THE DEVELOPMENT OF THE NUMERACY APPREHENSION SCALE FOR CHILDREN AGED 4-7 YEARS:

QUALITATIVE EXPLORATION OF ASSOCIATED FACTORS AND QUANTITATIVE TESTING

Dominic Petronzi

Doctor of Philosophy 2016
ABSTRACT .................................................................................................................................................. 10

ACKNOWLEDGEMENTS ............................................................................................................................. 12

CHAPTER ONE .............................................................................................................................................. 14

1 Research introduction .................................................................................................................................. 14

1.1 Mathematics education: The origins of anxiety? ...................................................................................... 15

1.2 What is meant by mathematics anxiety? .................................................................................................... 16

1.3 Mathematics anxiety and its development .............................................................................................. 17

1.4 Mathematics anxiety in older populations: progress with limitations .................................................... 20

1.5 The relationship between mathematics performance and mathematics anxiety ....................................... 22

1.6 The cognitive processes underpinning mathematics anxiety and performance consequences ............. 25

1.6.1 Working memory .................................................................................................................................. 29

1.7 Factors associated with children’s mathematics anxiety ........................................................................... 33

1.7.1 The influence of teachers and parents .................................................................................................. 41

1.8 Mathematics Anxiety Rating Scales: a traditional research method ......................................................... 45

1.8.1 The origins of quantifying mathematics anxiety ................................................................................... 46

1.8.2 Mathematics anxiety scales: revisions, developments and factor structures ....................................... 48

1.8.3 Limitations of mathematics anxiety measures ....................................................................................... 56

1.9 Chapter Summary .................................................................................................................................... 58

1.10 Emerging research: a shift towards exploring anxiety in the early years ................................................. 65

1.10.1 Parental influence and mathematics achievement ............................................................................... 65

1.10.2 Anxiety, achievement and brain mechanisms ...................................................................................... 67

1.10.3 Teacher anxiety .................................................................................................................................. 70

CHAPTER TWO ........................................................................................................................................... 72

2 Exploring the factors contributing to the development of numeracy apprehension in young children ... 72

2.1 Introduction ............................................................................................................................................... 72

2.3.1 Exploring numeracy attitudes through discussions .............................................................................. 75

2.4 Theme 1: responses to numeracy ............................................................................................................. 75

2.4.2 Positive: perceptions of high ability ...................................................................................................... 76
3.4.5 Data Collection........................................................................................................... 106
3.4.6 Transcription............................................................................................................... 107
3.4.7 Analysis ..................................................................................................................... 107
3.4.8 Ethical Considerations............................................................................................... 108
3.5 Results .......................................................................................................................... 110
3.5.1 Thematic Maps ......................................................................................................... 112
3.6 Mathematics experts ................................................................................................... 116
3.6.1 Pressure and numeracy in public ............................................................................. 116
3.6.2 Difficulty of numeracy ............................................................................................ 117
3.6.3 Influence of teachers (negative) ............................................................................... 119
3.6.4 Influence of teachers (positive) ............................................................................... 120
3.6.5 Low sense of ability ............................................................................................... 122
3.6.6 High sense of ability ............................................................................................. 123
3.6.7 Influence of parents (negative) ............................................................................... 124
3.6.8 Influence of parents (positive) ............................................................................... 126
3.6.9 Comparison/Competition ....................................................................................... 127
3.6.10 Fear/Anxiety .......................................................................................................... 129
3.6.11 Avoidance .............................................................................................................. 130
3.6.12 Awareness of a hierarchy ...................................................................................... 132
3.6.13 Mathematics expert thematic maps: Figure 3.2 .................................................... 134
3.7.1 Influence of primary adults - parents .................................................................... 136
3.7.2 Facilitate learning ................................................................................................... 137
3.7.3 Areas of concern .................................................................................................... 139
3.7.5 Positive Aspects ..................................................................................................... 142
3.7.6 Negative aspects ................................................................................................... 143
3.7.7 Comparison/competition and an awareness of a hierarchy ................................ 147
3.7.9 Stigma .................................................................................................................... 150
3.7.10 Difficulty ................................................................................................................ 151
3.7.11 Avoidance ............................................................................................................ 153
3.7.12   Failure in numeracy ........................................................................................................ 155
3.7.13   Parents thematic maps: Figure 3.3 .................................................................................. 156
3.8.1    Influence of primary adults - parents .............................................................................. 158
3.8.2    Teachers .......................................................................................................................... 160
3.8.3    Anxiety ............................................................................................................................. 162
3.8.4    Difficulty .......................................................................................................................... 164
3.8.5    Negative aspects .............................................................................................................. 166
3.8.6    Teachers thematic map: Figure 3.4 .................................................................................. 168
3.9.1    Introspective ..................................................................................................................... 170
3.9.2    Methodological: discussions and analysis ...................................................................... 172
3.9.3    Epistemological: researcher approach to understanding numeracy attitudes ............... 175

CHAPTER FOUR ...................................................................................................................... 186
4 Development of the numeracy apprehension rating scale ...................................................... 186
  4.1   Introduction ......................................................................................................................... 186
  4.2   Summary and outline of study 2 ......................................................................................... 186
  4.3.1  Design ............................................................................................................................... 188
  4.3.2  Participants ....................................................................................................................... 188
  4.3.3  Materials .......................................................................................................................... 189
  4.3.4  The Numeracy Apprehension Scale ................................................................................ 189
  4.3.5  Item Redundancy of the NAS .......................................................................................... 190
  4.3.6  Research Procedure ....................................................................................................... 191
  4.3.7  Ethical Consideration ...................................................................................................... 192
  4.3.8  Analysis ............................................................................................................................. 192

Table 4.1 - Summary of the participant demographics from study 2 for each school ............... 193

4.5   The 44-item NAS ................................................................................................................ 193
4.6   Discussion ............................................................................................................................. 199

CHAPTER FIVE ....................................................................................................................... 205
5 Further development of the numeracy apprehension scale ................................................ 205
  5.1   Introduction ......................................................................................................................... 205
6.2 Synthesis of the three studies.................................................................................................................................. 241
6.3 Numeracy apprehension: support for a foundation phase of mathematics anxiety ........................................... 242
6.4 Socio-economic status, culture and other forms of anxiety ............................................................................... 245
6.5 Research limitations and future directions .................................................................................................... 247

REFERENCES ......................................................................................................................................................... 251
FIGURES AND TABLES

Figure 1.1  The cyclic process of mathematics anxiety and mathematics performance.

Figure 3.1  Thematic map extract.
Figure 3.2  Thematic map – mathematics experts.
Figure 3.3  Thematic map – parents.
Figure 3.4  Thematic map – teachers.
Figure 5.1  Correlation graph between numeracy problem scores and the NAS.
Figure 5.2  Histogram – standardised residuals.
Figure 5.3  P-P plot - standardised residuals.
Figure 5.4  Scatterplot – standardised predicted values.
Figure 5.5  Curve fit numeracy performance scores and numeracy apprehension rating scale scores.

Table 4.1  Participant demographics for study 2.
Table 4.2  Factor loadings of items (2 factors) for the numeracy apprehension rating scale (.35) in study 2.
Table 5.1  Participant demographics for study 3.
Table 5.2  Single factor loadings of items for the numeracy apprehension rating scale (.35) for study 3.
Table 5.3  Factor loadings for the numeracy apprehension rating scale (.40) for study 3.
Table 5.4  Correlations and significance values for numeracy performance, age and gender with numeracy apprehension, in study 3.
Table 5.5  Means and standard deviations for age and gender in comparison to numeracy apprehension scores (19-items) in study 3.
Table 5.6  Means and standard deviations for age and gender in comparison to numeracy performance scores (%) in study 3.
Table 5.7  Comparison between the items maintained for the two factors maintained in study 2 and the single factor in study 3.
DECLARATION

I hereby declare that this PhD thesis has been composed by myself and the work conducted is my own. All research within this body of work obtained ethical approval by the University of Derby Ethics Committee.

Signed:

Dominic Petronzi
ABSTRACT

Previous psychological literature has shown mathematics anxiety in older populations to have an association with many factors, including an adverse effect on task performance. However, the origins of mathematics anxiety have, until recently, received limited attention. It is now accepted that this anxiety is rooted within the early educational years, but research has not explored the associated factors in the first formal years of schooling. Based on previous focus groups with children aged 4-7 years, ‘numeracy apprehension’ is suggested in this body of work, as the foundation phase of negative emotions and experiences, in which mathematics anxiety can develop.

Building on this research, the first piece of research utilized 2 interviews and 5 focus groups to obtain insight from parents (n=7), teachers (n=9) and mathematics experts (n=2), to explore how children experience numeracy and their observations of children’s attitudes and responses. Thematic and content analysis uncovered a range of factors that characterised children’s numeracy experiences. These included: stigma and peer comparisons; the difficulty of numeracy and persistent failure; a low sense of ability; feelings of inadequacy; peer evaluation; transference of teacher anxieties; the right or wrong nature of numeracy; parental influences; dependence on peers; avoidance and children being aware of a hierarchy based on numeracy performance. Key themes reflected the focus group findings of children aged 4-7 years. This contributed to an item pool for study 2, to produce a first iteration of the Numeracy Apprehension Scale (NAS) that described day-to-day numeracy lesson situations. This 44-item measure was implemented with 307 children aged 4-7 years, across 4 schools in the U.K. Exploratory factor analysis led to a 26-item iteration of the NAS, with a 2-factor structure of Prospective Numeracy Task Apprehension and On-line Number Apprehension, which related to, for example, observation and evaluation anxiety, worry and teacher anxiety. The results suggested that mathematics anxiety may stem from the initial development of numeracy apprehension and is based on consistent negative experiences throughout an educational career. The 26-item iteration of the NAS was further validated in study 3 with 163 children aged 4-7 years, across 2 schools in the U.K. The construct validity of the scale was tested by comparing scale scores against numeracy performance on a numeracy task to determine whether a relationship between scale and numeracy task scores was evident. Exploratory factor analysis was again conducted and resulted in the current 19-item iteration of the NAS that related to a single factor of On-line Number Apprehension. This related to the experience of an entire numeracy lesson, from first walking in to completing a task and was associated with, for example, explaining an answer to the teacher, making mistakes and getting work wrong. A significant negative correlation was observed between the NAS and numeracy performance scores, suggesting that apprehensive
children demonstrate a performance deficit early in education and that the NAS has the potential to be a reliable assessment of children’s numeracy apprehension. This empirical reinforces that the early years of education are the origins of mathematics anxiety, in the form of numeracy apprehension.
ACKNOWLEDGEMENTS

First and foremost, I offer gratitude to my supervisors, Paul Staples, David Sheffield and Sandra Fitton-Wilde for their support, guidance and patience throughout my thesis – it has been a journey filled with lessons and experiences, and I could not have chosen a better team to be a part of in order to achieve this goal.

I further acknowledge and thank all those who participated in this research and for providing the foundations of knowledge.

To put it simply, I would not have written this thesis without my parents, Giuseppe and Marcella. The following words pale into insignificance as words cannot describe just how much my parents have done for me – but here’s my attempt. Their contribution has been life-long. Everything I am and achieve is a result of their love, guidance, support and sacrifice and I thank them from the very depths of my heart and with all my love. A PhD is an emotional rollercoaster, and they have had front row tickets and been there with me through all of the ups and the downs. Yet, they were by my side throughout and picked me up when I needed it most. They have always encouraged me, and I thank them for providing a caring home for me to write this thesis. I would further like to thank my mother for keeping the fridge full and contributing to the maintenance of my health throughout this PhD and my father for standing in the rain on many occasions to maintain the health of my car – of which I would have been lost without. I would also like to thank my brother, Mario, and sisters, Pasqualina and Bianca, for always raising my spirits and being a huge part of the person I am today. I love you all.

A special mention goes to my Grandma, Anna, who passed during the completion of this PhD, but who too provided me with a loving home to work on this thesis and who always kept the coffee flowing.

I would also like to thank my good friend Michael, who started his PhD at the same time and who has always been a bright light in the office, particularly during the difficult times. I also owe a tremendous amount to my friend James - he has been a huge support in life and has always reminded me of the lighter side of life…and of the world outside the office.

There have been many others who have influenced my life and supported me throughout all my endeavours that have led to this point. To them, I also say a heartfelt thank you.
Finally, there’s Becky, whom I met during the final stages of completing this PhD thesis. As one era ends, another begins, and as the chapters of this thesis close, I look forward to the chapters we will write together in life.
CHAPTER ONE

1 Research introduction

The main body of this PhD thesis relates to mathematics anxiety, with a focus on children aged 4-7 years. This PhD thesis also draws upon the author’s previous qualitative research with this same age range. Based on this work and continuing through this research, the author suggests ‘numeracy apprehension’ as a novel construct that relates to the numeracy experiences of children in early education, rather than mathematics anxiety. Numeracy apprehension is suggested as an origin of and foundation phase to mathematics anxiety. Three individual studies were conducted with the aims of:

1. Exploring the attitudes and experiences of primary care providers to understand their influence on children’s numeracy experiences, their personal issues with numeracy/mathematics, their observations of children’s numeracy experiences and whether these reflect the factors previously discussed by children aged 4-7 years.

2. Developing the numeracy apprehension scale (NAS) for the assessment of numeracy apprehension in children between the ages of 4-7 years.

3. Further development of the shortened NAS with children aged 4-7 years and comparison of scores and performance scores.

The aims of the three studies were met by:

1. Conducting interviews and focus groups with mathematics experts, parents and teachers, and to compare findings with the author’s previous qualitative MPhil research with children aged 4-7 years.

2. The data were used to develop an item pool for an initial list of items to undergo item redundancy and testing with children aged 4-7 years, and using exploratory factor analysis to determine the factor structure of the NAS.
3. To re-test the shortened NAS with children aged 4-7 years and to test construct validity by comparing apprehension scale scores with performance on a numeracy task.

For the purposes of this PhD thesis, mathematics anxiety will be defined as a negative emotional response that inhibits the ability to work with numbers and solve mathematical problems that has a negative impact on performance (Richardson & Suinn, 1972).

In this chapter, I shall examine the relationship between mathematics performance and anxiety. In addition, I shall assess theories and evidence relating to the cognitive consequences of anxiety, focussing particularly on the processing efficiency theory (Eysenck & Calvo, 1992) and the implication of working memory. Building on this, I shall assess young children’s experiences of mathematics and assess the complexity of factors that may contribute to the development of ‘numeracy apprehension’ (Petronzi, Staples, Sheffield, Hunt & Fitton-Wilde, 2012) a suggested origin of and foundation phase of mathematics anxiety. First though, it is important to consider what is meant by mathematics anxiety and to appreciate the complexity of its development through interacting factors.

### 1.1 Mathematics education: The origins of anxiety?

Sound comprehension and application of mathematical concepts is an essential facet of education and may define the career opportunities available to an individual (Ashcraft, 2002; Rahim & Koeslag, 2005; Rossnan, 2006). With continuing international competition in scientific and technological fields, an emerging generation of mathematical minds will contribute to maintaining a competitive economy (Mahmood & Khatoon, 2011). Although mathematics anxiety already exists in the classroom, a tougher and narrower mathematics curriculum may further serve to increase anxiety in young children, and isolate more learners from the subject. Recent U.K. government statistics have indicated that Britain’s economic performance is jeopardised by poor numeracy skills that was shown to be a problem in almost half of the English population (National Numeracy, 2012). With Ofsted (2012) additionally questioning the standards of mathematics teaching in the U.K., the government (Department for Education, 2012) proposed a transformation in mathematical standards through rigorous methods via a curriculum change. However, some critics deemed these as a risk to children’s development and the application of mathematical theory (National Numeracy, 2012). If implemented, children would be expected to recite the 12-times table by the age of nine (U.K. Year 5) and experience an overall more challenging approach to mathematics. Further,
although the Department for Education suggest a focus on the basics of mathematics, the proposals are criticised for failing to consider the content and the practicalities of implementation. With the new curriculum potentially flawed by increasing numeracy difficulty in primary schools and with the U.K. unable to compete with nations that rank higher in mathematical international tests, children who encounter problems with the subject may begin an adverse trajectory towards mathematical anxiety (Baptist, Minnie, Buksner, Kaye & Morgan, 2007).

1.2 **What is meant by mathematics anxiety?**

Despite varied definitions of mathematics anxiety (Tobias & Weissbrod, 1980) the essence of these is similar, maintaining that negative emotional responses adversely impact upon some people’s ability to solve mathematical problems. It is most commonly accepted as tense and anxious feelings that impede the ability to manipulate numbers and solve mathematical problems in academic and ordinary life situations (Richardson & Suinn, 1972). Mathematics anxiety is thus considered as a performance-based anxiety. Harari, Vukovic & Bailey (2013) and others (Vukovic, Roberts, Green & Wright, 2013; Mutodi & Ngirande, 2014) have likened mathematics anxiety to social phobia. This relates to the anxiety and worrisome thoughts that are experienced in anticipation of and when performing mathematics in the face of potential negative evaluation. Typical responses that are symptomatic of performance based-anxieties include: physiological arousal such as increased heart rate and sweating (Dew, Galassi & Galassi, 1984); avoidance behaviours (Haase, Julio-Costa, Pinheiro-Chagas, Oliviera, Micheli & Wood, 2012; Dowker, Bennet & Smith, 2012) and performance deficits and negative cognitions commonly labelled as intrusive thoughts (Ford, Staples, Sheffield & Vanono, 2005). However, mathematics anxiety is unlike general anxiety, as it relates specifically to working with numbers and mathematical concepts, rather than continuous worrying and tension relating to various aspects of life (Brown, Moras, Zinbarg & Barlow, 1993). Preis and Biggs (2001) considered the negative effects of mathematics anxiety to be cyclic, as shown in figure 1.1. However, this places emphasis on poor performance, negative feelings, avoidance and poor preparation. Relating to this PhD thesis, figure 1.1 exemplifies how negativity in mathematics, including poor performance, preparation, feelings and avoidance have an association and can continue to adversely impact an individual’s mathematical education. Like figure 1.1, the current research did not assume causality and instead attempted to understand which factors have an association with numeracy apprehension.
1.3 Mathematics anxiety and its development

Although a well-researched construct in older children and adults, a definitive foundation for mathematics anxiety has yet to be identified (Harari et al., 2013). Rather than a single cause, a complex combination of mathematics related factors is postulated (e.g. Mutodi & Ngirande, 2014) as a more likely basis of this anxiety. These factors include: a genetic basis of mathematics difficulty, suggesting that some are born with innate poor ability (Adams, 2007); prior negative experiences (Ashcraft & Krause, 2007) that Petronzi et al (2012) found to primarily be associated with failure and dysfunctional beliefs about performance ability (Mazzocco, Hanich & Noeder, 2012). With regard to perceived factors, the interaction processes that contribute to the emergence of mathematics anxiety remains to be understood, and the scant research attention paid to the early years of education is only now being addressed. This is due to an emphasis on evidencing mathematics anxiety in older populations and determining the underlying factors through scale measurement, which is discussed in chapter 4. Rossnan (2006) assumed that mathematics anxiety can develop at any age and the associated fear is deeply rooted within a child’s first experience of school mathematics. It remains unclear as to when anxious feelings towards numeracy/mathematics develops in the early educational years and is a limitation that this PhD research aimed to address. The influence of early negative experiences in the classroom is becoming widely accepted as a key factor in mathematics anxiety development. Skemp (1986) believed this anxiety to develop as early
as age 5-6 years in response to the classroom environment, particularly in response to rote-
memorisation teaching strategies and manipulation of symbols with no concept understanding. 
Negative experiences associated with the classroom include: strained student-teacher relationships, 
particularly if teachers are hostile or place children under pressure (Mata, Monteiro & Peixoto, 
2012; Harari et al., 2013; Petronzi et al., 2012); a teacher’s own mathematics anxiety and the risk of 
transference to children (Vinson, 2001; Maloney & Beilock, 2012; Aslan, Ogul & Tas, 2013) and 
children’s awareness of a deficit in their ability (Petronzi et al., 2012; Erdogan, Kesici & Yuksel- 
Sahin, 2011). In the author’s previous research using focus groups with children aged 4-7 years, a 
number of additional factors were found to have their roots in the classroom, most notably: 
dependence on friends and competition arising in mathematics; children becoming aware of an 
intelligence hierarchy, children being punished due to incomplete work and disproportionate 
negative emotional reactions (Petronzi et al., 2012). However, the factors that emerged through 
analysis of the discourse cannot be directly compared against other findings. To the author’s 
knowledge, previous research has not qualitatively explored the numeracy/mathematics experiences 
and attitudes of children so young. Nonetheless, limitations exist in this research method with 
young children. The author found that some children in reception groups (aged 4 years) responded 
to questions following research prompts and did not necessarily elaborate on their feelings. The 
aims of the current PhD research attempt to address this, by determining whether the observations 
of mathematics experts, parents and teachers correspond to the self-identified factors of young 
children, particularly those in the reception years. Relating to this, Hadfield and McNeil (1994) 
identified factors as contributing to mathematics anxiety, including: environmental factors 
(negative classroom experiences associated with teachers and rigid rules of mathematics); 
personality (shyness and low self-esteem) and intellectual factors (attitude, self-doubt, confidence 
and viewing mathematics as unnecessary). Taken together, these findings suggest that negative 
experiences in the classroom create an environment for mathematics anxiety to develop by 
reinforcing mathematics as unpleasant.

The emotional response to mathematics anxiety may have a more profound effect on those whose 
ability is already poor (Witt, 2012). Anxious individuals may become avoidant of working with 
numbers (Brady & Bowd, 2005) and perceive that they are incapable of learning and applying 
concepts, leading to withdrawal, and often, guilt and shame. Chinn (2012) described the avoidance 
of work as the “no attempt” error. This particularly relates to the internalization of persistent 
negative feedback as a consequence of repeated failure, and can lead to feelings of inadequacy 
(Mutodi & Ngirande, 2014). This is predominantly the case when failing to complete complex
mathematical problems (Ashcraft, 2002). Thus, it is likely mathematics anxiety will emerge following a significant period of time in which a child has repeatedly internalised failure (Harari et al., 2013). Yet, causality cannot be assumed as, for example, mathematics anxiety may have an association with a single, but significantly negative experience of failure.

Sir Peter Williams (2007) conducted a governmental review to assess the teaching of mathematics in early year’s settings and primary schools and found that there was a detrimental and negative cultural attitude towards mathematics. Yet, the then shadow education secretary Michael Gove believed that the review methods failed to capture the full extent of the critical situation of mathematics education in England. Based on such reviews, educational schemes are altered but it can be argued that the changes do little to rectify the negative mathematics attitudes that are learned in the classroom. Research has demonstrated a negative correlation between mathematics anxiety and performance with children and older populations (Ashcraft & Kirk, 2001; Maloney & Beilock, 2012). Collectively, this suggests that mathematics anxiety can develop in the early years of education and continue to adversely impact performance throughout the educational years. The negative association between mathematics anxiety and performance is discussed in greater depth later in this chapter (section 3).

Empirical evidence has also implicated the role that parents have in the development of children’s mathematics anxiety (Erden & Akgul, 2010; Gunderson, Ramirez, Levine & Beilock, 2012; Vukovic et al., 2013). Parental influence on the formation of mathematics attitudes suggests that influential factors are not constrained to the classroom and interact in a complex manner to foster mathematics anxiety. This also relates to socioeconomic background and community as influencing academic achievement and mathematics performance (Mahigir, Venkatesh, Kumar & Karimi, 2012). Again relating to children’s mathematics anxiety, Mazzocco et al. (2012) considers the importance of children’s early comments about mathematics, and suggests efforts should begin in early childhood to steer them away from paths that lead towards negative outcomes. Yet, it remains regrettable that research in this area has given little opportunity for children to voice their feelings and explain their attitudes. Instead, research often attempts to relate children’s feelings to pre-formulated assumptions. This limitation can be overcome by reducing reliance on adapted mathematics anxiety scales that are often validated with older populations, and by directly exploring children’s feelings. Relating to this, Mazzocco et al. (2012) further consider that mathematics anxiety in older children may be rooted within the early years of education. Taken together, the discussed research indicates that the origins of mathematics anxiety may be based in numeracy
difficulties in young children, rather than in complex mathematics in older children. As research on mathematics anxiety has increased, it has become widely recognised as a prominent, debilitating and early developing condition. Yet, it remains unclear as to what stage in early education mathematics anxiety emerges and as yet, research has not explored the direct feelings and attitudes of younger children through qualitative procedures. Although qualitative research with young children poses a risk of confounding variables, i.e. insight in discussions being missed due to other children becoming restless, informative and novel findings can emerge (Petronzi et al., 2012). Thus, this is a potential avenue for further research to explore.

Difficulties associated with mathematics have been linked to the development of mathematics anxiety (Adams, 2007; Ashcraft & Krause, 2007). Considering the discussed research, it could be suggested that in early education, the formation of mathematics anxiety relates to an interaction of factors that are associated with the classroom, particularly failure, evaluation anxiety and teachers, whilst parents also play a key role. Despite this, it should be acknowledged that in some instances, anxiety may only relate to a specific concept, e.g. fractions. Accordingly, at this stage, the term ‘numerical apprehension’ is highlighted in relation to young children, as an alternative term to what is typically referred to as ‘mathematics anxiety’ throughout this PhD thesis, when discussing the anxiety of children aged 4-7 years. Research data suggests ‘mathematics anxiety’ is a subsequent and further developed issue that is unrepresentative of the experiences of young children, who are familiar with numeracy, a subset of mathematics.

1.4 Mathematics anxiety in older populations: progress with limitations

Despite research attention turning towards the educational experiences of young children, the substance of mathematics anxiety understanding has come from elsewhere. At this stage, it is important to address psychological research in older populations that has explored and given light as to the distinguishing characteristics and dimensionality of mathematics anxiety. These studies have assessed individual consequences of mathematics attitude and anxiety, influential factors and the detrimental effects on mathematics achievement (Wigfield & Meece, 1988; Hembree, 1990; Kargar, Tarmizi and Bayat, 2010). This has led to the assertion that mathematics anxiety is an emotional, rather than intellectual problem (Luo, Wang & Luo, 2009) and has importantly demonstrated a performance deficit in the highly mathematics anxious (Ashcraft and Kirk, 2001). These issues will be explored in detail, later in this chapter. However, the key aspect of research with older populations is the range of factors that have been evidenced, and their potential to stem
from negative experiences in primary education. These experiences include mathematics teacher anxiety; mathematics evaluation anxiety; mathematics observation anxiety; public embarrassment in the classroom; failure to understand the wider practicalities of mathematics; resignation to failure and difficulties in conceptual understanding; self-confidence and motivation.

Traditionally, this data has been obtained through quantitative scale measurement, and has been a key feature of mathematics anxiety research in older populations. Mathematics anxiety rating scales focus on the measurement of individual responses to mathematics related factors and are developed and adapted to represent age appropriate experiences and situations. Similar scales do not exist for the same measurement in children aged 4-7 years and the focus age range of this PhD thesis, overlooking potential development at this educational stage. Scales that have measured mathematics anxiety in older children have typically focused on the age of seven years and above. A majority of the scales have been developed and implemented in the United States (US) with older populations. Mathematics anxiety measurement scale items are often pre-formulated and adapted from previous scales and have not been specifically developed for the target population. Thus, it is even more essential for research to employ qualitative procedures to create age and culturally appropriate scales for the measurement of mathematics anxiety. Mazzocco (2007) and Ashcraft and Moore (2009) state that the appropriate tools have not been developed in order to examine anxiety and those at risk of mathematics difficulties in early education. Again relating to the aims of this PhD thesis, studies 2 and 3 attempted to address this shortfall and are discussed in detail in chapters 4 and 5.

