets, calculated spending and chose mortgages. When their attention was drawn to the mathematics within these activities, it was quickly dismissed as 'the basics' [Stuart] or 'a bit of number crunching' [Gail] and the only requisite to being able to do it was to 'not be totally stupid' [Anna]. Anything that could be done on a calculator or spreadsheet was not considered to be mathematics but simply 'plugging the numbers in' [Gemma]. Any acknowledgement of what they could do was qualified with what they could not do, namely algebra, quadratic equations, formulas and long division. Even parents who explicitly used mathematics in their jobs, such as calculating drug amounts or understanding statistical norms when assessing patients, felt that this was not significant or evidence of understanding but just adaptation to the things they needed to do. As referred to in Section 5.3.1, this may be a defensive reaction to protect their view of themselves as being poor at mathematics.

The very limited interpretation of what counted as mathematics was demonstrated by the difficulty many parents had in finding examples of visual or creative applications for mathematics. The ability to see the applications of mathematics was a distinct difference between parents who were more or less confident in mathematics. The more confident parents quickly gave examples of visual mathematics in nature, in architecture, modelling and coding and of creative uses of mathematics in art, music and gaming. It is understandable that parents who only interpreted mathematics as a school exercise, without real-world application, might find it difficult to motivate a child or pass on meaningful reasons why they should engage with it.

In terms of the value of mathematics, there were parents who were sure it was valuable and wanted their children to see it. This was not delineated by disposition; this view was held by both anxious and confident parents:

> Well, I mean, obviously, I do want them to pass. But yeah, so, to me, the key for doing that is to see why maths is useful, so that they see the benefits. [Stuart]

> I've actually just bought her a book called … What's the point of Maths, that's a really great book and it sort of relates a lot of the stuff she's done. You know, the shapes, hieroglyphics. There's lots of different things throughout the book that it relates maths back to. [Anna]

> And so if one of my children says yeah, I want to be an Arctic Explorer, I'm going to be like, yes, you know, go and study all the earth sciences, you know, carry on with your maths carry on with your science. [Dawn]

The importance of seeing the purpose of mathematics learning is emphasised in the literature. Section 3.5.4 described a number of interventions which specifically targeted this. One study found that children whose mothers made frequent, elaborated, personal connections between their child and a STEM course, just as Dawn does in the example above, took more mathematics courses (Hyde *et al.*, 2017).

5.5.4 Theme 4 – Natural Ability

The description of mathematics ability as somehow natural or innate was another consistent theme. Many parents referred to hardwiring, DNA, genetics, inherited IQ and nature over nurture when explaining success in mathematics. Some parents mentioned this in positive terms, for example, that children had probably inherited mathematics abilities from a parent or that they have a 'natural aptitude'[Dawn] and 'just get it straight away' [Gemma], are 'bright' or 'just really clever' [Gail]. However, it was more usually mentioned in negative terms, for example, many parents claimed that they themselves were not naturally capable at mathematics:

> I haven't got an engineering brain; I haven't got a maths brain and it's not something that comes naturally to me at all. [Maryam]

> I was nowhere near the natural sponge with my brother was. [Harriet]

The most concerning aspect of these widely held beliefs is the implicit, or in some cases explicit, view that there are limits to how well some people can do. That, whatever teaching they experienced, a child was born with either a creative or a logical brain and that is what they have to work with. There were many references to a 'cap' [Maryam] on ability, a fixed distribution of intelligence [Gail] or some children simply not being as academically able [Cora]:

> My kids are not going to be Mensa candidates or going off to Oxford or Cambridge. So you know, they just need enough maths that they can go into whatever career they need to go in, you know, which won't major in maths. I don't need them to be geniuses. [Mark]

This view, of the hardwired mathematics brain and a fixed level of ability, was by no means universal, but it was certainly the majority view in this study. The extent to which this can be a barrier to achievement is discussed in Section 3.4.1.6. This data echoes findings in the literature that Europeans, Americans and Australians were more likely to hold a fixed, innate-ability view of mathematics than their Asian peers (Jerrim, 2015; Li, 2004; Stevenson and Stigler, 1994). The importance of understanding how this view of intelligence can undermine children's motivation is demonstrated by Eccles' Expectancy Value Theory (Eccles *et al.*, 1983), which models how a child's achievement-related choices are directly influenced by their expectations of success in a task and the value they place on it (see Section 2.2.2).

5.5.5 Theme 5 – Gender

References to gender stereotypes in mathematics were entwined in the data with the references to innate ability detailed above. Gender is a significant theme when discussing views of mathematical success (Section 3.4.2.3). The stereotype, stated in its crudest form, is that boys have an innate advantage in mathematical subjects and are more likely to enjoy and succeed in them than girls. There were a small number of comments that reflected this view:

> So he loves working things out. I think, you know, he's got that scientific mind that he likes understanding how things work and engineering and facts. And you know, that kind of typical kind of boy – boy, science brain really. [Gail]
>
> It's a bit of a generalisation. But I think boys certainly at primary age are more competent in maths – tend to be, I don't know if it's the way their brain's wired or what but they, they seem to get it. [Laura]

There were also a couple of comments suggesting that the way boys succeeded in mathematics was somehow superior to the way girls did:

> I look at my, my nephew, he's 10 and my niece who's a bit older, but at the same age, she didn't have the … she gets it and she does it, but she didn't have that flair that he has. [Claire]
>
> I was nowhere near the natural sponge with my brother was. [Harriet]

Several mothers in the study referred to their own achievement in these terms, as somehow less valid, but this was not confined to women. One father also said of his own A level pass:

> So I think I sort of crammed it and managed to get a C, but I never really properly … I never felt I understood, if I'm honest. [Mark]

This differing assessment of the quality of girls' and boys' mathematics has been discussed in the literature for decades: there it is argued that girls' successes are more likely to be attributed to effort and boys' to ability (Espinoza, Arêas da Luz Fontes and Arms-Chaves, 2013; Skelton and Francis, 2003; Tiedmann, 2000); solutions given by boys 'tend to be viewed as gifted and elegant while those given by girls tend to be viewed as routine and rule following' (Burton, 1986 cited in Ivinson and Murphy, 2007, p.88); and both teachers and parents underestimate ability in girls and overestimate it in boys (Murphy *et al.*, 1998; Gipps and Murphy, 1994; Walden and Walkerdine, 1986).

When asked directly in the interviews most participants felt that there was no difference in mathematical potential between boys and girls and that these gendered views were a thing of the past and only encountered among the older generation:

> Yeah, it's just not something I've come across. If they if they ever said something like that, I'd be very quick to tell them to stop talking nonsense. [Gail]

Several of the parents were very aware of the pervasive social stereotypes that existed and deliberately tried to counter them by providing access to the same toys, referring to female STEM role models and being positive themselves. One mother was considering a single-sex secondary school for her daughter in part because she believed this avoided any social pressure against mathematics and science that might exist in a mixed school. She was keenly aware of the stereotyped interaction in families:

> I'd like to do my math GCSE now and things like that, but purely because of the idea of having a daughter and that whole thing of women not, mums not knowing, knowing maths, and it defaults to the dad, and then that's just an ongoing cycle of women not being able to do maths. So I'd quite like that cycle not to continue. [Alice]

The view expressed by the majority of participants was that gender stereotypes regarding mathematics were confined to history. This is contradicted throughout the literature, where numerous recent studies have found subtle differences in the ways boys and girls are socialised in mathematics by both parents and teachers (McCoy *et al*., 2022; Leech *et al*., 2021; Uscianowski *et al*., 2020; del Río *et al*., 2019). The key point here is the subtlety: differences are found in ways of playing, ways of talking and attributions of success, rather than through stating overtly held views. As Thippana *et al*. (2020) found, in a study discussed in Section 3.4.2.3, parents behaved similarly with boys and girls when doing an explicitly mathematical activity, but differences were found when the activity was not mathematical.

This contradiction is echoed in the data above, as almost all participants rejected the stereotype when asked specifically whether boys were more capable that girls, but some then made unconscious stereotypical comments. Having a mother who strongly rejects the stereotype, such as Alice, is, however, a protective factor against the negative impact of stereotype threat on performance (Galdi, Cadinu and Tomasetto, 2014).

5.6 A Return to the Research Questions

At the end of Phase 1 of the study, all the data intended to answer the first three research sub-questions had been collected and analysed. The findings related to each, which have been discussed in detail in Chapters 2, 3 and 5, are summarised below. The process of design is detailed in Chapter 6.

1) What beliefs, attitudes and opinions do parents hold regarding mathematics learning?

The beliefs about mathematics that parents expressed in research interviews were inevitably diverse, influenced by each individual's educational experiences and levels of confidence. There were, however, trends: excluding the joyful parents, the majority of interviews corroborated findings in the literature that mathematics was neither seen nor valued. It was frequently viewed as an academic subject with little relevance to daily life. The interpretation of what counted as mathematics was narrow and often limited to calculating manually. Many did not recognise the mathematics they were doing in their own lives, despite working in IT or psychology or managing household budgets and mortgages. One of the distinguishing features of the more confident parents was their ability to give examples of the applications of mathematics, particularly visual or creative ones.

Ability in mathematics was believed by many, including the joyful parents, to be innate, inherited and the result of nature over nurture. This view was less prevalent in the group of parents described as 'coping'; among these parents, success or failure was more likely to be viewed as the result of quality of teaching and relationships with teachers. This supports the argument made in the literature and referred to in Section 5.5.4 that European and American cultures are more likely to hold this view of ability.

In terms of beliefs about mathematics and gender, the majority of parents explicitly stated that there were no differences in mathematical ability between girls and boys and that gender stereotypes were historic. There were, however, a number of comments made during the interviews suggest some parents did hold biases or assumptions about the way boys and girls approached mathematics. As discussed in Section 5.5.5, the ubiquity of gender stereotypes related to mathematics in social discourse is well documented in the literature.

The attitudes parents expressed about mathematics, with the exception of the joyful parents, were overwhelmingly negative, ranging from dislike to dread. This reflects the description of attitudes in the general population referenced in Section 1.1. Mathematics was seen, even by parents who could themselves do the calculations, as a necessary means to an end rather than enjoyable in its own right.

There were varying opinions held about mathematics. Whilst it was considered an essential skill and a number of the parents invested considerable effort in supporting their children (see Section 5.3.1), it was also seen as an abstract school subject of little relevance. Opinions about how it should be taught also varied: some pragmatic parents thought there should be more calculation practice and a focus on accuracy; coping parents were more likely to prioritise positive attitudes, confidence and making mathematics relevant to children's lives.

2) What are parents' experiences of supporting their child with mathematics and what, if any, barriers do they face?

The experiences of supporting homework, as discussed in Section 5.5.1, were overwhelmingly negative, conflict laden and frustrating. The small number of positive experiences that were reported were either from joyful parents or related to specific activities which had gone well. The barriers to supporting children were dominated by the impact of these heightened emotions, stemming from either a child's frustration at finding something difficult or an adult's stress at their perceived inability to help. The parents in this study were unsure how to handle the emotional reactions of their children, whether this was lack of resilience or perfectionism. Alongside this were multiple barriers created by misunderstandings, either of the mathematics itself or the expectations of the teachers (Section 5.5.2). Several parents mentioned how uncomfortable they felt attending any mathematics-related events at school (Section 6.3.1); their anxiety about what these events might involve was a barrier to engaging.

The emotion invoked by mathematics homework is supported in the literature and has been referred to over a number of decades (Section 3.3.2). There were, in addition, many barriers described in the literature that were not referenced by this small sample of parents. For example, the socio-economic barriers of buying resources or having sufficient time to help children were not mentioned in this study, either because they were not applicable to these participants or because they would have been difficult to acknowledge in a face-to-face interview. It is clear from the literature, however, that this, along with the barriers attributable to ethnicity or language competence, remains relevant to a wider sample.

3) How do parents' opinions, attitudes and beliefs about mathematics affect the way they approach mathematics with their children?

Parents' own feelings opinions, attitudes and beliefs did significantly impact the way they approached mathematics with their children. There were examples of withdrawing from involvement, delegating to a partner or being impatient with children because of their own discomfort. There were also accounts of mathematics homework bringing back remembered helplessness from their own education, and thus causing distress. Alongside these negative descriptions were many examples of resilience and multiple attempts to find a better dynamic. Parents reported buying books about mathematics and workbooks to practice and employing tutors. Two parents, who did not believe that the school was doing enough, had bought extra materials for their children. One parent, herself anxious about numbers, had deliberately volunteered to do scout book keeping to model to her children that mathematics was nothing to be afraid of. Another was considering returning to education to do GSCE mathematics herself so that she could support her daughter in secondary school. This demonstrates that there is, among many parents, motivation to engage and support children but uncertainty about the best way to do this. In general, parents were far more confident and relaxed when school tasks moved away from calculation to practical activities such as measuring. The parents who were more confident in mathematics also seemed more confident in their parenting in this context. They were playful and able to follow the child's lead and less controlling; an approach argued in the literature to be most effective for learning (Section 3.4.1.4).

The data from all of the sources above informed the design of the intervention, which is detailed in the following chapter.

Chapter 6 – The Creation of the Intervention

6.1 The Sources of Evidence Which Informed the Intervention

This research set out to create and evaluate a brief, social psychological intervention to enable parents to better support their children in mathematics and reduce the intergenerational transmission of Mathematics Anxiety (MA). As was discussed in the Introduction, social psychological interventions target thoughts, feelings and beliefs. Ideally, they target a single keystone belief which creates a barrier; by changing this belief and so removing the barrier, a positive, self-reinforcing change in behaviour can be instigated (see Section 1.2.3). Phase 1 of this research gathered evidence to inform the design of the intervention. This evidence included a systematic literature review and analysis of previous interventions (Chapter 3), qualitative interviews with parents (Chapter 5) and theoretical perspectives on motivation and parental influence (Chapter 2). The diagram in Figure 9, reproduced here from Chapter 1, demonstrates how these sources contributed to the focus, format and content of the intervention. This chapter will describe the rationale for the decisions made during the design process and then describe the resulting intervention.

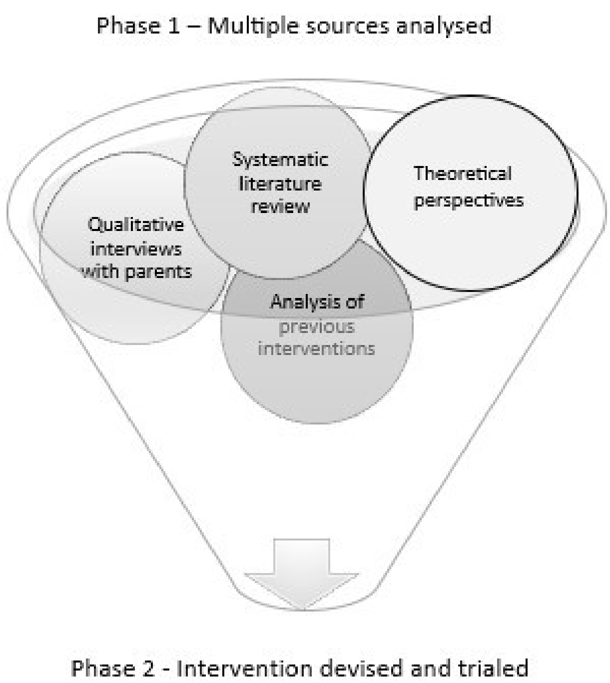


Figure 9 Phases of the study which informed intervention design

6.2 The Subjectivity of the Design Process

Although informed by the multiple sources of evidence described above, the design process was, of course, subjective; it was influenced by my own experiences as a teacher and a parent and as a learner of mathematics and a researcher. My experiences and my opinions influenced the decisions I made. This subjectivity is inevitable and is compatible with the constructivist epistemology of this research (Section 4.2.1). Other, equally valid decisions could have been made and other forms of intervention could have been created, grounded in the same array of evidence. In this chapter I will discuss the rationale for decisions made and reflect on the factors that influenced them. In Chapter 8, I will return to this issue and discuss other possibilities that could be trialled in future.

6.3 The Selection of a Keystone Belief to Target

There were a number of beliefs about mathematics, raised across all sources of evidence, that were potential targets for an intervention. In this chapter, the decisions over which specific beliefs to target with this intervention are discussed in detail. First, however, I explain the reasons for not including two potential subjects: teaching mathematical content and reducing parents' own MA. I do this because the former is often the first suggestion made by both schools and parents when considering how to help support mathematics at home. The latter because it would seem an obvious way to prevent the transmission of MA.