Ramirez, Gunderson, Levine and Beilock (2013) consider the importance of addressing mathematics anxiety at the earliest age possible, to prevent a “snowball” effect, leading to increased anxiety, dislike and avoidance of mathematics. However, studies have not focussed on exploring the factors that may contribute to the emergence of numeracy apprehension and whether it is present at a young age (Mazzocco et al., 2012; Ramirez, et al., 2013). Thus, to date, the factors relating to mathematics anxiety in older populations can only be suggested as being rooted in primary education. To rectify this limitation, direct and detailed insight was obtained from children aged 4-7 years in the author’s previous research (Petronzi et al., 2012). Further to this, PhD study 1 explores the direct insight of mathematics experts, parents and teachers, who discuss children’s (aged 4-7 years) experiences of numeracy, providing an understanding of factors that may be influential in the formation of their numeracy attitudes and achievement.

In summary, mathematics anxiety research with older populations has informed psychologists of an emotional element and a negative correlation with achievement. Research has also shown anxiety
to relate to multiple factors that potentially stem from experiences in earlier education. A limitation remains that obtained evidence has traditionally been found using mathematics anxiety rating scales in older populations that do not relate to the experiences of younger children and are often developed in the US. Furthermore, as anxiety does not exist objectively, an over-reliance on scale measurement may narrow the scope of data. This can be addressed by also exploring attitudes through qualitative methods that in turn, creates a more ecological foundation for a measurement scale to be based upon. The link between mathematics anxiety and achievement and cognitive processes will now be discussed, as these are two key aspects to have emerged through research with older populations.

1.5 The relationship between mathematics performance and mathematics anxiety

It has recently been stated that no other relationship is as troublesome as the negative correlation between mathematics anxiety and mathematics achievement (Ashcraft & Moore, 2009). This is due to the underachievement of those with high levels of mathematics anxiety, although they may have an underlying ability (Luo et al., 2009). However, up to the turn of the century, mathematics anxiety and mathematical cognition, including underlying processes used in arithmetic and performance, were typically researched in isolation, overlooking mathematics anxiety as having a negative impact upon mathematics performance (Ashcraft & Kirk, 2001). The adverse emotional responses induced by mathematics anxiety range in severity from a degree of frustration to causing overwhelming emotional disruption. Despite normal performance in most thinking and reasoning tasks, mathematics anxious individuals demonstrate poor performance when solving numerical problems (Maloney & Beilock, 2012). This suggests that the negative emotional elements of mathematics anxiety are adversely interfering with performance on mathematical tasks. Tobias and Weissbrod (1980) explored self-reported symptoms of the highly mathematics anxious when solving mathematical problems. The results included panic, paralysis and mental disorganisation. The effects of anxiety are pronounced in mathematics, as success is dependent on developing conceptual understanding of structures that are communicated and manipulated through symbols. Lundberg and Sterner (2006) consider that, amongst other cognitive functions, arithmetic performance is influenced by a number of motivational and emotional factors that include helplessness, depression, anxiety, and self-esteem. As it is the typical assumption that anxiety is induced in response to negative stimulus, it follows that consistent mathematics failure leads to the development of negative attitudes and ultimately, mathematics anxiety. This does not mean to say
that mathematics anxiety is most associated with failure, nor that it is a consequence of failure. The author of this PhD maintains that a combination of factors is linked to anxious responses.

The possible impact of mathematics anxiety on calculation ability has been hypothesized to revolve around avoidance behaviours, resulting in a vicious cycle of less calculation practise, a deficit in learning and further negative emotional consequences (Ashcraft, 2002). Relating to this, Perry (2004) adds that fearful responses seem to develop through failure in early education and Ashcraft and Kirk (2001) and Maloney and Beilock (2012) have suggested that the mathematics anxious are simply less practised and skilled than individuals with low anxiety levels. However, whilst accepting that less practise in mathematics is associated with lower performance and increased anxiety, this does not explain research results that have demonstrated that alleviation of anxiety can improve mathematical performance (Sheffield & Hunt, 2007).

Luo et al (2009: 18), based on their research findings, stated that mathematics anxiety is seemingly an emotional, rather than intellectual problem, stating that it is “very necessary and timely” for attention to be given to the emotional experiences of students, as anxiety may be masking true ability. Prior to conducting their research, they considered mathematics anxiety as relating to unhealthy mood responses. These place the sufferer in a cognitively passive state, experiencing panic, depression, helplessness, nervousness and fearfulness. Through research with middle school students using the mathematics interest, self-efficiency and mathematics anxiety questionnaire, Luo et al. (2009) demonstrated a negative correlation between mathematics anxiety and mathematics performance, with a correlative coefficient of -.41. A coefficient of .33 further indicated a relationship between cognitive elements of mathematics anxiety and mathematics performance. The overall results were stated to be consistent with common knowledge, demonstrating that those who have higher levels of mathematics anxiety perform poorly on mathematics tasks with an association to negative emotional elements. Whilst presenting insightful findings, these do not relate to children within the age range of the current PhD thesis (aged 4-7 years). In order to determine whether the mathematics anxiety factors identified by Luo et al (2009) are relevant to the experiences of children in early education, further research should qualitatively explore their attitudes. Indeed, the factors found in previous qualitative research have led to the development of the age specific apprehension measurement scale of this PhD research (chapters 4 and 5).

Additional research has evidenced the association between emotion and mathematics anxiety, Lyons and Beilock (2011) have shown that those with high levels of mathematics anxiety show activity in the frontoparietal network that is involved in the regulation of emotion, through simply
anticipating a mathematics task. Yet when taught strategies to regulate negative emotions, the high mathematics anxious are able to perform at almost the same level as the low mathematics anxious. This demonstrates that an emotional element is influential in the maintenance of mathematics anxiety and can be alleviated to reveal genuine ability. Again, these results are constrained to college students in the US (mean age 20.47 years) and similar brain imaging would be difficult to measure in young children, from a consent and methodological perspective. The evidenced negative emotional responses support an association with mathematics anxiety that contributes to a decline in performance, although results are difficult to apply to the experiences of children. The author considers the emotional responses of children to be a key determinant of numeracy attitudes and performance. Thus, negative emotional responses observed in children by mathematics experts, parents and teachers is anticipated to be a key discussion point in study 1.

Similarly, Harari et al (2013) reinforce the emotional elements of mathematics anxiety, by addressing the dimensions assessed in previous research, including worry (negative cognitions), negative reactions (tension and physiological reactions), test anxiety and numerical anxiety that indicate a multidimensional construct. They considered mathematics anxiety as an anxiety that affects performance and explored this in young children. It was hypothesized that numerical anxiety, negative reactions and worry would encompass mathematics anxiety. Longitudinal research conducted with 106 first-grade students (U.K. age 6 years) in the US aimed to explore the multidimensionality of mathematics anxiety and how each of the identified dimensions independently affected mathematics performance. Mathematics anxiety levels were measured using a 12-item scale created by the authors, in which items were adopted from the 26-item MARS-E and the 11-item Mathematics Anxiety Questionnaire (Wigfield & Meece, 1988) that measures worry and negative reactions. Mathematics achievement was assessed across four domains: (1) whole number computation skills, (2) counting skills, (3) mathematical background knowledge and (4) number series in which children complete sequences. The authors conclude that the scale reflected two forms of anxiety (i.e. worry and emotionality) and were statistically significantly related to each other. Children were identified as having moderate levels of mathematics anxiety that was found to significantly negatively correlate with computation skills, counting skills and mathematical concepts. This suggests that children are not fully learning and understanding concepts in the classroom, perhaps relating to teaching practices. Additionally, a significantly negative correlation was found between mathematics anxiety and attitude, suggesting a further negative association, although causality cannot be assumed. Many factors have been evidenced to influence mathematics anxiety, and researchers should be cautious of assumptions of causality. With regard to this
research (Harari et al., 2013), negative classroom experiences may have led to a negative attitude, ultimately leading to mathematics anxiety. In contrast, repeated failure may have caused anxiety, and a negative attitude developed as a consequence. Overall, the results support the multidimensional view of mathematics anxiety and its association with emotional elements, by identifying worry and negative reactions as further components in young children. This relates to evidence obtained with older populations, suggesting that mathematics anxiety has its roots in the early years, as hypothesized by the aforementioned research.

In summary, a significant association exists between mathematics anxious individuals and poor performance on mathematical tasks. Anxiety is suggested to relate to negative emotional responses, including depression and self-esteem. In addition to these, external factors including failure, avoidance and less calculation practise are considered to adversely influence performance. Similarly, research discusses mathematics anxiety as placing learners in a cognitively passive state, in which they experience, for example, panic, depression and mental disorganisation. Further research in younger children has shown a negative correlation between mathematics anxiety and skill level, as well as attitude. However, the causal relationship between mathematics anxiety, negative responses and performance remains unclear. Relating to the aims of this PhD research, anxiety has been suggested as forming in the early educational years following repeated failure. This supports exploring children’s numeracy experiences and developing an apprehension rating scale to determine children at risk of apprehension. Yet, mathematics anxiety is not entirely associated with failure. The author maintains that a combination of factors is linked to anxious responses. In addition to this, whilst factors such as avoidance and less practise in mathematics is associated with lower performance and increased anxiety, this does not explain research results that have improved mathematical performance through alleviating anxiety. Yet, research exploring the relationship between mathematics performance and anxiety has used varying self-report measures of anxiety and participant demographics and sizes. Thus, comparisons must be made with caution. Further to this, research and scale development has typically been based in the US and are not entirely applicable to the U.K. and populations worldwide.

1.6 The cognitive processes underpinning mathematics anxiety and performance consequences

It is postulated that emotional factors may influence cognitive abilities (Krinzinger, Kaufmann & Willmes, 2009). Research that suggests that the negative emotional components of mathematics
anxiety, such as tension and physiological reactions, worry and negative reactions (Wigfield & Meece, 1988) affect performance through encouraging avoidance behaviours and by interfering with cognitions, does not address the specific underlying cognitive processes. Research has implicated working memory as being adversely affected by anxiety and has shown its limited capacity to be drained by the cognitive strain of emotional elements of anxiety.

Sarason (1988) had initially considered that the experience of anxiety centred on worrisome thoughts that are task-irrelevant and reduce the cognitive attention an individual can devote to the central task. This particularly applies to tasks that place high demand on short-term memory, such as solving a mathematical problem. However, Sarason (1988) exaggerated the role worry plays in mediating anxiety effects on performance (Wilson, 2008). He considered that the experience of anxiety centred on worrisome thoughts that are task-irrelevant and reduce the cognitive attention an individual can devote to the central task.

Eysenck and Calvo (1992) considered that anxiety adversely interferes with the efficiency of the central executive, a limited capacity component of the working memory model that is involved in a range of arithmetic procedures (Baddeley, 1986) (Eysenck & Derakshan, 2011) and one of the three major subcomponents of mental processing, along with the auditory rehearsal loop, and the visuo-spatial sketchpad. In essence, intrusive thoughts were hypothesized to compete for limited working memory resources, particularly in the highly mathematics anxious, as they become focussed on these thoughts, and less so on the task. The consequence of excessive working memory demands are lower cognitive efficiency and is reflected through reduced task accuracy and performance. This will be evidenced throughout this section. Highly maths anxious individuals must devote increased cognitive effort to match the performance level of the low mathematics anxious (Derakshan & Eysenck, 2009).

Ashcraft and Faust (1994) and Faust, Ashcraft and Fleck (1996) provided evidence from initial lines of inquiry to support the impact of anxiety on performance. Simple arithmetic problems were completed in an automatic fashion by using memory retrieval, although the effect of anxiety became more apparent when college student participants were required to solve more complex addition and multiplication problems. Highly mathematics anxious individuals encountered particular difficulty when faced with two-column addition problems, due to the procedural carry operation. When the highly mathematics anxious provided a correct answer, their response time was three times longer than the low mathematics anxious, demonstrating more effortful procedural
processing. Perhaps most notable in terms of the relationship between anxiety and mathematics performance and relating to avoidance behaviours, the highly mathematics anxious, although much slower at responding, had sacrificed accuracy in favour of speed, which was assumed to relate to wanting to avoid the stimulus problem (Ashcraft & Kirk, 2001). These results again demonstrated a relationship between anxiety and performance, and evidenced increased effort in cognitive processing. Specifically, mathematics anxiety was shown to have a detrimental effect on performance. In the context of a child in a numeracy/mathematics lesson, anxiety places them at an immediate disadvantage. Although these results are not directly applicable to children aged 4-7 years, if anxiety is present in early education, it can be suggested that performance will suffer. To determine whether young children are developing negative attitudes and anxiety towards numeracy, a standard and reliable measurement tool is required, and relates to a key aim of this PhD research.

Ashcraft and Moore (2009) state the importance of understanding how mathematics anxiety affects performance in the moment of solving problems. Ashcraft and Moore (2009) subsequently coined ‘affective drop’, relating to a drop in performance that is independent of competence or achievement and is attributable to mathematics anxiety. The research showed that, with the removal of time constraints and implementing a pencil-and-paper format, equivalent performance was seen for one and two-column addition and multiplication problems, across low, medium and high anxiety groups. Within this research, an anxiety effect was found that related to decision making, as the error rate increased for the highly mathematics anxious for true/false judgements when problems became more implausible e.g. $9 + 7 = 39$, in comparison to the low mathematics anxious (Ashcraft, 2002). Ashcraft (2002) suggests that in a previous trial of this research, anxiety had interfered with mathematical ability, preventing participants from demonstrating their basic competence. This assumption was made, as when participants were tested in time conditions and solved the problems mentally, there were substantial anxiety effects. The contrast in the two pieces of research suggest that when mathematics performance is solely dependent on mental calculation, as opposed to using working strategies, the high mathematics anxious individuals show an increased error rate. Pen and paper strategies seem to reduce cognitive load and posits an on-line (in task) cognitive consequence of mathematics anxiety. In terms of working memory, individuals with high mathematics anxiety have difficulties with more complex problems as negative and intrusive thoughts occupy their working memory. Yet, though a comparison is made between the two pieces of research, it remains unclear as to whether Ashcraft and colleagues and Faust and colleagues conducted their research with the same population and age range. Again, relating the findings to the experiences of children, they suggest that mental arithmetic tasks and tests will cause
significant difficulty for anxious individuals. As exam results often determine classroom ability groups, anxious children are at a further disadvantage. Although children have revealed worries relating to arithmetic in previous qualitative research (Petronzi et al., 2012), the current PhD research aimed to verify these claims by exploring whether mathematics experts, parents and teachers have observed this in their children.

Ashcraft, Kirk and Hopko (1998) further explored the link between anxiety and ability. They administered a mathematics achievement test that increased in difficulty, line by line, to low, medium and high mathematics anxious. When the mathematics achievement test was marked, there were no mathematics anxiety effects for whole number arithmetic problems, and an effect of anxiety only became apparent on questions in the second half of the achievement test, that centred on mixed fractions (e.g. 10 ¼ - 7 2/3), equations, and percentages, i.e., the most difficult problems. For these problems there was a strong negative relationship between accuracy and mathematics anxiety, indicating that the highly mathematics anxious suffer a performance drop off when work becomes more complex. However, Ashcraft (2002) stated that researchers should always consider the competence-anxiety relationship and remain suspicious of this, as highly mathematics anxious individuals may be able to demonstrate increased competence under varying circumstances and on a range of mathematics concepts and difficulty levels.

Ashcraft and Kirk (2001) studied the effects of mathematics anxiety on mathematical ability. College students with low, moderate or high levels of anxiety, determined through the Shortened Mathematics Anxiety Rating Scale (sMARS), were required to concurrently remember strings of letters, ranging between 2 and 6, and then solve one- and two-column addition problems, with half requiring a carry operation procedure. The letters were presented before participants attempted to solve each problem, and then were required to recall the letter-string, in order of presentation. Ashcraft and Kirk (2001) assumed that limited working memory capacity became drained, with the excessive cognitive demand of letter recall. They further considered that when more letters had to be held in working memory, increasing the task difficulty, problem solving performance declined, and speed decreased. The combination of the tasks exceeded the capacity of working memory, and more errors occurred for the highly mathematics anxious, when the carrying operation was required and when a longer letter string had to be recalled (40%). This compares unfavourably against the low mathematics anxious in the same memory load condition, who made 20% errors. As Ashcraft (2002) reports, although working memory is implicated by these results, it does not explain them entirely. Differences between the working memory spans of high and low mathematics anxious
individuals did not vary on a verbal task and variations only occurred when assessed on an arithmetic task. This supports the influence of mathematics anxiety, and that this construct drains the limited working memory capacity of the highly mathematics anxious. This may be explained by Ashcraft (2002), who adds that whilst simple arithmetic does not require significant working memory processing, more advanced problems, including carrying and borrowing operations place demand on working memory, and mathematics anxiety is related to these. However, high levels of anxiety are associated with complex mathematics, such as algebra. The author of this PhD accepts the findings of previous research - that mathematics anxiety does likely occupy working memory capacity through negative intrusive thoughts, particularly on advanced procedural mathematical tasks. It is also their belief that the high mathematics anxious will struggle more in mental arithmetic tasks, particularly in timed conditions. Addressing the contrasting findings, it may be that simple arithmetic does not impact on working memory, due to the age of participants (college students) and their progressive understanding of such concepts throughout their educational career. Thus for older populations with mathematics anxiety, some will show a performance disparity, according to the difficulty of the task. Applying the findings to children aged 4-7 years, basic arithmetic concepts are the only concepts children encounter. Consequently, children with or at risk of apprehension may only experience failure due to apprehension occupying working memory resources. Based on their own research evidence, the author posits that children will either avoid their numeracy work, or develop strategies to ‘cover up’ their performance deficit. In this case, the early educational years are again highlighted as a key research area to understand the later development of mathematics anxiety with additional factors contributing to children’s reduced cognitive performance.

1.6.1 Working memory

Ashcraft and Krause (2007) suggest that when mathematics anxiety is aroused in a student, their attention is taken away from the work content. In this situation, all working memory resources, including phonological aspects crucial for counting and holding information in complex calculations, become focussed on worries (Mclean & Hitch, 1999). Subsequent experimental research also explored the effects of mathematics anxiety on accuracy and working memory. With a sample of 48 undergraduate students, Ford et al (2005) found mathematics task accuracy to be worse on a dual task (reading a string of letters, solving an addition problem and then recall the letters) than when performed in isolation, suggesting competition for limited working memory resources. Reduced task specific mental capacity negatively impacted the performance of high
mathematics anxious individuals. Mutodi and Ngirande (2014) proposed that mathematics anxiety disrupts the task-relevant activities of working memory. This slows performance and diminishes accuracy. Working memory research with student populations has led to insightful understandings, i.e. that intrusive thoughts occupy working memory resources and negatively effects performance, particularly on more advanced procedural tasks. Still, such results are difficult to directly apply to children, due to the differences in learnt concepts between the age groups. Recent research has directly attempted to understand the working memory consequences of anxiety.

Witt (2012) conducted research with 55 children with a mean age of 10 years to determine whether the presence of digits can induce an anxious reaction and impact upon working memory. The research measured children’s working memory, backward digit recall, and backwards letter recall and were shown visual pattern of digits and visual patterns of letters. Mathematics anxiety was measured on a 9-item questionnaire, adapted from the Mathematics Anxiety Rating Scale for Elementary children (Suinn, Taylor & Edwards, 1988). Children with higher levels of mathematics anxiety experienced a decline in working memory performance, specifically relating to storing and processing information. Witt (2012) suggests that the relationship between performance and anxiety may be bi-directional, as anxiety reduces working memory performance, leading to a decline in mathematical performance. Similarly, Ramirez et al (2013) found a negative relationship between mathematics anxiety and mathematics achievement for children (mean age 7 years) who relied significantly on working memory strategies. Anxiety disrupted working memory, leading to lower performance. Punaro and Reeve (2012) have also produced similar results, showing children aged 9 years in a high-worry group to make fewer correct judgements on difficult mathematical tasks, than children in a low-worry group. Such research has gone some way in showing that children with mathematics anxiety, like older populations, suffer a working memory deficit that impacts on performance. This is not directly comparable with older populations, whose working memory resources are also tested using complex mathematics, such as algebra. It also remains unclear as to the working memory consequences of children between the ages of 4-7 years and to what extent numeracy apprehension impacts on performance. Critically, young children’s memories are still developing during this age range. They are therefore restricted in how much information and experiences they can store in their short term memory (Croker, 2012). Thus, children’s numeracy difficulties may also relate to their natural cognitive development.

Although working memory is occupied in the high mathematics anxious during a mathematical task, it is possible to alleviate on-line cognitive demands. Karimi and Venkatesan (2009) conducted
research with 400 students (25 with high anxiety) aged 13-16 years who were measured for mathematics anxiety through the RMARS (Alexander & Martray, 1989). The 5-point Likert scale included 12 items relating to mathematics test anxiety and 13 items gauging anxiety in relation to completing mathematics tasks. Following completion of the RMARS, cognitive behavioural group therapy (CBGT) was conducted over 15 sessions, in which participants identified their negative thoughts and learnt how to cope with these. The RMARS was completed again, following the conclusion of consistent and intensive CBGT. The results indicated that mathematics anxiety scores had significantly decreased at post intervention, showing that CBGT had helped students to overcome their cognitive difficulties relating to mathematics. This supports the notion that mathematics anxiety is a negative emotional response affecting cognitions, rather than an intellectual deficit. This showed that although mathematics anxiety can affect mathematics attitudes, the effects on cognitive processing can be alleviated. Similarly, Eysenck et al (2007) offer another perspective of the association between anxiety and efficient functioning, and state that anxiety may not impair performance when it leads to compensatory strategies. These include increased effort and dedicating more processing resources to the task. Despite these results, a disproportionate amount of research has shown that mathematics anxiety negatively impacts the performance of high mathematics anxious individuals, rather than focussing on methods for alleviation.

In summary, mathematics anxiety has been shown to negatively impact the performance of high mathematics anxious individuals. Evidence suggests that there is an on-line cognitive consequence of anxiety that manifests as intrusive thoughts. These occupy the working memory resources required for mathematical task completion. Reduced cognitive efficiency is demonstrated by lower performance and accuracy by the high mathematics anxious. Research has shown that the cognitive load on working memory resources is most apparent on more complex mathematical tasks. In cases in which the high mathematics anxious can provide a correct answer; these are substantially slower than the low mathematics anxious, although research commonly suggests that accuracy is sacrificed for speed. When considering these findings in a practical setting, slower response times or reduced accuracy for speed places the learner at an immediate disadvantage, particularly in mental arithmetic tests. If this is specifically considered in the context of children in primary school, slower response times will lead to lower performance in comparison to peers. This is particularly detrimental as ability groups are often dependent on end-of-year test scores. In addition to this, in a day-to-day classroom setting and when learning multiplications collectively as a class, children who struggle with mental arithmetic are exposed to negative peer evaluation. This can also be influential
on anxiety. Practically, teachers cannot assess for working memory deficits in children. Thus, the author considers this as further supporting the aims of the current PhD research, to develop a measurement tool to identify children at risk of apprehension, at an early age. In contrast, although again with older populations, research has demonstrated that when strategies, i.e. pen and paper, and time constraints are removed, the high mathematics anxious can perform equal to the low mathematics anxious on two-column and multiplication tasks. This suggests that solving strategies reduce the cognitive load for the high mathematics anxious. Although, on a task of increasingly implausible true/false judgements, their error rate increased in comparison to their low anxious peers. Working memory research is often compared against other similar work, although procedures and participant demographics and size are not always similar. Significantly more research has been conducted in the US, and again, cannot be directly related to U.K. or other international populations. Furthermore, researchers often implement different mathematics anxiety rating scales to gauge self-report measures of factors relating to anxiety. The validity and reliability of such scales are not standard, and so will also lead to variations in results. For instance, on one scale, a participant may be judged as high mathematics anxious, but on another, their score may suggest that they are not.

It has been posited that reduced working memory does not entirely explain a performance deficit in the high mathematics anxious, and instead, this may relate to lower competence in mathematics. Nonetheless, tasks that have been designed to strain the memory spans of participants (dual tasks) have shown that the high mathematics anxious make substantially more errors on memory recall. Again, this suggests that anxiety loads cognitive resources required to solve mathematical problems. The author also considers that differences in college students’ results between ability on basic arithmetic and more complex tasks, may relate to their age and a progressive understanding of these, even for those with high mathematics anxiety. This is founded on the notion that although some may have mathematics anxiety, this does not necessarily mean that they are unable to complete some mathematical tasks. Yet, their ability on challenging concepts is evidenced as being lower. Despite working memory relating to reduced performance, research has shown that it is possible to alleviate the negativity that is associated with intrusive thoughts that load cognitive resources (Sheffield & Hunt, 2007).

Working memory research with older populations cannot be applied to the experiences of children, as the concepts they are familiar with are not as advanced as those used to test older populations, i.e. algebra and equations. Despite this, research with children has also shown that working
memory is adversely affected by mathematics anxiety. The working memory consequences of children aged 4-7 years with numeracy apprehension remain unclear, although numeracy difficulties may also relate to their natural cognitive development. This further highlights the importance of understanding what leads to numeracy apprehension at an early age. Conflicting results in this area may suggest that sufficient results have not yet been made available for appropriate conclusions to be drawn and further research is required. Despite methodological differences in research and in the retrieval and strategies of participants, it is clear that mathematics processing is dependent on working memory, particularly as difficult mathematics rarely becomes an automatic procedure in the same way as day-to-day cognitive processes (Ashcraft & Guillaume, 2009).

1.7 Factors associated with children’s mathematics anxiety

Literature indicates that mathematics anxiety is a multidimensional construct, and Harari et al (2013) recently hypothesized numerical anxiety, negative reactions and worry as the dimensions of this construct in children. However, as previously discussed in this chapter, explicit factors within and outside a classroom setting have been identified in research, including that of the author. These factors are posited to influence children’s negative attitudes and apprehension in numeracy. Despite speculated methodological issues relating to the authors measurement of anxiety, more recent research with children (mean age of 7 years) has found that worry and mathematics attitudes, including mathematics anxiety, did not affect mathematics performance (Krinzinger et al., 2009). Taken together, this suggests that not all mathematics anxiety dimensions directly affect performance, again suggesting a complex factor interaction that warrants further research, particularly in early education. Mohamed and Waheed (2011) considered three categories of mathematics anxiety factors: those relating to the individual; those associated with the school, including teachers and teaching practices and those associated with the home environment, including the influence of parents. In other instances, factors may relate to the specific mathematics task, for example, a child may struggle with percentages and fractions, but perform better on ratio.

Research conducted by Ma and Xu (2004) relates to individual factors, specifically, previous mathematics achievement and experiences at school. They attempted to determine the cause and effect relationship of mathematics in 3,116 U.K. children aged 12-17 years, using a longitudinal method. Across fifty two schools and over six years, students completed achievement tests in mathematics and science, and also completed a questionnaire that related to a variety of measures, including mathematics anxiety. These specifically related to feeling anxious when doing
mathematics and being scared when facing a page of mathematics problems. Four subscales within the mathematics achievement test measured basic skills, algebra, geometry and quantitative literacy. The results indicated that prior mathematics achievement had a greater impact on later achievement than prior mathematics anxiety on later mathematics anxiety. However, mathematics anxiety was not represented to the same extent as mathematics achievement, due to fewer measures. Crucially, the lower mathematics achievement scores in the early grades were associated with higher mathematics anxiety scores in the later grades, showing mathematics achievement to have an association with mathematics anxiety (Ma & Xu, 2004). An explanation for these results may be that early influential factors have already exerted their negative impact and lower mathematics achievement is then sustained by mathematics anxiety. Conversely, the results could be explained by children becoming avoidant of numeracy at an early age, and consequently have a concept understanding deficit, that reduces performance. In spite of this, factors that are influential in the early school years are currently under researched. At this stage, the term ‘numeracy apprehension’ is reiterated, as the foundation phase of mathematics anxiety that reflects the early primary school years.