6.3.1 The Decision Not to Create an Intervention to Teach Mathematical Content

The literature review included accounts of a number of interventions aimed at increasing parents' confidence with the content of the school mathematics curriculum (see Section 3.5.1). In my experience, as a teacher and a parent, explaining mathematical content to parents is the most common focus of meetings, workshops and information sent home from schools. This type of intervention was mentioned frequently by the parents I interviewed:

> They used to do a maths thing where they'd invite the parents and you do it with your kids and that was quite nice. And we've got these things about what they're studying. So you get a sheet that would say, you know, we're learning fractions this half term, and then this, it's not like every lesson, but you'll get an overview of what they're studying across the term. [Mark]
>
> Before lockdown, the school did a couple of maths workshops to help parents to see what was going on … like the way they do long multiplication and stuff. [Jason]

A lack of understanding of children's school mathematics, in terms of content and methods, was repeatedly cited by parents as contributing to their lack of confidence. Several parents expressed the belief that a more thorough understanding of what their children were learning, in effect a content-based intervention, would make it easier for them to support their child:

> This is maybe obvious but the most useful thing, would be if they got the homework and then we got like a sheet. 'This is how you do it'. Like a refresher session. [Stuart]
>
> In ideal world you'd have one [workshop] for every year group you know … so you're studying what they're going to study. [Anna]

The account of the theme 'Confusion and Misunderstanding' encapsulates many parents' feelings towards the school mathematics curriculum and their understanding of their role (see Section 5.5.2). One parent later expressed some frustration in their evaluation that Mathsbreak itself had not taught any content:

> We might still struggle to explain things the way she's taught at school, which is part of the problem … I'm still at a bit of a loss as to how to help her with her maths homework. [Antony]

Critically, parents' willingness to engage with a content-based intervention was related to their own attitude to mathematics. Whilst the joyful parents saw a workshop as a great opportunity and something they would 'love to do' [Daisy], the anxious parents expressed reservations about attending and revealing their own inadequate knowledge. Several gave vivid accounts of their fears or their fraught experiences of attending such workshops in the past. These are quoted at length as they encapsulate the intense, but often hidden, emotions, beliefs and attitudes that parents bring to these events:

> Something like a workshop I'd actually get quite anxious in because I just think, oh, God, all the other parents know it … Doing maths with other people is really stressful when you're not good at maths. So, for me things like sitting in a group around a table, and then like a shared problem, and how it would be really, I would really freeze up doing something like that. [Jackie]
>
> I just think I'm done … beyond like help, I couldn't, I wouldn't be able to understand it. [Kaylee]

> It would worry me to go because it would. It would remind me of back when I was, do you know what I mean, because obviously someone can still tell me til they're blue in the face. And I still wouldn't get it. So I could be in a group full of like other adults and they'd be sitting there going … oh, … I get it now … and I'd be sitting there going, do you because I flippin don't. [Kaylee]

> I'd slip in the back of the class out the way, because we were expected to have a go at some maths. Yeah. I've got hang ups about public humiliation. And also, that the maths workshops haven't actually told us how to do it, if that makes sense. They show us what they're doing. And they sort of skip over how they do it fairly rapidly, because they assume you understand it, right. Where it is that they're still trying to understand it when they're asking people to demonstrate … things like that. [Jason]

Interestingly, one of the joyful parents felt that, as previous events at school had been well attended, this would be most parents' preference:

> Sometimes it's just the parents, sometimes it's parents and kids doing something together. And they're quite, they're very well attended, actually. So I've got a feeling that parents would prefer that. [Mark]

This quote represents the difficulties caused when events are planned by teachers who are confident in mathematics; if parents are consulted at all it tends to be those who routinely attend such events. This risks a skewed perspective of parent opinions and the views of more anxious parents being lost. There is also a risk that schools misinterpret lack of attendance at such events as lack of interest, when in fact it is due to other barriers, such as the levels of anxiety described above. I have organised, delivered and attended these events in different contexts. My experience concurs with the evidence from the interviews: confident parents enjoy them and the least confident avoid them.

The premise of fully preparing parents to explain all elements of mathematics homework to their children is, in reality, unrealistic. It would involve developing an understanding of the details of all seven years of the primary mathematics curriculum, its content, methods, progression and common misconceptions, and a time commitment similar to that of training teachers. For many schools, familiarising parents with their child's mathematics learning takes the form of an annual workshop or talk. It is unlikely that a parent could listen to an overview of the Year 4 mathematics curriculum in October and then remember how to use a certain method when it comes up in a homework the following May. The most these meetings can do is to describe the school's approach to the curriculum and inform parents of the support they can access during the year.

Despite their ubiquity, the studies of the content-based interventions reviewed in Section 3.5.1 found that gains in children's mathematics were small. They also required high levels of engagement from researchers, teachers and parents. Similar results were found with the interventions involving homework; whilst they were popular with parents and may have resulted in more positive interactions at home than traditional homework, there was no evidence to show any benefit remained after the intervention finished. However, as parents cannot be expected to envisage a type of intervention which they have no previous experience of, it is unsurprising that support with content is frequently requested. Finally, in terms of this intervention, the teaching of content would not fall within the scope of a social-psychological intervention. The most this type of intervention could do is to target the belief that the content was too difficult to learn; removing that barrier may then allow parents to engage more effectively with understanding the content.

6.3.2 The Decision Not to Focus on the Parents' Own Anxiety

When designing an intervention aimed at preventing the transmission of MA, it would seem self-evident that reducing parents' own MA would be valuable. As raised in Section 3.5.5, there are studies showing the benefits of relaxation or mindfulness techniques on the performance of students with MA. However, these were extended interventions and targeted at students themselves engaged with mathematics courses. Firstly, a full-scale intervention to reduce parental MA was considered beyond the scope of this study. It was also decided that a second possibility, of teaching parents these techniques to use with their children, had potential value but would be more appropriate to a face-to-face intervention.

Having explained why two potential areas for intervention – mathematical content and parents' own MA – were not considered, the following paragraphs explain what has been learnt from the other categories of intervention described in the literature review and how they influenced the design process.

6.4 Learning from the Interventions Seeking to Foreground Parents' Knowledge

One group of interventions in the literature focussed on parents' mathematical knowledge outside of the school curriculum (Section 3.5.2). Highlighting the value of this potentially rich and culturally diverse area of knowledge could engage parents and increase motivation around mathematics. Also, working with the mathematics that parents are already familiar with would be less likely to create anxiety than curriculum-based mathematics. However, the accounts of these interventions in the literature showed that they were highly demanding of both parent and researcher time. The model of bringing home knowledge into school was unfamiliar to most involved and thus needed time, openness and flexibility on behalf of both parents and researchers. There was no longitudinal element to these studies to demonstrate whether the benefits sustained lasted beyond the time frame of the intervention and whether parents were able to continue to engage children in this wider view of mathematics without direct support. However, these interventions did demonstrate that parents were highly motivated to be involved in their children's mathematics but were prevented from demonstrating this to the school by barriers such as confidence, time or cultural knowledge.

6.4.1 Learning from Interventions Intended to Facilitate Mathematics Conversations

Another set of interventions, described in Section 3.5.3, aimed to increase the number of mathematical conversations parents had with their children. Two interventions from this set were particularly salient; both were digital and neither was highly demanding on teacher or researcher time. Paz (2019) prompted parents by weekly text messages to have a short, simple conversation with their teenagers, such as estimating the distance between two local places. The content was then integrated into the following mathematics lesson. Schaeffer *et al*. (2018) used a mathematics app to structure and encourage parents' conversations with their first-grade children in a variation on a bedtime story format. These studies were both targeted at attitudes and beliefs: they promoted the fact that mathematics was part of life and that children could enjoy talking about it. They also aimed to build a routine of positive, relaxed interactions around mathematics. They both demonstrated a positive effect that remained beyond the duration of the intervention; increasing conversation appears, therefore, to be a valuable focus for an intervention.

There were also, in this set of interventions, several designed to increase parents' mathematical talk with the very young; these are referred to as home numeracy environment interventions (Section 3.5.3). Analysis of these interventions suggested that learning about the *approach* to playing mathematically with their children – such as the importance of getting down to a child's eye level or letting children take the lead – was more likely to endure than *content*, or ideas for activities themselves. They found that integrating mathematical play and talk or suggesting mathematical activities did not appear to become instinctive for many parents but remained a conscious activity dependent on prompts and structures. Any intervention would therefore need to explain why the nature of interactions mattered and be clearly structured with a variety of examples.

6.4.2 The Decision to Choose a Utility Value Intervention

The decision to focus on utility value (UV) was influenced by the positive outcomes of these interventions in the literature (Section 3.5.4), combined with data from the interviews (see Seeing and Valuing in Section 5.5.3). The Expectancy Value Theory of motivation (Eccles *et* *al.*, 1983) was also influential in this decision. This theory emphasised how important seeing the purpose of learning was to motivation (see Section 2.2.2).

I found the study reported by both Harackiewicz *et al*. (2012) and Hyde *et al*. (2017), which posted brochures promoting the usefulness of STEM subjects to parents of 14–15-year-olds, the most persuasive. Its aim was to facilitate and increase the effectiveness of conversations around course choices. It harnessed the unique position parents were in, with their knowledge of their own child's interests and future plans, to make genuinely relevant connections with STEM subjects. As discussed in Section 3.5.4, teenagers from the families who received the brochures took significantly more STEM courses than the control group and this was particularly true for teenagers with less-educated parents and fewer family resources. The other UV interventions included in the review also demonstrated the benefits of tuning students in to the relevance of mathematics learning for their lives. Two quotations particularly influenced my decision to focus on UV:

> In essence, it may be easier for parents to demonstrate the utility value of academic pursuits than to help their children find those pursuits interesting. For example, even if parents cannot convince their child that mathematics is enjoyable (Intrinsic value) or that he or she is good at mathematics (Expectancy), they can discuss how useful mathematics is for careers in engineering or computer science and for gaining college admission. (Harackiewicz *et al.*, 2012, p.900)

> We found that math importance beliefs significantly predicted children's maths performance above and beyond other predictors. In the context of high maths anxiety, parents who believed that maths was particularly important had children with above average performance whereas parents who rated math as less important had children with lower-than-average performance. (Silver, Elliott and Libertus, 2021, p.13)

The first quotation argues that belief in the importance of mathematics may be a more malleable belief for parents themselves and for their children. The second argues that a parent's belief in the value of mathematics could be a protective factor against the transmission of MA. My interviews with parents offered clear evidence that this belief in the value of mathematics was not commonplace. Many parents did not notice or value the mathematics they were doing routinely (Section 5.5.3). An intervention which focussed on how mathematics is used could be valuable in several ways. It may be enlightening to the parents who had not previously considered the applications of mathematics. It could also give those who already consider this to be important a means to discuss this with their children. In addition, one of the characteristics of the East Asian parents' approach was the value placed on mathematics and an assumption that it was an essential skill (Section 3.4.2.4).

The decision was made, therefore, to focus on UV and on persuading parents that mathematics was all around them and that it would be useful to their children. Influenced by the learning from the other interventions, the intervention included stimulus for mathematical conversations and also guidance on ways to engage children effectively. Before 'the mathematics in jobs' was chosen as the vehicle for discussing how mathematics was used, other areas were considered. Examples included the hobbies and interests of primary-aged children, such as card collecting or gaming and the mathematics of family life, such as running a car or a home or arranging a holiday. Whilst these would be valid areas to demonstrate many mathematical applications, the mathematics in jobs was chosen as this was an easily defined topic, it was relevant to parents of all age groups, it was a subject that would be likely to be discussed by parents and children into the future and it would be easy to delineate from homework activities.

The UV of mathematics was therefore the keystone belief on which this social psychological intervention was based. The hypothesis was that, instead of believing mathematics to be an abstract and difficult subject that they had never succeeded in, parents would start to notice the applications of mathematics in the world and become more aware of the mathematics they themselves engaged in regularly. Participating in the course would persuade parents that mathematics was a valuable subject for their children to learn. The more they tuned into the ubiquity of the mathematics around them, the more this belief would be reinforced. The quotations above support the argument that this belief could be a protective factor against the transmission of MA. Although social psychological interventions are described as involving just one belief, the decision was made to target other, supplementary beliefs in the intervention. The rationale for this is described below.

6.4.3 The Decision to Address Other Beliefs about Mathematics alongside UV

Given the wide range of beliefs that had been identified as barriers to supporting mathematics effectively, the decision was made to include some of these alongside the UV focus. Personal experience at the school gate and several examples from the interviews, showed that some parents routinely spoke to their children about mathematics in a way that would risk undermining the benefits of the intervention. These included comments that revealed a belief in natural ability or a fixed mindset, such as 'I just couldn't do maths at school' [Kaylee] or assumed negativity 'It's tricky isn't it? … You don't like maths. Do you?' [Cora], and comments that promoted the gender stereotype that boys were more likely to enjoy maths, '[he's got] that kind of typical boy-boy science brain' [Gail].

In addition, the fraught accounts of mathematics homework and the strength of the 'Emotion and Conflict' theme in the data (Section 5.5.1) suggested that some guidance over handling mathematical interactions could be valuable. Bandura's theory of vicarious conditioning (Bandura, 1971) emphasised how children's attitudes and fears were learnt from the attitudes of the adults around them. Conversations about the UV of mathematics would not be effective if they were framed by a fearful or negative attitude. Finally, the lack of confidence expressed by many parents in the interviews and the fears that they were alone in finding mathematics with their children difficult persuaded me that an element of reassurance was needed. I felt that 'the subtle aspects of parenting' (Jeynes, 2010), referred to in Section 1.2.2, through which parents could make a genuine difference, needed explicitly introducing and that this could be a reassuring message.

The decision was made, therefore, to create an intervention that focussed primarily on the UV of mathematics but also incorporated information to counter other beliefs which could prevent the intervention having an impact and to persuade parents of the power of being a positive role model.

6.5 Influences on the Format of the Intervention

In the interviews, parents were asked directly about the type of intervention they would be most likely to engage with. They were asked to express a preference between face to face and online, and also asked for any other suggestions. They held a range of views and these were related to their attitudes to mathematics. When responses were analysed according to personas, the majority of the anxious parents would not attend a face-to-face workshop; only one parent from this group felt they would enjoy the interaction and one had no strong preference. The other anxious parents felt that anything held at school to be too stressful and to carry too many negative associations for them to attend (Section 6.3.1). The preference of parents characterised as coping or pragmatic were evenly split between online or face to face delivery. Those who preferred an online intervention from these groups were motivated by convenience rather than fear of attending in person. All of the parents characterised as joyful about mathematics expressed a preference for going into school but were also positive about interacting online. One parent suggested a third option of a printed workbook. Overall, the preference was for an online intervention; only two parents thought they definitely would not participate online, although a couple more felt they might not be motivated enough when the occasion arose. Given this preference, particularly among the anxious parents, coupled with the unpredictable restrictions on meeting in person which remained from Covid-19, the decision was made to create a wholly digital intervention.

A number of parents did express a desire to interact with the other parents during a course. Suggestions were made for closed Facebook groups or live webinars with discussion functionality. Whilst the creation of a community around an intervention could certainly have merit (see Jay, Rose and Simmons, 2017; Kritzer and Pagliaro, 2013; Civil, Bratton and Quintos, 2005), the moderation involved in allowing interactions between parents was deemed too practically difficult and ethically complex for inclusion in this single-researcher study.

Several formats were considered before settling on the idea of a video-based course. These included live webinars, an interactive text- and image-based website and a website with prompts for parents to enter descriptions of the mathematics they do use confidently in their daily life. This was influenced by the examples of social psychological interventions in which students wrote about their own values (Gaspard *et al.*, 2015; Cohen *et al.*, 2006). One key influence when designing the format was the online course described in the study by Boaler *et al*. (2018). This MOOC (massive open online course), first discussed in Section 3.5.4, was a free, web-based, distance-learning class with unlimited participation. It consisted of six 15-minute online sessions, which were a mixture of Boaler herself speaking to the camera and short videos of her students explaining or acting out key messages. This was aimed at teenage learners rather than parents and conveyed multiple messages about everyone's ability to succeed and the utility of mathematics. This also demonstrated that an intervention which tackled more than one belief about mathematics could be effective.

A decision was made to build this course around short, pre-recorded videos highlighting the mathematics in jobs and the other key messages planned for inclusion. Once this had been decided upon, several formats for these videos were considered, including narrated animation of the key messages and videos of acted out conversations between parents and children. The final format, which involved videos of people discussing their jobs accompanied by animated sketches, was chosen as it was hoped the combination of film and varied expert voices would be engaging, the animation would 'collect' the mathematics and a choice of jobs could be offered which may be of interest to parents. The details of the intervention itself are described below.