Young et al. (2012) offer additional support for the association between individual factors and mathematics anxiety, specifically relating to emotional processing. Their research investigated the neurodevelopmental origins of mathematics anxiety in children aged 7-9 years, attempting to demonstrate the impact on brain functioning when acquiring mathematics skills in the early learning stages. The authors created the Scale for Early Mathematics Anxiety (SEMA) based on the MARS as a reliable and valid measure of maths anxiety in children aged 7-9 years. The SEMA enabled identification of high and low mathematics anxious children. Whilst participants determined whether addition and subtraction problems were correct or incorrect, functional brain imaging data was analysed for increases and decreases in brain activation. Supporting a neuro-biological basis of mathematics anxiety, an association was found between mathematics anxiety and the amygdala, which processes negative emotions. Specifically, within the high mathematics anxious, the amygdala was found to be linked with cortical regions that process negative emotions and was particularly evident in relation to lower problem solving accuracy. In contrast, the amygdalae of low mathematics anxious individuals were coupled with brain areas that assist task processing. Similarly, greater deactivation of the ventromedial prefrontal cortex which regulates emotion was found in the high maths anxious along with reduced response of cortical and sub cortical areas that are implicated in mathematics and numerical reasoning. The results demonstrated that mathematics anxiety is associated with a distinct pattern of neural activity (Maloney & Beilock, 2012) and is
unrelated to general anxiety, intelligence, reading ability and working memory, with increased activation in brain regions that regulate emotions (Haase et al., 2012). This relates to similar measures of trait anxiety in the high and low mathematics anxious, which suggests that mathematics anxiety, rather than general anxiety, was the cause of brain differences. In summary, the research findings suggest that individual factors, specifically emotional responses to mathematics, have a key association with mathematics anxiety. Although insightful data was obtained through this research and a novel measurement scale was created, this and the results cannot apply to children aged 4-7 years. Indeed, it would be beneficial to understand the emotional processing of children when completing mathematical tasks, although there are potential methodological limitations, i.e., parental consent, and ethical limitations, i.e., children becoming distressed due to brain monitoring equipment, may prevent this.

Evaluation anxiety is postulated to be another individual factor associated with mathematics anxiety. Donaldson, Gooler & Scriven, (2002) considers this to be inherent in human beings and is encapsulated by emotions such as embarrassment and ridicule. Potential negative consequences of evaluation are also thought to induce behavioural and cognitive responses, such as avoidance. Beck (1989) had previously considered negative evaluation to be a particular issue in early childhood. In relation to mathematics anxiety in children, Ashcraft and Krause (2007) predict this to be learned in the classroom and consider negative evaluation by peers and teachers to cause embarrassment when publicly performing mathematics poorly (Hadley & Dorward, 2011). Children’s evaluation anxiety and repeated failure in mathematics places them at risk of developing a negative self-perception of their abilities that in turn, can harm their performance in the future (Awanta, 2000). Comparison against peers has also been suggested as leading to a negative self-concept (Erdogan et al., 2011; Mutodi & Ngirande, 2014). A negative self-concept can lead to poor mathematics attainment, anxiety and the instigation of a vicious cycle (Dowker et al., 2012). According to Nicolaidou and Philippou (2003), children starting school inherently hold positive attitudes towards mathematics. Their research supported this by demonstrating that negative mathematics attitudes related to persistent failure and difficulties when solving problems. These negative attitudes may become permanent. Again, a cause and effect assumption cannot be made due to the complexity of factors and their interaction with one another. Similarly, in research with children aged 7-12 years, studying the impact of psychosocial competencies (i.e. general anxiety) and mathematics anxiety on mathematics and spelling performance Haase et al (2012) found mathematics anxiety to be related to the specific cognitive aspect of self-assessment in mathematics. Children’s self-assessment in mathematics can predict performance. Taken together, research suggests that evaluation anxiety is
common within classrooms and negative evaluation from peers and teachers can lead to a negative self-perception. This can further harm performance and persistent failure has an association with mathematics anxiety. Contradicting assumptions and evidence of factors influencing mathematics anxiety and performance, moderate levels of mathematics may encourage achievement striving. Further to this, Ashcraft (2002) found that despite some children insisting on mathematics difficulties, their competence scores are not affected.

However, individual factors, such as explanatory styles in response to difficulties, can differentiate the nature of mathematics experiences. In a longitudinal study, Yates (2002) examined the relationship between optimistic and pessimistic attitudes and mathematics achievement. In the face of failure, an optimistic response involves viewing mistakes as rectifiable, whereas pessimism relates to internalising the cause of failure. The results from children between grades 3-7 (U.K. age 8-13) showed a statistically significant difference between optimism and pessimism relating to grade level. Those who held a pessimistic explanatory style at primary school had a lower relative level of achievement in mathematics three years later. Pessimism in mathematics is associated with a decrease in persistence, assertiveness and mathematics anxiety. In contrast, results from the study showed that initially optimistic children reduced in their optimistic explanatory styles as they progressed through school, yet their achievement in mathematics increased. This is considered to be the result of developed skills and constructive work habits the children had learned in their earlier years, due to their optimistic approach. Optimism has also been shown to relate to confidence in decision making, mental rigidity and emotional intelligence. In contrast, pessimism relates to worry, despair, guilt and depression (Al-Ansari, 2003). In summary, children’s explanatory styles to difficulty and failure in mathematics have been shown to be a performance differentiator, with an optimistic style to have an association with higher achievement in mathematics. Yates (2002) stated that the primary school years are crucial, as this is where attitudes towards mathematics develop. This supports the nature of this PhD research, as it attempts to build on the author’s previous research and further explore the attitudes and experiences of young children, through the perspective of primary adults (parents and teachers). The research conducted by Yates (2002) measured optimism and pessimism from the age of eight, omitting several prior educational years of attitude development.

Pessimism and negative attitude in mathematics relate to a low self-efficacy (Zimmerman, 2000) that can lead to motivational and cognitive deficits (Kolacinski, 2003). Self-Efficacy Theory relates to social cognitive theory (Bandura, 1986) and is based on the premise that individuals will more
likely engage in activities if they believe they have the capability to complete them. Relating to this, individuals often consider the difficulty level of the task, and evaluate their belief of succeeding at varying difficulties. Self-efficacy can be an outcome-dependent factor in a wide-range of activities.

In relation to the focus of this PhD thesis, Meece, Wigfield and Eccles (1990) regard self-efficacy as a crucial factor that can determine a person’s mathematical achievement. They also consider the development of skills as a critical component for ensuring longevity of higher self-efficacy. Mastering cognitive skills may not only increase self-efficacy, but also improve persistence, performance and interest. However, if young children have already developed a negative attitude towards numeracy, this may obstruct the learning of new and advanced skills. Research has considered the effects of self-efficacy, and how self-belief determines one’s ability to complete a task. Pajares and Graham (1999) studied self-efficacy and the effects of various motivation variables (anxiety, self-concept, self-efficacy for self-regulation, perceived value, engagement) on performance with 273 students beginning middle school (U.K. age 10-11). The authors aimed to determine whether the influence of these variables would alter after a year. Responding to the mathematics self-efficacy instrument, children rated their confidence in solving twenty mathematical problems, similar to those in an end of year test, thus increasing ecological validity. The children’s self-ratings demonstrated that self-efficacy was the only motivational variable to predict mathematics performance at the start and end of the year. The results of this study suggest that self-efficacy in mathematics is a key regulator of performance and students with a higher-self efficacy are less at risk of developing anxiety.

This is an assertion shared by Zimmerman (2000). Similar effects of children’s self-efficacy have been found by Linder and Smart (2010) who investigated mathematics motivation constructs in 1,018 grade one (U.K. age 6) to grade five (U.K. age 10) pupils. Following implementation and analysis of the 17-item Mathematics Motivation Inventory (Smart & Linder, Under Review), three factors emerged as having an association with performance: mathematics anxiety, mathematics self-efficacy and the value of mathematics. Across five schools and 117 classrooms, the results showed that children in the lowest year reported lower mathematics anxiety, higher self-efficacy and higher value for mathematics than children in the later years. In summary, self-efficacy is suggested as a determinant of mathematical achievement, with an association with persistence and learning new skills. Taken together, research results in children have shown self-efficacy to be a predictor of mathematics performance and have an association with mathematics anxiety.
Throughout the educational years, self-efficacy has been demonstrated to decrease as mathematics anxiety increases. Although similar results were obtained between the research of Pajares and Graham (1999) and Linder and Smart (2010), as previously discussed, varying self-report measures are used with the differing participant age range. Moreover, relating to sample size, although both large, there is a 745 participant difference between the two studies and it may be argued that similar sample sizes would have yielded different results to those reported. Thus, it is difficult to make a clear comparison between the results, although the role of optimism and pessimism in mathematics achievement cannot be overlooked. In addition to this, Linder and Smart (2010) consider additional factors that may influence the issue of increased mathematics anxiety and reduced motivation, including a rise in difficulty as children progress through education, the classroom environment and teacher quality. Similarly, mathematics anxiety is postulated to be a cognitive consequence of low self-esteem and Hughes (2003) found this to negatively affect mental arithmetic. Such factors, including self-efficacy, may influence children’s attitudes and anxiety before the age range of the discussed research (Petronzi et al., 2012).

Mathematics anxiety and performance has been evidenced as having an association with additional factors, including failure, the language of mathematics and motivation. Ashby (2009) adopted a qualitative approach to exploring the mathematics attitudes, behaviour and beliefs of year three U.K. children (aged 7 years). Discussions followed completion of a short worksheet, and children’s responses related to feelings when completing these. Immediately, this highlights a limitation of the research in that the discussion findings may not reflect the children’s everyday attitudes to numeracy. Additionally, the study may be limited by a focus on year three pupils in a single school, restricting the generalizability as to how early negative responses to mathematics develop. Nonetheless, analysis of discourse found a resignation to failure and that children faced problems with understanding the language of mathematics, relating to Thompson and Rubenstein (2000). High and low achieving children were also failing to understand the wider practicalities of mathematics, and could not make a connection between their work on paper and real world applications. Ashby (2009) adds that this is especially detrimental to the low achievers, as their ability and persistent failure cannot inspire the motivation required to advance their concept knowledge. Ultimately, the motivation of low achievers in particular will decline if they are unable to comprehend the benefits of mathematics comprehension, further impacting their performance and participation. This has been shown, as previously discussed, to have an association with mathematics anxiety and may increase in severity through the educational years. These factors may represent and contribute to the suggested ‘numeracy apprehension’ – the foundation phase of
mathematics anxiety (Petronzi et al., 2012). The research conducted by Ashby (2009) was an insightful attempt at qualitative feedback from children, exploring attitudes and experiences towards mathematics. Multiple factors emerged through discussions, and highlight the importance of exploring the same experiences of younger children, as in the author’s previous qualitative research, which has been the foundation for this PhD research.

Exploring motivation further, Tella (2007) conducted research with secondary school children and found that negative attitudes can result in poor performance, which in turn, creates a lack of motivation. It may be argued that the low anxious are intrinsically motivated (Nicolaidou and Philippou, 2003) and particularly in tasks that a person enjoys and takes fulfilment from (Tella, 2007). In contrast, children with negative numeracy attitudes may lack this fundamental impetus, and therefore rely heavily on extrinsic motivation; a reward to be obtained on completion of work. However, if the reward loses its value or if the child is unable to complete their numeracy work, their motivation will diminish. There is a need to understand the effects of motivation on numeracy/mathematics performance due to its influential command over other variables (Tella, 2007). In summary, motivation, amongst other identified factors, appears to have a key association with mathematics anxiety, although the causal relationship is unclear. In particular, motivation relates to persistence and failure in mathematics and those with the intrinsic motivation to learn and succeed are likely to develop and maintain positive attitudes.

Research with older children has also found that a perceived or genuine lack of preparation can produce anxiety (Wong and Evans, 2007). Situational factors, such as time limits and awareness that an exam is measuring ability, can also increase levels of mathematics anxiety. Additionally, failure and the right or wrong nature of mathematics has been shown as an associate of anxiety for learners (Chinn, 2012). Chinn’s (2009) survey of secondary students aged 11-15 years, showed that high levels of anxiety were self-reported in response to scale items: “waiting to hear your score on a mathematics test”, “having to take a written mathematics test”, and taking an end of term mathematics test”. Students also reported high anxiety when considering the need to solve mathematics questions quickly, which reflects the belief that mathematics must be done quickly in order for a learner to be considered competent. It is suggested that in the classroom, more emphasis is placed on a correct response, rather than conceptual comprehension (Baroody, Bajwa & Eiland, 2009). This relates to Vukovic et al. (2013) citing Gersten, Beckmann, Clarke, Foegen, Marsh, Star and Witzel (2009), suggestion that children who can solve number arithmetic problems struggle with contextual problems using the same numbers. This implies that children have not grasped the
required understanding of the mathematical concept. Again, this can place children at a disadvantage, which can have an association with failure, avoidance and anxiety. These factors are explored further in study 1. However, Chin (2012) measured children’s (aged 7-15 years) responses on a 44-item predominantly arithmetic test, consisting of problems ranging from $2 + 5 = \_\_\_\_$, to 20% of 140. The results indicated that older children perform better on the addition problems, however, when three digit addition is introduced and becomes more challenging, the percentage of “no attempts” increased. Chinn also found that subtraction was considered much more difficult, particularly for older children, whilst there was a less than 50% success rate for multiplication problems, leading to the suggestion that the anxiety and fear induced due to their perceived complexity has an association with “no attempts”. Division problems also resulted in a high rate of “no attempts”. Chinn considered that many mathematical procedures are unforgiving on inaccurate memories. Yet, it may be the case that children became fatigued with the testing process, in which case, a performance drop can be anticipated. Furthermore, it may be that participants lacked the core competence and their performance suffered as a consequence. Regardless, the research demonstrates the variation in factors that can influence children’s numeracy apprehension/mathematics anxiety, and the link between them, i.e. failure and avoidance. Yet, the causality of these can work in both directions. Again, the aims of study 1 of this PhD thesis are concerned with whether the factors evidenced in research, reflect those observed in young children by mathematics experts, parents and teachers.

A gender difference has also been evidenced as having an association with mathematics attitudes (Kargar et al., 2010). Mathematics is often considered to be a male dominated subject, although performance results between males and females are often similar (Haase et al., 2012; Mata et al., 2012). However, a difference relates to beliefs in which they hold, for instance, girls have previously demonstrated a lower mathematics self-concept than males (Skaalvik & Skaalvik, 2004), although when comparing attitudes, these have been shown to be both similar and dissimilar to males. Typically, females show behavioural signs of anxiety when attempting to avoid pressure situations in the classroom (Beilock, Gunderson, Ramirez & Levine, 2010; Mutodi & Ngirande, 2014). Additionally, males have been shown to demonstrate more resilience and persistence following mistakes in mathematics (Devine, Fawcett, Szucs & Dowker, 2012). Brady and Bowd (2005) have also suggested that girls receive less help in mathematics and are exposed to more ridicule when experiencing difficulty. Further to this, Beilock et al (2009) suggest that girls may be more likely to notice their teacher’s fears and negative attitudes towards mathematics. This implicates the influence of teachers, and will be discussed in the following section, along with the
influence of parents. Taken together, evidence again suggests that there are myriad factors, particularly relating to concept understanding and failure that influence the development of children’s mathematics attitudes and their level of performance. The gender differences relating to mathematics performance and anxiety are less clear however, and require further research.

In summary, a large number of numeracy/mathematics factors have been identified as relating to the individual, for example: brain mechanisms regulating emotional responses; negative self-perceptions of abilities; self-comparison against peers; explanatory styles of achievement and failure; self-efficacy; motivation and concept understanding – all with a link to gender differences. These factors have been shown to have an association with mathematics achievement and anxiety. However, additional key factors influencing numeracy/mathematics attitudes and anxiety relate to the classroom environment (teachers) and the home environment (parents). Although many of the discussed factors were expressed in some form in the author’s previous research with children aged 4-7 years, it was of interest to explore the perspectives of primary care providers. The author anticipated a number of factors to be discussed in focus group discussions in study 1: avoidance; emotional responses; evaluation anxiety; failure and fear of this; children’s explanatory styles; the language of mathematics; children struggling to understand the practicalities of mathematics; the right or wrong nature; awareness of ability groups and gender differences.

The author’s previous research, as aforementioned, considers the ages of 4-7 years to be the development stage of numeracy apprehension, in which the factors identified as influencing older children, are also involved in the formation of young children’s attitudes. Hachey (2009) states that the early years forms the basis for future attitudes towards mathematics, and initial positive attitudes are at risk of repression from increasing worry about performance. Harari et al (2013) also suggest that the pre-cursor to mathematics anxiety relates to negative reactions and confidence in numeracy, and is evident at an early age. Moreover, Norwood (1994) stressed that a single cause was not attributable to the development of mathematics anxiety and was rather the product of a number of aspects such as poor coping strategies, low self-image and avoidance i.e. Petronzi et al (2012).

1.7.1 The influence of teachers and parents

Teachers play a crucial role in children’s approach to learning and their attitudes towards numeracy/mathematics. Dodd (1999) has previously stated that it is essential for the teacher to believe that students have the ability to learn mathematics, and must pass on this same belief to the student. Following research with children aged 9-14 years, Chiu and Henry (1990) found that
factors of the Mathematics Anxiety Scale for Children, included learning mathematics and mathematics teacher anxiety. Additionally, in an attempt to understand the dimensions of mathematics anxiety in 9-11 year olds (U.K. years 5-6) Newstead (1994) compared a traditional teaching approach (teacher demonstrations and individual practice) against a teaching approach that centred on problem solving and strategy discussions. Children’s levels of anxiety in each teaching approach were measured using the Mathematics Anxiety Questionnaire (Newstead, 1992). The results showed children had higher anxiety levels in the traditional teaching approach, particularly when asked questions by teachers and explaining an answer, solving mathematical problems in front of peers and being observed during problem solving. This research specifically identified evaluation and teacher anxiety as key dimensions of mathematics anxiety. Evaluation anxiety may be imposed by a teacher, by placing a child in a pressure situation, such as solving a problem in front of peers. This may also lead to stigma and potential fear of teacher’s reactions if a child is unable to complete numeracy tasks (Whyte & Anthony, 2012). The child may perceive such actions as hostile (Vukovic et al., 2013), further damaging their relationship with the teacher. The formation of a positive student-teacher relationship is therefore crucial to a productive learning environment (Mata et al., 2012). Fiore (1999) previously stated that a child’s success in mathematics corresponds to how they are made to feel in class.

Higbee and Thomas (1999) previously reported the increase in emphasis on the role of teachers, course content and structure, in relation to the mathematics achievement of students. However, research has suggested and shown that teachers can suffer with their own anxieties relating to mathematics. Bibby (2002) explored teacher attitudes towards mathematics through a series of in-depth interviews, in which she stated there were clear statements relating to fear or anticipation of judgement against the standards they were required to meet. Teachers also stated that they would struggle with mathematics in pressure situations, such as in-service education training (INSET).

Beilock et al (2012) also found a significant negative relationship between teachers’ anxiety and female students’ achievement at the end of a school year. This demonstrates how anxiety can be transferred from teachers to students, reinforcing them as a critical factor in the development of children’s mathematics attitudes. In particular, female teachers have been considered as transferring their negative attitudes to children (Eden, Heine & Jacobs, 2013; Vinson, 2001; Maloney & Beilock, 2012). However, it remains unclear as to the extent of female teachers transferring mathematics anxiety to male pupils and the extent of male teachers transferring anxiety. Aslan et al (2013) considered teachers using basic methods in their lessons as having a degree of
mathematics anxiety. However, their research did not demonstrate the same negative relationship between teacher anxiety and children’s (n=400, aged 6 years) performance.

Rahim et al (2005) proposed anxiety reduction in junior and intermediate pre-service teachers, as an early intervention. They believe studying their feelings of discomfort with numeracy and mathematics is a logical step. By alleviating mathematics worries in teachers, they should be more suitably prepared for students they encounter with similar feelings, and not convey negativity to the children, or intensify any underlying numeracy worries. Hamlett (2007) wrote in acknowledgment of the shame often felt by adults, and particularly teachers, due to their lack of mathematical knowledge. Poor comprehension may be the consequence of unconstructive school experiences, leading to negative coping strategies and attitudes, and ultimately apprehension, which students are at risk of learning as this is transferred to them. Teachers who lack confidence in their mathematics abilities are more likely to teach children procedurally by rote which is more challenging to learn (Skemp, 1986; Chinn, 2012). Consequently, children may not develop comprehensive understanding of the concept they are learning, particularly if they struggle to understand the language of mathematics presented to them (Thompson & Rubenstein, 2000). However, other teachers may have an awareness of their anxieties and attempt to improve areas of weakness in order to promote the positive aspects of numeracy/mathematics to children.

Hamlett (2007) designed and implemented the multiliteracy unit to provide pre-service teachers with the opportunity to tackle their specific mathematical difficulties and anxiety, through a variety of methods, including group work; self-paced work, use of websites, pen and paper work, practical tasks, and access to a skilled tutor. The unit aimed to encourage and build mathematical confidence, and familiarise the students with concepts and strategies that they may have forgotten. Moreover, Hamlett relates to Anthony (2000) who identified motivation, task completion, and seeking help as behaviours that lead to success, which the unit further attempted to promote. Results indicated that confidence ratings had improved, but pre-service students maintained low confidence with regard to teaching a skill as opposed to performing the task themselves. This was in spite of a decrease in anxiety and stress as competence increased. Uusimaki and Kidman (2004), add that large numbers of primary pre-service teachers experience mathematics anxiety and negative beliefs when entering teacher education courses. Their research attempted to reduce anxiety through an online workshop course that involved placing teachers in a safe and supportive environment that promoted risk taking and group support, whilst mathematical activities were focused on content areas that had been indicated as causing anxiety. The results they found suggest that mathematics anxiety reduced with heightened awareness of emotional state and feelings in
relation to each mathematical activity. The research implies it is anxiety that interferes with teaching performance, justifying progressive research into the most effective interventions for teachers. This in turn, would reduce an educational risk factor for children. Mazzocco (2007) states that due to the influence of teachers’ attitudes on children’s mathematics outcomes, they do children a disservice when demonstrating a dislike of mathematics.

Taken together, the body of research suggests that teachers have an association with children’s numeracy/mathematics attitudes, anxiety and achievement. Some children are anxious about negative evaluation and responses to failure of teachers, affecting the student-teacher relationship. Despite workshops designed to increase teacher confidence, pre-service teachers maintained low confidence in their ability to teach a mathematics skill. This serves to demonstrate the rigidity of anxiety, and how understanding the origins of mathematics anxiety can prevent its full development. Teachers have also been shown to have their own mathematics anxieties that children are at risk of learning. Lazarides and Ittel (2012) consider that individual differences will exist between children in how they judge the quality of mathematics instructions, and relates to previously discussed individual factors. This serves to demonstrate the complexity of factors that are involved in the formation of children’s numeracy attitudes and anxieties. In relation to teachers, their attitudes developed in their own education and teaching experience, and these can subsequently shape the attitudes of pupils. Uusimaki (2004) considered this to be a cyclic process. The perspective that attitudes are formed through experiences in education is significant, because those that are formed at an early age can persist throughout educational careers.

According to Mazzocco (2012) parents, as well as teachers, should provide children with feedback about the value of numerical tasks to facilitate the formation of positive and accurate perceptions of their abilities. Dowker, Ashcraft and Krinzinger (2012) also highlight the importance of parents, regarding them to be a strong influence on children’s educational attitudes and Vukovic et al (2013) consider them to be a key facilitator of success. However, with regards to transference, children can also learn negative attitudes from their parents (Rossnan, 2006; Gunderson et al., 2012). Erden and Akgul (2010) believe this to be the case when parents state that they found numeracy/mathematics difficult at school. This provides children with an ‘excuse’ to withdraw when they struggle with work. Additionally, achievement in mathematics may not be valued by some parents; an attitude that can also transfer to children (Fraser & Honeyford, 2000). Exposure to such attitudes may affect the mathematics participation and effort of children, whose achievement may suffer as a consequence. In contrast, the Mathematical Association (2012) stated that parents are struggling to facilitate children’s numeracy and mathematics as most do not understand modern
methods. So, in these situations, children who may rely on support from their parents to overcome numeracy/mathematics difficulty will be unable to complete work. This places them at a disadvantage in comparison to peers who receive sufficient help in the home environment. However, children may also develop negative attitudes in numeracy/mathematics if their parents place significant expectation and pressure on them to achieve (Yuksel-Sahin, 2008; Krinzinger et al., 2009).

In summary, research suggests that parents are another key factor in the development of children’s attitudes, and children are likely to adopt the attitudes they are most exposed to. Thus, it is advantageous to obtain direct insight into the perspectives of parents. However, teachers and parents as numeracy apprehension factors are multi-faceted, and increase the complexity of our understanding of what may influence the formation of children’s attitudes. For example, a parent may endeavour to help their child and place a high value on comprehension of the subject, yet are unable to facilitate their child’s learning due to their own ability and difficulty understanding modern methods, such as the multiplication grid method and chunking. Due to the significant roles they play in education, the influence of parents and teachers is explored directly in the first study of this PhD thesis. It is anticipated that factors outlined in previous research relating to the influence of parents will also emerge in focus group discussions.

1.8 Mathematics Anxiety Rating Scales: a traditional research method

Research with older populations has been a key knowledge base for mathematics anxiety research. This has led to an assertion that this issue may relate more to emotions and does not necessarily indicate an intellectual deficit (Luo et al., 2009) although reduced performance and working memory resources have been shown as a consequence of mathematics anxiety (Ashcraft & Kirk, 2001; Ashcraft & Krause, 2007). The data obtained with older populations has naturally increased understanding of mathematics anxiety factors and their consequences.

However, it has been suggested that the lack of appropriate tools for measuring mathematics anxiety and its emergence in young children has limited our knowledge (Mazzocco, 2007) and this was addressed in PhD study 2. The following section will present measurement scales and previous research have notably found discomfort and nervousness in older children, when performing mathematics. This has implicated negative attitudes, self-confidence and motivation, and a neuro biological basis of mathematics anxiety.
This section will outline the traditional quantitative measurement methods of mathematics anxiety rating scales. These have been fundamental to the understanding of the construct and are central features throughout a proportion of prior research. Mathematics anxiety rating scales remain prominent in research with older populations and have been designed and validated psychometrically over many years. Standardised rating scales have enabled accuracy in the measurement of mathematics anxiety through identifying underlying factor structures and continue to be refined in search of increased validity, internal consistency and reliability (Kline, 2000).

1.8.1 The origins of quantifying mathematics anxiety

The Number Anxiety Scale (NAS) (Dreger & Aiken, 1957) emerged as the first rating scale for measurement of this construct, though it was adapted from the Taylor Manifest Anxiety Scale (Taylor, 1953) that measured anxious behaviours and emotions through true or false response statements. Specifically, trait anxiety was measured relating to the propensity to experience anxiety in multiple situations (Taylor, 1953). An initial limitation of this scale was the omission of an opportunity for ambivalent judgements, with respondents obligated to self-report using either extreme. Spector (1992) stated that limited response options provide no way to distinguish between participants, resulting in insufficient exactitude. Three items relating to number induced anxiety were extracted by Dreger and Aiken (1957): (1) nervousness when required to do arithmetic; (2) “freezing up” when encountering a mathematics problem and (c) believing that one is not as good at mathematics as at other subjects. These items were subsequently tested with 704 students between eighth and tenth grade completing a basic mathematics course. Based on the subsequent results, participants were deemed to suffer from number anxiety, distinct from general anxiety, if they declared feeling two or more of the aforementioned statements. Despite pioneering quantitative measurement of mathematics anxiety, this scale had limited items to gauge a person’s feelings when working with numbers and resulted in limited validity and reliability.

Silverman (1993) considers that quantitative methods allow for predictions and theories to be tested. Due to the maintenance of objectivity and the quantification of outcomes to be statistically analysed, comprehensive mathematics anxiety rating scales emerged. Through applying the knowledge gained from the NAS, subsequent rating scales were required to include a greater range of items to measure the construct, due to its complexity and effects. These would allow for a more accurate measurement of anxiety when doing mathematics in a variety of situations.
Richardson & Suinn (1972) constructed the Mathematics Anxiety rating scale (MARS), the first comprehensive scale to specifically measure mathematics anxiety. This was used as a diagnostic tool for college students, who commonly experienced mathematics anxiety and to test the efficacy of anxiety treatments. Richardson and Suinn (1972) created the MARS for various reasons, and intended it to be: a mathematics anxiety diagnostic tool; to be used in research to evaluate the efficacy of interventions and treatments for other anxieties; to form control groups based on normative data that could be compared against individuals identified as mathematics anxious and to determine the structure of the mathematics anxiety. This was considered to be hierarchical, as anxiety is experienced at ranging levels, rather than simply anxious or non-anxious. This scale was designed on the premise that mathematics anxiety is unidimensional, although subsequent factor analytic studies have identified a number of factors that influence mathematics anxiety scores. Additionally, the qualitative data of the current PhD thesis suggests that apprehension in numeracy for children aged 4-7 years is influenced by more than a single factor, including teacher anxiety and failure. Yet despite this assumption and due to the novelty of the NAS, the author could only theorise at this stage prior to testing and factor analysis.