6.6 The Intervention

6.6.1 The Choice of Platform

The final form of the intervention was a video-based, online course for parents, published on an educational platform called Teachable©. This platform, designed to host online, educational courses, was chosen as it was able to combine surveys, videos and text within lessons. It was also able to collect usage data to show participants' interaction with the course, down to the precise sections of videos watched. There were also a number of practical considerations that meant it was chosen above other similar platforms: it was affordable, straightforward for participants to access, complied with GDPR and sent no marketing to students enrolled on the courses.

As discussed above, the main intention of the course was to persuade parents that mathematics is widely used and valuable to learn. Alongside this, it aimed to inform parents about motivation in relation to their children, to increase their self-efficacy to support them and to reassure them that they were not alone in feeling anxious about mathematics and finding it challenging to support homework. It also emphasised the importance of the 'subtle aspects' of parenting; how they can make a difference by creating a positive atmosphere around mathematics and passing on the belief that it is useful.

6.6.2 The Rationale for the Name Mathsbreak

Figure 10 Mathsbreak logo

The name, Mathsbreak, was designed to be informal and friendly and to emphasise the short, coffee-break-length sessions in the course. The coffee-cup logo and irregular, informal font reinforced this message. Mathsbreak also held another meaning of break – to break the chain of transmission of MA.

6.6.3 The Content of Mathsbreak

The course consisted of three parts, each intended to take around 20 minutes to complete. At the core of the course were videos, each around five minutes long, which featured a person describing the primary-school mathematics that they used in their work. As they spoke, an animated hand sketched and noted this mathematical content. These notes collected on the side of the screen.

Figure 11 Still from Mathsbreak: Making Jewellery video

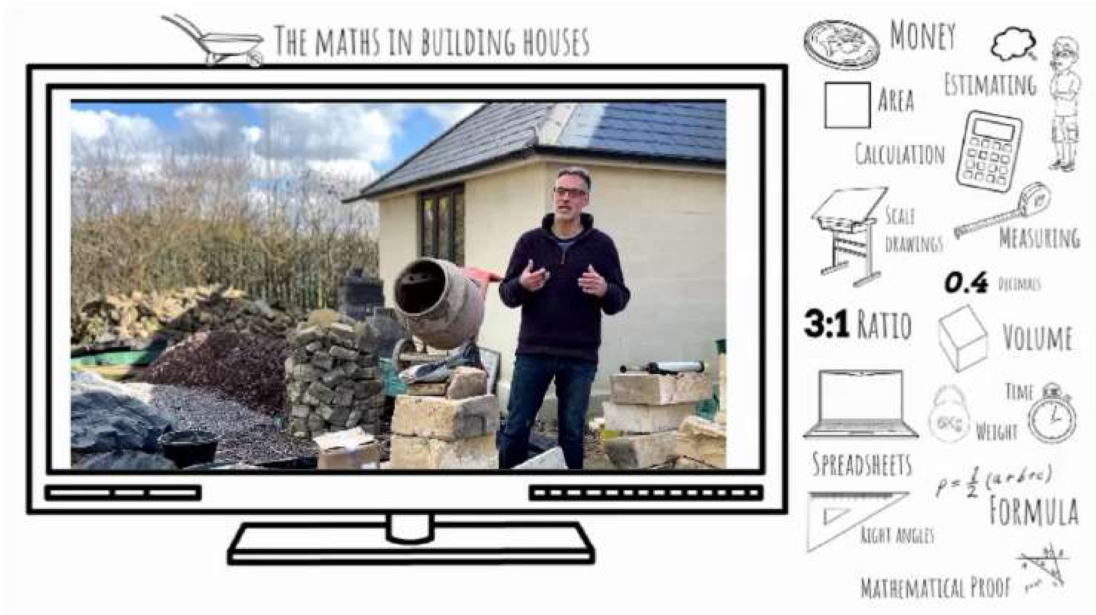


Figure 12 Still from Mathsbreak: Building Houses video

There were choices of videos for parents to view. There were also videos of the researcher, talking to the camera about different aspects of supporting children in mathematics.

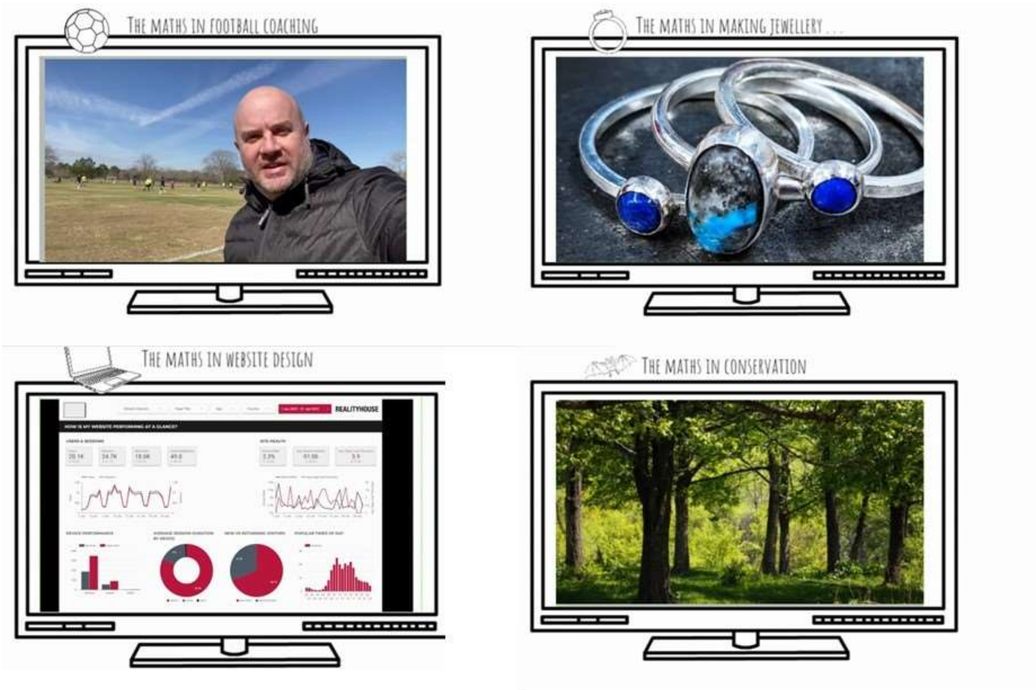


Figure 13 Thumbnail choices from Mathsbreak

Figure 14 Still from Mathsbreak: video on Motivation

Initially the course was set to release each part at weekly intervals after the participant had signed up. This was driven by a concern that if participants watched the whole course in an hour and never returned to it then the impact would be reduced. However, feedback from early participants suggested that they wanted more control over how they engaged and that it was frustrating to have to wait once their interest had been piqued. The platform settings were therefore altered to allow access to all the content on sign up. There is a detailed discussion in Section 7.2.4 of how participants did, in fact, interact with the course.

Mathsbreak Course Content

Part 1

- Piece to camera – Introduction (1 min)
- Piece to camera - 'How do we motivate our children to learn maths?' (5 min)
- Printable sheets - Maths Anxiety and Mindsets.

Part 2

- Piece to camera - 'You don't have to be a maths teacher' (6 min)
- Job Videos - football coaching, jewellery making, conservation and website design (Each 5 min)
- Printable sheets - 'What to say when your child does well' and 'What to say if your child is stuck and you are too'.

Part 3

- Piece to camera - 'Gender stereotypes are still a thing' (2 min)
- Job Videos - veterinary medicine, building houses and composing music (Each 5 min).
- Prompt - plan a mathematics conversation with a child related to their interests.
- Printable sheets - 'Ways to bring maths into the conversation' and summaries of each jobs video.

Figure 15 Mathsbreak Content.

Scripts of the videos and copies of the printable sheets contained in the course are attached in Appendix 12 and 13.

6.6.4 The Theory of Change of the Intervention

A theory of change was drawn up as part of the design process (See Figures 16 and 17 below). Articulating the assumptions behind the design of an intervention in this way was argued by Weiss (1998) to be an effective means to ensure that all the contributing elements to a long-term goal were in place. Clarity about how the change process would unfold, she argued, would also allow evaluators to test whether the expected outcomes at each stage were produced. In this way, improvements in the 'components and strategies' (Weiss, 1998, p.32) of the intervention could be made. Looking ahead to evaluation, Pawson (2003) argued that being able to track the 'inner workings' (p.473) of an intervention also meant that, if changes occurred, they could be directly attributed to it. The evaluation of *Mathsbreak* (See Chapter 7) examined various elements of this theory of change to assess whether changes in beliefs and attitudes were unfolding as intended.

Mathsbreak was designed as a social psychological intervention. These interventions are intended to instigate positive, self-reinforcing changes in beliefs and behaviours over time (See section 1.2.3). The linear theory of change diagrams below should, therefore, be viewed as part of a cycle; if the intervention is effective, incremental changes will occur, which lead to further cycles of change. For example, having recognised some of the mathematics used in daily life, parents become more able to draw their children's attention to it and those conversations lead to further recognitions of applications of mathematics.

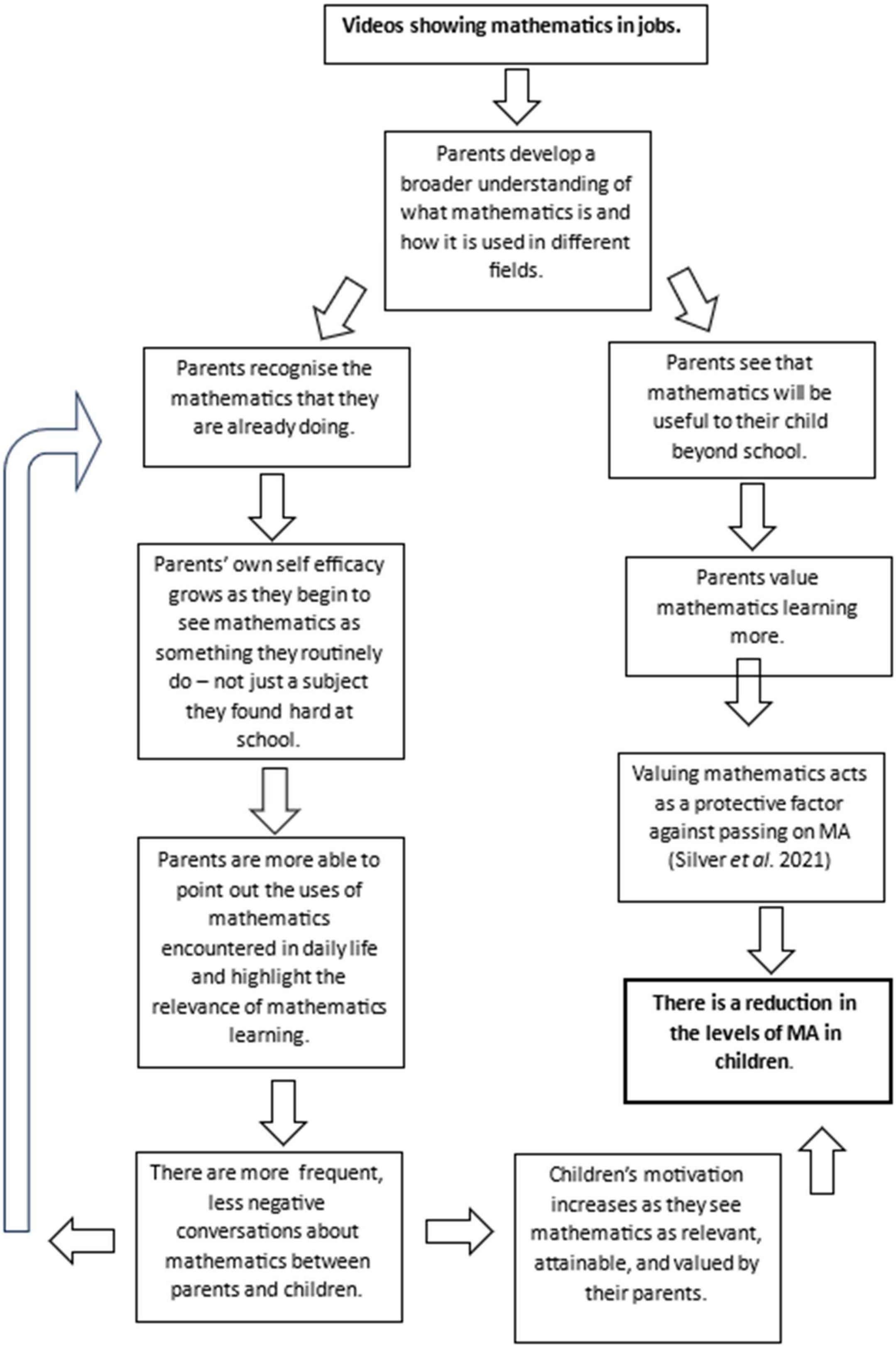


Figure 16 The Theory of Change for the inclusion of the 'Mathematics in Jobs' Videos.

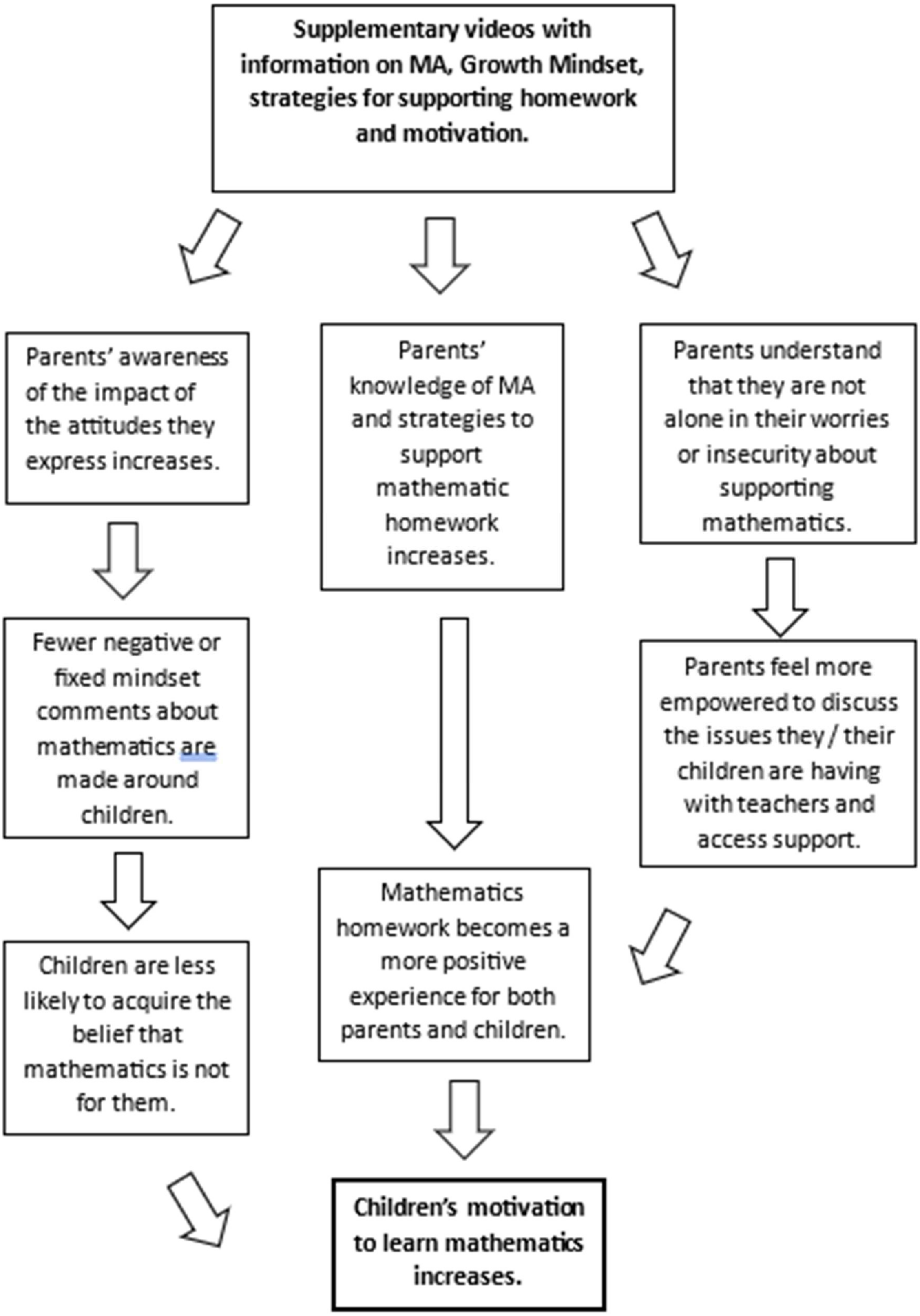


Figure 17 The Theory of Change for the inclusion of supplementary videos.