The original MARS consists of 98-items relating to a wide range of mathematical situations that further enabled this scale to be administered to non-students. However, the original implementation of the instrument required 397 college students to rate their current anxiety towards mathematics on a 5-point Likert-type scale, ranging from ‘not at all’ to ‘very much’. A total score is attributed by summing all the values, with high scores reflecting high levels of mathematics anxiety (Richardson & Suinn, 1972). The reliability of the MARS was confirmed through a test-retest reliability coefficient involving 35 students tested at the beginning and end of a seven week period. A Pearson-product-moment coefficient provided a highly significant value of .85 between the two sets of scores, indicating that the scale was consistently measuring mathematics anxiety. Reliability of the MARS was further demonstrated through a statistically significant and high Cronbach’s alpha value (α = .97) (Kline, 2000) that indicated inter-correlation of the scale items and a homogeneous factor, considered to be mathematics anxiety (Richardson & Suinn, 1972). The original validity of the MARS was demonstrated by a reduction in mean scores following mathematics anxiety intervention and construct validity was further demonstrated by MARS scores that did not decline significantly for a non-intervention control group (Suinn, Edie & Spinelli, 1970; Suinn & Richardson, 1971; Richardson & Suinn, 1972). Based on these empirical results and using the MARS in conjunction with a mathematics aptitude test, Richardson and Suinn (1972) were able to suggest that high MARS scores are associated with reduced mathematics performance.
To summarise, despite the demonstrated validity and reliability of the MARS, the 98-items posed administration issues, due to the potential for participant fatigue and also researcher error when scoring the data (Ashcraft & Moore, 2009). A scale of this length would not be functional with the current age range of children aged 4-years, as they would lose interest and struggle to complete the scale. Additionally, Tavakol and Dennick (2011) have suggested that some scale items may be redundant if the alpha value is too high, recommending that this does not exceed 0.90, unlike the value of .97 originally obtained by Richardson and Suinn (1972). A score of .97 suggests that some items need to be omitted from the scale, as its focus may be too narrow (Nunnally & Bernstein, 1994). Further to this, the original MARS assumes that mathematics anxiety is unidimensional. Yet, subsequent factor analysis studies have produced a variety of factors associated with mathematics anxiety; with test/evaluation anxiety being a significantly recurring single factor in analysis (Newstead, 1995).

1.8.2 Mathematics anxiety scales: revisions, developments and factor structures

Since the development of the MARS, revisions have been published, with varying alpha values and factor structures. For example, Suinn and Edwards (1982) developed the 98-item Mathematics Rating Scale for Adolescents (MARS-A) through collecting data on over 1,200 junior high and senior high students (U.K. age 16 – 18). The items reflected everyday mathematical situations and responses were measured through a 5-point Likert scale. In conjunction with the scale, participants completed a survey that included queries concerning grades in coursework, career choice and parent occupation. To determine the construct validity of the scale, participant grade averages in mathematics were compared against their MARS-A scores, and results indicated that participants with high MARS-A scores, also had lower mathematics grade averages (Kidd, 2003). The factors of numerical anxiety and mathematics anxiety were found and the alpha value, reflecting the internal consistency of the scale, was sufficiently high ($\alpha = 0.89 – 0.96$) (Lacobucci and Duhachek, 2003).

The factors identified in this revised scale, compare to those of the original MARS, in which Rounds and Hendel (1980) identified two underlying factors: ‘mathematics test anxiety’ that relates to being evaluated in the subject and, ‘numerical anxiety’ that related to completing two number sums. However, whilst 89 items loaded onto the numerical anxiety factor, only nine loaded onto the test anxiety factor. By contrast, following another independent factor analysis of the MARS, Richardson and Woolfolk (1980) found that only a single factor relating to emotionality emerged,
due to the MARS being primarily a measure of negative reactions to mathematics (Wigfield and Meece, 1988). Similarly, Alexander and Martray (1989) found additional mathematics anxiety factors, through the development and implementation of the Revised Mathematics Anxiety Rating Scale (RMARS); an abbreviated version of the MARS. The underlying factors included mathematics course anxiety, evaluation anxiety and arithmetic computation anxiety. To summarise, these factor analytic studies demonstrate the variance in scale results and show the influence and combinational effect of multiple factors. The variance in obtained factors may demonstrate progressive development of scales, particularly when considering the RMARS which highlighted a further three factors of mathematics anxiety. Thus, mathematics anxiety began to be represented as multidimensional. However, it remains that items have been adapted and revised from the original MARS and have not been developed for a specific population based on qualitative data, as the current PhD thesis has. Further to this, the MARS is limited by being a predominantly negative measure of mathematics anxiety and could be misleading to the numeracy experiences of children aged 4-7 years, who are still developing and understanding their attitudes towards the subject. To rectify this, the NAS items of this PhD thesis will be neutrally termed for children to respond to.

Additionally, as not to dismiss children as being susceptible to mathematics difficulties, particularly as it is thought that difficulties can develop early in education (Rossnan, 2006), Suinn, Taylor and Edwards (1988) developed the Mathematics Anxiety Rating Scale for Elementary School Students (MARS-E). The 26-item scale that uses a 5-point Likert system, similar to that of the MARS, was developed with 1,119 fourth (U.K. age 9-10, year 5), fifth (U.K. age 10-11, year 6) and sixth graders (U.K. age 11-12, year 7) from six schools. Children were asked to indicate the level of anxiety they experienced in relation to each scale item, such as reading a mathematics chapter. To determine construct validity, MARS-E scores were correlated with SATs scores, in which a significant relationship between each participant’s scores was found (Kidd, 2003). Factor analysis revealed two factors; the first was identified as mathematics test anxiety and the second was identified as mathematics performance adequacy anxiety. The internal reliability of the MARS-E was estimated (α = 0.88) and the items were found to be well understood by participants, who would have better maintained focus due to fewer items than the original 98 item MARS. To conclude, the MARS-E was more developed for the target population and significantly decreased the number of items, to improve the data collection and analysis process. However, McMorris (2004) later stated that the two underlying factors identified in the MARS-E accounted for less than 30% of the variance. In addition, the age range of this scale omits the earlier years, when anxiety may have begun to develop, and the factors identified in later years may potentially be the
consequences of earlier negative experiences. To demonstrate this point, in study one of this PhD thesis, mathematics experts discussed observing anxiety in children when performing numeracy in front of others. This relates to the mathematics performance adequacy factor of the MARS-E, although found with an older population. This suggests that factors that define numeracy and mathematics anxiety have developed in the early years and are consistent over time. This further supports the development of a scale for children in the early years of education. Furthermore, the scale items were not generated from a qualitative data item pool with children aged 9-12 years, whose experiences will differ greatly to those of college students, as used for validating the original MARS items. However, rating scales began to represent mathematics anxiety as multidimensional.

The Revised Mathematics Anxiety Rating Scale (RMARS; Alexander & Martray, 1989) also assumed mathematics anxiety to be a multidimensional construct. Exploratory factor analysis of the 69 item scale revealed a three factor structure consisting of Mathematics Test Anxiety (evaluation situations), Mathematics Course Anxiety (mathematics class reactions) and Numerical Anxiety (anxiety relating to basic mathematics) (Baloglu & Zelhart, 2007). The original construct validity of the RMARS was obtained from a sample of 517 undergraduate students, although the three factors identified only accounted for 31% of the variance in the RMARS scores. Subsequent research has retested the factor structure of the RMARS, and obtained dissimilar results. For example, Bowd and Brady (2002) as reported by Ashcraft and Moore (2009), conducted principal components analysis, following the implementation of the scale with 357 undergraduate students. A three factor structure of the scale was also identified, and reflected the structure found in the initial construct validity. However, the three factors now accounted for 73% of the variability in the RMARS scores. Moreover, a confirmatory and exploratory factor analysis conducted by Baloglu and Zelhart (2007) following implementation of the RMARS with separate samples of 559 and 246 participants, also revealed a three factor structure of the RMARS, although these accounted for 66.08% of the variance and suggested construct validity. This subsequent research further reinforced mathematics anxiety as a multidimensional construct, but again showed the variance in scale results. The variance observed in factor structures may relate to population and demographic differences and implementation with contrasting populations sizes. This would affect the factor analysis and thus, factor structure. However, as previously mentioned, this may be viewed as progressive understanding as to the underlying factors of mathematics anxiety. This is a point further reinforced by Kazelskis (1998) who identified six factors associated with mathematics anxiety: mathematics test anxiety; numerical anxiety; negative affect towards mathematics; worry; positive effect towards mathematics and mathematics course anxiety, relating to the RMARS, the
Mathematics Anxiety Scale and the Mathematics Anxiety Questionnaire. This again revealed multiple factors associated with mathematics anxiety, a positive affect towards mathematics and the identification of a factor correlation between numerical anxiety and mathematics course anxiety (0.09). This was discussed as significant as numerical anxiety is the factor that best fits the accepted definitions of mathematics anxiety, due to the anxiety caused from the manipulation of numbers. Further revealing the complexity of mathematics anxiety, Mahmood and Khatoon (2011) discuss the findings of Ling (1982) who researched mathematics anxiety as a multidimensional construct and found six underlying factors that accounted for 76% of the variance (personal effectiveness; assertiveness; mathematics anxiety; outgoingness; success and dogmatism). To summarise, it can be seen that the validation and re-testing of mathematics anxiety assessment rating scales has provided contrasting factor structures. Although this variance could suggest inconsistencies in implementation, the current author again proposes that the testing and evolution of such scales has provided a larger set of underlying mathematics anxiety factors for researchers to consider and explore. Further to this, factors identified with, for example, the RMARS, have been discussed in the authors previous research with children (mathematics class reactions) (Petronzi et al., 2012) and by primary care givers in study one of this PhD thesis.

Chiu and Henry (1990) added to factor analytic research with development of the 22-item Mathematics Anxiety Scale for Children (MASC), based on the shortened MARS (Flake & Parker, 1982). Again, this demonstrates the adaptation of items from previously validated scales, rather than the creation of items for the specific age range. However, Chiu and Henry considered this scale to be a consistent measure of mathematics anxiety, based on their research with 562 children from fourth grade (U.K. age 9-10, year 5) to eighth grade (U.K. age 13-14, year 9) across several school districts in North-Central Indiana. Citing the guidelines of Tinsley and Tinsley (1987), DeVellis (2003) suggests that there should be a ratio of 5 to 10 participants for each scale item, and in this case, the MASC can be judged to have a ratio of roughly 26 participants per item (25.5 x 22 = 561), complying with the suggested guidelines. Participants rated their level of nervousness in response to items on a 4-point Likert scale, relating to, for example, feelings when taking a mathematics test and when asked to interpret mathematics statements (Kidd, 2003). In order to determine construct validity, MASC results were compared against the shortened version of the MARS, mathematics results achieved in that school term, results from completing the Test Anxiety Scale for Children (Wren & Benson, 2004) and the School Achievement Motivation Rating Scale (Chiu, 1997). Significant results were obtained, which demonstrated that participants who scored highly on the MASC, had lower achievement in numeracy, higher test anxiety and lower
achievement motivation. The factors identified were (1) concern with mathematics evaluation (2) the learning of mathematics (3) solving mathematics problems and (4) mathematics teacher anxiety, although this was only defined by two items. The reliability of the scale was estimated to range between .90 and .93, although as aforementioned, this may suggest that some items may be redundant (Tavakol and Dennick, 2011). Nonetheless, the factors identified with older children reflect key discussion points identified in the current author’s previous research (Petronzi et al., 2012). For example, children discussed their teacher based anxieties which was considered as a main differentiator between those with high and low apprehension. Similarly, the primary care providers in study one, spoke of their observations of some children’s anxieties and response behaviours when performing numeracy in front of their peers. To conclude, whilst the MASC targets a young population, the author reiterates that several years of potential development of a negative attitude towards numeracy/mathematics have been overlooked. In addition to this, the items are again adapted from the MARS (undergraduate population) and not created specifically for the aged range of 9-12 years. Furthermore, whilst items were revised for use with young children, their pre-determination disallows children the opportunity to reveal their personal thoughts and feelings to certain aspects and experiences of mathematics. However, as the MASC is compiled of 22 items, responses are likely to be more accurate, as this minimises the opportunity for fatigue and boredom, when compared to the original 98-item MARS, deemed as cumbersome (Ashcraft & Moore, 2009).

Fennema and Sherman (1976) created nine domain specific Mathematics Attitudes Scales that measured varying aspects of mathematics learning attitudes (Kidd, 2003). The cluster of nine scales, that could be administered individually or collectively, included (1) the Attitude towards Success in Mathematics; (2) the Mathematics as a Male Domain Scale; (3) the Mother/Father Scale; (4) the Teacher Scale; (5) the Effectance Motivation Scale in Mathematics; (6) the Confidence in Learning Mathematics Scale; (7) the Mathematics Usefulness Scale and (8) the Mathematics Anxiety Scale (MAS) (Kidd, 2003). Each of these scales was designed to focus on a specific factor of numeracy learning and experiences, although the MAS was a main component of this cluster of scales, designed for use with high-school students in grades 9-12 (U.K. age 14-17 years). This scale consists of twelve items, divided into six positively and six negatively worded statements, with the intention of measuring anxious feelings and nervousness associated with mathematics using a 5-point Likert scale. Responses ranged from strongly disagree to strongly agree. Although the MAS was found to have a high internal consistency and reliability (α = 0.88), Mahmood and Khatoon (2011) cited Rounds and Hendel (1980) who stated that due to scant research relating to the validity
and reliability of the scale, its use for research is limited. The importance of this is outlined by DeVellis (2003) who stated that if the stages of scale development are not adhered to, including the testing of validity; incorrect conclusions may be inferred about a construct. However, the MAS was subsequently used to demonstrate concurrent validity of the Fennema-Sherman Attitude Scale (1976), revealing negative relationships, in that students who had a more positive attitude towards mathematics reported less mathematics anxiety (Baloglu & Zelhart, 2007). Additionally, the MAS attempted to be multidimensional with the inclusion of items measuring positive aspects of mathematics (e.g. “I have usually been at ease during math tests”), as opposed to solely focussing on negative effects of mathematics anxiety.

The MAS was later adapted and reformed by Betz (1978) as reported by Bai, Wang, Pan and Frey (2009) to form a ten-item bidimensional scale, that had an even division of items with positive and negative wordings towards mathematics. Analysis of the scale revealed a sufficient internal consistency of .72 (Dew & Galassi, 1983) and, following its implementation with a sample of 769 undergraduates, a two week test-retest reliability of .87 was established (Pradeep, 2011). The results were obtained in a study that aimed to investigate the relationship between mathematics anxiety and test anxiety, with a focus on the worry and emotionality associated with test anxiety. Students also responded to items on the MARS and the Test Anxiety Inventory (TAI; Spielberger, 1980). The results indicated that mathematics anxiety measures were more related to one another than test anxiety, although the two constructs are related (Pradeep, 2011). This suggests that those who are mathematics anxious are further disadvantaged in test conditions. Bai et al (2009) considered the inclusion of positive items in the measurement of mathematics anxiety as assisting the administrator in determining which aspects an individual is comfortable with. This would enable additional intervention efforts to be focussed on areas of negativity. However, Pradeep (2011) considers that positive or negative wording of items should not influence the testing of mathematics anxiety. This relates to Black (1999) who advised that scale items should be objective and not encourage one type of answer. In light of this, the current research will utilise neutrally worded items for children aged 4-7 years to respond to.

Hopko, Mahadevan, Bare and Hunt (2003) conducted research to establish the psychometric properties of the Abbreviated Math Anxiety Scale (AMAS); a measure of mathematics anxiety, consisting of nine items, participants indicated their anxiety level using a 5-point Likert scale. The scale consists of two subscales, and thus, a two factor structure, that incorporate 5 items focussing on the Learning Mathematics Anxiety (the process of learning mathematics) and 4 items relating to
Mathematics Evaluation Anxiety (testing situations), accounting for 70% of the variance (Vahedi & Farrokhi, 2011). The AMAS achieved a high initial internal reliability ($\alpha = .90$) and a two-week test-retest of reliability revealed a sufficiently high value ($\alpha = .85$). This suggested that the AMAS is a valid measure of mathematics anxiety with the factors of anxiety associated with learning mathematics and evaluation being identified as main elements. Dissimilar to the MAS, the AMAS was unidimensional and did not attempt to measure positive affective aspects of numeracy. Although the AMAS only consists of nine items, the scale was administered to a significantly large sample size ($n=1,239$) and tested for convergent and divergent reliability. However, Hopko et al (2003) consider that the omission of convergent and divergent reliability is a common limitation of scale development, along with small sample sizes and no retest data. Further to this, they consider that scale factor structures are often accepted without the reinforcement of further empirical study, which can lead to models that do not represent the emotional experiences of mathematics anxiety. The utilisation of such scales in subsequent research places a limitation on validity (Hopko et al., 2003). In light of this, PhD study 2 will administer the scale to children aged 4-7 years, and following factor analysis, study 3 would re-test the numeracy apprehension rating scale. However, due to the novelty of the NAS relating to the target age range, convergent validity could not be tested, as other rating scales do not fit the experiences of children aged 4-7 years. Concurrent validity could have been tested for in this PhD thesis, but it was already anticipated that there would be different scores of the NAS in comparison to the MARS-E, for example, due to the different experiences of children, particularly when comparing the US to the U.K.

A brief Mathematics Anxiety Rating Scale (MARS-30 item test) is an additional and shorter derivation of the MARS, developed by Suinn & Winston (2003) based on the same attempts of others (Rounds and Hendel, 1980; Alexander and Martray, 1989) to shorten the original MARS. To increase construct validity, the criteria for inclusion of previous items were that in at least two previous studies, they were found to be of importance and showed the highest loadings amongst the factors of mathematics test anxiety and numerical anxiety. Following implementation of the scale, a two factor structure emerged, with one factor being mathematics text anxiety (59.2% of the variance) and Numerical Test Anxiety (11.1% of the variance), accounting for 70.3% of the total variance. Again, these factors reflect those found through factor analysis of the MARS and its derivations. However, this scale evidences the reuse of items, rather than novel creation through alternative research methods. It additionally demonstrates how researchers have focussed on measurement in older populations and failed to explore the concept in the earlier years to understand progression towards mathematics anxiety. Ashcraft and Moore (2009) reinforce this
critique and state that like the Abbreviated Mathematics Anxiety Scale (Hopko et al., 2003) the sMARS is centred on advanced concepts such as algebra, and younger respondents would encounter difficulty in providing meaningful responses. Again, this supports the aim of this PhD thesis to develop an assessment rating scale for children aged 4-7 years.

To rectify the shortcomings of previous scales, McMorris (2004) suggested the revision and development of scales, to improve the measurement of mathematics anxiety. Subsequent to this claim, Bai et al (2009) adapted the MAS to form the Revised Mathematics Anxiety Scale (MAS-R). Research to identify its bi-dimensional effects was conducted with 78 undergraduate mathematics students, who rated their level of agreement to 14 items, equally divided by positive and negative wording, using a 5-point Likert scale. A limitation of the original MAS was that intended positive items were not worded as such, and so these were made more explicit. The psychometric properties of the MAS-R were determined by Bai et al (2009), although the sample size (n=78) was small and could be viewed as a limitation, an issue aforementioned by Hopko et al (2003). However, in a cross validation study, Bai (2011) found the scale to have high internal consistency and reliability ($\alpha = 0.91$) and acceptable construct validity, that was increased by randomly ordering the scale items (Bai et al., 2009). In the validity study, exploratory factor analysis revealed a two factors structure of the MAS and accounted for 66.7% of the total variance, with factors loading between .67 and .89, which is sufficient for the small sample size (Stevens, 1992). The results suggest that the MAS-R is a valid inventory for the measurement of mathematics anxiety in undergraduate students and also considers aspects of mathematics that students may consider or experience as positive. The development of the MAS-R provided additional information relating to the underlying factors of the construct of mathematics anxiety.

Recently, Hunt, Clark-Carter and Sheffield (2011) developed and validated the 23-item Mathematics Anxiety Scale-U.K. (MAS-U.K.) as a reliable, valid and simple to administer tool for the assessment of mathematics anxiety. Originally 38 items, psychometric tests were implemented following research with 1,153 U.K. undergraduate students. Exploratory factor analysis initially revealed a four factor structure accounting for 53.7% of the variance. However, low loading scores and scree plots indicated that the analysis should be re-run with a 3 factor extraction. Subsequent factors identified were (1) mathematics evaluation anxiety (42.5% of variance) (2) everyday/social mathematics anxiety (4.7% of variance) and (3) mathematics observation anxiety (4.5%). As 27 items had low factor loadings (0.45) particularly in relation to the high sample size (Stevens, 1992), Hunt et al minimised the scale to 23 items, which was shown to have a high internal consistency ($\alpha$
The factors extracted from the MAS-U.K. are similar to those identified in the original MARS and subsequent adapted scales that have predominantly been developed in the US, suggesting universal underlying factors of mathematics anxiety. However, whilst the MAS-U.K. is highly useful for understanding mathematics anxiety in undergraduate populations, this again exemplifies the lack of tools being developed to identify mathematics anxiety in children in early education. Nonetheless, the factors of mathematics evaluation anxiety and observation anxiety are issues that have been identified by the current author’s previous qualitative research, relating to the numeracy experiences of children aged 4-7 years. This further reinforces the development of an assessment scale for this age range, particularly as issues in the later years of mathematics may stem from this phase of education.

Although difficult to define and measure, rating scales were developed in order to assess the underlying factors of mathematics anxiety (Baloglu & Zelhart, 2007). Initially created with a unidimensional representation of negative mathematics affect (Bai et al., 2009) factor analytic research has subsequently identified various constructs in mathematics anxiety, suggesting a multidimensional construct (Fennema and Sherman, 1976; Alexander & Martray, 1989). Derivations of the original MARS identified a number of factors associated with mathematics, with evaluation anxiety and numerical anxiety found to be the most frequent across research (Newstead, 1995). However, the emergence of several distinct factors through factor analytic studies has added to the ambiguity surrounding mathematics anxiety and similar research is obtaining further findings relating to the construct of mathematics anxiety. This is demonstrated by the recently developed Scale for Early Mathematics Anxiety (Young, Wu and Menon, 2012) and use of the Mathematics Anxiety Questionnaire (Thomas & Dowker, 2000) to extend research to Germany and Brazil, in which the same internal structure of mathematics anxiety was found, supporting universality of mathematics anxiety.

1.8.3 Limitations of mathematics anxiety measures

Despite tests that can suggest whether a scale is measuring an intended construct, the measurement of mathematics anxiety may raise issues of validity, as it does not exist objectively (Spector, 1992). Clark and Watson (1995) argue that construct validity cannot be determined from an observed factor structure, correlations with other measures or varied results between groups. Instead, they assert that investigations that implement the scale are only the foundations of identifying the underlying psychological constructs. This relates to assumptions made by factor analytic
researchers, who have often assumed the validity of adapted mathematics anxiety ratings scales, following only a small number of tests. Gorard (2001) states that evidence formed on the basis on quantitative research can often be accepted uncritically, and re-analysis can reveal a contrast in results, which has been evidenced in the measurement of mathematics anxiety. Messick (1995) states that reliability and validity are not just measurement principles but social values with an influence on decisions made outside of measurement. The variance in results obtained in factor analytic research may relate to the manner in which previous mathematics anxiety scales have been re-adapted and developed from a purely quantitative perspective, and will later be discussed in this PhD thesis. However, Kline (2000) considers additional factors that can contribute to measurement error, such as poor test instructions, subjective scoring and unrepresentative samples.

Although a majority of the mentioned scales created and implemented in the US are of particular worth, they intrinsically hold little significance to the experiences of students in the U.K. Whilst conversion of American termed items to British terms is possible, followed by validation and reliability analysis, this is still less ideal than a fully U.K. developed anxiety rating scale. Due to a focus on older populations, these scales also hold little significance to the experiences of children (Ashcraft & Moore, 2009). For example, a majority of items that comprise the sMARS are based on algebra and other advanced concepts, whilst items of MARS-30 focus on the experiences of college students. Additionally, although the MARS-A identified numerical anxiety and mathematics anxiety as affecting mathematics endeavour in high school students, it is unable to inform of underlying factors that contribute to developing negative mathematics attitudes in early education. Moreover, the MARS-E and the MASC would only be applicable to U.K. children aged nine to twelve and nine to fourteen and is also omitting the early primary school years. Prior to any mathematics anxiety tool being developed; it first seems necessary to develop a comprehensive understanding of how children experience day to day mathematics and what factors impact upon their experiences. This is reinforced by Mazzocco (2007) who highlights the lack of tools for the assessment of mathematics difficulties in children in early education. Baptist et al (2007) also considers that a positive trajectory in mathematics can be encouraged by screening children for mathematics difficulties at an early age, and this can also include anxiety. The limited attention of the effects of anxiety on young children’s numeracy performance is evidenced by a lack of assessment tools being implemented in primary school, although screening materials exist for dyscalculia.
1.9 Chapter Summary

The key discussion points throughout this chapter will be summarised to provide a clear understanding of what is understood about mathematics anxiety and the limitations that exist and are key to this PhD thesis.

Mathematics has the potential to influence the educational experiences and career choices of an individual (Ashcraft, 2002; Rahim & Koeslag, 2005; Rossnan, 2006). A comprehensive understanding of the subject is a valued attribute in professional vocational positions and is a key area contributing to the maintenance of a competitive U.K. economy (Mahmood & Khatoon, 2011). Yet, there exists a negative cultural attitude and half of the population have poor basic numeracy skills (National Numeracy, 2012). It is thought that the current and next generation of mathematical learners are set to experience increased pressure and anxiety from a demanding curriculum that expects more understanding at earlier ages, i.e. to recite the 12-times table at the age of nine. Changes to the U.K. mathematics curriculum have previously been criticised for merely altering schemes, rather than employing strategies proven as successful in countries with greater mathematical achievement.

In addition to increasing educational demands on children, for some, mathematics anxiety can also have an adverse impact on their effort and overall performance. This places them at a disadvantage in comparison to peers. Relating to negative emotional responses, mathematics anxiety specifically interferes with one’s ability to manipulate numbers and solve mathematical problems (Richardson & Suinn, 1972). When completing mathematical tasks, a sufferer of mathematics anxiety may experience an increased heart rate, sweating, negative cognitions and avoidance behaviours.

Researchers have evidenced the influence of a number of factors that are posited to be involved in the developmental and maintenance of mathematics anxiety. These include a genetic basis (Adams, 2007), prior negative experiences (Ashcraft & Krause, 2007) and a low sense of ability (Mazzocco et al., 2012). The variation in measured factors suggests that a complex interaction of these is a likely explanation for the formation of mathematics anxiety. Yet, the emergence of mathematics anxiety has not been shown to have an association to a specific age, highlighting a knowledge limitation within this body of research. Like Skemp (1986) and more recently Mazzocco et al. (2012) the author of this PhD, supported by their own previous research with children (Petronzi et al., 2012) has considered whether children between the ages of 4-7 years also experience anxiety.
when working with numbers. Research has found that negative classroom experiences, including strained teacher relationships, limited concept understanding, failure and avoidance are underlying factors that affect the mathematical performance of older children (typically age 7 years and above).