6.6.5 The Evaluation of Mathsbreak

Mathsbreak was evaluated through a qualitative survey and through analysis of digital usage data. Participants were asked to complete a questionnaire before commencing the course in which they answered questions regarding their attitudes to mathematics. They then completed evaluation questionnaires at two points: on completion of the course and around five months later. Complete sets of this data were obtained from 12 participants. The findings of this evaluation are discussed in detail in Section 7.2.

Chapter 7 – The Evaluation of the Intervention

7.1 The Evaluation of Mathsbreak

To recap, in Phase 1 of this study, data was collected from multiple sources of evidence to inform the design of a brief, social psychological intervention aimed at reducing the intergenerational transmission of Mathematics Anxiety (MA). The result of this process was the Mathsbreak intervention, which was aimed at parents of primary-aged children and targeted their beliefs about the usefulness of mathematics. The rationale for targeting the utility value of mathematics was discussed in Section 6.4.2. Alongside this core purpose, Mathsbreak aimed to raise awareness of how mathematics is commonly spoken about and the impact this can have on children's motivation; highlight the impact of gender stereotypes; reduce the emotion and conflict created by mathematics homework; and, finally, reassure parents that they were not alone in finding supporting mathematics challenging.

The evaluation described in this chapter explored how the Mathsbreak intervention was experienced by the parents who trialled it. This was an outcome evaluation (see Section 4.2.3.2). In it, participants were asked to rate various elements and to illustrate their experiences with memories, examples and reflections. In this way, the evaluation provided a vehicle for further learning rather than a summative judgement of success or failure. It set out to uncover whether salient points were similar for all participants or whether this varied, and whether there was any evidence of sustained changes in attitudes, beliefs or behaviours as a result of participation. It sought to answer the final two research sub-questions, introduced in Section 1.3:

4. What is the effect of parents' participation in a short online intervention on attitudes and opinions and the way they talk about mathematics to their children? Is this effect sustained over time?
5. Is the format of the intervention enjoyable, accessible and scalable?

Data was collected from participants through questionnaires at three points: before they started, immediately upon completing and, finally, between four and five months after completion. Digital usage data was also collected from the platform on which the course was hosted. In this section, the rationale for the design of each of the questionnaires is explained. Following that, the data is presented and discussed using a combination of graphs and thematic analysis. This chapter begins with a description of the evaluation instruments –

three questionnaires and a set of website-usage data - and explains the rationale for their content. The findings of the evaluation are then presented.

7.2 The Evaluation Questionnaires

7.2.1 The Pre-course Questionnaire

The pre-course questionnaire (PreQ) was embedded in the intervention after the introduction in order to collect data on participants' dispositions, their levels of confidence towards mathematics and how useful they considered mathematics to be. Collecting this data allowed comparison between participants with different profiles. This questionnaire was brief; early questions were framed as multiple choice for ease of completion. Demographic data, such as age, race, occupation or educational levels, was not requested to avoid the questionnaire being experienced as intrusive. As participant numbers were small this information would not add meaningfully to the analysis. The questionnaire is included below in full (see Figure 15), followed by a discussion of the rationale for each question.

The first two questions were intended to judge the levels of anxiety parents held about mathematics. There are well respected, detailed scales to measure MA, including the 98 item Mathematics Anxiety Rating Scale (Richardson and Suinn, 1972), the 25 item Short Mathematics Anxiety Rating Scale (Alexander and Martray, 1989) and the 13 item Mathematics Anxiety Scale (Fennema and Sherman, 1976). However, there is also more recent research suggesting that the Single Item Mathematics Anxiety Rating Scale can give a valid and reliable measure of MA whilst being significantly quicker to administer (Hart and Ganley, 2019; Núñez-Peña and Suárez-Pellicioni, 2014). In my study, a single question asking participants to rate their MA was used and then triangulated by asking parents to choose from four descriptions the one that best represented their attitude to mathematics. These descriptions were based on the personas devised in Phase 1 (see Section 5.3).

The third question, which used adjectives taken from the interviews in Phase 1 (see Section 5.5.1), provided a baseline for each parent's experiences of mathematics homework. The fourth question was intended as a measure of mathematical ability in the context of homework. Both of these questions were intended to allow comparison of how parents with different prior experiences reacted to the intervention. Question 5, about ages of children, enabled the participants' responses to be placed in context: a parent of a 5-year-old would have a very different experience of mathematics homework to the parent of an 11-year-old. Questions 6 and 10 were intended to record the participants' current view of the utility value of mathematics.

Pre-Course Questionnaire (PreQ) – How do you feel about maths?

1. Which description sounds most like you? [multiple choice]
    a. I enjoy maths and enjoy doing maths with my child. We often talk about numbers or play games involving numbers.
    b. I can do maths fairly well but don't enjoy it. I know it is important for my child to learn maths but it isn't something I enjoy doing with them.
    c. I just about get by with the maths I need for my life but I don't feel confident.
    d. I really don't like maths. I feel really stressed if I have to do any maths or my child asks for help with homework.

2. How anxious do you feel about maths? [1-10, with 10 being most anxious]

3. Which words best describe your experience of helping with Maths homework [multiple choice]
   Calm, frustrating, emotional, enjoyable, tense, fun, argumentative, uninvolved, other___________

4. Generally, how confident are you that you can do the maths your children bring home, even if you use your own methods [1-10 with 10 being confident]

5. Which year groups are your children in?

6. How useful do you believe maths will be to your child/children in the future. [1-10, with 10 being essential?

7. Imagine you are working on some homework with your child. They have to read information on a graph. They ask why they need to know this. What would you tell them?

8. Imagine you are working on some homework involving weighing objects. Your child asks why they need to know this. What would you tell them?

9. Imagine your child has brought a homework home involving fractions. You look at it and realise you have no idea how to do it. What do you do? What do you say to them?

10. Which areas of maths do you think are most useful in life beyond school?

11. What would you like to gain from this course?

Figure 18 Pre-course questionnaire

Questions 7–9, beginning ‘Imagine’, asked parents to think about what they would say and do in hypothetical scenarios. This idea was influenced by a research project which asked parents how they would respond to hypothetical questions from their teenager about the purpose of STEM subjects (Hyde *et al*., 2017). One of these questions was mirrored in the post-course questionnaire (PostQ) to enable comparison of responses.

7.2.2 The Post-course Questionnaire

This second questionnaire was embedded at the end of the Mathsbreak intervention and is shown below (Figure 16). The intention of these questions was to elicit participants’ initial reactions. Question 1 asked for a simple, overall impression of usefulness and questions 9–12 explored in more detail which elements were valuable and why. Question 2 was intended to uncover which messages had been remembered by participants and whether there were different views over the most salient points. Questions 3–5 were open-ended questions which asked participants to reflect on whether the course had influenced their beliefs or intended actions. Question 6 was replicated from the PreQ, as discussed in Section 7.2

Post-Course Questionnaire (PostQ) – What did you think of Mathsbreak?

1. Overall, how useful did you find the course 1-10 [10 most useful]

2. What are the main points you will remember from this course?

3. Do you think your beliefs about maths have changed at all? Can you say how?

4. Do you think you will change anything about the way you talk to your child about maths? Can you say how?

5. Do you think anything will change about the way you do homework with your child? Please explain

6. Imagine you are working on some homework weighing objects. Your child asks why they need to know this. What would you tell them?

7. How did you find the length of the course [multiple choice – Too long, too short, about right]

8. Did you like accessing the course online? [multiple choice -Yes, No, I'd prefer face to face]

9. How useful did you find the videos with background information and advice eg motivation, maths homework and gender stereotypes? [1-5, 5 most useful]

10. How useful did you find the videos showing maths in different jobs? [1-5, 5 most useful]

11. How useful did you find the printable resources? [1-5, 5 most useful]

12. Can you tell me more about why these elements were useful or not? Topics? Format? Quality?

Permission was asked to contact participants again for a follow up.

Figure 19 Post-course questionnaire

7.2.3 The Longitudinal Evaluation

A further, longitudinal questionnaire (LongQ) was sent by email to participants between four and five months after they had completed the course (see Figure 17). This was intended to explore whether the content and ideas from the course had been remembered. Participants were asked to reflect again on whether their attitudes or beliefs had changed as a result of participating in the course and whether, in their view, these changes had been sustained. There were a mixture of multiple-choice and open-ended questions. The latter were designed to encourage detail, nuance, reflections and examples. As discussed in Section 4.4.5, all of these participants had agreed to being approached again and all accepted a £10 voucher for completing this questionnaire. It was anticipated that these participants, who had now been involved with the project and the researcher for some time, would want to give positive responses, motivated by the desire to please. To avoid this, questions were phrased to avoid a default to a positive answer. For example, in Question 3 there was one positive answer and three variations on a negative answer, all of which asked for more detail in a secondary question. This was intended to emphasise that all types of answer were valuable. A very definite negative, ‘I have not tried to talk to my child about how maths is used’, was included in order to make the choice of the other, more subtle, negatives, feel acceptable.

Longitudinal Questionnaire (LongQ)

1. What are the 2-3 things that have stuck in your mind most clearly from the Mathsbreak course?
2. Have you changed anything about the way you approach math homework or maths activities since participating in the course? Has this been successful?
3. Please choose the description which fits best. This will take you to a follow up question where you can explain more:

I intend to talk to my child about how maths is used in the world around them but life is busy and it doesn't come up naturally so slips my mind.

- What type of reminder or resource do you think would help get conversations started?

I have talked to my child about how maths is used in the world and they were interested.

- That's brilliant. Can you give me an example of a conversation you've had.

I have tried to engage my child in conversations about how maths is used in the world but they were not interested.

- Don't worry, this is all useful feedback. Can you give me an example of what you've tried. Do you have any ideas why it didn't engage them?

I haven't tried to talk to my child about how maths is used.

- Can you tell me why? Do you think they are too young? Is it hard to think of ways to start the conversation?

4. Do you think your views of who can be good at maths have changed? Can you explain how they have changed and what caused the changes?
5. Have you taken any of the following actions since participating in the course?

   Choose as many as you like. Feel free to use the text box below to tell me more.

   I have stopped making negative comments about my own maths ability.
   I have bought a maths related book for myself or my child.
   I have expressed more interest and/or enthusiasm for the maths my child is learning.
   I have talked to my daughter about money.
   I have praised my child for effort rather than right answers.
   I have given my child examples of how the maths they are learning could be useful in the future.
   I have drawn my child's attention to times I am using maths in my daily life.
   I have challenged a gender stereotype about maths with my child or someone else.

6. Is there anything else you'd like to tell me about the impact of the course. Or any further information about the choices above? Details, examples or anecdotes are all useful.

Figure 20 Longitudinal evaluation questionnaire

7.2.4 The Website Data

There was one further source of data related to how participants interacted with the course. The hosting platform, Teachable©, collected the following data for each participant:

- The number of times each participant logged in
- The percentage of each video that was watched on each viewing including visual mapping
- The number of times each video was played.

This allowed analysis of how many sessions each participant took to complete the course, which videos were more popular and whether individual videos held participants' attention. This data triangulated the self-report of course completion; it shows whether all sections of the course were interacted with by participants.

7.3 The Participants

Recruitment for the intervention was described in detail in Section 4.3.2. The Pre-course Questionnaire (PreQ) and the Post Course Questionnaire (PostQ) were completed by 12 people (see Figure 18). The Longitudinal Questionnaire (Long Q) was completed by 11 of these. The following analysis is based on these responses. The PreQs from participants who did not go on to complete the course have been removed from the evaluation data. There were four of these non-finishers; their interaction with the course is discussed separately.

Name (pseudonyms)	**Self-selected persona**	**Single-scale MA score**	**Age of children**
Antony	Pragmatic	3	8
Tegan	Joyful	3	3 and 6
Amanda	Coping	10	Twins 10
Maryam*	Pragmatic	6	2 and 6
Jude	Coping	8	10 and 12
Priya	Joyful	5	4, 6 and 8
Nicky	Coping	8	9
Gemma	Coping	3	9 and 11
Lucy	Joyful	3	10 and 15
Laura*	Joyful	3	9
Claire	Coping	6	4 and 6
Jess	Coping	7	8
Non-finishers			
Ross	Pragmatic	5	5
Sadie	Joyful	2	7
Victoria	Joyful	2	8
Kate	Joyful	5	8,12,14

Figure 21 Mathematical profiles of Mathsbreak participants

*Also participated in the Phase 1 interviews.

7.4 Results of the Evaluation

The findings of the three questionnaires and the course data are discussed below. The implications of these findings are discussed further in Section 8.3.

7.4.1 Findings from the Pre-course Questionnaire

The PreQ gave insight into the current experiences of participants and their hopes for the course. These are outlined below using both graphs and discussion of qualitative answers. All names in this analysis are pseudonyms.

7.4.1.1 The Current Experiences of Participants

This analysis is based on the PreQs of the 12 participants who went on to complete and evaluate the course. They were overwhelmingly female, with only one father participating (see Section 7.9 for further discussion). Their children were spread across the primary age range, with most in Key Stage 2. In the UK, Key stage 1 includes children aged 5–7; Key Stage 2, children aged 7–11; and Key Stage 3, children aged 11–14.

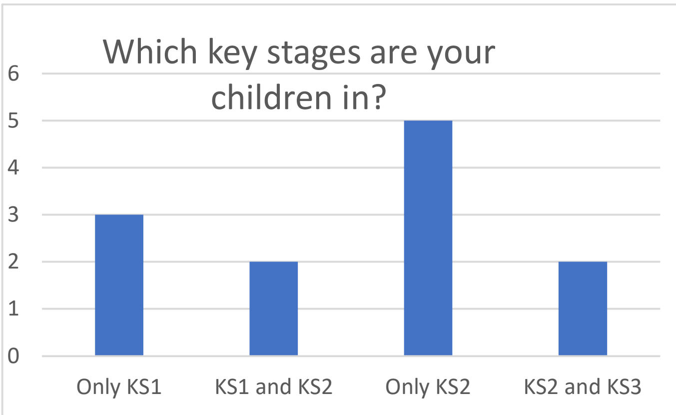


Figure 22 Key Stages of participants' children

These parents identified themselves with three of the four possible personas (see Figure 20). No one identified themselves with the most anxious persona. However, on the single-scale anxiety measure one parent did rate themselves at 10, the highest measure of MA. Seven parents rated themselves above 5 on the scale, so were to some extent anxious about mathematics. This inconsistency would suggest that the persona descriptions would need further trialling to be used in this way.