A significant premise of this PhD thesis relates to inappropriate assumptions that mathematics anxiety, a construct evidenced as relating to the experiences of older children, adolescents and adults, is applicable to the experiences of younger children. Thus, the author has suggested the term ‘numerical apprehension’ to describe a separate but related construct that relates to the anxieties of children in early education. This is more representative, as at this educational stage, numeracy is taught in the classroom, rather than mathematics. Research data suggests that mathematics anxiety is a subsequent and further developed issue, as it has been shown to have an association with complex mathematical procedures i.e. difficult multiplications, algebra and fractions (Ashcraft, 2002). Traditionally, measurement scales have been developed and adapted to determine the underlying factors of mathematics anxiety in older populations, particularly in the US. Such scales do not relate to the experiences of U.K. populations, especially young children. Thus, this is the basis of a further consideration of this PhD thesis; that appropriate measures have not been implemented to understand the underlying factors of young children’s numeracy apprehension (cf. Ashcraft & Moore, 2009; Mazzocco, 2007). Yet, in order for measurement scales to be in keeping with contemporary standards (Creswell, 2003) a mixed methods approach should be considered. This relates to qualitative data with the target population acting as the foundation for scale items, following analysis of discourse, as adhered to by the author of this PhD (Petronzi et al., 2012). Understanding what factors are influential in the formation of children’s numeracy attitudes can prevent a “snowball” effect of negativity leading to a further dislike of numeracy (Ramirez et al., 2013). This effect can potentially lead to mathematics anxiety.

As discussed, mathematics anxiety has been shown to have a negative association with performance. Although able to match low mathematics anxious peers in thinking and reasoning tasks, the highly mathematics anxious perform poorly in comparison on mathematical tasks (Maloney & Beilock, 2012). Amongst other factors, this performance deficit is linked to depression, anxiety, self-esteem, persistent failure and avoidance. Again, the author reiterates that a combination and interaction of factors is the likely basis of mathematics anxiety. In contrast, it has been put forward that those with high anxiety may simply be less practised and skilled (Maloney & Beilock, 2012). However, research has evidenced that alleviation of mathematics anxiety can improve performance (Sheffield & Hunt, 2007) suggesting that it is an emotional rather than
intellectual issue (Luo et al., 2009). Again, although such evidence has been useful, it has not been applicable to children in early education. In other instances, where research has been conducted with children within the age range of this PhD thesis, i.e. Harari et al (2013), this has centred on US populations, using adapted scale items from other mathematics anxiety rating scales. Nonetheless, research evidence often indicates that the formation of negative numeracy/mathematics attitudes relate to early classroom experiences. Again, this is to be addressed by this PhD thesis. Yet caution must be made when considering causality, as for instance, negative attitudes and anxiety may impact on performance, although persistent failure may in fact be the cause of negative attitudes.

The cognitive consequences of mathematics anxiety have also been a key area within this body of research. It has been posited that the working memory capacity, required to solve mathematical problems, becomes occupied by negative and intrusive thoughts in the high mathematics anxious. Due to lower cognitive efficiency, a performance drop off has been observed (Derakshan & Eysenck, 2009; Ashcraft & Faust, 1994; Faust, Ashcraft and Fleck, 1996). Although the high mathematics anxious can complete simple arithmetic with few issues, when mathematical tasks become increasingly complex, i.e. algebra or when completing a dual memory task (Staples et al., 2005) their performance suffers in comparison to the low mathematics anxious. In addition, accuracy is typically sacrificed for speed, suggesting avoidance. Conversely, when comparing the research of Ashcraft and Kirk (2001) and Ashcraft (2002) the high mathematics anxious are able to perform equally to low anxious peers when allowed to used pen and paper strategies on a true/false judgment task. Again, this implicates working memory by suggesting that strategies reduce the cognitive load of mathematics anxiety. In a classroom setting, these results would suggest that anxious children are at an immediate disadvantage in timed mental arithmetic tasks and tests. This is particularly crucial as ability groups are formed on the basis of such results. Yet, the working memory consequences of children aged 4-7 years remains unclear, and so only assumptions can be made. However, Witt (2012) recently measured the working memory and anxiety levels of children aged 10 years and found that the high mathematics anxious experienced a drop in working memory performance that related to storing and processing information. Ramirez et al (2013) found similar results with children aged 7 years. This suggests that children with apprehension in the early years of education are also likely to experience a cognitive deficit. If this is the case, it reinforces the author’s position that apprehension in the early years will negatively impact on performance, and without intervention, will continue to exert a negative influence through the schooling years. Although understanding the cognitive consequences of mathematics anxiety is key, it is perhaps
more functional to understand what factors lead to anxiety, that consequently occupies task specific cognitive resources.

Attention has also been given to factors that influence children’s mathematical attitudes outside and within a classroom setting. These specifically relate to the individual, the school and the home environment (Mohamed & Waheed, 2011). In some cases though, anxiety may only relate to certain mathematical concepts, i.e. ratio, again showing the complexity of mathematics anxiety. Nonetheless, research has demonstrated the importance of the early educational years, by showing prior mathematics education to have an impact on achievement in later years (Ma & Xu, 2004). Thus, if suffering with apprehension at a young age and performance suffers as a consequence, this can have a prolonged effect throughout a child’s education. Brain imaging research has also shown mathematics anxiety in children aged 7 years to have an association with brain regions that regulate emotion (Young et al., 2012). Specifically, cortical regions that process negative emotions are particularly evident in the high mathematics anxious and relate to reduced problem solving accuracy. Unfortunately, research that observes brain activity in on-line mathematical tasks are not easy to replicate with young children due to methodological and ethical considerations.

Additional factors including evaluation anxiety (Ashcraft & Krause, 2007) and a negative self-concept (Erdogan et al., 2011; Mutodi & Ngirande, 2014) are thought to relate to classroom experiences, particularly in situations where a child is embarrassed or ridiculed for poor performance. Children’s optimistic and pessimistic attitudes have also been evidenced as acting as a differentiator between high and low mathematics anxiety. For example, primary school children who were typically pessimistic in mathematics, had a lower level of achievement three years later in comparison to peers, who had been more optimistic in primary school (Yates, 2002). This may relate to previous assumptions that the high mathematics anxious internalise the cause of failure whilst optimism relates to decision making confidence, mental rigidity and emotional intelligence (Al-Minshawi, 2006). Again, this places emphasis on the importance of understanding the early educational years, as Yates (2002) posited that optimistic children were more able to learn constructive numeracy/mathematical techniques.

Similarly, self-efficacy has been suggested as relating to persistence, performance and interest (Meece et al., 1990) and has also been shown as having an influence on mathematical anxiety and achievement (Pajares & Graham, 1999). However, the results were obtained with US children between the ages of 6-11 years, using different measurement scales. Qualitative research with
children aged 7 years has also revealed that children had a resignation to failure and difficulties understanding the language of mathematics (Ashby, 2009). A resignation to failure could be seen as relating to optimism and self-efficacy, further suggesting a complex interaction of factors. The issues identified by Ashby (2009), including children failing to understand the wider practicalities of mathematics, may lead to decreased motivation (Tella, 2007), negative attitudes, avoidance and ultimately, anxiety. Yet, as mentioned previously in this summary, causation should not be assumed, or at least made with caution. In research measuring the responses of children aged 7-15 years, Chinn (2012) found that subtraction, multiplication and division were considered most difficult and lead to “no attempts”. Again, this emphasises avoidance and learners who would rather disengage from mathematics, rather than attempt to solve a problem. This demonstrates the size of the issue posed by mathematics anxiety. Further implicating working memory, Chinn (2012) added that those with imprecise memories will encounter difficulties with some mathematical procedures.

Gender has also been evidenced as having an association with mathematics anxiety (Kargar et al., 2010) in what is typically regarded as a male dominated subject. Although females have shown a lower mathematics self-concept than males (Skaalvik & Skaalvik, 2004) their attitudes have been evidenced in research as being similar and also dissimilar to males. Research that reports on gender differences and mathematics anxiety has often been contradictory and perhaps enough research has not yet been conducted to fully understand this. For example, males have been shown to be more resilient and persistent following mistakes in mathematics than females (secondary school pupils) (Devine et al., 2012) and Brady and Bowd (2005) have suggested that girls receive less help in mathematics.

Primary school teachers have also been considered as having a key influence on the formation of children’s numeracy/mathematics attitudes and anxieties (Chiu & Henry, 1990; Newstead, 1994). Some children can be anxious about evaluation from teachers (Whyte & Anthony, 2012) and judge them to be hostile if they place them in a pressure situation, i.e. solving a problem in front of the class (Vukovic et al., 2013). A main aspect to emerge from research in this area is that some in-service and pre-service teachers suffer with their own anxiety (Bibby, 2002) and can transfer negative attitudes to children in the primary years of education (Eden et al., 2013; Vinson, 2001; Maloney & Beilock, 2012). A negative relationship has been demonstrated between female teacher’s anxiety and female student’s end of year achievement (e.g., Maloney & Beilock, 2012) emphasising the importance of the role that teachers play in the formation of mathematics attitudes.
With research highlighting a key influence of teachers on pupil attitude formation, this reinforces the exploration of teacher attitudes and experiences in PhD study 1. However, in similar research, Aslan et al (2013) did not demonstrate the same negative relationship between teacher anxiety and children’s (aged 6 years) performance. Although alleviation strategies via workshops have been attempted with pre-service teachers, Hamlett (2007) found that despite improved confidence ratings, low confidence was maintained in the context of teaching a maths. Thus, in some instances, it may be that children are intrinsically motivated to learn mathematics with positive attitudes (Nicolaidou & Philippou, 2003) but begin to form negative attitudes if they sense this in their teacher. Similarly, Lazarides and Ittel (2012) consider that individual differences will exist between children in how they judge the quality of mathematics instructions, and relates to previously discussed individual factors. The role of teachers is considered as cyclic by Uusimaki (2004), in that teacher attitudes are formed and passed on to students, who will eventually pass on the same negative attitudes. Further to this, teachers who lack confidence in their mathematics abilities may use counter-productive strategies i.e. rote learning (Chinn, 2012). Thus, children may not develop a comprehensive understanding of concepts.

The role of parents in the formation of numeracy/mathematics attitudes is considered as equally as important (Dowker et al., 2012) and Vukovic et al (2013) consider them as a key facilitator to success. Yet anxiety can also be transferred from parents to children (Rossnan, 2006; Gunderson et al., 2011) and this may relate to a number of factors, including under valuing achievement in mathematics (Fraser & Honeyford, 2000) and a failure to understand modern methods (Mathematical association, 2012). In this situation, children who may rely on support from their parents to overcome numeracy/mathematics difficulty, will be unable to complete work, placing them at a disadvantage in comparison to peers. However, children may also develop negative attitudes in numeracy/mathematics if their parents place significant expectation and pressure on them to achieve (Yuksel-Sahin, 2008; Krinzinger et al., 2009). The role of parents is another key influence on children’s numeracy/mathematics attitudes, yet further demonstrates the complexity of additional factors and the interactions between these.

Regarding previous assessment measures, a wide range of scales have been, and continue to be developed for the assessment of mathematics anxiety. The implementation of scales with varying populations have provided an increasing inventory of potential underlying factors of mathematics anxiety. Yet the variance in factor structures identified in scale studies and also differences in the reliability scores, may relate to sample sizes and demographics. This is particularly evident when a
developed scale identifies other factors not previously observed, or finds the same factors but account for less of the overall variance. The latter of these issues, as discussed, has been a particular issue for the RMARS (Alexander & Martray, 1989). This could be seen as progressive development – the identification and validation of factors associated with mathematics anxiety, or, as stated by Hopko et al (2003) methodological limitations. Adding to this, factor structures have not always been empirically scrutinised, leading to validity and reliability consequences for subsequent research that utilised a given scale.

In order to compare the qualitative data obtained in the author’s previous research with children, the first study presented in this body of work, focussed on exploring the mathematics attitudes of mathematics experts, parents and teachers, to determine whether their perspectives reflect those of the children. There is a distinct lack of qualitative data obtained with children in the early years of education regarding their numeracy experiences. This has contributed to a lack of understanding the factors that contribute to the formation of numeracy attitudes and when these begin to develop. Thus, the qualitative research of study 1 focussed on addressing this limitation by gaining insight from primary adults involved in the numeracy education process of children. The discussions also explored their own experiences with numeracy and mathematics and whether these had influenced their career choices and attitudes. Further to this, discussions provided an opportunity to explore any issues that parents and teachers face in the context of assisting/teaching children numeracy.

Through this PhD thesis, discussions with mathematics experts, parents and teachers of how children experience numeracy, will allow comparison to the findings of the author’s previous qualitative research with children aged 4-7 years. Collectively, this data will inform the item pool of a novel numeracy apprehension rating scale for children (NAS) and this will be developed and implemented with children aged 4-7 years. Following this phase, the scale will be statistically refined and then further validated with a replication sample, to determine that the scale can be a reliable tool for the assessment of numeracy apprehension and also a predictor of numeracy performance.

Study one of this PhD research followed the author’s previous work and employed qualitative methods. Prior to introducing the first piece of research of this PhD thesis, the previous qualitative research will be summarised, as it served as a starting point for the research in this thesis and will afford comparison.
1.10 Emerging research: a shift towards exploring anxiety in the early years

At the time of commencement of this PhD thesis, there was limited research focus placed on the early educational years as the origin of mathematics anxiety. More specifically, there were few assessment measures for early mathematics difficulties (Mazzocco, 2007) that contributed to the limited understanding of its emergence in young children. This led to quantitative findings from older populations being suggested as rooted in early experiences of mathematics. A quantifiable measure did not exist for the numeracy experiences and reactions of children aged 4-7 years, nor had research provided children with a platform to discuss their numeracy experiences and attitudes.

1.10.1 Parental influence and mathematics achievement

During the completion of this body of work, mathematics anxiety research has more noticeably turned towards the educational experiences in the early years and how certain factors can influence achievement, performance and attitudes, including the development of anxiety. As a main finding of the author’s previous MPhil research (Petronzi et al., 2012), parents were found to have a key association with their children’s numeracy attitudes and achievement. The role of parents has since become a significantly acknowledged factor relating to children’s mathematics anxiety. Relating to this, Berkowitz, Schaeffer, Maloney, Peterson, Gregor, Levine and Beilock (2015) also recently considered the role that home life has on mathematics achievement. Berkowitz et al (2015) acknowledge that many parents consider mathematics education to be the responsibility of schools, overlooking that input at home is an important predictor of children’s success in mathematics. They also consider that in cases when parents have their own mathematics anxieties, they will typically avoid talking about mathematics with their child. Yet, in cases when they do, the quality of their input is low. They conducted research with 587 first-grade children (U.K. aged 6-7 years) and focused on testing an educational intervention to promote interactions between children and parents relating to mathematics. This was based on the premise that increased mathematics activities at home would increase children’s mathematics achievement at school. The intervention took the form of an iPad application that included mathematics passages, with associated questions and covered topics including counting fluency, geometry and arithmetic in which children and parents could complete together. A control group was also incorporated, and children and parents completed tasks that related to reading comprehension, vocabulary, phonics and spellings. Each child’s mathematics achievement was assessed in a one-to-one session with a researcher, prior to the intervention and at the end of the school year. The results of the research showed that the more
frequently parents and their children used the app each week, the higher children’s mathematics achievement was at the end of the school year. This was a finding that was only evident for the mathematics group. This demonstrated that mathematics achievement in school relates specifically to engagement with mathematics tasks between parents and children. Placing more importance on the findings, the children in the reading group showed no relation between the frequency of application usage and their mathematics achievement at the end of the year. Moreover, children of high anxious parents who used the application more frequently had higher mathematics achievement at the end of the year than children of high anxious parents who did not use the application frequently. The findings from this research suggest that quality parent-child interactions about mathematics can improve performance. In the research by Berkowitz et al (2015) the participating children were aged between 6-7 years and demonstrates a greater focus on the earlier educational years, when experiences and other factors have a significant association with attitudes. However, based on the collective findings of this empirical body of work (to be discussed throughout), the early school years are crucial for the development of numeracy attitudes, yet remain overlooked.

Similarly and again conducted during the completion of this thesis, Maloney, Ramirez, Gunderson, Levine and Beilock (2015) aimed to explore the effects of parents’ mathematics anxiety on children’s mathematics achievement and anxiety. Like the research of Berkowitz et al (2015) and that comprising this thesis (4-7 years), the age range of child participants was age 6-7 years, further indicating a shift in research focus in the area of mathematics anxiety. In this way, the research is more relevant to the foundation phase of numeracy apprehension, rather than mathematics anxiety. With a key interest on whether children’s mathematics achievement could be predicted by parental mathematics anxiety, the results indicated that children’s learning and progress was significantly lower in comparison to others, over a school year period. However, this was more the case when high anxious parents had reported attempting to facilitate their child’s learning, and relates to findings from discussions held in the first piece of research in this body of work. More specifically, parents attempting to help their children, despite a degree of anxiety resulted in them reverting to their outdated methods. This is perhaps an explanation of parental support having reduced benefit to the child and not enhancing their learning, whilst also transferring a degree of anxiety. Importantly, parent’s mathematics anxiety did not predict children’s reading achievement, suggesting that children’s mathematics achievement is specifically effected by parental mathematics anxiety.
To summarise, a growing body of research, since the commencement of this body of work, has become focussed on the children’s early experiences of mathematics and factors that influence their achievement and anxiety. The results from recent research suggests that the early years are the origins of mathematics anxiety. However, the recent research outlined so far in this section has still not explored mathematics anxiety in children as young as 4 years of age, in which this empirical work remains novel. This suggests that research should still be attempting to explore anxiety in the earlier years, as the age of 6 years may still be too late, and negative attitudes and behaviours may be already developed.

### 1.10.2 Anxiety, achievement and brain mechanisms

Further demonstrating a move in research towards children, Supekar, Luculano, Chen and Menon (2015) state that mathematics anxiety during early childhood has adverse long-term consequences and that it is important for early identification and alleviation. Their own research centred on remediating childhood mathematics anxiety with an intensive 8 week one-to-one cognitive tutoring program, that aimed to improve mathematical skills. The identification of brain mechanisms involved in mathematics anxiety was also a key element of this research. Forty-six children in grade three (U.K. age 8-9 years) participated and Supekar et al (2015) considered this to be a critical early-onset period for mathematics anxiety. The research within this body of work would agree that the later primary school years represent a progression towards mathematics anxiety as concepts become more complex. However, the findings also suggest that the ages of 4-7 years can also be regarded as a critical early-onset period, but for numeracy apprehension and will be discussed in detail throughout this body of work. Supekar et al (2015) reported that children with high mathematics anxiety showed a significant reduction in mathematics anxiety after tutoring, and suggested that this was a result of consistent exposure to mathematical stimuli. Decreases in the amygdala were also associated with reduced mathematics anxiety, suggesting that the cognitive emotional element of working with numbers had been reduced through the intervention.

The implication of the amygdala relates to the research conducted by Young et al (2012) also during the completion of this body of work. Advancing knowledge of the brain mechanisms involved in mathematics anxiety, an association was found in children aged 7-9 years, between mathematics anxiety and the amygdala that processes negative emotions. Specifically, within the high mathematics anxious, the amygdala was found to be linked with cortical regions that process negative emotions and was particularly evident in relation to lower problem solving accuracy. In
contrast, the amygdalae of low mathematics anxious individuals were coupled with brain areas that assist task processing. Young et al (2012) demonstrated that mathematics anxiety is associated with a distinct pattern of neural activity (Maloney & Beilock, 2012) and is unrelated to general anxiety, intelligence, reading ability and working memory. The findings that implicate the amygdala in the emotional responses of mathematics anxious children is a key finding, as it shows the effects of anxiety on an individual and how an underlying ability can be masked by worrisome thoughts. More crucially, this has been evidenced in children aged 7-9 and 8-9 years e.g. Harari et al. (2013) suggesting that the earlier years are the foundations for negative attitudes and emotions to develop. Thus, this places emphasis on an assessment measure, such as the Numeracy Apprehension Scale to identify children at risk. Whilst the results of the research conducted by Supekar et al (2015) demonstrate the importance of the cognitive intervention for mathematics anxiety, the age of participants remains a limitation, particularly in relation to the empirical research within this body of work.

To summarise, recent mathematics anxiety research, conducted during the timeline of this body of work, continues to make progress in the area of mathematics anxiety, particularly in the identification of brain mechanisms and the application of functional interventions. However, in most cases, the age range of participants is beyond that of the current empirical research, and thus, still overlooks the early years of education as the origins of mathematics anxiety.

Ramirez, Chang, Maloney, Levine and Beilock (2016) have further explored the association between mathematics anxiety and achievement, with an emphasis on the problem solving strategies that children employ. In young children, the strategies used are rudimentary, such as finger counting, but following repeated use, they develop “problem-answer associations” (Ramirez et al., 2016:84) such as understanding that $3 + 3 = 6$. Building on this, children begin to use strategies such as retrieval, decomposition and reconstruction, which is suggested as a more working memory intensive strategy (Ramirez et al., 2016). Similar to the rationale of this body of work, they acknowledge that mathematics anxiety research has focused on adults, but that there is evidence to suggest that it is rooted in the early years. They refer to research that indicates that children in first and second grades (U.K. ages 6-8 years) report experiencing mathematics anxiety. Whilst the empirical research of this body of work would concur that mathematics anxiety is likely to develop at around this age, and perhaps later, the findings of this body of work indicate and support a foundation phase of numeracy apprehension, that develops and transitions into mathematics anxiety. Thus, despite a shift in research focus to the mathematics experiences of children, these
are still older children, and the foundations of mathematics anxiety are being overlooked. It is perhaps necessary for a change in thinking when regarding the development of mathematics anxiety, to considering the experiences and influences of a child’s early educational career. Mathematics anxiety may not simply emerge, but be the result of a process of experiences in the numeracy apprehension phase - as evidenced in the author’s MPhil research (Petronzi et al., 2012).

For Ramirez et al (2016) to explore the relationship among strategy use, mathematics anxiety and achievement, 564 children participated (256 in first grade & 308 in second grade) with an average age of 7.13 years. Mathematics anxiety was measured using the authors 16-item Revised Child Math Anxiety Questionnaire (CMAQ-R) and was based on the Child Math Anxiety Questionnaire (Ramirez et al., 2013) and the MARS-E (Suinn et al., 1988). The CMAQ-R asked children how they feel during various mathematics related situations, in which they could respond on a 5-point Likert scale, represented by emoticon faces. Some items directly gauged children’s feelings towards particular mathematics problems, whilst some items were more general and asked how they would feel if their teacher required them to explain an answer. Mathematics achievement was measured using the Applied Problems subtest from the Woodcock–Johnson III (WJ-III; Woodcock, McGrew & Mather, 2001). All tasks were completed in a school setting on a one-to-one basis. In terms of mathematics anxiety, the results showed that 26% of children self-reported medium to high levels of anxiety, suggesting that there is variability in children’s feelings towards mathematics in the later primary school years (Ramirez et al., 2016). Reflecting previous findings, children with higher working memory showed a marked negative relationship between mathematics anxiety and mathematics achievement. Moreover, mathematics anxiety was found to negatively relate to advanced strategy use for children with higher working memory. The advanced problem solving strategies they could otherwise employ were disrupted by anxiety, placing them at a performance disadvantage.

This research by Ramirez et al (2016) again demonstrates the existence of mathematics anxiety in children, although older than the age range focus of this body of work, and its effects on achievement. Specifically, mathematics anxiety in children aged 6-8 years was shown to disrupt working memory capacity, preventing children with high mathematics anxiety from utilizing more advanced problem solving methods. The results of this recent research support and exemplify the consequences of mathematics anxiety, and show that the working memory of children with high mathematics anxiety (within the age range of 4-7 years) is adversely effected.
1.10.3 Teacher anxiety

Although to be discussed in detail, this body of work identified teachers as a key influence in the development of negative attitudes in children aged 4-7 years. This is based on a number of factors, for example, negative evaluation, as found by Whyte and Anthony (2012). However, recent research has suggested that teacher anxiety can be transferred to students (Maloney & Beilock, 2012; Eden et al., 2013) and is also a key influence on children’s numeracy attitudes and experiences. Indeed, a mathematics expert in the first empirical study believed that some teachers underestimate the importance of the basic concepts in numeracy. To further explore teacher anxiety, Sari (2014) aimed to develop a scale for determining the extent of a teacher’s mathematics anxiety. A 37-item scale was developed based on existing literature and discussions with ten classroom teachers, who assisted with item redundancy. The 37-item scale was implemented with 348 classroom teachers. Factor analysis results revealed a three factor structure, relating to a refined 23-item iteration of the scale, with a high internal reliability ($\alpha = .89$). However, whilst there is worth in developing and implementing assessment measures with teachers to determine the extent of their own mathematics anxieties (that may lead to additional training for them); children remain at risk of transference.

To conclude, recent research that has emerged during the time of completion of this empirical body of work has begun to focus on the mathematics education influences of primary care providers, particularly parents and teachers. However, the research that has emerged has not qualitatively explored the factors that children consider to be influential in their numeracy and mathematics experiences and attitudes, particularly viewpoints relating to parents and teachers. Thus, the first piece of research of this body of work still holds a key advantage in this area. Additional research with older children has shown that mathematics anxiety adversely effects achievement, implicating working memory and emotional brain mechanisms, such as the amygdala. The disruption of working memory from the age of 6 years is a key finding and shows that mathematics anxiety can develop and begin to influence achievement early in education. However, unlike the empirical work of this PhD thesis, research has not explored the factors in early education that have an association with negative attitudes and experiences. To be discussed in detail throughout this body of work, numeracy apprehension has been evidenced in children as young as 4 years and has been shown to have a negative association with performance. These findings suggest that children are at risk of early numeracy difficulties and with increased research understanding, intervention efforts
could be aimed more towards younger children, to avoid a progression towards mathematics anxiety.
CHAPTER TWO

2 Exploring the factors contributing to the development of numeracy apprehension in young children

2.1 Introduction

Using similar rationale to that outlined in the introduction of this PhD thesis, in this qualitative study, children were asked to discuss the experiences that influenced their thoughts and feelings about numeracy. The research aimed to explore the origins of anxiety towards numeracy in children aged 4-7 years. Focus groups were implemented to obtain anecdotal and reflective insight on a specific topic, and essentially involved engaging children in a group discussion, guided by a sequence of questions to facilitate dialogue (Wilkinson, 1998).

This qualitative study was previously conducted by the author, and is a separate piece of empirical work from the three studies that form this PhD. However, this can be regarded as a foundation for the three empirical studies presented in this body of work, as it obtained direct insight from children, relating to their numeracy experiences and feelings. These findings, along with insight from parents and teachers at the same schools, and also mathematics experts, provided an all-encompassing view of children’s numeracy experiences and behavioural responses.

The previous qualitative work with children aged 4-7 years is outlined in this chapter, as well as the key findings.
2.2 Research Overview

This study used convenience sampling with groups of children, aged 4-7 years, to obtain a more complex perspective of the causes, extent and effects of children’s thoughts and experiences of mathematics. Participants for the research were recruited from three UK primary schools across the East Midlands region. Participants were 41 children (28 girls) aged of 4-7 years old across reception, year 1 and year 2. Twenty-two children participated from the first school (4 reception, 12 year one, 6 year two; 6 male, 16 female), 16 children participated from the second school (7 reception, 6 year one, 3 year two; 6 male, 10 female) and three children participated from the third school (3 year two; 1 male, 2 female). The demographics of the first two schools were similar, with a catchment of predominantly white, middle class families, whilst the third was situated in a more culturally diverse and economically poorer area (Derby City Council, 2011).

A focus group schedule to facilitate discussions was adapted from a scale developed by the first author (Petronzi, 2009) based on Newstead’s (1995) mathematics anxiety questionnaire, Chiu and Henry’s (1990) mathematics anxiety scale for children, and Alexander and Martray’s (1989) anxiety rating scale and discussions with teachers. Children discussed their day-to-day numeracy experiences at school and at home. They described their general feelings, responses to difficulty, evaluations of performance and feelings towards their teachers. When children began to discuss numeracy issues that did not relate to the listed questions, the author would explore their thoughts further with novel questions, for example, “why do you feel that way about the teacher?” All questions were open and broad to allow free discussion.