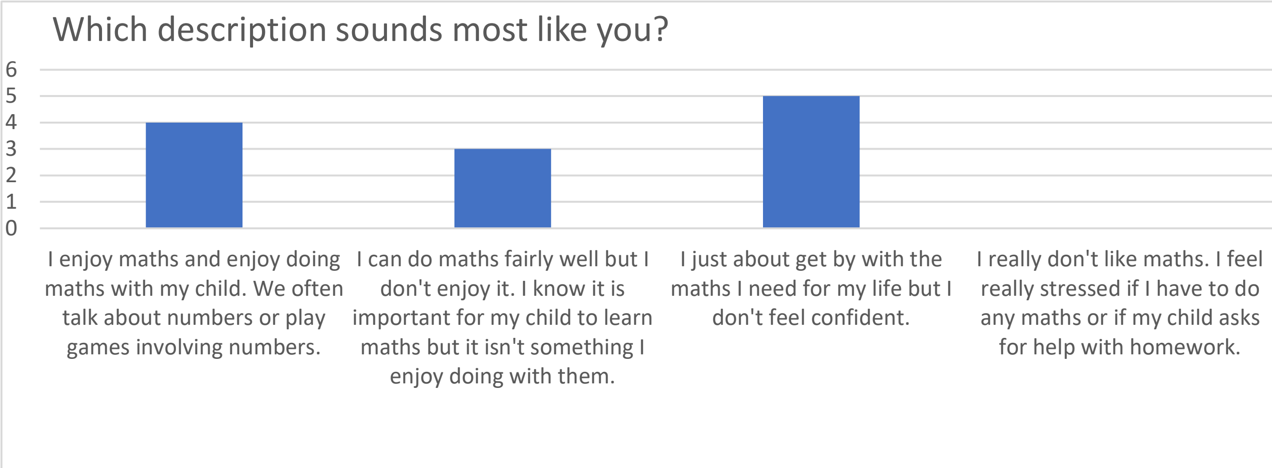


Figure 23 Self-selected personas of participants

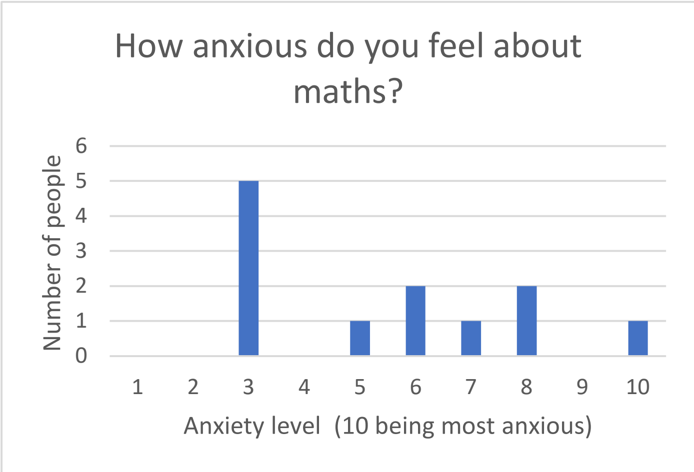


Figure 24 Self-selected anxiety levels of participants

The majority felt able to do the mathematics that their children brought home; only two had a confidence level of below 5/10, although this does need to be seen in the context of the young age of many of the children concerned. Most parents felt mathematics to be very useful to their child's future, with 10 being the most frequent usefulness score and only one placing usefulness below 5.

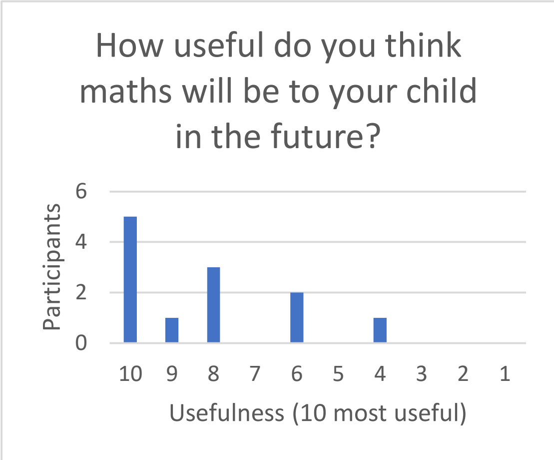


Figure 25 Participants rating of the usefulness of mathematics for their children

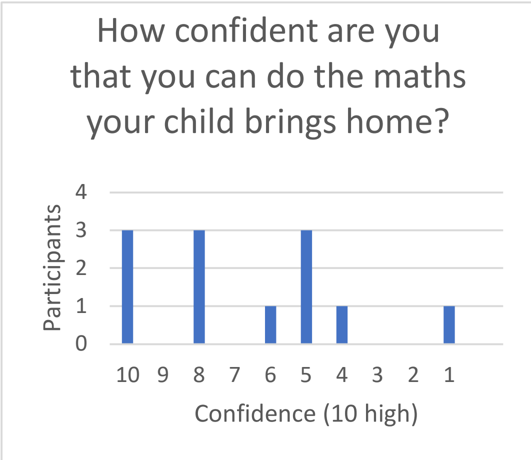


Figure 26 Participants rating of their confidence to do the mathematics their children bring home

Despite reasonable levels of confidence with the actual mathematics and the majority holding the belief that mathematics would be useful, the emotions evoked by homework present a turbulent picture. This echoes the findings of the interviews conducted in Phase 1 (Section 5.5.1) and the literature review (Section 3.3.2). The negative emotions overwhelm the positive, with a total of 27 selections of negative words compared to 4 positive words (see Figure 24). 'Frustrating' was selected by 9 out of 12 participants to describe their experience of homework.

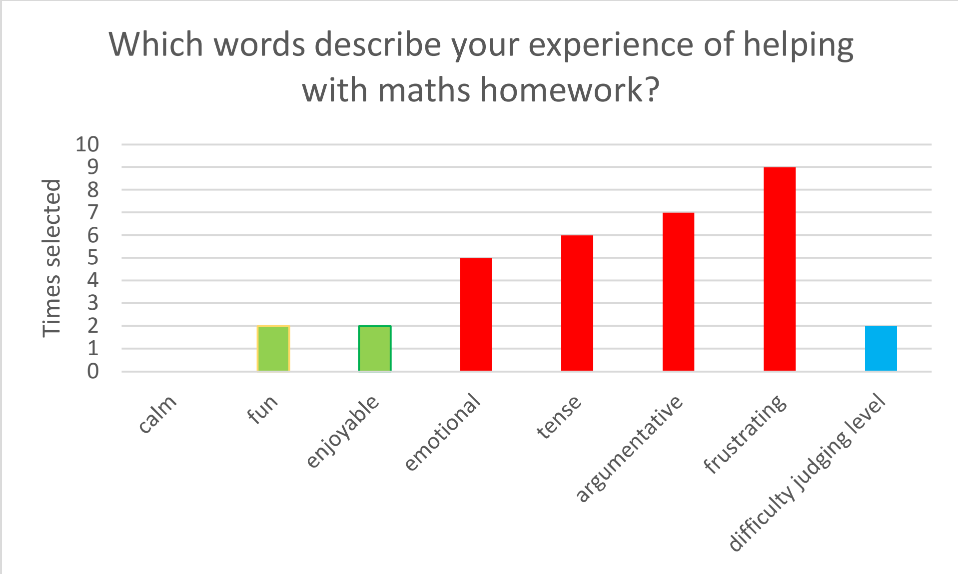


Figure 27 Words selected to describe mathematics homework

7.4.1.2 Hopes for the Course

When asked what they would like to achieve from the course, the majority of participants hoped to reduce the emotion, particularly frustration, impatience and fear, around mathematics, either their own or their child's.

> To be able to support my year 2 child who panics at new topics, getting emotional despite her actually being able to do it if she just gave it a go calmly. For me to not get frustrated with her. [Tegan, PreQ]
>
> How to lessen fear of numbers for my children. [Amanda, PreQ]

Three parents hoped to build their own confidence in supporting their children. One parent explicitly mentioned developing a growth mindset. Three wanted to make mathematics more fun and relatable for their children. Another recurring theme in these answers related to content: new methods, tips for explaining concepts and ways to judge the correct level of difficulty. This reflects the Confusion and Misunderstanding theme discussed in Section 5.5.2. Two of the participants who did not finish were also looking specifically to learn new methods and gain a better understanding of how to explain mathematics at primary level. One participant, Antony, who did complete, initially said he wanted to 'be able to support my child to enjoy, or at least not hate, maths' but reported in the final evaluation that he 'still felt at a loss as to how to help with maths homework' and 'might still struggle to explain things in the way she's taught at school'. This suggests that for some parents it is difficult to see any other way of support than becoming a more competent teacher of mathematics.

7.5 Findings Related to Course Access

There was considerable variation in the way participants accessed the course. According to the log in data, three accessed and completed the course in one session; seven completed across two sessions and the remaining two logged on three and six times respectively (see Appendix 14 for viewing data). However, one missing aspect of this data was how long a device remained ‘logged in’; it was not possible to tell whether returning to watch a video an hour later would be regarded a separate log in. There is a contradiction between the multiple sessions recorded for each video on the video-viewing data and the indication from the log-in data that most completed the course in one or two sessions, suggesting that devices remained logged in across several sessions. The video-viewing statistics suggest fragmented attention, as would be expected for parents of young children. For example, there are 20 examples of a five-minute video being watched in two or more sessions, compared to 40 examples of a video completed in one session.

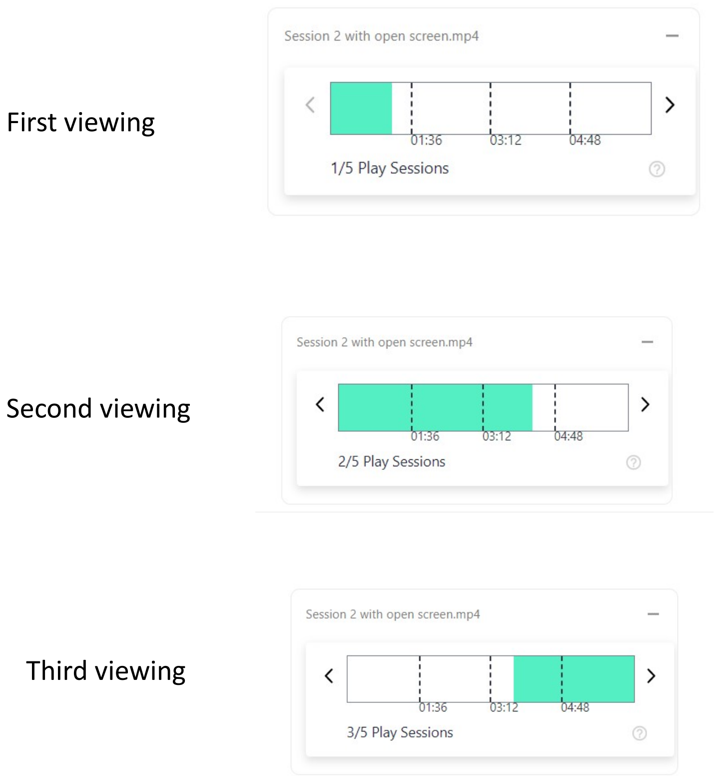


Figure 28 An example of visual mapping of video viewing

There were also 32 examples of videos that were skipped through, or partially watched. On average, a participant who completed the course watched five videos completely. Although there were 11 videos available, there were choices and the course recommended watching between six and eight. The data suggests people may have scanned videos while making a choice. It was not possible to collect data on the devices used to access the course but responses to survey questions indicated it was accessed on both phones and PCs:

> I accessed some at home on my laptop, but I also accessed it on my phone out and about, for example when I was waiting for my daughter outside gymnastics. [Gemma, PostQ]

7.6 Findings from the Evaluation Surveys

This section draws on data from the two evaluation surveys: the PostQ and the LongQ. It also uses information drawn from the PreQ to make before and after comparisons and to distinguish between groups of participants with differing dispositions towards mathematics.

7.6.1 Findings Regarding the Usefulness of the Course

All participants scored the course 6 out of 10 or above and it had an average rating of 8 out of 10 (see Figure 26). The job videos were perceived to be the most useful, with an average rating of 4.9 out of 5. This was followed by the pieces to camera (4.5 out of 5) and the printed resources (4.3 out of 5). When analysed by persona, the joyful parents found the course most useful, followed by the coping parents. The pragmatic parents found it the least useful on average (see Figure 27). When analysed by anxiety rating, there does not appear to be a relationship between this and the perceived usefulness of the course (see Figure 28).

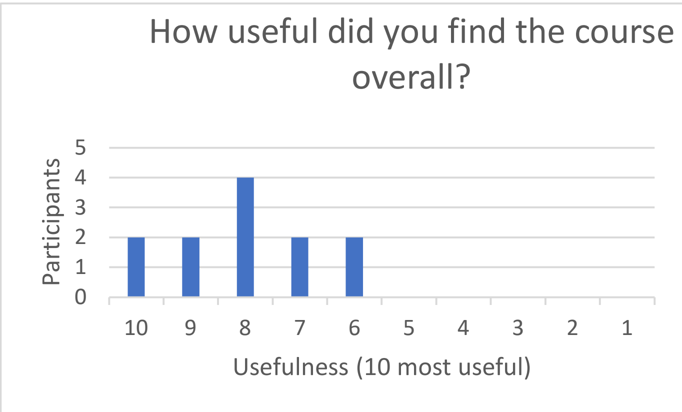


Figure 29 Course-usefulness ratings

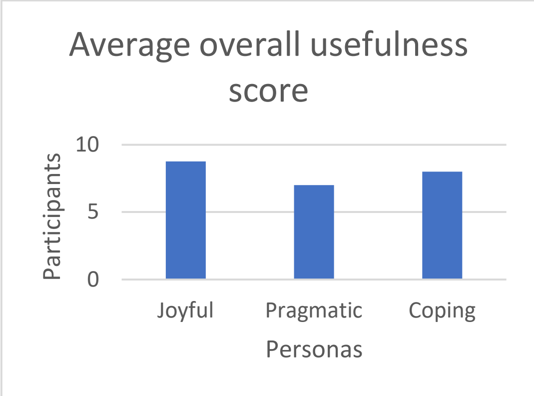


Figure 30 Course-usefulness ratings by persona

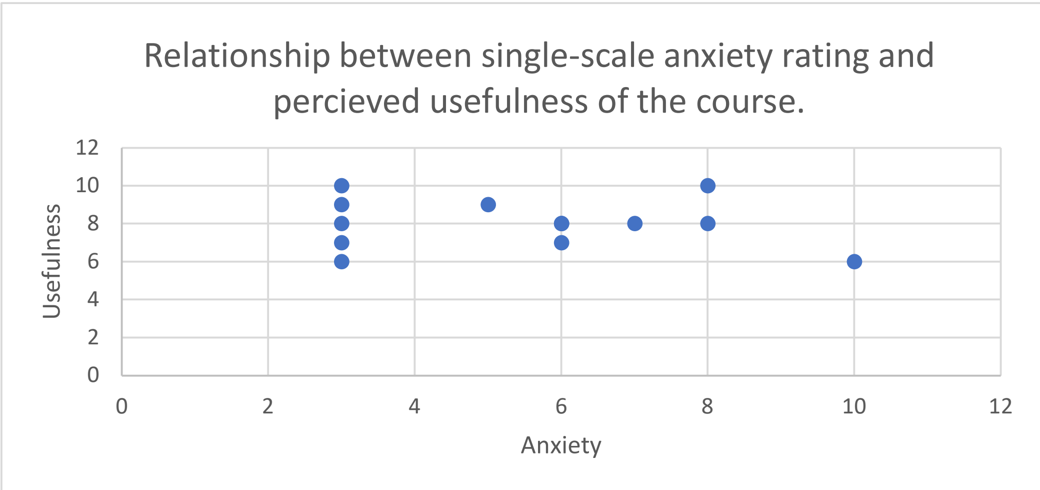


Figure 31 Graph of relationship between anxiety and perceived usefulness

<u>7.6.2 Characteristics of Participants Who Did Not Complete the Course</u>

Of the four participants who started but did not complete the course, one identified with the pragmatic persona and three with joyful, both personas with good levels of mathematical confidence. They rated themselves as 2 or 5 on the MA scale and so had either low or moderate levels of anxiety. All chose negative adjectives to describe homework: frustrating x4, emotional x2, tense x2 and argumentative x2, with one mention of 'occasional fun'.

However, all were looking for mathematical content rather than support with emotional aspects from the course:

> A better understanding of new methods. [Ross, non-finisher, PreQ]
>
> Ways to explain mathematical content. [Sadie, non-finisher, PreQ]
>
> An understanding of lower-level maths and the terms they use. [Kate, non-finisher, PreQ]
>
> Ways to meet my son at his level. [Victoria, non-finisher, PreQ]

As the course did not offer mathematical content this may explain why these participants did not complete it. As they did not perceive themselves to be anxious about mathematics, they may have felt that the messaging in the course was not applicable.

7.6.3 Key Points Recalled by Participants

There was a question on both the PostQ and the LongQ which asked participants to note the key points they had remembered from the course. The answers were coded to categories and collated on the graph below. The message that 'maths is everywhere' was recalled by the majority of participants. The other most commonly recalled ideas were that everyone can learn mathematics, adult talk influences children and that the attitude displayed by adults is key. Reference to these key messages were fairly evenly split across the two evaluation surveys. References to MA and to gender stereotypes were minimal; both were mentioned once in the PostQ and neither was mentioned in the LongQ. When responses of the same participants are compared across the two evaluation surveys, their key points are broadly similar. This graph shows specifically the aspects of the course recalled as 'key points'; it does not include references to other aspects of the course made by participants across other questions.

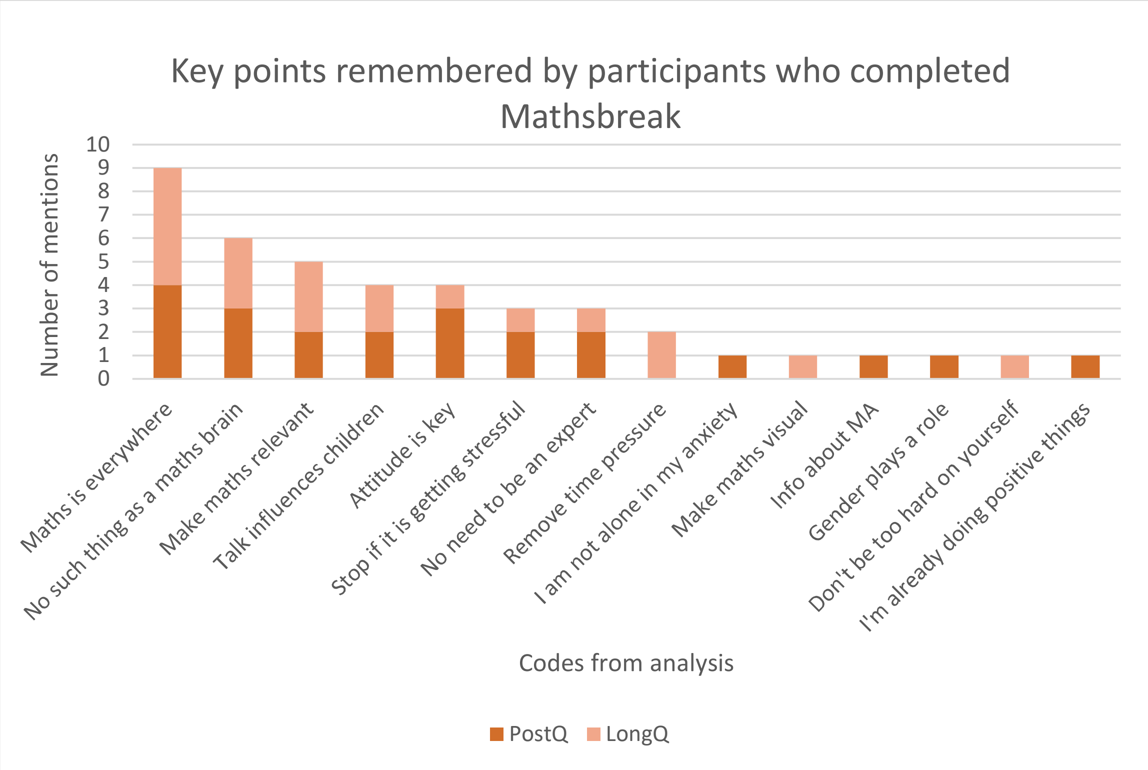


Figure 32 Key points remembered by participants who completed Mathsbreak

7.7 Thematic Analysis of the Qualitative Answers.

In order to explore the main ideas expressed in the longer-answer questions, these were collated and analysed using reflexive thematic analysis (Section 4.2.4.2). Initially all qualitative answers from both PostQ and LongQ were combined into one data set for analysis. This decision was made as the themes that were addressed across the questions were overlapping and complementary: participants chose different questions to comment on the same ideas. Excerpts from data are used in an illustrative way here (Braun and Clarke, 2022, p.136). Whilst interpretation is inevitably involved in the selection of the data and the commentary around it, the drawing of conclusions and implications will be returned to in Section 8.3.

The data was organised under six main themes:

- Seeing, valuing and highlighting the mathematics
- Examples of mathematical conversations
- Parental self-efficacy
- Subtle aspects of parenting

- Gains in knowledge
- Obstacles.

Below is the coding tree for the theme 'Subtle Aspects of Parenting' as an example:

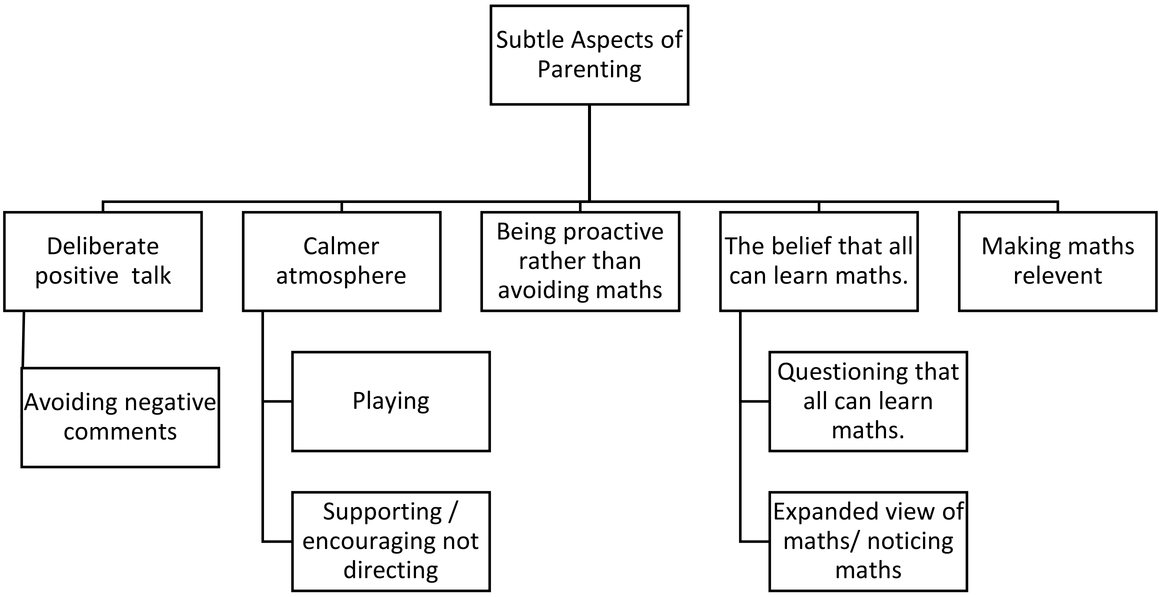


Figure 33 Coding tree for the Subtle Aspects of Parenting theme.

7.7.1 Seeing, Valuing and Highlighting the Mathematics

There were multiple references in the data to the uses of mathematics. There were several aspects to this theme; the most common included an expression of surprise over the breadth of applications of mathematics.

> I am not sure that my approach to maths itself has changed, but my perception of in how many different ways it is applied has certainly expanded. [Lucy, LongQ]
>
> This course has certainly opened my mind to how prevalent maths is. [Jess, PostQ]
>
> How it is not such a dry, uninteresting subject. How it can help in jobs that are quite artistic which was a surprise. [Claire PostQ]
>
> Maths is everywhere and we use it much more than we think! It might not be labelled as fractions or equations but the concepts are the same. The videos really brought this idea to life for me. [Jess, PostQ]

There was also an increased recognition that there was a value in pointing this mathematics out to children and raising their awareness of its applications. Nine of the eleven participants reported drawing their child's attention to the mathematics of everyday life in a multiple-choice question in LongQ. There were also a number of longer answers which support this:

> I will definitely make more tangible links for them in conversation between maths and the wider world, to make it more obvious! [Amanda, PostQ]

> The course encouraged me to be a bit more conversational about the details behind the events. I suppose basic business accounting – how much money we made and how much was profit and why. Just getting him to think about numbers in a more practical sense. [Jess, LongQ]

Several parents also mentioned engaging their children in the mathematics of everyday life, using things from around the house to illustrate homework for example, or involving them in chores:

> I have used maths when doing everyday jobs in the house i.e. cooking, weighing out dry dog food. Encouraging a knowledge that maths/numbers are everywhere, even pointing out road signs e.g. speed limits. Making numbers fun and relevant. Yes I think this has been successful. [Claire, LongQ]

A related theme included examples of how parents had engaged their children in conversations. These examples are taken from the LongQ when participants had had several months to initiate conversations with their children. The most common context for talking to children was money. Several of these examples related to letting children pay with coins for items, calculate amounts and build an understanding of cost:

> Like giving some money to my kids for paying themselves in the shop. By adding themselves. And telling how much is more money and less money. [Priya, LongQ]

> Let her pay for food in a cafe and get change. [Maryam, LongQ]

There are also examples involving more complex consideration of budgeting, saving and deferring reward. The following is a quote from Jude, a parent who described herself as very anxious (8/10) about mathematics and really lacking in confidence that she could do the mathematics her child brought home (1/10). The course persuaded her that the activities she describes below count as mathematics and that she does them regularly:

> Discussions around money are very pertinent for a 13-year-old … She is learning how long it will take to save up for something. To look for discounts and work out if something is 10% off how much it will be now. We are actually going into town today, she has a budget to buy a Christmas present for her sister, some lunch, a bubble tea and with the leftover money she can buy an item of clothing for herself. So she needs to make choices about where she will shop and how much she will spend on each item … I think it is hard for many children to see into the medium and long term about how much they could save and the benefits of it so a conversation and gentle coaching on saving can really help. [Jude, LongQ]

Aside from money, participants reported conversations across a range of contexts. Some are drawn directly from ideas presented in the videos:

> It was a tree surgeon in their grandparents' garden. We talked about the calculations they must have made for rope, angles for when the branch drops, distance and time. [Amanda, LongQ]

> When I said maths was used in football, he disagreed so I said what about the angle you shoot a goal at? And how many players his club needs to recruit and the membership fee they need to charge them to keep the club afloat. Hopefully it got him thinking! [Laura, LongQ]

However, there were multiple examples of how participants had applied the concept themselves and were drawing the mathematics out from novel situations:

> Driving with my son yesterday I asked him why he thought roundabouts were circles and would it work if they were squares? He said no because the angles would be too tight for the cars to turn properly! I'd take that as a win. [Laura, email]

> We were talking about space and how maths calculations are used to work out whether other planets are habitable or not. [Priya, LongQ]

In the multiple-choice question, 8 of 11 participants had given examples of how mathematics learning could be useful in future. The key question, which will be returned to in the following chapter, is whether these conversations have become habitual or whether they depended on the prompt of receiving requests to complete questionnaires:

> I am glad of the reminder to point out when I am using maths in my life, which I did for a short while after doing the course, but have forgotten to do since! [Lucy, LongQ]

7.7.2 Parental Self-Efficacy

Another aim of Mathsbreak was to increase parents' own sense of self-efficacy in supporting their children. The data was examined to find any evidence of changes in parents' feelings towards their own efficacy, positive or negative. This theme was created from the following four codes: being less self-critical, feeling more self-confident, feeling less alone and feeling empowered. There were no references to a loss or reduction in confidence, although if this were the case it may not have been something participants wanted to mention. There were multiple references to participants recognising the value of what they could do:

> I tend to think of maths as being beyond me but I'm probably better than I think. I feel more confident to 'own' my ability and to try to engage with harder concepts at work. [Jess, PostQ]

> I don't think my beliefs have changed. I've always felt that maths is an important part of any job/day to day life but I do feel a bit more positive about my own ability! [Amanda, PostQ]

There were also references to increased confidence in supporting mathematical exploration:

> I have however noticed (and encouraged) my toddler (3yro) learning basic maths, and have had more confidence to join him on that journey, talking about some of those early principles, i.e. is that longer or shorter, heavy or light? I hope that this will continue and set us in good stead for when he starts primary school and we can have a better conversation. [Jess, LongQ]

There was evidence that participants had realised they did not need to be so critical of themselves. There were multiple references coded as 'no need to be an expert', of which the following are indicative:

> That I don't need to know everything about maths and that's OK. Just having a positive attitude is the main thing. [Jude, PostQ]
>
> I don't beat myself up if it all goes pear shaped. Your course has helped me to chill. [Nicky, LongQ]

Some also felt the value of having the difficulties they felt recognised. This echoed a theme from the initial interviews that parents felt alone in finding mathematics homework stressful as this was not discussed either by schools or parent groups. The words parents chose to describe homework in both the interviews and the PreQ (see Sections 5.5.1 and 7.6) emphasised how common negative, stressful experiences were:

> I began the course feeling quite alone in how I felt supporting my children in their maths but have realised that I am not alone in my maths anxiety. [Amanda, PostQ]

Several parents described actions they had taken, and felt empowered to take, to improve their children's experience of mathematics. These included speaking to the school about their child's anxieties, challenging the appropriateness of the homework set and being more proactive and stepping up to support their child rather than avoiding it or leaving it to a partner. An increased recognition of the impact of MA and how it can be triggered has enabled at least one parent to have these conversations:

> I'm trying not to put any time pressure on my child (proving hard as homework is via an online platform that works against the clock) So now we do our own thing! Making it visual, especially for times tables learning. Using building blocks etc. … I have become aware of learning anxiety and spoken to my daughter's school teacher about my child's needs and why we may not always do the homework as set by the school but do it in a way that works for our daughter. [Tegan, LongQ]

There was also hope for the future: with this empowerment came the realisation that things could change and the cycle of disliking or fearing mathematics was not inevitable. In the words of one participant: 'Our own childhood experiences of maths don't have to be our children's' [Claire, LongQ]. Another felt reassured that there was a lot she was 'already doing in daily life that creates a positive atmosphere around maths for my children' [Amanda, PostQ].

7.7.3 Subtle Aspects of Parenting

This theme was created from a variety of codes that referenced the less tangible aspects of support: the belief that all could be successful, awareness of motivation, the importance of a calm, positive atmosphere and the positive framing of mathematics in conversations. These fitted under the umbrella description, discussed in Section 1.2.2, of the 'subtle aspects of parenting'. These are the 'variables that reflected a general atmosphere of involvement, such as parental expectations and parenting style' (Jeynes, 2010, p.40). There were several references to participants having changed their beliefs over who could be successful in mathematics. In many cases this was linked to an expanded view of mathematics itself.

> I suppose my views have changed. People can be good at maths in a practical and applied sense. It isn't just an academic subject. [Jess, LongQ]
>
> My views have changed definitely. To be good at maths doesn't mean that you are an expert from the get-go. It means that you have an attitude of openness and curiosity to finding things out, to giving it a go and not having to be right the first time. [Jude, LongQ]

For others, however, the belief in natural ability was more established. This father, for example, was struggling to see the growth-mindset message as anything other than a means of encouragement. One of the challenges he mentioned on the initial survey was that his daughter already had a negative view of her ability from a history of 'disliking and not understanding maths':

> I think that thinking anyone can be good at maths is helpful for building confidence when someone feels that they'll never be good at maths. I'm sure it's the case if people put the effort in. Though I still think some people are just more able to pick up the concepts quicker than others – i.e., a natural ability. [Antony, LongQ]

This may mean that the nuance of the growth-mindset message was not clearly explained; the model is not undermined by the fact that some people learn a subject more quickly and easily. There were, however, other comments suggesting some participants had gained a more open mind towards different ways to be good at mathematics:

> I don't think [my beliefs over who can be good at mathematics] have changed but I can see that just because someone's mental arithmetic may be slower, it doesn't mean they aren't capable of all maths at all. [Amanda, LongQ]

Positive talk around mathematics, or simply the avoidance of negative talk, was emphasised within the Mathsbreak course and was promoted as a small but powerful change to enact. Five of the eleven parents who completed the LongQ reported they had stopped making negative comments about their own mathematics ability. There were also multiple comments in both questionnaires citing this as an intended or actual change in behaviour:

> I won't moan about how I hated maths at school that really isn't helpful or how I am 'No good' at maths. [Jude, PostQ]
>
> I do need to be aware of how I talk about Maths in front of my child – I used to say things like 'I can't do maths' because I was anxious about trying to help my child. I can see having a more 'can do' attitude and an openness to giving it a go and not having to be an expert can help my child change their attitude to maths too. [Jude, LongQ]
>
> I was already convinced that maths was useful in everyday life, so that hasn't changed. However, I'll be more aware of how I talk about maths to my child. [Antony, PostQ]

The heightened emotions that mathematics homework evoked were strong themes in the initial interviews and the PreQ, making this a highly relevant area to address. There were multiple comments in the data about reducing the pressure or stress around mathematics activities, again either intended or actual changes in behaviour. This is potentially a more complex area to address as there are multiple triggers for both parent and child emotions and an external pressure to return homework to school (see Section 3.3.2). Participants approached calming the experience down in different ways. One approach was through emotional coaching:

> Not sure if related to the course or not, but we've taken a much calmer approach to maths – encouraging her to not get upset about not being able to do things straight away and to not be scared to admit she doesn't understand things. It's been fairly successful – she seems to have generally got over her fear of maths (or perhaps fear of failure in maths), or at least fears it less than she used to. [Anthony, LongQ]

Other parents stepped back, placing less pressure on themselves for making sure their child understood their homework, reframing their role as supporting rather than teaching:

> I have told school that I no longer scaffold for my son. I sit with him, encourage him, but in no longer do HW for him. [Nicky, LongQ]
>
> I will take the time pressure away and offer to sit quietly with them and be available to support if they ask. Encourage her to slow down and relax. [Tegan, PostQ]

There were also several accounts of parents approaching mathematical activity in a more playful, less formal way:

> I bring questions into everyday life so it's not formal or pressured. Using memory game type approaches is helping as there is no anxiety provoked in the informal approach. [Tegan, LongQ]
>
> Since starting we've already had a nice chat around Minecraft and at bedtime this evening, looked at some number quizzes in the back of a magazine, which we enjoyed doing together in a light-hearted way. [Jess, PostQ]

There were a few responses that related to motivation, to the importance of showing how the task related to the real world. One parent planned to use a more 'hands on' approach, using things around the house, such as tape measures and weighing scales, to demonstrate concepts [Claire, PostQ]. Another hoped to be 'more creative' [Lucy, LongQ] in changing the contexts of mathematics problems to interest her child. One parent saw the motivational possibilities of utility value in action when visiting secondary schools:

> I was thrilled to see what a great job one of them was doing in showing the kids how their subjects can be translated into a career – Even in year 7! Since taking the course, I am mindful of how important this approach is to motivate children through (any) subjects they struggle with. [Jess, LongQ]

7.7.4 Gains in Knowledge

This theme related to any knowledge that had been acquired from the course that was not necessarily represented by a change in behaviour or attitude. These included knowledge about MA, gender stereotypes and growth mindsets. Only two participants mentioned that they had learnt about MA from the course. As the existing knowledge of MA among those I interviewed was very minimal, this low number is likely to be because it was not a salient feature of Mathsbreak rather than because they had existing knowledge. It is likely that only those with a specific interest downloaded and read the additional information included in the printable resources. This was not problematic; whilst the overall aim of this research was to reduce the transmission of MA, the decision was made to do this indirectly, through increasing perception of utility value, rather than by increasing knowledge of MA itself.