Focus groups were conducted in a separate area of the school to reduce distraction and encourage a more engaged discussion of numeracy experiences and attitudes. Focus groups were kept to a duration of twenty minutes to avoid fatigue (Porcellato, Dugdill, Springett & Sanderson, 1997). Before starting, introductions were made and general conversation took place to create a relaxed atmosphere. All discussions began with the first question from the question schedule and whilst children were encouraged to talk freely about numeracy, the facilitator ensured that all questions were covered.

The focus groups were audio recorded and analysed through the identification and comparison of dominant themes from each transcript (Kinder & Elander, 2012). Data for each focus group was
extracted and coded within an initial codes table when the author deemed that something had been raised of particular importance.

Focus group data were analysed using thematic analysis, in accordance with the guidelines of Braun and Clarke (2006), who urge (1) familiarisation with the data, (2) the production of an initial list of codes, (3) identifying potential themes, (4) refining those themes, (5) specifying themes (6) and the written report of findings. Thematic analysis provided a flexible structure to encode the meanings young children attach to their numeracy experiences (Berg, 2004). The systematic approach enables higher accuracy in interpreting the subjective meanings children attach to numeracy and contributing situational factors (Boyatzis, 1998).
2.3 Findings

2.3.1 Exploring numeracy attitudes through discussions

Young children’s accounts of their numeracy experiences suggested a number of influential and interacting factors relating to the development of positive and negative thoughts and feelings when encountering numbers. Children revealed multiple influences and experiences that impacted on their attitudes to numeracy. Four main themes captured the data in its entirety; these were: Responses to Numeracy; Coping Strategies; Teachers and Teaching and the Influence of Others. Within these themes, sub themes were further identified, each capturing an aspect of children’s early numeracy experiences.

2.4 Theme 1: responses to numeracy

A majority of children across all focus groups revealed strong and constant polarity in emotional responses to all facets of numeracy, though for others, initially gauged generic feelings towards the subject were unreliable predictors of situational specific emotional judgments. Therefore, though claiming to be “happy” when doing numeracy and seeing lots of numbers, they felt consistently “sad”, “nervous” and “unhappy” in response to ecological situations. Demonstrating the complexity of emotion and thoughts children encounter during the first years of numeracy, some immediately present as potentially at risk, though specific situational questions are crucial to uncover accurate emotional accounts and elaborated explanations. In some young children, fundamental feelings are seemingly detached and inconsistent from those expressed towards the array of experiences that encapsulate working with numbers, exemplifying how acceptance of face value judgments may be misinforming an underlying emotional obstruction to learning, resulting in an incorrect label of intellectual problems (Luo et al., 2009). Furthermore, there is a danger that children want to believe their generic positive feelings and report comfort with numeracy, though attain low results, again leading instructors to consider intellectual difficulties. This relates to Ashcraft’s (2002) findings of unaffected performance despite claims of a numeracy problem characterized by negative emotions.
2.4.1 Positive: success

Achievement in numeracy was clearly the ambition and motivational force for a number of children and to realize their target promoted positive emotional responses. In particular, their sense of attainment and emotions were reinforced by reward systems that promoted rivalry and comparisons amongst some children during discussions, emphasizing the driving force of incentives and a desire to experience the associated positive emotions.

*I like getting a smiley face for number work (Year 1).*

By year one, children seemed to have a casual awareness that enjoying numeracy results in doing more of it, making their own connections between positive emotions, quantity of individual work and performance. This suggests that those who enjoy the subject are higher achievers, in part, due to additional practice.

*If you like doing numeracy, you have to do lots of it (Year 1).*

2.4.2 Positive: perceptions of high ability

A number of children found that positive emotions related to a sense of high ability (Wigfield & Meece, 1988) and enabled them to maintain confidence and successfully complete numeracy work, even when all sources of help were restricted. Equally, when help was available to them, they stated it was unnecessary due to their positivity and belief in their ability.

*I don’t really need any help (Year 2).*

*there is nothing that is hard for me (Year 2).*

Some even expressed and maintained feeling “happy” and “excellent” when acknowledging that help was required. A perception of high ability seemingly enabled children to recognise limitations in their knowledge without suffering any negative emotional consequences. Others expressed positivity and belief in ability when faced with a high amount of class work and seeing lots of numbers. This again shows awareness that practice leads to greater understanding and demonstrates early development of constructive numeracy attitudes. A child also informed of gaining confidence
through achieving correct answers, providing them with the belief to apply their knowledge to similar numeracy work.

I get confident when I answer some right, then I know how to do that and then I do the same with the others (Year 2).

Relating to the aforementioned discussion of generic and specific situational numeracy emotions, a child appeared to support this theory, as they paradoxically claimed, “I don’t like numeracy but I’m good at it”. This was in response to a generic question, though their emotions became positive when asked about specific situational feelings. Despite this, most children expressed positivity as contributing towards their sense of ability. They consequently gained confidence to complete work individually, yet receive help without considering it as a weakness and can explain their reasoning to teachers without nervousness.

2.4.3 Negative: fear

Children described feeling afraid when presented with numerical tasks, with some believing they lacked the ability to complete the tasks. These worrisome thoughts may place the child at risk of developing negative attitudes towards numeracy.

This is terrible, this is a disaster, and I’m not going to make it (Year 2).

Sometimes you’ve got like twenty answers and then you think, oh God, how am I going to do this? (Year 2).

These children were perhaps presenting as the most apprehensive, as their attention diverts from work to focussing on worries, reflecting Ashcraft and Krause (2007). Children’s fears and worries were elevated out of context and demonstrated how some are already developing strong negative numeracy emotions that obstruct performance. For these children, their developed fear towards numeracy seems rooted within early negative experience of numeracy at school, that discourse indicated may be experiences of failure. These findings correspond to Ashby’s (2009) qualitative findings of resignation to maths failure in year three pupils. Conversely, one child stated that fear acted as a motivator and urged them to work harder, relating to Karimi and Venkatesan (2009) who reported that moderate levels of apprehension may encourage achievement striving.
In addition, a number of children expressed physiological anxiety associated with numeracy. A year one child also stated that they “need the toilet” in class when they get lots of crosses for incorrect work, with another child stating that “you feel that your heart was beating so fast”.

*It makes me need the toilet (Year 1).*

### 2.4.4 Negative: avoidance

Avoidance presented struggling children with the opportunity to conceal difficulties they had. As their difficulties with numeracy remain unnoticed, a lack of motivation may develop through consistently low performance and enjoyment. A number of children expressed a desire to avoid numeracy classes whenever they couldn’t manage the situation. When numeracy is perceived as a threat, apprehension may be aroused in these children and their response is to flee or avoid doing it, believing they lack the personal resources to cope with the threat posed by this stressor.

*Sometimes I’m a little bit bored and then I want to get out (Year 1).*

*A bit tired because I have to do lots of things (Year 1).*

### 2.4.5 Failure

Failure in numeracy was a prospect that produced most fear and critical self-evaluations in children. Their constant apprehension about failing demonstrates an issue with task completion, something Anthony (2000) identified as behaviour crucial to sustained success. Moreover, genuine ability may be masked by a focus on failure and children presenting at risk of numeracy apprehension seemingly visualize the negativity failure will bring, rather than the positivity of success.

*A bit ashamed if I got it wrong (Year 1).*

*Kind of nervous I’ll get them wrong (Year 2).*
Whilst some acknowledged that a greater internal effort was required to overcome this, others were angry with their situation and sought to blame others for their difficulty, demonstrating differences in responses to the threat of failure.

> I get butterflies in my tummy and say why do I have fifty thousand sheets and I’ve only done two, how do I do this in like ten minutes because these are really hard answers and I’m like, teacher, why did you do this? (Year 2).

The thought of failure for most had a substantial negative impact on emotional response and children seemingly most at risk of numeracy apprehension focus on their inability to complete work, which interferes with solving numeracy problems.

### 2.4.6 **Negative: perceptions of low ability**

A number of children in year one and two believed themselves to be of low ability in numeracy and whilst previously discussed that a sense of high ability evoked positive emotions, a sense of being unable to do numeracy had the reverse and undesired effect. This again relates to Ashby’s (2009) results from year three pupils with low self-belief who believed they were academically weak and incapable of solving numeracy problems. The discussions demonstrated that some children genuinely had no confidence in their numeracy ability and whilst some would still attempt the work, they had already developed pessimistic expectations of the outcomes of their efforts.

> I’d work it out, but probably get the wrong answer (Year 2).

> I get frustrated and then I get angry with my brain (Year 2).

These children were also aware of their specific weaknesses, and when these aspects were called upon in lesson, for example, explaining an answer, negative emotions would intensify. Furthermore, some children discussed their aspiration to complete numeracy work, though felt incapable of doing so showing that whilst they may have developed an early low sense of self, their motivation and attitude remains intact. Thus, numeracy apprehension may yet still be a reversible obstruction. This was supported by others acknowledging their own difficulties, though rather than directing negativity at themselves; they express constructive forms of overcoming their knowledge deficits.
I feel like I can’t do this (Year 1).

I think I might need some more practice at maths (Year 2).

2.4.7 Negative: difficulty / confusion

Children expressed significant emotional negativity when discussing experiences of attempting hard work. The difficulty of numeracy work was either met as a positive challenge by those who are secure with numeracy or as an unbeatable obstacle by others apparently suffering with apprehension. Those finding numeracy difficult again expressed their resulting thoughts and feelings to a variety of situations. Problems understanding concepts were indicated by others explaining which aspects of working with numbers posed the greatest difficulty for them, particularly dividing and times tables.

Because it’s really complicated and I really have to tell the truth (Year 2).

Again, anger and frustration emerged in some children when considering doing hard numeracy work and their reactions suggested that resignation was the ideal solution to their problems. Through destroying their work, children may re-establish a sense of control over their situation.

I just want to rip it up (Year 1)

It makes me cross until there are cracks in my eyes (Year 1).

In younger children, confusion also contributed to negative thoughts and feelings towards aspects of numeracy, such as number recognition and representation (Adams, 2007).

That kind of makes me feel like, is this a long number or a short number? Well I get mixed up with my numbers sometimes (Year 1).

Like if it’s two you say five because they look the same (Year 1).
Pressure was expressed as a consequence of confusion, as children were conscious that when they were unable to do the work, they were also falling behind. The notion of pressure seemed to arise through an awareness of the teacher or fellow pupils observing their struggle.

*It makes it even more complicated when someone’s watching you (Year 2).*

*Harder because your brain gets mixed up. Yeah, and you can see the shadow (Year 2).*

### 2.4.8 Discussion: theme 1

Fear emerged as a significant contributory factor in the development of numeracy apprehension and was associated with negative thoughts and feelings. Intrusive worrisome thoughts about completing number tasks disrupted children’s ability to attempt and complete those tasks. This is in line with previous research that suggests that intrusive thoughts directly impact task performance by taking up working memory capacity (Eysenck, Derakshan, Santos & Calvo, 2007). Children’s descriptions also suggest that increasing worrisome thoughts and confusion surrounding more complex concepts may hinder numeracy performance. Some children avoided numeracy work; this may have been because of their negative thoughts and feelings towards numeracy.

### 2.5 Theme 2: coping strategies

Children, particularly those presenting as uncomfortable with numeracy, revealed methods they would employ to cope with numeracy lessons. Significant emphasis was placed on friends and how their help eased the pressure of the situation, whilst other children discussed co-developed tactics to achieve the correct answer without being found out. This may explain how some children’s actual discomfort with numeracy and genuine low performance remains unnoticed in the early school years. Additionally, a change of emotions was apparent when help was received, whilst when coping strategies were removed, negativity and apprehension became dominant. Furthermore, for some children, parents acted as another coping strategy, used whenever numeracy became difficult, though for others, this strategy was either not in place or to a lesser extent.
2.5.1 Friends

Friends were clearly identified as a form of help, readily available to assist in numeracy work and this typically had a positive impact upon children’s emotional responses. However, for some, having to accept help from friends caused negativity as this seemingly confirmed their inability to understand and complete the work. This may signify a difference within those struggling with numeracy as some recognised that their difficulty was not ideal whilst others were simply happy to get through. Demonstrating a survival approach employed by those struggling with numeracy, some children directly stated that they would copy the work of others. Presumably, their inability to work out the numeracy problem leaves them to consider that an answer they assume has been worked out by their friend is better than a blank space.

*You just wait until they say the answer or you can just copy their work (Reception).*

*...We’re all copying each other (Year 1).*

One child stated that even when helping others had been forbidden by the teacher, they would still help.

*Even if we can’t do it [work together] we can do it with our friends (Year 1).*

Also, children as young as age four seemed to have developed an awareness of exactly who was good at numeracy, and thus, worth copying from.

*_____ is really good so I copy her work (Reception).*

A significant emphasis was placed on friends in coping with numeracy and the help they provided eased negative reactions to numeracy, though some sought a sense of accomplishment by merely focussing on obtaining an answer without having to attempt work themselves. Others developed a strong dependence on their friends to get through numeracy each day. However, as their performance does not reflect that of their actual ability, children who are apprehensive or have not properly grasped basic numeracy will remain unnoticed, and fall further behind. For children
conceptually struggling with numeracy or who had developed negativity, friends were a reliable and consistent coping strategy that allowed them to complete work and reduce the fear it produced.

### 2.5.2 Removal of strategies

When presented with the situation of strategies being removed or disallowed by the teacher, negativity arose in children who were most at risk of numeracy apprehension, as their methods for completing the lesson without having to face their difficulties had been taken away. The children expressed that without their coping strategies; they felt unable to do the work and would leave questions unanswered, though this would give a more accurate indication of their ability and is more beneficial for the child in the long term.

*Sometimes the teacher says you’re not allowed to be helping people so you just carry on with your own work and it’s kind of difficult and you can’t really concentrate properly (Year 2).*

Some children believed that when help was forbidden, their work would be wrong and the teacher would be frustrated with them. Others were worried about isolation from their friends when help was removed, leaving them to solve problems by themselves. Similarly, children were aware that their friends would finish before them and they would remain alone at the table.

*You feel lonely when you’re doing work if it’s not with someone else (Year 2).*

*Because if you’re like the only person left, you’re going to be all alone on that table (Year 1).*

Children across all age groups demonstrated negativity when having to complete numeracy work without help and revealed that they felt incapable of doing work in this situation. It seems apparent that when dependent upon their own ability, children who conceptually struggle with numeracy or are experiencing apprehension have a fear of being discovered and of the consequences, relating to evaluation apprehension.
2.5.3 Parents

Highlighting the importance of numeracy support outside school, enthusiastic children who believed in their ability discussed receiving help from parents that facilitated and supported their learning. Children with parents in a position to help with numeracy will be spared from feeling incapable and apprehensive, supported by their identification as a means of coping when difficulty intensified, relating to Mazzocco (2007).

*My mum and dad can help me (Reception).*

*If it was really hard, I would ask my dad to help me (Year 2).*

Parents were discussed as important contributors in coping with numeracy, particularly by children who perceived themselves to be secure in their numeracy ability.

2.5.4 Discussion: theme 2 (coping)

Children presenting as numeracy apprehensive relied heavily on friends to ease the pressure and negativity of their inability to complete work. Children from reception to year 2 described depending on others and learning to copy work to attain success. For some children, managing each numeracy lesson was the priority, rather than understanding concepts. Children’s reliance upon friends was demonstrated by negative thoughts and feelings when coping strategies were removed by the teacher. This altered children’s perceptions of numeracy from positive, when working with friends, to negative when working alone.

2.6 Theme 3: teachers and teaching

Children’s perceptions and interpretations of teachers were clearly divided into positive and negative aspects. The apprehensive children predominantly viewed teachers as an authority figure in place to punish mistakes and failure to complete work, whilst indirectly blaming their presence for interfering with their numeracy ability. Dissimilarly, the non-apprehensive children expressed comfort in seeking help from the teacher and considered them a figure of guidance, enjoying their presence in the classroom rather than fearing it. The constant state of awareness of apprehensive
children appeared to significantly impair their concentration and ability to work, which fed negativity further.

2.6.1 Positive

Although children discussed numerous aspects of teachers from a constructive perspective, neither of these emerged in adequate detail and thus did not constitute sub themes in their own right, though remain important factors. For some secure with numeracy, teachers were regarded and respected as the instructor who guided them through work before attempting numeracy themselves.

*She tells us what to do first before we go off to do it (Year 1).*

Some conceded that prior task instructions are more beneficial than asking afterwards as this presumably wastes time, suggesting that these children would display good behaviour in order to fully comprehend what was being asked of them. In contrast, others may misbehave and miss instructions, leading to dependence on others. It is a possibility that some children who valued guidance had learnt from mistakes of misbehaving and altered their behaviour accordingly to avoid the negativity associated with being incapable of completing numeracy work. Supporting that children consider behaviour an influential aspect to success, children stated that listening to instructions results in work being correct and evokes positivity.

*But if we’ve done it really well and we’ve listened carefully, we’ll get a tick on each one and it gets good (Year 1).*

This relates significantly to others aiming to please teachers and holding them in high regard as they are in a position to reward and confirm their work efforts. Some children thrived on success and as the teacher could implement reward systems, they became a positive figure in the child’s educational life.

*The same because I think she might say to me go on a smiley face or something (Year 1).*

Additionally, it seems some children valued other rewards, for example, playing in the playground, rather than those based around work, though this still provided sufficient motivation to learn. Tella
(2007) suggested that intrinsic motivation is evident in tasks that a person takes fulfilment from, whereas others lack this drive and seek extrinsic rewards upon completion of work. However, whilst those comfortable with numeracy demonstrated intrinsic motivation, there was also evidence of extrinsic motivation due to a focus on rewards and affirmation, and is contrary to assumptions prior to data analysis.

Discourse further evidenced that children who enjoy numeracy take pleasure in the teachers presence and demonstrate strong positive feelings in situations that the high apprehensive would consider pressuring. These children also take comfort knowing that the teacher is observing them as presumably, they feel of value and supported in their endeavour, though observation would cause apprehension for those uncomfortable with numeracy. Additionally, children expressed happiness when having to explain answers to the teacher as this provides an opportunity to demonstrate their knowledge that evokes pride and a sense of high ability, reinforcing their numeracy and teacher attitudes (Mazzocco, 2007). This is supported by children claiming that being able to explain your answer proves your independent ability, and not requiring help is the ideal, which by year one is emerging as widespread belief.

*Because you’ve done your work and you didn’t need any help (Year 1).*

The expectation of the teacher further provided an impetus to work and gave energy to the children, though this would be a source of discomfort for the high apprehensive.

**2.6.2 Negative: provokes apprehension and punishment**

Some children expressed fear and apprehension in response to all aspects of their teacher’s presence. A child in reception assumed their teacher would not like them for being unable to do numeracy. Another child believed their numeracy work at home to be of a better standard as the teacher would not be watching them.

*The teacher won’t like you if you get it wrong (Reception).*

*Because the teacher’s not watching you, and you get it correct (Year 2).*
Those already uncomfortable with numeracy developed a fear of being incorrect, believing they would be punished in some form. This might explain their dependency on others to ensure they provided correct answers. The children expressed concern that the teacher would be angry or cross with them.

*Very scared because if you get the answer wrong she’ll probably shout at you or tell you to go back to your seat and work again (Year 2).*

*If you’re doing the wrong thing she’ll probably give you a yellow card (Year 2).*

Additionally, failing to work at the pace of others induced fear of punishment, which was extensively articulated. Despite apprehensive feelings being expressed by a number of children, punishment was broadly discussed as the greatest cause for negative thoughts and feelings towards teachers.

*I think if you get a red card you have to stay in when all the people are outside for about three days (Year 2).*

*When you don’t do all your work, you have to stay inside and do it in the hall (Reception).*

Numeracy was a negative aspect of some children’s education, potentially leading to apprehension about it.

### 2.6.3 Discussion: theme 3

Children discussed fearing punishment by the teacher for incomplete or incorrect work. Punishment can impact on children’s motivation and may not help them to master the concepts they are learning. For those children who frequently fail in numeracy, negative thoughts and feelings can develop and these may be focussed on the teacher. In contrast, children with positive thoughts and feelings took solace from their teacher’s presence and felt supported by their attention.
2.7 Theme 4: influence/perceptions of others

It has been established that children’s numeracy experiences are influenced by others and their perceptions of those persons being either a facilitator of work or a threat. A strong emphasis was placed on friends as a coping strategy in numeracy, with the high apprehensive relying heavily on their input to ease pressure and remain unidentified. However, other factors surfaced relating to friends, particularly competing with them, and attributing blame to them for failure. Though parents were also previously discussed as a coping strategy, typically available to the low apprehensive, more specific details were expressed by children and clearly influenced their approach and attitude to numeracy.

2.7.1 Friends: comparison/competition and awareness of a hierarchy

Children, typically the low apprehensive, saw numeracy as a competition and fellow students were rivals who they were motivated to beat, and achieving their ambition would reinforce a sense of high ability and self-dependence.

*I sometimes beat them, I can when I’m working on my own, I just think it’s a race* (Year 2).

*If it’s maths then I can do it really fast, in like two minutes, I can do it before anybody* (Year 1).

However, discourse suggests that numeracy is a subject that all children acknowledge as highly contested and the high apprehensive are unable to maintain the pace and work load of those who are comfortable and less apprehensive. Thus, with the realisation of falling behind others in a task, negativity emerges and children begin to feel left out and isolated from their friends.

Another aspect that provided a sense of inferiority in the competition of numeracy was requiring help from friends, evoking negative feelings as this confirmed that others had understood a concept at a higher level. Additionally, the competitiveness of numeracy resulted in negativity when children finished work after others. For some children, this led them to internalise the cause of their failure, viewing themselves as idle and needing to work quicker in order to remain competitive with other children in the class.
I feel that I’m lazy (Year 2).

I’ll feel that I need to do more work quicker (Year 2).

It’s like everybody stopped and leaves the table and you’re still on the table, you need to start working really fast (Year 1).

This though was common amongst the low apprehensive, as those uncomfortable with numeracy focused on getting through lessons rather than challenging others, despite their acknowledgment of a competitive edge in the subject that may further contribute to their nervousness. However, those presenting as at ease with the subject restated their confidence by claiming to be unconcerned if others finished before them. Again demonstrating how numeracy inspires competitiveness, those capable of working independently expressed satisfaction at other children having different answers to theirs, as this assured them that work had not been copied.

It means they’ve done their own working out instead of copying (Year 1).

Don’t worry because that means they’re not copying us (Year 1).

Children of high ability would appreciate their own efforts and as they are competing with others of the same ability, using reward systems as a measurement of relative success, they were naturally protective of their numeracy work. Conversely, others were significantly concerned when their numeracy answers were different to their friends, adopting the view that their own work was of a higher level to ease their sense of inability and negativity. Additionally, the high apprehensive typically assumed that their answers were wrong if dissimilar to others.

You feel like you’re going to get it wrong (Reception).

Because they might have got it right and we might have got it wrong (Reception).

This exemplifies the pessimistic attitudes of those uncomfortable with numeracy (Yates, 2002). However, these children can better accept failure when others are in the same situation, also revealing a resignation to failure, resulting in disruptive behaviour to distract from inability.
Crucially, through revealing a sense of competition, some children in year one and two indicated an awareness of hierarchy in terms of intelligence that had been established through numeracy. A child concedes that a group of children received more challenging work as they were “brainier” than others.

*What because rockets are like more brainier than stars so stars get different work from rockets* (Year 2).

Another child identified a group that didn’t listen to instructions and thus were likely to be considered as of lower ability.

*Because red table talk a lot. Red table don’t listen at all they just talk and talk* (Year 1).

This demonstrates how children are comparing themselves against the ability of others, using numeracy as the subject to define intelligence and are beginning to observe and acknowledge the unproductive behaviours of low achievers that they consider accountable for numeracy inability.

### 2.7.2 Friends: attribution of blame

Some children attributed blame to their friends for their personal failure. A child expressed dissatisfaction with being told off after taking incorrect guidance from a friend. Another stated that they enjoyed being observed by the teacher as this prevented distraction from others, and they were happy when friends finished before them as they had the appropriate conditions to concentrate.

*It makes me not silly because my friend always makes me get things wrong* (Year 1).

*My friends leave the table and I have peace and quiet to concentrate* (Year 1).

Children expressed awareness that friends can have a detrimental effect on their numeracy performance, typically through encouraging disruptive behaviour. Other children, who were dependent on friends and unable to complete work individually, blamed them when they provided incorrect guidance and answers.
Parents: receiving help or not and parents working with mathematics

The assurance that parents would help children with numeracy at home evoked positivity and prevented panic and fear.

*I don’t worry, I don’t care if it’s at home because my mum or my dad will help* (Year 2).

*Well my mum’s next to me and she sometimes helps me a bit and that helps me a bit* (Year 1).

This was the typical response of those presenting as able in numeracy, though they commonly expressed requiring assistance from parents when difficulty increased. This appeared to allow them to overcome their issues immediately, without experiencing negativity and self-critical evaluations. Moreover, resolving areas of weakness avoided fearing teacher evaluations and possible punishments for incorrect or incomplete homework. For these children, receiving further explanations and guidance outside school maintained their positive attitude towards numeracy and thus their learning is unhindered by apprehension. Occasionally, parental help extended to them doing a majority of the work to spare their child negativity as they were simply focused on being correct.

*I feel a bit grumpy, I don’t do it, I just ask my mummy to do all the answers so I can get it correct* (Year 2).

*So when mum’s doing the work she just tells me how to do it* (Year 1).

In contrast, children who did not receive help at home experienced negativity and this would be amplified when faced with difficult work.

*You feel lonely when you’re doing work if it’s not with someone else* (Year 2).

*A bit sad because no one will give me help* (Year 1).
As aforementioned, if children are struggling at home without support, the fear that ensues will impact upon motivation causing the development of an understanding that numeracy causes apprehension and undesirable feelings and should thus be avoided. It is worth considering that as techniques and terminology have altered significantly in numeracy; the methods of some parents are now outdated and meaningless to children, potentially confusing them more. However, in some cases, parental help had escalated to the point of placing significant pressure on their child through making numeracy work too difficult. This may place even the most able children at risk of apprehension if they are expected to reach targets significantly above their age level.

Well it’s because my mum makes them really really hard, I don’t know just like really difficult ones and I’ll be like, oh my God I can’t do them, mum help me (Year 2).

Interestingly, some children revealed that comfort with completing numeracy at home resulted from their parents, though typically fathers, from working with maths. This clearly demonstrates the criteria detailed by Mazzocco (2007) of educated parents providing an intellectually stimulating environment in the household, providing children with a sense of security in that they will always be able to overcome any difficulties they encounter. Parents who work with maths are likely to take pleasure from the subject, particularly those who teach maths, and so not only is the joy of the subject transferred to children, but also the practicalities and the real world applications (Ashby, 2009) encouraging children to achieve in numeracy.

It’s because my daddy is a mathematician, he does maths with important people at British Aerospace (Year 1).

Because maths is easy for me, my dad is a maths teacher (Year 2).

Because my dad goes at work and does sums at me, he takes them from work and brings them home so I can learn them (Year 2).

2.7.4 Discussion: theme 4

Numeracy was found to be competitive throughout the early school years, with the low apprehensive endeavouring to obtain the status of most capable. High apprehensive children also
acknowledged this competition, yet were unable to keep up and experienced negative thoughts and feelings about the causes of their failure. Some high apprehensive children blamed their friends for their failure, which may have eased negative self-perceptions, and allowed children to maintain the belief that they were capable of completing numeracy work in the right circumstances. Parental help was identified as providing a sense of security about numeracy work. Children with negative thoughts and feelings stated that they rarely received help at home, leaving them to fear the consequences of failure.

2.8 General Discussion

Numeracy apprehension was discussed as influencing emotional responses during numeracy lessons (Rossnan, 2006; Luo et al., 2009). Those who were secure with numeracy expressed a desire for success and were motivated by reward systems, whilst an important relationship between fear and failure was emphasised by apprehensive children. Those comfortable with numeracy thrived on independent success, whilst apprehensive children expressed dependence on friends to complete work, although apprehension increased when this coping strategy was discouraged or forbidden. Negative thoughts and feelings were also expressed by some apprehensive children who perceived the teacher as a figure of punishment. In contrast, children who were secure in numeracy viewed the teacher’s presence as motivating. Numeracy was seen to be competitive throughout the early school years, and was associated with an awareness of a hierarchy of ability, with the low apprehensive endeavouring to obtain a higher status within their peer group. However, children who discussed negative thoughts and feelings were unable to compete with children of higher ability due to their limited conceptual understanding and their lack of belief in their ability (Skemp, 1986; Awanta, 2000).

The lead researcher had spent a number of years as a higher level teaching assistant, working with children from reception (age 3-4) to year seven (age 11-12) and with complex difficulties. This experience had influenced the questions asked and the interpretation of children’s discussions. For example, the experience of working with children may also have impacted on data extraction by selecting discourse that corresponds to work related observations of negative mathematics experiences. Additionally, this may have influenced the development of the final four themes, which may be argued to disproportionately represent more negative than positive aspects.
The current findings build on previous research examining mathematics anxiety in older populations. Replication and extension of this research would be of importance, particularly if similar findings were uncovered in a more socioeconomically diverse population across a wider area of the UK. It would be beneficial for children for numeracy apprehension in the early years to receive similar attention to mathematics anxiety in older populations, and to develop intervention strategies. In addition, comparison of these findings with teachers’ and parents’ perceptions and attitudes may help with teaching and learning practices. These research findings provided rationale and support for the first study of this body of work to conduct discussion groups with parents, teachers and mathematics experts, in order for comparisons to be made to the insight of children, and to determine whether similar themes emerged, as well as novel insight. This is detailed further in chapter 3. Obtaining the insight of primary care providers alongside the direct insight from children would allow for an all-encompassing view of children’s numeracy experiences. The findings would be able to contribute to the development phase of an identification scale measure, which the results from the MPhil suggest is required, as children expressed discomfort and apprehension in certain situations in numeracy lessons.
3 Exploring the perceptions and influence of primary care providers in children’s early numeracy education

3.1 Introduction

At this stage of the PhD thesis, the author introduces study one, which fulfilled the first aim of this body of work.

The aim of study one had its foundations within the author’s previous qualitative research. This was conducted with the premise that numeracy apprehension develops between the ages of 4-7 years and is influenced by the same factors and interactions that have been identified with older children (see appendices for summarised results). The data revealed that some children in early education were having negative experiences of numeracy and they were able to attribute reasons and consequences to these. Two of the four main themes centred on parents and teachers, and these factors will be discussed later in this chapter introduction.

In this body of work, it is posited that learners between the ages of 4-7 years may experience numeracy apprehension, and this is suggested as an origin of mathematics anxiety. Supporting this, Kazelskis (1998) considered that numerical anxiety is distinct from other dimensions of mathematics anxiety. This has been evidenced by the identification of numerical anxiety as an underlying factor of mathematics anxiety in research utilising mathematics anxiety scales (Richardson & Suinn, 1972; Suinn and Edwards, 1982). Kazelskis (1998) consequently suggests that the experience of anxiety due to the manipulation of numbers, is a foundation phase of mathematics anxiety, although at the time of his theorisation, an age range was not identified.

A numeracy apprehension phase, prior to the development of mathematics anxiety is supported by a number of factors identified with younger learners. Children in early education can often encounter negative evaluation from peers and teachers, particularly if they consistently under perform in numeracy (Beck, 1989; Ashcraft & Krause, 2007). The risk of developing a negative attitude and self-concept will further compromise numeracy performance (Nicolaidou and Philippou, 2003; Dowker et al., 2012) and Haase et al., (2012) further evidenced this by showing that the self-assessments of children with mathematics difficulties can predict lower performance, compared to typically achieving children with more positive self-evaluation. The proposed foundation phase of
mathematics anxiety has also been demonstrated by Yates (2002) who found that optimistic attitudes (mental rigidity and emotional intelligence) towards numeracy in primary school, correlated with higher performance three years later. The opposite was evident for those who had pessimistic numeracy attitudes in the primary years. Similarly, some children have been shown to have higher self-efficacy than their peers (Meece et al., 1990). The effect of self-efficacy on mathematics was shown by Pajares and Graham (1999) who found that children in grade 6 with higher self-efficacy (U.K. age 10-11 years) demonstrate heightened persistence, interest and performance at the end of the school year, in comparison to those with lower self-efficacy. Self-efficacy is a key determinant of mathematics achievement, and has an association with mathematics anxiety (Linder & Smart, 2010) such that those with a higher self-efficacy are more likely to persist with mathematics, particularly when it becomes difficult. To summarise, if children develop a negative attitude towards numeracy at an early age, this may prevent them from understanding key concepts and advancing their knowledge as they progress through the educational years. If children hold the belief that they are incapable of completing a numeracy task, they will disengage and fall further behind their peers contributing to the onset of numeracy apprehension.

Similarly, qualitative research has found that some children aged 7 years can have a resignation to failure in mathematics and have difficulties understanding terminology (Ashby, 2009). Again, these factors can further influence whether a child will become anxious and develop numeracy apprehension that sets a trajectory to mathematics anxiety in later years. Ashby (2009) also found that children failed to understand the wider practicalities of mathematics, which can be linked to decreased motivation (Tella, 2007), negative attitudes, avoidance and lower performance. Anthony (2000) specifically identified motivation, task completion, and seeking help as behaviours that lead to success and may be adversely affected by anxiety. In his questionnaire study, findings were obtained with 92 undergraduate students and 26 lecturers, gauging agreement or disagreement with statements based on factors influencing success in mathematics. Poor performance was associated with students being uncertain of the skills required for mathematics courses or being unable to apply these appropriately. To conclude, the difficulties faced by older populations relate to those identified in children, suggesting that the apprehension experienced at this stage, can be maintained and develop into mathematics anxiety. This places emphasis on understanding the numeracy experiences of children during the early years of education.

The consequences of low motivation in the early years can persist into further education, as shown by Zakaria and Nordin (2008). They report from their research measuring mathematics anxiety on
matriculation students in relation to achievement and motivation using the Fennema-Sherman Maths Anxiety Scale (MAS) and the 12-item Effectance Motivation Scale (EMS) (Fennema & Sherman, 1976) that low achievers often have high mathematics anxiety and reduced motivation. The results from their own research showed that students with low anxiety obtained significantly higher motivation scores and also found a significant low positive correlation between motivation and achievement, showing variables to be interrelated. Zakaria and Nordin (2008) demonstrated that mathematics anxiety has a negative effect on learning mathematics and performance. In summary, mathematics anxiety in the later years could relate to low motivation in earlier educational years and may be the outcome of an apparent lack of purpose of mathematics to the wider world, as evidenced by research (Ashby, 2009). However, causality of factors cannot be assumed and low motivation could relate to persistent failure and low self-esteem, which may also relate to negative self-evaluations. This again demonstrates the complexity of factors and their interaction.

Avoidance of numeracy and mathematics has further been identified as a factor influencing anxious responses and performance. Chinn (2012) found that if children perceive a mathematics task to be complex, this can induce anxiety and fear that causes them to avoid the task and leads to “no-attempts”. Specifically, subtraction, multiplication and division place greater demand on working memory capacity. Children’s avoidance of these more complex tasks suggests that some may not have a positive self-concept, have low self-efficacy and optimism and may fear failure. This further suggests that an interaction exists between the factors involved in the formation of attitudes towards numeracy in the early education years. Norwood (1994) considered that mathematics anxiety was not the product of a single cause and is rather the outcome of a number of factors. Hachey (2009) wrote that the early years are the foundation of mathematics attitudes in the later years and initial positive attitudes are at risk from consistent worry relating to performance. Harari et al (2013) also suggest that the phase prior to mathematics anxiety relates to negative reactions and confidence in numeracy, and is evident at an early age.

To summarise, research suggests that there are a number of factors that influence the early attitudes towards numeracy and which can place a child in the phase of numeracy apprehension. At this point, negative attitudes can become reinforced with further failure; self-doubt; pessimism; shame; embarrassment and avoidance, whilst children may compare themselves unfavourably against their peers. Again, the causality of factors cannot be assumed. Yet, the experience of these underlying factors can further harm participation in numeracy and prevent a child from learning the basic
concepts and advancing their knowledge. Mathematics can develop as the child progresses through education and the concepts become increasingly complex.

3.2 What role do parents and teachers play in the formation of apprehension or positive numeracy attitudes?

The introduction has, to this point, emphasised that children can have negative numeracy experiences and attitudes, which places them at risk of numeracy apprehension. However, to what extent are parents and teachers aware of the difficulties some children encounter in numeracy and what factors do they identify as influencing positive and negative attitudes? Focus was also given to the role of parents and teachers, who were identified as key factors in the author’s previous qualitative research with children aged 4-7 years. Study one of this PhD thesis expanded on the author’s previous research, to obtain insight from primary care providers involved in the numeracy education of children. There is currently limited literature based on qualitative insight of the numeracy experiences of young children and factors that influence attitude formations. This was further addressed in study 1. The focus groups explored the attitudes and experiences of primary carers in order to understand their influence on children’s numeracy experiences, their personal issues with numeracy/mathematics and their observations of children’s numeracy experiences. Also of interest was whether the insight from primary carers reflected the factors previously discussed by children aged 4-7 years.

Research has suggested that teachers can influence children’s numeracy attitudes, anxiety and achievement (e.g., Chiu & Henry, 1990). As identified, some children may be anxious of being evaluated by teachers (Whyte & Anthony, 2012) and can perceive their actions as hostile if they are placed in a situation where their difficulties are exposed in front of peers. However, some in-service and pre-service teachers also experience mathematics anxiety (e.g., Bibby, 2002). It was of interest to the author of this body of work to explore this aspect further through interviews and focus groups. Hamlett (2007) reported that some teachers often experience feelings of shame due to their lack of mathematical knowledge and are more likely to teach children procedurally (Chinn, 2012), potentially restricting children from developing a comprehensive understanding of foundation concepts. Again, the current research was interested in whether discussions with teachers would reveal any anxious feelings towards numeracy/mathematics and if these could be identified as stemming from negative school experiences, as further suggested by Hamlet (2007). Additional research has suggested that teacher anxiety can be transferred to students (Maloney &
Beilock, 2012; Eden et al., 2013) and potentially suppress any intrinsic motivation and positive attitudes towards numeracy. Rahim et al (2005) considered that anxious teachers may not be able to adequately support children they encounter with negative attitudes in numeracy/mathematics. Again, if discussions reveal that some teachers experience anxious feelings, it is of interest as to how they manage these in the classroom environment and if any pre-emptive measures are taken.

In general terms, teachers as influential factors in children’s numeracy attitudes and experiences was to be explored through focus groups in study one, as well as their own educational experiences and what factors had shaped their development. More specifically, the research was interested in how teachers and mathematics experts perceive children’s experiences, attitudes and behavioural responses. In addition, the author was interested in the extent of their awareness that some may struggle emotionally with numeracy, and that this may not necessarily indicate an intellectual deficit. The numeracy behaviours and responses of children were also explored with teachers and mathematics experts.

Study one considered parents as central in the formation of children’s attitudes to numeracy. The focus groups explored how parents perceived their own ability and numeracy/mathematics experiences and if these contributed to their current attitudes and career choices. Following from this, parents discussed their own children’s attitudes and behaviours surrounding numeracy and their experiences of facilitating learning. Like teachers, parents have a strong influence on their children’s educational attitudes and are considered to be a key factor of success (Dowker et al., 2012; Vukovic et al., 2013). The author’s previous qualitative research with children aged 4-7 years found that positive attitudes were associated with children being assured that their parents would assist them with their numeracy work (Petronzi et al., 2012). Mazzocco (2012) states that it is crucial for parents to promote the value of numeracy. However, this seems idealized and assumes that parents are able to set aside any negative attitudes that they may have. Indeed, Fraser and Honeyford (2000) considered that some parents may not value achievement in mathematics, and children are susceptible to adopting this same belief. With regards to transference, children can learn early negative numeracy attitudes from their parents, (Rossnan, 2006; Gunderson et al., 2012), particularly if they are expressive of their personal difficulties with numeracy and mathematics to their children (Erden & Akgul, 2010). Exposure to such attitudes may affect the mathematics participation and effort of children and may have an association with achievement and anxiety. This can contribute to the onset of numeracy apprehension. Thus, it is important to consider any difficulties that parents may encounter when attempting to assist their children with learning
The Mathematical Association (2012) stated that parents are struggling to facilitate children’s numeracy and mathematics as most do not understand modern methods, placing children at an educational disadvantage. An area of interest was the specific aspects of numeracy proving difficult for some parents and whether they were up-to-date and aware of their children’s numeracy progress? This was another interest of the research. Relating to this, MyPaper (2015) reports that parents in Singapore are taking tuition to learn numeracy and mathematics and to understand what their children experience. A key focus of this new scheme is for parents to be in a position to provide greater assistance to children when they have questions. This further highlights the key role of parents and how measures are being taken to prevent the onset of anxiety. The new scheme being implemented in Singapore is made all the more important as Pisa (2012) rankings placed the country second overall for mathematics education and compares favourably to the U.K. placed in 26th. An alternative perspective of the influence of parents is that negative attitudes towards numeracy may develop in situations where children are placed under significant pressure by parents (Yuksel-Sahin, 2008; Krinzinger et al., 2009), supporting the importance of the explorative nature of the current research.

To summarise, research has suggested that parents are a key influence in children’s attitudes towards numeracy, and will likely reflect the attitudes they are adopt. A child’s early attitudes can ultimately influence performance and achievement. These can be guided by specific factors relating to parents, for example: whether they have had negative educational experiences of numeracy; if their career is based around mathematics and if they place their child under pressure to succeed in numeracy. Due to the significant roles they play in education, the influence of parents and teachers is explored directly in the first study of this PhD thesis.

Relating to the author’s pervious research with children aged 4-7 years and previous literature, the author anticipated a number of factors to be discussed in focus group discussions in study one. These included avoidance; emotional responses; evaluation anxiety; failure and fear of this; children’s explanatory styles; a sense of either high or low ability; the language of mathematics; children struggling to understand the practicalities of mathematics; the right or wrong nature; awareness of ability groups; comparison with other children and observed gender differences.
3.3 The current study: A qualitative process to scale development

At this stage of the introduction, qualitative and quantitative perspectives are briefly discussed, due to the implementation of both methods in this PhD thesis. Deriving from the philosophical approaches of positivism and interpretivism, quantitative and qualitative methodology enable divergent research. These variances are described by Silverman (1993) who considered quantitative research as enabling theory testing based on predictions and adding a degree of control to research. In contrast, a qualitative approach studies the area of interest in a person’s natural setting, attempting to form a complex picture through making sense of the meanings people attach to their experiences (Abawi, 2008).

The polarity in approaches to research (Silverman, 1993) have been associated with continuous disagreement regarding which is the most appropriate for the study of humans. Those favouring quantitative methods consider that these enable the author to remain distant from those being observed, maintaining objectivity and allowing for context free generalisations. In turn, reliable and valid inferences can be made (Johnson & Onwuegbuzie, 2004). In contrast, the qualitative perspective argues that generalisations cannot be context free and that human behaviour cannot be explained by numerical data. Johnson and Onwuegbuzie (2004) stated that such is the level of disagreement, the proponents of each method have stated that the two methods should never be mixed.

Despite this, Olson (n/d) states that the ontological and epistemological stance of the author should be the foundation of the research, rather than a focus on a preferred methodology. Indeed, the problem of interest and areas of curiosity should lead the research approach and methodology (Gorard, 2001). The author of this PhD thesis acknowledges the value of both methods and has utilised qualitative and quantitative approaches, allowing the research questions to guide methodology.

As discussed, mathematics anxiety has traditionally been researched using quantitative methods, typically through rating scales. In this way, subsequent mathematics anxiety rating scales have often adapted items from previously validated scales. However, the author deemed it necessary for contemporary scale development to consider the advantages of qualitative methods and to develop a scale based on direct insight from and relating to the target population. In this body of work, qualitative data was required for the development of a numeracy apprehension scale. Creswell
(2003) wrote in acknowledgement of mixed methods, whilst Johnson and Onwuegbuzie (2004) later stated that using both methods is to utilize the strengths and reduce limitations, e.g., adapting items from mathematics anxiety rating scales with older populations for children to complete.

For this research, the author refers to Morse (1994) who considered qualitative research as the heart of important work and that observation is the theoretical foundation for quantitative methods to test, leading to science. Thus, in order to develop a numeracy apprehension scale in accordance with mixed methods, the first study within this body of work focussed on conducting focus groups with parents and teachers and interviews with mathematics experts. As only two mathematics experts participated, it was considered that each would be able to discuss their experiences and observations in greater depth, than if placed together in a focus group setting. This would provide in-depth data relating to their perceptions and observations of how children aged 4-7 years, experience numeracy and would complete an all-encompassing insight, as the parents and teachers in study one were those of the children who participated in the author’s previous MPhil research (Petronzi et al., 2012). Based on the data obtained from children, mathematics experts, parents and teachers, items for the Numeracy Apprehension Scale were produced and underwent item redundancy with, for example, mathematics anxiety researchers, teachers and head teachers. The findings of the first study within this body of work, produced the foundations for scale development and allowed the scale items to be formed based on direct insight from the target population (children aged 4-7 years) and their primary care providers.

The objective of study one was to explore the attitudes and experiences of primary care providers to explore their influence on children’s numeracy experiences, their personal issues and experiences with numeracy/mathematics and their observations of children’s numeracy experiences and responses to situations. It was of interest as to whether the insight and themes that emerged through discussions with primary care providers reflected the findings from the qualitative research outlined in chapter 2. Thus, comparisons are made to the findings of the author’s previous qualitative research with children aged 4-7 years.
3.4 Method

3.4.1 Analytic Approach

The findings were obtained through focus groups with parents and teachers and interviews with mathematics experts. The two participating mathematics experts were interviewed separately as this would enable more in depth conversations, allowing each of them to fully elaborate on their individual careers and observations. The data was analysed using thematic analysis, in accordance with the guidelines of Braun and Clarke (2006). (1) The guidelines urge familiarisation with the data and for immersion to the extent of in depth understanding of the content, (2) which then enables an initial list of codes to be produced representing the interesting aspects of the data. (3) Themes can then be generated through refocusing the analysis and sorting codes (4) that are then refined with some becoming redundant, (5) leaving themes that best encapsulate the data, though further refinement and analysis of the data within them is required. (6) At this phase, a full set of themes has been established and the data can be reported. The utilisation of each of the outlined six phases is highlighted throughout this method section.

Thematic analysis allowed for exploration of the meanings parents, teachers and mathematics experts placed on their personal and children’s experiences of numeracy. The author’s involvement in discussions allowed for understanding of detailed data. This enabled the author to identify and extract key themes and sub-themes. More specifically, qualitative analysis provided the author with perceptions of how children negotiate contemporary numeracy education and the social and psychological factors that characterise and influence their numeracy behaviours and attitudes (Berg, 2004). The discovery and analysis of key themes within the discourse would also allow for comparison with the discussed numeracy thoughts and feelings of children in early education (Petronzi et al., 2012). Specifically, this would support whether adult observations and awareness of numeracy difficulties are synchronised with self-reports of children aged 4-7 years.

In conjunction with the process of thematic analysis, the research also implemented content analysis. This is the process of quantifying qualitative data obtained in focus groups and interviews and extracting and classifying important phrases and themes into an efficient number of categories based on frequencies within discourse (Webb & Kevern, 2000). The systematic coding process related to this analytical method enabled the author to construct replicable and valid inferences (Elo & Kyngas, 2007), essentially providing rigorous scientific procedure to the interpretation of subjective data and the testing of theory (Moretti, Van-Vliet, Bensing, Deledda, Mazzi, Rimondini,
Though able to be utilised inductively or deductively, the current research employed inductive content analysis to obtain new insight, by allowing the data to naturally inform, rather than imposing preconceived categories (Moretti et al., 2011). Although the author’s previous discussions with children had generated key themes, these were not referred to during the analysis process. Similarly, the author chose to analyse manifest content of numeracy discussions as opposed to latent content (silence, sighs, and laughter) as searching for and attempting to subjectively interpret meaning within body language and behaviour, contradicts the intentions of data driven research (Elo & Kyngas, 2007). The interpretation of body language and behaviour is subjective, for example, a teacher presenting as restless during a discussion may be perceived by the author as finding the discussion difficult, although in reality, this may simply relate to time pressure and needing to be elsewhere.

The process of analysis adhered to the five step framework as detailed by Moretti et al (2011) that emphasises (1) familiarisation with text and marking aspects that relate to the research question, (2) followed by making notes on the content of intrinsic interest (3) that are grouped into exclusive categories and given an initial label. (4) Categories are then revised, whilst others emerge and links are established between them. Finally (5) linked categories and subcategories are organised and placed into a hierarchical structure. Throughout the analysis section of this method, the author states at which point each of the phases of the content analysis process were implemented.

### 3.4.2 Participants

Parent and teacher participants were recruited across three primary schools in the East Midlands region of the U.K., utilizing an opportunity sample. The children who participated in focus groups in the previous MPhil research (Petronzi et al., 2012) were recruited from the same schools as the parents and teachers in the current empirical work and some were the children of the participating parents. As informed by school head teachers, the demographics of two schools reflected middle class status with a catchment of predominantly white, middle class families, whilst the third was situated in a more culturally and economically diverse area (Derby City Council, 2011). Mathematics experts were secured through imposing the criteria of having experience of teaching numeracy within primary schools and mathematics with older students, including at degree level. This enabled identification of suitable participants within the University of Derby’s education department. In total, eighteen participants (N=18) discussed their experiences, consisting of seven parents (38.9%) nine teachers (50%) and two mathematics experts (11.1%). The parents and teachers who participated were from the same schools as where the children focus groups took
place (Petronzi et al., 2012). Parent data was collected through an interview in Primary School (PS)-C (N=1, 5.6%, female) and three focus groups, with two in PS-A (N=2, 11.1%, females & 2, 11.1%, females) and one in PS-B (N=2, 11.1%, male and female). Teacher data was obtained through two focus groups; one taking place in PS-A (N=5, 27.7%, females) and the other in PS-B (N=4, 22.2%, females). Finally, mathematics expert data was collected through two interviews, that took place at the University of Derby (N=1, 5.6%, female & N=1, 5.6%, male). The mathematics experts had a range of experience, working with and teaching a variety of age ranges throughout their careers, including primary school children and undergraduate mathematics students. The parents who participated were also varied in their careers and involvement with their respective school. For example, some at PS-B stated that they had been an active member of an internal school group that aimed to help parents learn contemporary numeracy methods. Finally, the teachers who participated in discussions included those that teach the relevant age range (4-7 years), a head of numeracy and mathematics, a head teacher and teaching assistants.

3.4.3 Materials

To obtain school participation, head teachers received a letter of invitation (See appendix i) and a subsequent consent form with a returnable slip was sent to parents via each primary school (See appendix ii). Question schedules intended to facilitate discussions were created for teachers and jointly for parents and mathematics experts (See appendices iii - iv). The schedules were separated into three key areas of perceptions and experience, with identical questions compiling (1) thoughts and feelings of numeracy now and (2) thoughts and feelings as a child. Schedules became participant specific in the third and final phase of questions; (3) thoughts and feelings of your children. The questions were intended to gauge the educational development and experiences of participants in order to understand how these have shaped their attitudes and the influence this has had on children. Specific questions relating to children in the teacher’s class and the children of parents were formulated through empirical data, discussion points of literature and were further based on conversations with head teachers in a previous study (Petronzi et al., 2012). The focus group and interview questions for all participants reflected the intent to be all encompassing, as opposed to focusing on any particular factors involved in numeracy education. Additionally, a researcher script was constructed to standardize an introduction and explanation of the procedure that was delivered to participants. (See appendix v). Finally, an Olympus DS-2400 digital voice recorder was used to record the focus group conversations, whilst the corresponding computer software and foot pedals were used for transcription.
3.4.4 Procedure

Preceding data collection, letters of invitation to participate in the research were sent to schools across the East Midlands Region. These informed that the author would subsequently contact the school administrator to arrange an appropriate date to discuss the research opportunity in greater detail. Head teachers expressing particular interest in the numeracy education focus of the research scheduled a meeting with the author, allowing the purpose and aims to be detailed and the procedure and requirements to be explained in depth. For clarity and to assure of research suitability, all materials intended for use were presented to head teachers. Permission to conduct focus groups was subsequently granted and introductions were made to teachers who were each provided with a consent form. Additionally, children in reception, year one and year two were provided with consent forms to pass on to their parents, with a specified two week return period being. After this time had elapsed, consent forms were collected and later made secure in a locked filing cabinet residing within a postgraduate research office of the University of Derby, accessible solely by the author. Mathematics experts were approached for participation via email, in which the details of the research were outlined, as well as what their participation would entail.

3.4.5 Data Collection

Data collection for parents and teachers of each school was spread over a two week period, though all focus groups were held in the afternoons. Parents were contacted in liaison with the schools through the contact numbers they provided to determine which allocated date and time they could attend. Upon determining teacher participation through returned consent forms, head teachers organised a combined focus group session during a mutually convenient lunchtime. Through an inclusion criteria of having worked in a classroom setting with primary school children (aged 4-7 years) appropriate mathematics experts interested in the research responded to an invitation email and a suitable date was arranged to conduct interviews, with both taking place on the same afternoon. For each focus group, a separate room was allocated to minimise disturbances and external noises interfering with the clarity of recordings. Decreasing distraction was ultimately intended to encourage focus on the issues of numeracy education, providing an engaged and intuitive discussion. Prior to starting, the author and the current study were introduced in greater detail, enabling participants to ask questions and engage in general conversation, contributing to a relaxed atmosphere. This period provided an opportunity to note all participant names and allocate each of them an individual number that was recorded each time they made a contribution to ensure
accuracy when transcribing the discourse. This was not required with mathematics expert interviews. Additionally, each group was allocated a name based on its school initials, order of taking part and the year group, for example, the second group to participate consisting of parents would be titled ‘XXPS Group 2 Parents’. For mathematics experts, the interview names were titled using the initials ‘ME’ and either 1 or 2. This allowed the author to have a reference for the specific details of each group. Participants were read the standard research script and informed of the focus group guidelines and the role and level of involvement of the author within discussions. Due to their careers, mathematics experts and teachers were accustomed to speaking about their experiences and observations of children’s numeracy behaviours, although some parents required further prompting from the author. Upon declaring full understanding and comfort, participants were reminded of their right to withdraw at any stage of the discussions and were kindly asked to not speak over each other or discuss what other’s had said outside of the focus group environment. The discussion began with the first question from the appropriate schedule and whilst discussions were guided by mathematics experts, parents and teachers, all questions were utilised to ensure the direction of discourse remained relevant to numeracy. Following discussions and to conclude the research, participants were able to ask any questions about the research or other aspects of numeracy apprehension, and were finally thanked for their time and insight.

3.4.6 Transcription

All focus group recordings were listened to three times to allow the author to become familiar with the data that had been obtained. This refers to Braun and Clarke’s stage one for thematic analysis. They were then transferred to computer and discussions were typed using Microsoft Word 2007. The numbers allocated to each child in the focus group settings were applied in the written versions of the recordings, so participants remained anonymous. The author was always allocated the pseudonym ‘R’. Transcriptions were written exactly as the words were spoken as the author was focused on content in order to accurately reflect what had been said. To aid the analysis stage, page and line numbers were added to transcripts to allow simple reference to data that would be extracted and coded.

3.4.7 Analysis

On completion of each transcript, discourse was again read three times to ensure familiarisation and comprehensive understanding of the content. Following the thematic analysis process, aspects of
interest received commentary on the left side of the document whilst emerging codes were recorded on the right. This again refers to stage one of the thematic analysis guidelines stipulated by Braun and Clarke (2006) and stage one and two of content analysis Moretti et al (2011). The extracted codes related to previous mathematics anxiety literature to varying extents. Other aspects offered an in depth perception of numeracy/mathematics factors that positively and negatively influenced the three groups of participants and their children. Extracted data from corresponding focus groups was coded within an initial codes table that included primary sub-codes, relating to stage two of the thematic analysis process and stage three of content analysis. These were titled according to the group names previously allocated. Each table presented the question asked as the author thought it necessary to show which aspect each group had responded to or had produced other related thoughts, feelings and experiences. Following the completion of data tables (appendix vi), transcriptions were re-analysed, with codes and related extracts being redefined and altered. Three lists emerged of significant aspects representing mathematics experts, parent and teacher discourse. This reflects stages three and four of the thematic analysis process (Braun & Clarke, 2006).