Gender, or rather surprise at the existence of gender stereotypes related to girls and mathematics, was mentioned by three participants:

> I don't have daughters and I have only recently been made aware of the idea that girls can't be good at Maths. I have never encountered that attitude! All my Maths teachers were women! [Jess, LongQ]

Only two participants reported having challenged a gender stereotype about mathematics with their children. This lack of awareness of the existence or impact of such stereotypes echoes views expressed in the initial interviews. In contrast, analysis of the literature suggests that the subtle influence of gender-stereotypical beliefs is prevalent (Section 3.4.2.3).

One parent appreciated the signposting to more growth-mindset information

> Particularly the growth mindset information, thank you for the recommendations, I will follow them all up. My daughter struggles with this in most areas of life despite being told all her life that mistakes are good and vital for the learning process. She doesn't like to be in a position where she might not know the answer. Also the suggestions of what to say in the different situations are really helpful. 'Don't ask children to do sums on demand' - Got it! [Gemma, PostQ]

This points to the fact that participants responded to different elements of the course; salience was a result of their personal circumstances or their children's dispositions.

7.7.5 Obstacles

The final theme in this section is related to the obstacles perceived by parents: the reasons why they may not be able to support their children in the ways suggested by Mathsbreak. The most frequently mentioned obstacle was the unengaging nature of school homework and the difficulty of using this as a springboard into conversations about the uses of mathematics:

> If I'm perfectly honest I probably haven't changed a lot, mainly because the maths homework we get back from school (year 6) is a list of basic procedural sums each week and is not very engaging. I just let my son get on with it on his own as he finds it quite easy. (Laura, LongQ)

There is an intense focus on times tables in lower KS2 brought about by the introduction of the government multiplication tables check for 8- and 9-year-olds (see Section 1.4.2). Many schools use homework to prepare for these. A number of parents in both interviews and surveys mentioned online platforms or games set for practice:

> To be honest, we haven't had a lot of maths homework this term (just Times Table RockStars) [Jess, LongQ]
>
> Unfortunately my 9 yr old's homework is literally timetables every night and a few more difficult sums at the weekend but it's not very inspiring. It's difficult to explain why being able to work out 19x13 in your head is a valuable life skill! [Laura, LongQ]

The rationale for this from a school's point of view is clear: the stakes for these tests are high, times tables are a relatively straightforward aspect of mathematics to practice and parents are likely to understand them. However, the speed recall that characterises practice risks being anxiety provoking (Boaler, 2015). If this is the only mathematics parents engage with, they are likely to get a very one-dimensional view of school mathematics and of their child's interest and progress. It is also difficult to make many meaningful real-world applications for recalling tables facts at speed.

7.7.6 Did Answers to the Hypothetical Weighing Question Change between the Pre-course and the Post-course Questionnaire?

The following question appeared in both the PreQ and the PostQ:

> Imagine you are working on some homework involving weighing objects. Your child asks why they need to know this. What would you tell them?

The purpose of repeating this question was to explore whether participants' responses had changed after viewing the videos in the course – many of which referred to weighing and measuring in different contexts. The hope was that their experience of the course would enable them to give more detailed, specific examples from a greater range of contexts. However, when individual participants' responses were compared there were few noticeable differences in either context or detail in their answers:

> They need to be able to know how much of a certain ingredient they need when cooking. [Claire, PreQ]
>
> You may need to work out how much weight a surface will take. How much luggage you can take on holiday. [Claire, PostQ]

In both the PreQ and the PostQ, the majority of responses involved weighing ingredients for baking. Other topics included travel, postage and shopping. One participant had moved from a general discussion of units of measurement to a more child-specific and creative example:

> It's useful to know. Even if it seems easy in a digital world you never know when this might actually be something you need. It's a good way to get a grasp of what a gram or kilogram is. [Lucy, PreQ]
>
> Imagine we were weighing diamonds to decorate a sword. [Lucy, PostQ]

One participant saw that this question could be returned to in the context of a practical activity:

> I would suggest we did some baking together and then ask how important it was that we weigh the ingredients … I would invite discussion rather than just try and get it done. [Amanda, PostQ]

There remained in the PostQ a number of vague or general responses rather than specific applications:

People weigh items for lots of reasons. [Jess, PostQ]

It's important to know how to use measurements. [Nicky, PostQ]

This analysis could imply that whilst the concept of linking mathematical activities to real-life contexts has been embraced, the ability to apply it in different situations may need further modelling to be effective. It may, however, be that a question asked in abstract on a questionnaire would not elicit the same answer as a verbal question from a child.

7.7.7 Findings Related to the Format of the Intervention

The format of the intervention, namely a sequence of short videos accessed through an online education platform, was very positively evaluated. Eleven of the twelve participants found the length about right and one that it was too short; only one participant would have preferred a face-to-face workshop. There were no references to any difficulty accessing the course platform or using the technology. The short length of the videos was appreciated by a number of participants:

The videos were a great length, clear, welcoming and great to have the reminders. [Amanda, PostQ]

Good quality. Short impactful and relevant videos. [Jude, PostQ]

Format good – bite-sized. Too long and I may have zoned out. [Lucy, PostQ]

The animated sketches were noted as a positive feature:

The job videos were fab, really liked the little images on the side listing the maths involved!! [Amanda, PostQ]

I really like the design of the videos with the sketching hand, I found it made the videos more engaging. [Gemma, PostQ]

There were also positive comments about having a variety of expert voices included:

Was good to hear how maths is useful in different jobs from the people themselves. [Maryam, PostQ]

I found the videos really enlightening (particularly the football coach!) – hearing from an 'expert' talk in their own setting also provided more credibility. [Jess, PostQ]

Would not have talked to these professionals in my everyday life. [Claire, PostQ]

Several participants were keen to share these videos with their children:

> I thought they were a good length and even though you said they weren't made for children they might be good for Yr6 to help understand these ideas before they get fixed in their thinking at secondary school. [Jess, PostQ]
>
> I could share some of the videos with maths in them with my child to get them thinking. [Laura, PostQ]

The website data showed different levels of interaction with the different jobs (Appendix 14). The conservation video had the most views, followed by football, jewellery, veterinary medicine and music. The building and the website videos had least interaction. Only two participants specifically mentioned the printable resources. This could either be because they were seen but not considered relevant or because they were not obvious enough within the course and were missed.

7.8 To Return to the Research Questions

In this section the findings of the evaluation are considered in the light of the final two research sub-questions and the detailed analysis above is summarised.

4) What is the impact of parents' participation in a short online intervention on attitudes and opinions and the way they talk about maths to their children? Is this impact sustained over time?

Parents reported that they found the course useful (see Section 7.6.1): ratings of usefulness were similar across the different personas and did not appear connected to anxiety levels. The key messages recalled were varied but did mirror those intended in the design (see Section 7.6.3). The course fulfilled its aim of raising awareness of the utility value of mathematics: several parents expressed surprise over the breadth of applications of mathematics, particularly in creative contexts, and its prevalence. The majority of parents went on to discuss mathematics with their children, draw their attention to real-life examples and engage them in relevant mathematical activities as a result of participating in the course (Section 7.7.1).

There were a number of responses suggesting improved feelings of self-efficacy among the parents towards supporting their children (see Section 7.7.2). In terms of promoting the idea that everyone can learn mathematics, there was evidence that some parents had embraced a broader understanding of what being mathematical involved and had started to question the 'innate ability' narrative. Many of the participants reported they had stopped making negative comments about mathematics or their own ability in it. There were also a number of reported changes in the way families approached homework support in order to reduce emotion and conflict and to connect abstract tasks to a more relevant purpose (see Section

7.7.3). There was some limited evidence that participants felt their knowledge of MA, growth mindsets and the impact of gender stereotypes had improved through the course (Section 7.7.4). Improving knowledge of these areas was a supplementary aim of the course and not its key objective.

The LongQ was intended to answer the question of whether the impact outlined above had been sustained over time. When asked to recall the key messages of the course, the responses after 4–5 months were very similar to the responses immediately afterwards (Figure 29), suggesting that these were memorable and embedded. There were numerous detailed recounts of conversations parents had engaged in between the completion of the course and the LongQ, which suggests their interest and intended changes in behaviour continued (Section 7.7.1). However, one participant mentioned that it was the email with the survey that prompted them to talk to their child about the mathematics in an activity. This may not be the only example of this and it raises the question whether nudges would be required to keep changes in behaviour in the front of participants' minds or whether a change of belief is enough to trigger different responses when relevant occasions arise. Social psychological interventions are intended to act at a subconscious level, altering how people respond to particular situations rather than requiring a particular behaviour to be remembered.

The positive responses to the intervention support the numerous examples in the literature of parents' reactions to invitations to be further involved (Section 3.5.1). It underlines the evidence from both the literature review and the interviews that parents are motivated to engage more effectively but need appropriate support to do this. Very few of the reported interventions returned to participants for a longitudinal evaluation. This is one area in which this study contributes to the literature. This contribution will be considered in more detail in Section 8.4.

The final research sub-question related to the type of intervention that was trialled:

5) Is the format of the intervention enjoyable, accessible and scalable?

The format of the intervention was evaluated very positively by participants (Section 7.7.7) and the majority of people who started the course, completed it (12 out of 16). The online format was popular and it was accessed successfully on both laptops and mobile phones; there were no reported technical issues. An intervention of this format could easily be scaled to allow many more participants to access it. Whilst participants reported the videos to be of a good length, the website access data showed that many participants watched them in sections rather than all the way through. It also showed that many of the videos were skipped through (Section 7.5). The shortest video, the piece to camera about gender stereotypes, which was two minutes, had the greatest number of complete views. For future iterations of the intervention, creating videos of two minutes in length rather than five may be more effective.

7.9 Limitations of This Evaluation

The main limitation of the evaluation was the small number of participants. More secure conclusions could have been drawn from a larger set of data. The participants themselves were predominantly female: only 5 out of 33 respondents to the social media advert were male (15%) and one father completed and evaluated Mathsbreak (8%). Two reasons for this were suggested in Section 4.3.3: women were more likely to be providing homeschooling during the lockdowns and mothers were more likely to be engaged with the school-related social media platforms on which this course was advertised. There was however anecdotal evidence in the interviews that fathers routinely supported mathematics homework or stepped in when mothers felt unable to help. In future trials of the intervention, it would be valuable to advertise the course in places where more fathers would see it, or present information in person at groups aimed at fathers. Conducting a focus group, something that was impossible because of the Covid-19 restrictions at the time of the intervention design, could potentially help tune the advertising, and the intervention itself, to be more relevant to fathers. Demographic information was not collected from participants in this intervention as the total numbers were small. However, in a larger-scale study, this information would enable comparisons of engagement across different social, ethnic, age and geographical groups. One study in the literature trialled an intervention with cohorts of African American and Latino parents to compare their responses to it and allow for specific cultural adaptations (Starkey and Klein, 2000).

The methodological choice to use emailed or embedded questionnaires for evaluation had both strengths and limitations. They were easy to distribute to participants across the UK and, as they were not time consuming to complete, achieved a very good return rate. Having standard questions allowed the comparison of responses. Also, the social distance provided by an online questionnaire may have allowed more honesty and less pressure to give certain responses than an in-person interview. However, responses to questionnaires are brief; answers can be over-simplified, ambiguous or vulnerable to social desirability bias. The most this questionnaire data can capture is indications of changes in beliefs, evidence of increased knowledge and understanding and intended changes in behaviour. It would take a further, more in-depth follow up, after more time had passed, to explore whether any of the desired positive, self-reinforcing changes in behaviour have been triggered. Following up the course with evaluation interviews would have allowed a greater exploration of nuance and detail. However, these would have been more demanding for both participant and researcher and are likely to have resulted in fewer responses. An improvement to the study would be to have a greater time period before the longitudinal evaluation, for example, six months to a year after participating in the course, as this would give more time for changes in attitudes and beliefs to be embedded.

The data collected to evaluate the intervention was, with the exception of the video-viewing data, exclusively self-reported. Such data can only capture participants' views at a specific point in time and record their intentions regarding behaviour change. There was no way of triangulating this with an analysis of the actual conversations parents had with their children or any changes in the atmosphere around homework. It is difficult to see how this could be done by any other means, although there was one study (Linder and Emerson, 2019) (see Section 3.5.3), which used pre- and post-intervention videos to compare how parents interacted with their children before and after an intervention. Whilst complex, this could be interesting to explore as it could collect data on the quality and manner of interactions as well as the content.

Notably absent in this data were the voices of the children themselves; they were spoken about but not spoken to. The earliest conception of this research, before the onset of the Covid-19 pandemic, included collecting children's views of mathematics before and after their parents participated in the study. As the children involved are young, this would have been an ethically complex area of data collection, even without the closure of schools to most children. However, speaking to or surveying children could have provided a more tangible insight into the intergenerational transmission of changed attitudes and beliefs.

Despite these limitations, there is much that is useful in the evaluation data analysed above, such as parents' interest in engaging with the course, their increased awareness of the applications of mathematics and nascent feelings of self-efficacy and empowerment. In the following chapter these evaluation findings are discussed further in the context of the literature.

Chapter 8 – Discussion and Conclusion

8.1 The Content of This Chapter

This chapter concludes this research study by placing the findings in the context of the literature, drawing conclusions and making a case for contribution to the field. It is the culmination of the third phase. To summarise, in the first phase, data was collected and collated from theoretical models (see Chapter 2), there was a systematic review of the literature and analysis of previous interventions (see Chapter 3) and there were interviews with parents (see Chapter 5). In the second phase, the intervention was designed, created and trialled (see Chapter 6). In the third phase, the intervention was evaluated (see Chapter 7). In this final chapter, findings, contradictions and anomalies which arose during the study are returned to and discussed and recommendations are made for policy. The effectiveness of the chosen research methods is evaluated and possible improvements to the research design are suggested. Finally, recommendations are made for future research directions in this area.

8.2 To Return to the Purpose of the Study

To place this research in context, the overall aim was to explore whether the transmission of MA and other negative attitudes to mathematics from parents to children could be reduced through an intervention. The evidence in the literature seemed clear: improving parents' attitudes to mathematics would improve children's motivation, enjoyment and success in the subject (Section 3.4.1). The decision was made to create Mathsbreak, an online intervention for parents targeting awareness of the utility value of mathematics; the rationale for a social psychological intervention aimed at parental attitudes is described in Section 1.2. The rationale for targeting the utility value of mathematics and other supplementary beliefs is explained in Section 6.4.2. As outlined there, the Mathsbreak design was based on the hypothesis that increasing parents' awareness of the applications of mathematics in the world and also of the validity of the mathematics they themselves engaged in would persuade them that it was a useful and achievable subject for their children. In order for this key message to be effective, other unhelpful beliefs were targeted in the intervention, for example, the belief that ability was innate and only some people would ever be good at mathematics or that boys were more interested than girls. It also presented information about the extent to which parental attitudes influence children and advice on how to reduce the emotion and conflict involved in mathematics homework. It was hoped that participation in Mathsbreak would instigate a positive, self-reinforcing change in behaviour: the more parents became aware of the ubiquity of mathematics, the more they would believe it was valuable and the more they would communicate this value to their children in their words and actions (See section 6.6.4 for the Theory of Change). Measuring the extent to which the intervention initiated this positive spiral was deemed beyond the scope of resources and time in this study. Instead, the evaluation was framed around a more open question:

> What are the effects of a brief, social psychological intervention on the beliefs, attitudes and opinions parents hold about mathematics and the way they talk about it to their children?

The aim was to explore the effects of participation, intended and unintended, to determine whether there was any evidence that it led to changes in beliefs or behaviours that could contribute to the positive chain of events outlined above.

8.3 Conclusion

This study found that an online intervention that aimed to raise awareness of the utility value of mathematics was welcomed by parents and responded to positively. The evidence of engagement from the website data, along with the reports of usefulness from the evaluation data, confirmed this could be an effective means of intervening. The responses to the evaluation questionnaires revealed that many of the parents were unaware of the ideas about mathematics the intervention contained. It also extended their knowledge of practical applications and facilitated their recognition of the mathematics they already did. Parents' responses showed they had gained awareness of their own influence on their children's attitudes and had realised that the way they spoke about mathematics and the way they acted during mathematical activities was important. The evaluations recorded intentions to change behaviour, for example, refraining from negative or defensive comments or reducing the conflict when supporting homework. A number of comments from parents also indicated increased self-efficacy and empowerment when supporting mathematics and working with schools. There is less evidence that parents had changed their views on the innate nature of mathematical ability; this view represents a complex set of assumptions and beliefs that are ingrained in British society and therefore likely to take more than a short intervention to change. It is hoped, however, that the course raised awareness of the damage that comments like 'I just don't have a maths brain' can do to children's motivation. This could be one step in the process of challenging prevalent social messaging. Similarly, the evidence on changes of view in relation to gender was limited. As many participants had not previously noticed a gendered social dynamic to mathematics, it would be beyond the scope of this brief intervention to create awareness and change beliefs.

A number of participants did record an intention to change the dynamic around homework in the evaluation questionnaires. Several did, however, comment that their intentions to make changes to the way they supported their children with homework, or their attempts to discuss the practical applications of tasks, were often hampered by the nature of the homework their children received: ‘It’s difficult to explain why being able to work out 19x13 in your head is a valuable life skill!’ [Laura, LongQ]. This is a reminder of the interconnected role of parents, schools and children and this tension is discussed in Section 8.5.

Although it would be difficult to establish evidence of lasting changes in beliefs or attitudes in the available timescale, the longitudinal evaluation did confirm that the key messages of the course had been remembered several months later. The questionnaire responses contained numerous and varied examples of conversations with children that had happened since completing the course, indicating that the suggestions in the course had been acted upon through that period. This exploratory study replicated many of the findings from the literature: it showed that parents were motivated to support their children; that many did not feel confident in their ability to help with homework and this provoked stress, anxiety and frustration; that they were confused over the role they should take in supporting their children or how they should manage their children’s emotional responses. The study also confirmed there were still prevailing negative attitudes to mathematics and widespread belief that success was due to innate ability. It showed that many parents were not aware of the applications of the mathematics their children were learning and did not acknowledge the validity of the mathematics they did routinely.

Many social psychological interventions in the literature report a ‘Robin Hood’ effect (Section 3.5.4): that those with fewest resources gain most. It was expected that this intervention would benefit anxious parents most. This did not appear to be the case in this study as there was not a relationship between anxiety levels and perceived usefulness. However, this is a complex area to quantify as different parents may have understood different elements to be useful; parents more familiar with the key ideas may have recognised the benefit of other information. There were also not enough participants to enable a statistical analysis that might reveal such a pattern.

8.4 Contribution to Knowledge

This study contributes a novel intervention to the field and a longitudinal evaluation of it indicates that it has potential to lead to changes in attitudes, beliefs and behaviours. The intervention design process was also original and could be replicated.

8.4.1 The UV Intervention

This small-scale trial demonstrated that parents were interested by, and motivated to participate in, an intervention focussed on the utility value of mathematics. They found the information and ideas it offered new and valuable. The evaluation showed evidence that participation in this intervention led to the intended changes in behaviours, beliefs and attitudes, as described in the Theory of Change (See Section 4.2.3.2). Participation in the intervention is therefore likely to gradually reduce the levels of MA transmitted to children. To add to this, this research demonstrated that such an intervention could be delivered effectively online and would therefore be scalable at minimal cost. It is therefore a powerful contribution to the literature on parental engagement in mathematics.

Whilst there were many examples of both utility-value interventions and digital interventions in the literature, Mathsbreak combined these elements in a unique way. There are no other accounts of digital interventions which directly target parents' beliefs about the utility value of mathematics. Mathsbreak was designed to circumvent the limitations of other interventions. Firstly, it was brief so that it did not demand a significant commitment from busy parents. Secondly, it did not need the intense professional support that other interventions demanded, which made them difficult to replicate outside the research environment. Thirdly, it was digital; participants could access it from home and there were almost no costs involved in distribution. The evaluation of the study went further than many previous studies in that it had a longitudinal element; this allowed participants to report changes to their attitudes and behaviour that had occurred over a period of several months. It is acknowledged that this research was on a small scale and would need trialling with a larger, more diverse group of participants to confirm findings. However, it was intended to be exploratory rather than conclusive and it does provide clear evidence that this would be an area worthy of further research.

8.4.2 The Intervention Design Process

The process of designing the intervention in three phases was also novel. The inclusion of an extensive initial phase of the study, including primary and secondary data, confirmed the need for this type of intervention. It also ensured that the content and design were based on a deep understanding of the contemporary context. The use of personas to facilitate the design process was also novel. These allowed a direct line to be drawn between the initial interviews, the design process and intervention participants. Whilst the use of personas had some limitations in this context (See Section 7.4.1.1), it enabled useful insights into the experiences of different users. In summary, this phased design process could be replicated to create and evaluate other interventions with different foci and the use of personas could be developed further.

8.5 Limitations of This Study and What Could Be Done Differently

The key limitations of the study, the small number of participants and the fact that they were mostly female, are discussed in Section 7.9. There are a number of other elements of the intervention and of the study as a whole which could be improved.

In terms of Mathsbreak itself, the video clips could be shorter and more focussed. The data from the online platform revealed that many of the five-minute videos were watched in shorter sections, but the two-minute videos were watched in their entirety (see Section 7.5). Also, the access process could be streamlined for users to avoid the multiple steps and the problem of lost passwords. A technology known as one-time-use link, would allow parents to click straight through to the course from a reminder email. There are a number of potential improvements to the Mathsbreak course which would make it more accessible. These were beyond the scope of this single-researcher, exploratory study but could be included if it was trialled on a larger scale. For example, including subtitles on the videos would make them accessible to those with hearing difficulties or those for whom English is not their first language. Including audio narration would aid understanding for people who are blind or partially sighted. The number of videos showcasing the mathematics in jobs could be increased to allow greater choice and a greater diversity of role models across class, geography and ethnicity. The current set of videos reflected the social network of a middle-class researcher living in the south of England. Finally, the marketing of the intervention would need further consideration. The interviews and pre-course questionnaires revealed that many parents believed that improving their own mathematical skills and knowledge of current teaching methods was the only way they could support their children better. It was therefore difficult to explain what an intervention which explicitly did not do this could offer. One way to avoid this problem for future iterations would be to launch the course in collaboration with schools, who could use their relationship with parents to encourage participation.

In terms of the research design, the main limitations of the study were its small scale and that it was conducted by a single researcher. My own identity, elaborated in Sections 1.6 and 4.5, inevitably influenced the entire study – from conception, to design, to data collection and analysis to evaluation. The details of the Mathsbreak study were devised by me; I was on screen myself, speaking words that I had written. Other contributors to the content were drawn from my own family and friends. Every effort was made to hold in mind my positionality whilst analysing and describing the data. Figure 34 below outlines the actions taken to ensure reflexivity was maintained.

Stage of the Study	Action Taken
Phase 1	• The use of a mapping tool to elucidate my own positionality in order to reflect on it. (Jacobson and Mustafa, 2019) (See section 4.5) • Consideration of the power imbalance between the parent being interviewed and myself as a researcher. Planning how to introduce myself and piloting questions with parents outside the study in order to discuss their reactions. • Writing down my expectations before interviewing to avoid 'overweighting' responses that conformed to them. • Consideration of the 'rapport' after each interview. Noting my own responses to the participants and how that may influence my interpretation of the data (see section 5.3.2) • Continuing to code every line of the interview transcripts to avoid cherry picking elements that caught my attention (see section 5.2.1)
Phase 2	• Discussing with the creators of each video where **they** saw the mathematics in their jobs to ensure views other than mine were included. • Including, as far as was possible with limited resources, diverse jobs in the videos. • Asking people of different ages and education levels to read recruitment materials and listen to the videos and give feedback on both content and tone.

Phase 3	• In writing up the evaluation, extensive quotation of participants voices, before framing in my own analysis. • Discussion of the evaluation data with supervisors to gain a diversity of perspective.

Figure 34 Examples of actions taken to maintain reflexivity.

However, despite these actions, there is no doubt that a study involving multiple researchers would be able to draw more robust conclusions. Recruiting co-researchers who had themselves experienced anxiety about mathematics or were of different socioeconomic backgrounds or ethnicities would enable different conversations with participants and a richer understanding of the data itself.

8.6 Policy Recommendations

The study demonstrated that an online intervention for parents was effective and that there would be value in a larger-scale trial. The discussion above describes how the course itself could be improved to make it even more effective. However, in terms of education policy, there are wider implications from this study than recommending a course for parents. The messages on which the course was based would be far more effectively disseminated by schools themselves, particularly if they were proactive in doing so and if the principles outlined in the course underpinned their own messaging to parents about mathematics.

8.6.1 Policy Recommendation 1 – Talk about Mathematics Anxiety

MA is evidently widespread (Section 2.1). The first policy recommendation is that schools acknowledge MA, make it a priority in their approach to mathematics and talk about it directly with both parents and children. I would recommend they adopt the bio-psycho-social model of MA, introduced in Section 2.1.6, rather than relying exclusively on the deficit model advocated by Ofsted. Unfortunately, recent advice to schools does nothing to support this view and instead breezes past this complex area with the claim that better teaching of foundational skills would resolve MA in pupils, who 'will then begin to associate the subject with enjoyment and motivation' (Ofsted, 2021, p.11). Instead, children should be encouraged to discuss their feelings about mathematics and offered some autonomy to choose ways of working that suit them best. The potential impact of different teaching strategies on anxious students should be taken into account when planning lessons and activities. I am not recommending reducing the mathematical content taught to anxious children, but I am advocating giving children choices whether to engage in activities that may induce anxiety, such as timed or competitive activities and public performance. This approach should also be applied to parents and any events should be planned with highly anxious parents in mind, to avoid alienating them further and preventing them from engaging.

8.6.2 Policy Recommendation 2 – Positive Homework Practices

This study provided clear evidence that the current homework practices are not effective for many families. This was evidenced by responses in the initial interviews and the pre-course survey, which recorded 'frustrating' as the most common emotion associated with mathematics homework (Section 7.4.1.1). This confirmed multiple other studies reporting the negative effects of certain types of mathematics homework (Section 3.2). The common practice of setting calculations for homework is problematic in many respects. Firstly, parents are not likely to be confident with the methods children have been taught and may not be able to help them. This creates frustration and conflict and results in homework becoming fertile ground for passing on negative, anxious attitudes. Secondly, tasks of this type advance a view of mathematics as an abstract, calculation-based subject with clear right and wrong answers, as does the ubiquitous use of homework to encourage times tables practice. This practice has been exacerbated by the recently introduced multiplication tables check for 9-year-olds (Section 1.4.2) and risks promoting the idea that mathematics is about recalling facts quickly under pressure. Boaler (2015) is particularly critical of this view of mathematics, which she argues can diminish the confidence and motivation of children whose strengths may lie in other areas of mathematics. She argues that memorizing facts encourages shallow learning and can have debilitating consequences for students who may think deeply but work slowly (Boaler, 2018).

Neither of these types of homework takes advantage of the areas where parents could make a unique contribution: they have knowledge of their child, their interests and experiences and also knowledge of the wider world. Also, however limited their time is, they have more capacity for individual conversations than a teacher with a class of 30 children. It would seem far more effective to take advantage of this than asking them to support homework that results in defensive, stressed and frustrating interactions. The second policy recommendation is that schools set genuinely collaborative, open-ended and discussion-based homework that focusses on the utility value of mathematics. Homework that connects mathematics to the wider world would allow parents to contribute their own knowledge and experience, whatever their levels of mathematical competence. Homework tasks with clear instructions, examples, open-ended tasks and multiple ways to engage, depending on available time and resources, would remove some of the conflict and anxiety of more traditional homework.

This recommendation is supported in the literature, with numerous writers arguing that parents need both tools and support to work positively with their children (DiStefano *et al.*, 2020; Mohr-Schroeder *et al.*, 2017; Maloney *et al.*, 2015). The more approachable and relevant mathematics appears, the more children and parents are likely to engage with it positively.

8.6.3 Policy Recommendation 3 – Integrate Applications of Mathematics into Teaching

This focus on the applications of mathematics need not be confined to homework. There would be clear motivational benefits to integrating the utility value of mathematics into the teaching of the subject itself. If lessons routinely linked the mathematics being learnt with its practical application and children saw that people in many different professions used it confidently, it would increase both the belief that it was valuable and the belief that all could learn it; these beliefs, as Eccles (1983) argues, are key components of motivation.

8.6.4 Policy Recommendation 4 – Training for Teachers on Working with Parents

The experiences of homework described in this study are, it is assumed, far from the intentions of the teachers which set it. There appears to be a gulf of understanding between school and home. Teachers, it appears, are unaware of quite how anxiety-invoking homework can be and the extent of the emotion, confusion and conflict it can invoke. To return to my own experience, as a teacher I thought the tasks I set were straightforward, clear and self-evidently useful. As a parent with access to the WhatsApp communications of a class group, I can see the uncertainty, frustration and sheer exasperation circulating first hand. The fourth policy recommendation is therefore to increase training for teachers in this area. This could include raising awareness of the issues by organising focus groups within individual schools to discuss homework experiences.

8.7 Future Directions

This exploratory study demonstrated the potential effectiveness of this type of intervention. There are a number of different ways this study could be extended. Firstly, this brief, social psychological intervention could be trialled more extensively to test its effectiveness. Ideally, this would involve a larger number of participants from more diverse backgrounds and communities. To draw more secure conclusions, the longitudinal evaluation could be more in depth and conducted after a longer period of time. There may be an argument for involving children in the study, speaking to them or surveying them about their views of mathematics at the beginning of the study and then again after a year to see if any impact had been transmitted between generations. Although it would be complex to design, the impact of an intervention such as this on the intergenerational transmission of MA could be established by a randomised, controlled trial. This could compare the attitudes and attainment of children at the end of primary school taking into consideration whether their parents participated in the course as they began school. If conducted on a large enough scale, a randomised, controlled trial could control for other factors that influence attainment and attitudes, such as socio-economic status or parental education.

Another possibility would be to design a more conventional course, releasing regular videos, which could potentially be combined with activities to follow up with children, over a longer period of time. This would provide the 'nudge' to keep these ideas in the front of parents' minds and explicit instructions about how to put them into practice. This type of course has precedents in the literature, with the mathematics app reported by Schaeffer *et al.* (2018) or the texts to parents reported by Paz (2019). Although a course of this type could be hosted online, and would therefore be scalable, it would involve a far greater level of ongoing commitment from parents. This returns the discussion to the point made above, that material of this type would be far more effectively delivered through schools as they already have the relationships with families and are well placed to encourage and support participation.

8.8 Closing Comments

Although a small-scale study, it is hoped that the evidence collected here, from both literature and empirical research, will contribute to the debate on improving attitudes to mathematics. It is hoped that the ideas germinated here could be taken further and acted upon and that it adds a voice to the call for change in our approach to mathematics education.

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