These lists consisted of potential dominant themes and sub-themes, and in line with content analysis; the final theme formulation was based on frequency within transcripts. For each preliminary theme, the author determined which focus groups a theme appeared e.g. teachers and its total frequency noted. Similarly, sub-themes were extracted and noted, including their total frequency. This enabled the author to determine which themes and sub-themes were most representing the perceptions of each group, completing stages five and six of Braun and Clarke’s (2006) thematic analysis guidelines and stages four and five of the content analysis procedure (Moretti et al., 2011). Although the content analysis process was similar to that of thematic analysis, the overall themes and sub-themes were guided by frequency, providing some rigour to the interpretation process and to minimise the influence of the author. For instance, some sub-themes that were assumed to be of importance by the author were omitted due to a low frequency within the discussions. Other high frequency sub-themes and themes took precedent. Subsequently, thematic maps for each group were produced, incorporating the identified dominant themes and sub-themes, either under their previously determined label or one with a broader perspective so as to include similar low frequency themes and sub-themes that were not considerable enough to reside as separate entities in their own right.
3.4.8 Ethical Considerations

The research was cleared through the University of Derby Psychology Research Ethics Committee and adhered to the British Psychological Society ethical guidelines. In order to obtain participation, consent letters were sent home to parents through the school, outlining the research in a question and answer format, informing of anonymity and right to withdraw. Teachers also received this question and answer format consent form and maths experts read and signed this document prior to interviews. This provided all participants with the opportunity to make an informed decision regarding their participation and included on the letter was a guide for generating a unique reference code. Prior to and following focus groups and interviews, participants were reminded of their right to withdraw at any time, and upon completion, were thanked for their time and were each given a sticker.
3.5 Results

This analysis presents direct accounts of factors that mathematics experts, teachers and parents discussed as influential in their numeracy experiences. Discourse was examined in relation to the thoughts, feelings, experiences and observations of mathematics experts, parents and teachers. In accordance with the inductive thematic approach, initial themes and sub-themes were extracted due to their importance and data representation, prior to the formulation of the final dominant themes and sub-themes through inductive content analysis. This analysis revealed separate networks of themes and sub-themes relating to each participant group and captured the data in its entirety (See figures 3.2, 3.3 & 3.4). A number of these were generally discussed by all participant groups (1) Difficulty of Numeracy (2) Teachers/Teaching (3) Parents (4) Comparison/Competition (5) Failure/Anxiety (6) Avoidance. The difficulty of numeracy included discussions based on the right or wrong nature of the subject, whilst concept understanding and the language of numeracy/mathematics was further implicated. Discussions of teachers were predominantly negative in the mathematics experts and parent groups, with issues emerging, including a failure to teach concept understanding, the punishment of errors in numeracy and having a negative relationship with the teacher. Parents were discussed as reinforcing and facilitating numeracy learning. However, some participants spoke of parents transferring their own numeracy anxiety, being unable to understand contemporary numeracy methods and not seeing the relevance of mathematics. Comparison and competition of numeracy was centred on sibling, friend and gender rivalries, with the aim of being the most proficient in numeracy. All participant groups discussed negative numeracy experiences as influencing their career choice, and the mathematics experts expressed a particular enjoyment of the subject from a very early age that was maintained throughout their education. Some parents discussed the influence on their career choice as a desire to avoid working with numbers. Through all discussions of numeracy, fear, failure and anxiety were all expressed, though there were clear differences in how these experiences were dealt with by each participant group and how children faced these issues. All groups also acknowledged an association between negative numeracy experiences and avoidance. The key themes and sub-themes will be discussed in detail. Each extract follows the authors interpretation as support for the perspectives presented. Additionally, each data extract in the analysis is followed by group category initials (for example ME), group number (G), year group (Y), page and line number (for example 3:84) to enable location of the extract within the correct focus group transcript. Throughout the results section, the author offers an interpretation of discussion points and refers to previous psychological literature to support the explanations. At the end of each participant group
section, the author summarises the key themes and sub-themes in reference to the relevant thematic map.
3.5.1 Thematic Maps

The author has presented the thematic maps in a manner that reflects the thought process during the analysis phase and also which demonstrates the relevance of content analysis.

In the example thematic map extract, the author has created a sub-theme for parents that is entitled ‘Areas of Concern’, and is based on points of discussion. However, the corresponding red arrow leads to a box presenting a list of the main discussion points, providing you, the reader, with a clearer insight as to the core issues that led to the formation of this sub-theme. On the left side, the numbers relate to the initial coding process, where all important aspects were extracted and numbered. However, during the analysis process, some were placed into more appropriate sub-themes, hence why this list does not contain issue 2.1 or 2.7.

Again, looking at the discussion point box, after each issue, there is first a number. This relates to the participant group, for example, a number 2 represents parent discussion group 2. However, as can be seen, there are discussion points with more than one number and are presented as, for example, 1>2>3. This means that the discussion point was raised in parent discussions groups, 1, 2 and 3.

Finally, the last number placed in a bracket in the discussion point box relates to the overall frequency of that point within the participant groups. For example, if we consider point 2.2, the final number is (9), meaning that this issue was raised 9 times throughout the discussions, and was raised by group 1, 2 and 3.

Figure 3.1 - Thematic map extract
Figure 3.2 - Thematic map showing factors that mathematics experts considered most important in the development of children’s feelings and attitudes towards numeracy.
Figure 3.3 - Thematic map showing factors that parents considered most important in the development of children's feelings and attitudes towards numeracy.
Figure 3.4 - Thematic map showing factors that teachers considered most important in the development of children's feelings and attitudes towards numeracy.
3.6 Mathematics experts

3.6.1 Pressure and numeracy in public

Demonstrating how a fear of numeracy may be learned in the classroom, mathematics experts discussed occasions where they had witnessed children being asked to solve numeracy problems in front of others, placing them in a negative pressure situation (Ashcraft, Krause & Hopko, 2007).

*I saw negative experiences where children were put on the spot (ME1: 3:155-157).*

Expanding on this, males were identified as being generally more confident when completing numeracy in front of others and being less affected by mistakes in comparison to females. This is in line with Devine et al (2012) who found males to have more persistence and resilience following mathematical mistakes. Females were discussed as showing behavioural signs of anxiety in classrooms when attempting to avoid solving a numeracy problem in front of others (Beilock et al., 2009; Mutodi & Ngirande, 2014).

*Males are generally more confident and also more confident at making mistakes. Girls are a lot more reluctant to answer and they’ll sit back, their language changes and they actually physically recoil into their seats. (ME1: 7:359-365).*

However, it is not possible to attribute the cause of the avoidance to anxiety. Specifically relating to anxiety, a mathematics expert discussed the consequences to children who became overwhelmed with the pressure of numeracy, claiming that sudden reactions such as crying was observed and are specific to the subject of numeracy.

*Crying, literally crying. I could say almost in no other subject, only in maths, and it can be just a question, and you’ll carry on teaching the class and one child will just burst into tears because they don’t know the answer (ME1: 8:437 + 9:441-444).*

The mathematics expert expressed their own feelings of anxiety when teaching the subject, despite specialising in the subject and multiple years of experience, relating to teacher anxiety, further demonstrating an inherent anxiety associated with numeracy and when solving numerical or mathematic problems in front of others, (Beilock et al., 2010).

*I do get a little bit of anxiety creeping in, in front of the students (ME1: 1:16-17).*
Discussions revealed that for some, pressure can be induced when completing numeracy and is increased with the additional stress of solving problems in front of others. The inherent nature of numeracy and negative public experiences may place some children at risk of developing aversive emotional responses to working with numbers, which will adversely impact upon their learning and ability (Ashcraft, Krause & Hopko, 2007).

### 3.6.2 Difficulty of numeracy

Mathematics experts discussed the perceived difficulty of numeracy as contributing to the formation of how learners experience the subject. Polarities in feelings towards numeracy are often apparent and reinforced with self-critical or positive evaluations.

*If people actually begin to perceive it as being a hard subject that will increase their anxieties if they’re not feeling successful at it (ME2: 10:497-500).*

*There’s no in-between, no grey at all, and its either you really like it or you really don’t, but they usually say, because I’m not good at it or I love it because I find it really easy (ME1: 7:344-348).*

However, a mathematics expert revealed that they too encounter difficulties with mental arithmetic, but can overcome this in the right circumstances, citing situations where there is no time pressure (Wong & Evans, 2007).

*I’ve always not been so hot with my mental [arithmetic], but I’m ok working out solutions to problems if I’m given time and paper (ME1: 1:34-37).*

For some learners, particularly children who are consistently tested and placed in time pressure situations, if their performance and confidence declines due to the difficulty of numeracy, they may begin to withdraw from the subject. The right or wrong nature of numeracy personally appealed to a mathematics expert, although they stated that this is a further issue of the subject that adds to the difficulty and consequently, anxious reactions (Chinn, 2012). Once anxiety develops, mathematics experts conceded that this can take some time to alleviate (Cockcroft, 1982; Baptist et al., 2007).

*It’s just black and white, there is a set answer usually, and that’s when people’s anxieties usually begin (ME1: 8:391-393).*
It can take quite a long time to break down the kind of issues that they have (ME2: 3:121-122).

Reflecting upon their experience in primary schools, the method of teaching numeracy procedurally was discussed as contributing to a perception of difficulty and ultimately, feelings of anxiety.

*It becomes a subject where mathematics is taught procedurally and not a lot of thought is given to an understanding of what you are doing. Methods are often shown without any true understanding and I think that can lie at the heart of the anxieties that people have (ME2: 2:74-84).*

Additionally, a proportion of the difficulty of numeracy may be attributed to the language used in the subject, particularly when children encounter worded problems, as alluded to by Dowker (2004) citing Ginsburg (1977). Mathematics experts further discussed concepts, such as learning and working with the teen numbers, subtraction and division as being particularly difficult for children and causing a degree of anxiety (Chinn, 2012).

*The issue came when dealing with worded problems, where problems were put into context, where you had to read and decipher and interpret problems; I think that was tricky (ME2: 5:220-226).*

*Moving into teen numbers is a problem for young children and they can become anxious about that because they don’t act in the same way as numbers beyond that, and that’s a linguistic issue (ME2: 8:405-419).*

*Subtraction as an operation is quite tricky for children as well, they become anxious about that and have a sense they can’t do it. There’s a similar issue with division which remains quite a problem actually (ME2: 8:405-419).*

Demonstrating that negative numeracy attitudes are being learned in the early years when some children encounter the difficulty of numeracy, mathematics experts revealed that students they have taught in the later years bring negative attitudes towards the subject.

*I try to breakdown the inhibitions which I know that they have and bring along with them. I like to work with students who, in the past, have struggled with the subject (ME2: 2:61-64 + 2:65-67).*

Difficulty of numeracy was discussed as contributing towards whether an individual will develop a positive or negative attitude towards numeracy, and that attitudes are often formed on either end of
the positive or negative extremes. Outlined as contributing to the difficulty of numeracy were: a procedural approach to teaching numeracy without the depth of concept understanding; the right or wrong nature of numeracy and the language and number concepts that deviate from the rules, such as teen numbers. Through their experience, experts revealed that these aspects can cause anxiety in young children and can keep them in a cycle of negative experiences in which shame may also be felt and can leave an individual helpless (Preis & Biggs, 2001; Bibby, 2002).

### 3.6.3 Influence of teachers (negative)

Mathematics experts implicated their own teachers as contributing towards their attitudes towards learning numeracy, although some aspects they discussed related to how they negatively perceived their teachers. A reason outlined was that teachers would choose a child to provide an answer and continue to pressure them, even if they were unable to solve the numeracy problem. This relates to Harari et al (2013) who considered that hostile teachers may contribute to setting the conditions for the development of mathematics anxiety. In addition, teaching methods were also discussed as causing boredom and producing a lack of motivation, resulting in counterproductive behaviours, such as talking with friends.

> I used to think, that’s really not fair how the teacher’s grilling them and making them come up with an answer (ME1: 3:158-160).

> Her delivery was so dry, I did not enjoy going into her lessons because I knew that I would be bored to tears...but it enabled me to talk to my friends (ME1: 4:196).

This reflects the results obtained in a master’s research study (Petronzi et al., 2012). Children in a focus group setting discussed how they feared providing wrong answers to the teacher as thought they would be shouted at, whilst also expressing a desire to leave numeracy lessons as a consequence of boredom. To demonstrate the value of a varied approach in mathematics, Pyne, Bates, and Turner (1995) implemented varying teaching styles with college students with an emphasis on an investigative approach that was found to encourage independent thinking and confidence, keeping students engaged.

Again discussing the experience of working in primary schools, mathematics experts spoke of children encountering difficulties with incorrect numeracy terminology used by teachers who may not be confident with the subject. Thompson and Rubenstein (2000) also consider that teachers often forget that mathematical language is foreign to many students and identify issues with the
vocabulary used in mathematics to convey the “surface structures” that help students form ideas as they progress to the “deeper structures” of mathematics concepts.

Some teachers who are not very confident with their own subject knowledge will not use the correct vocabulary. That rubs off on the children because they’re not hearing the right vocabulary. For example, some teachers call calculations, sums and I’m not understanding that sums means addition (ME1: 11:593-599).

Further based on this experience, mathematics experts believed that some student teachers underestimate the importance of being able to teach basic numeracy/mathematics and concept understanding in a primary school classroom (Uusimaki and Kidman, 2004).

Some students that I teach now underestimate how important it is to teach basic maths and the pedagogies. They think because they’ve got their GCSE they’re fine, but putting it inside a primary classroom experience, it’s a completely different ball game (ME1: 1:51-2:57).

Hamlett (2007) who conducted an intervention for teachers also acknowledged the shame they often feel due to lack of mathematical knowledge. Tishler (1980) added that some teachers may not achieve their full potential due to mathematics anxiety, and Williams (1988) considered that negative attitudes can be transferred to children. This may contribute to some children disengaging from the subject, particularly if they are not understanding a concept and a teacher with less experience is unable to identify this and provide a method to facilitate their learning.

The influence of teachers was also discussed from different experiences of the mathematics experts, emphasising how pressuring a child for an answer and a dull delivery of the subject can result in the development of negative attitudes and avoidance behaviour. From current experience, it was revealed that some student teachers are not secure with their own knowledge of numeracy, creating the risk of this transferring to children, whilst the vocabulary they use may be incorrect. It was also stated that some student teachers underestimate the importance of basic numeracy/mathematics, and thus, some children may not fully understand concepts that places them at a disadvantage as they advance through school.

3.6.4 Influence of teachers (positive)

Despite negative experiences, the mathematics experts also discussed positive teacher experiences as recapturing their interest in the subject and as contributing to their subsequent success. This also
indicates a strong self-efficacy as they showed less negative reactions when encountering difficulties with some of their teachers (Zimmerman, 2000). This further reflects the attitudes of children from previous research (Petronzi et al., 2012) who demonstrated positive attitudes in numeracy learning, even after making mistakes.

There were people [teachers] who genuinely developed my motivation for the subject (ME2: 4:182-183).

In general terms, I was taught by teachers who were reasonably confident in their mathematics (ME2: 3:157-159).

Mathematics experts went on to discuss a personally developed teaching philosophy, based on experiences with their own teachers at school. They acknowledged that some learners will encounter difficulties with various aspects of numeracy/mathematics and that anxiety can develop as a consequence and without positive intervention.

I’ve taken that on-board as a teacher because you do reflect back to those times, and so I always made sure, if there was a child that was struggling, I’d ask them to come at lunchtime, to develop that area of weakness (ME1: 4:168-172).

Additionally, due to some of the deficits in numeracy teaching that they have observed through their experiences, they further discussed aiming to encourage numeracy learning by teaching the relevance of numeracy in an exciting manner and ensuring that learners understand the actual concept (Ashby, 2009). Creating a relaxed and engaging learning environment in numeracy is likely to prevent boredom that children have previously discussed. This will discourage the development of a fear of failure that is based on a belief that the teacher will punish mistakes (Petronzi et al., 2012).

I feel that within my sessions, I create an atmosphere where mathematics is seen as something that is accessible, that’s relevant, that’s exciting, and those kinds of things can help to break down anxieties (ME2: 3:124-128).

I make sure that children and students understand why we need to teach concepts (ME1: 6:287-289).

Despite encountering negative experiences with some teachers, the mathematics experts demonstrated how some children’s self-efficacy (Zimmerman, 2000) that relates to social cognitive theory (Bandura, 1986) enables them to continue learning and be less affected by difficulties, as
also found in the research of Petronzi et al (2012). This relates to Pajares and Graham (1999) who found that mathematics self-efficacy was a motivation variable that predicted grade six children’s (U.K. age 11 years) mathematics performance. The positive influence of subsequent teachers seems to have nurtured their numeracy learning, and encouraged them as teachers, to make a focussed effort to enable numeracy/mathematics to be accessible and engaging in their sessions, to minimise anxiety.

3.6.5 Low sense of ability

Through discussing primary school teaching experiences, mathematics experts revealed some of the behaviours and attitudes of children who felt they were of low numeracy ability, and thus, unable to complete numeracy work. Children would typically disengage with the subject and refuse to do the work immediately after looking at it, demonstrating a pessimistic explanatory style, due to a decrease in persistence and assertiveness (Yates, 2002).

_There was a sense that they felt that they couldn’t do it and therefore, weren’t prepared to engage with it (ME2: 6:312-314)._  

_In terms of the anxious ones, they will just look at something and say, I can’t do it; I won’t do it (ME1: 14:742-743)._  

In these cases, children may have adopted the belief that if they do not engage with numeracy, they have not failed to complete the work, as instead, they have chosen not to do it. Through experience, mathematics experts further discussed how some children would begin to feel anxious, due to other children struggling with their work. This may be due to some children relying on each other as a numeracy coping strategy, which when unavailable, may increase worrisome thoughts (Petronzi et al., 2012).

_Some children will notice what’s happening with others and begin to feel anxious about that (ME2: 6:303-305)._  

Mathematics experts also revealed feeling anxious about their own ability when placed in a pressure situation, such as teaching in a classroom, and asked a mathematics question that they were unprepared for (Hachey, 2009). This seems to replicate teachers placing children under pressure and causing anxiety when asking them a numeracy question in front of the class (Petronzi et al., 2012).
It’s when I’m not prepared for a student question. Now I’m a teacher, there are times when I start to question my own subject knowledge (ME1: 2:77-82).

Mathematics experts discussed children with a low sense of ability as disengaging with numeracy work, adopting the belief that they are unable to do the work and that there is no need to even attempt it (Yates, 2002). These children may well have already developed a degree of anxiety and their behaviour reflects that of learned helplessness as they consider themselves to have no control of their situation, leading to motivational and cognitive deficits (Kolacinski, 2003). It was also stated that other children would also begin to feel anxious due to the worrisome thoughts and attitudes of a child struggling with numeracy work. This may be a consequence of how a child identifies with another, and how a struggling child may have a negative influential effect on their friends. Mathematics experts further discussed questioning their own ability in a pressure situation that reflects the classroom experiences of some children.

3.6.6 High sense of ability

It became evident that the mathematics experts became aware of a numeracy/mathematical ability and confidence from an early age, motivating them to develop their understanding of concepts. The logic of mathematics, though anxiety inducing for some (Richardson & Woolfolk, 1980), was favoured by the mathematics experts, as different concepts follow specific rules, leading to either a right or wrong answer. This aspect, though anxiety inducing for some, was a clear appeal of the subject. As discussed, their teacher experiences were not always positive, suggesting that multiple factors are involved in whether an individual develops anxiety towards working with numbers or not. They further discussed their early childhood evaluations of their own ability as encouraging them to continue with numeracy/mathematics, demonstrating that attitudes in the early years are influential on the remainder of a child’s education (Witt, 2012).

It was a subject I always felt more confident in than other subjects. English was something I always found much more difficult, the logic of mathematics always appealed more to me (ME2: 1:28-31).

I always felt confident in dealing with maths in school, and I think confidence spirals and it made me feel that it was a subject I wanted to stick with (ME2: 3:135-138).

Numeracy and mathematics were also discussed as being intuitive, in terms of children being aware by a certain age of their ability level. Mathematics experts discussed the belief of ability as being a
motivator to challenge the subject further (Pajares & Graham, 1999) and also claimed that the performance gap would increase between children who were and were not secure with numeracy.

Mathematics is quite an intuitive area and I think if you become conscious by the age of seven that you have some kind of ability within it, you’re quite keen to move yourself on and to challenge it and the gap can begin to grow quite quickly (ME2: 6:299-303).

Mathematics experts considered age seven to be the point that children become aware of their ability and attitudes towards numeracy, potentially determining their trajectory in the subject for the remainder of their education. However, this contradicts Mcleod (1993b) who considered ages 9 to 11 years to be the critical stage for the development of mathematics attitudes and emotional reactions. Additionally, it was discussed that those with a high sense of ability may not necessarily understand a concept immediately, but have an intrinsic motivation to learn and to find a solution. As outlined as part of a low sense of ability, others may simply give up. Although ability is important, it seems enjoyment and appreciation of mathematics was also important for the career choice of the mathematics experts and the children in their classes would likely benefit from the enthusiastic learning environment they aimed to create.

The ones that are secure with their maths, they will not let go of the bone until they find the answer (ME1: 14:736-741).

I became a maths leader in primary schools because of my love for maths, rather than my ability (ME1: 3:126-131).

Mathematics experts revealed that from an early age, they developed an awareness of ability in numeracy that was maintained even through negative experiences with some teachers and motivated further learning and understanding. This aspect of the discussion emphasised the importance of educational experiences in the early years, as attitudes formed during this time may be maintained throughout an individual’s educational career. It was also discussed that by the age of seven years, the gap between ability levels increases, and if children feel they are unable to complete numeracy work, anxiety increases and motivation diminishes, as found by Petronzi et al (2012) – chapter 2.

3.6.7 Influence of parents (negative)

Mathematics experts discussed the role of parents in influencing how children experience numeracy and identified that many parents in the U.K. have faced difficulty in their own
numeracy/mathematics experiences. They considered the possibility of negative attitudes being transferred to the children, which would be influential in their belief in ability and the value they place on learning numeracy (Gunderson, Ramirez, Levine & Beilock, 2011).

A lot of parents within the U.K. have had fairly negative experiences with mathematics and those experiences often get passed on from them to their children (ME2: 4:196-198).

Developing the idea of transference of attitudes, the mathematics experts revealed experiences of parents stating that due to their own inability in numeracy, they knew their child would also have difficulties with the subject (Gunderson et al., 2012). If the child is aware that they are not expected to perform well in the subject, the mathematics experts believe that they will respond accordingly to this self-fulfilling prophecy. This further demonstrates another factor contributing to negative numeracy attitudes that children develop at an early age.

A lot of parents come into school and say; well I wasn’t good at maths so they’re not going to be good at maths. That rubs off on the poor child and they probably could be very able at maths, but it’s been beaten into them that they’re not ever going to be good (ME1: 5:268-270).

Offering an alternative perspective in relation to a negative influence of parents, mathematics experts briefly considered the pressure placed on children to perform as having a detrimental effect. This may lead to self-consciousness about numeracy performance and developing anxiety due to not matching parental expectations (Yuksel-Sahin, 2008). This is potentially the same negative pressure that mathematics experts have witnessed some teachers placing on their pupils.

What’s happening at home with the homework, do their parents put too much pressure onto them? (ME1: 9:453-454).

Expanding on this, if pressure is due to the parents being of a good mathematical ability and expecting the same from their child, mathematics experts considered that this may actually have the opposing effect on the child and lead them to feel insecure about their abilities. Mazzocco et al (2012) develop this further, stating that parents who believe mathematics to be male-orientated can overestimate their son’s performance that can lead to anxiety, whilst girls’ performance may be underestimated. Thus, their underlying ability may not be nurtured to its full potential.

I’ve seen it go the other way where children have actually felt quite negative about their own abilities because other people within their family seem so much more able,
Mathematics experts discussed the circumstances in which parents can negatively influence and affect their own child’s numeracy performance, further relating to Harari et al (2013) who consider that parenting practices are influential in the development of children’s anxiety. A main perspective to emerge during this stage of discussions was the potential for negative parental attitudes to be transferred to children; even if they intrinsically have ability in the subject. Acting as a self-fulfilling prophecy, the child will adopt the belief that numeracy is simply not worth the effort. In contrast, it was revealed that some parents can place too much pressure on their children to perform well, resulting in the child feeling inadequate in comparison to the ability of their parents (Yuksel-Sahin, 2008).

3.6.8 Influence of parents (positive)

Despite some negative influences, the positive aspects of parents in facilitating the learning of numeracy were also discussed. Initially speaking from their own experience, a mathematics expert revealed how they felt secure with numeracy from an early age, aided by positive reinforcement from their parents. This would have eased the pressure of learning numeracy and given them a sense of belief in ability.

Mum and dad would say you’re really good at maths, so I didn’t really sort of have to try any harder because I was just good (ME1: 5:268-270).

Similarly, they considered that if a child’s family are confident with numeracy/mathematics, this can be of benefit to them, as they will learn positive attitudes and will have the support to facilitate their learning, particularly when the work is difficult (Petronzi et al., 2012).

I think if they’re surrounded by people who are confident mathematically, that could be of benefit to them and be supportive (ME2: 9:469-476).

Relating to this, the mathematics experts believed that support at home was essential for overcoming difficult aspects of numeracy, allowing the child to continue learning without suffering negative consequences of being unable to complete or understand their work (Vukovic et al., 2013). This aspect contributes to maintaining a positive relationship with the teacher, as the child will not fear punishment for incomplete or incorrect work. Further to this, the experts discovered through
their experience that it is often fathers who are facilitating numeracy learning at home, reflecting the focus group findings of Petronzi et al (2012).

They’ve had a lot of support from home and input, and so if there are any areas of weaknesses, they’ve probably had a lot to do with that (ME1: 14:756-758).

It’s very rarely mummy, but more often daddy (ME1: 7:354-355).

Mathematics experts discussed the positive influences of parents in numeracy learning, and how their own parents support and reinforcement gave them a sense of ability in the subject. Generally speaking, mathematics experts considered parents as being able to facilitate numeracy learning, if comfortable with their own ability. The help they provide can assist a child in overcoming areas of weakness, without experiencing negative consequences.

3.6.9 Comparison/Competition

Mathematics experts discussed children as comparing themselves against others in numeracy lessons, and this would regulate how they perceived their own performance. Initially speaking of their own experiences, one stated that they acknowledged their own ability at school was not the standard to beat, but felt comfortable with numeracy nonetheless. This perhaps demonstrates that a child does not need to be outperforming a majority of the class to feel secure with numeracy, and indicates that other factors simultaneously influence numeracy attitudes, such as parents, friends and teachers. Mathematics experts were also aware of the aspects of numeracy they considered more difficult at school, but were still comfortable with their own ability, even though they acknowledged that other children may be better.

I never felt that I was the best at maths, I always felt that there were people around that were better than me at it, but I did feel secure I think with it in a way that I didn’t about other subjects (ME2: 3:141-144).

My mental maths, even though I’m relatively slow, I still knew the answers; it just took me a few more seconds to get the answer (ME1: 5:254-257).

Based on experiences, discussions revealed that when comparing ability, the children who have difficulty with numeracy begin to develop a negative self-perception (Erdogan et al., 2011) as they realise that other children are more secure with learning and doing numeracy. These children were
discussed as associating a negative self-image with numeracy that adversely affects participation and performance.

*I think it’s the recognition as well that there are other people around who seem to be developing more quickly, and that might create an image of yourself in relation to the subject that is not very positive* (ME2: 9:485-488).

It also emerged that children who are secure with their numeracy ability may negatively perceive children who have difficulties, with one mathematics expert considering them to be patronizing. If the children who struggle with numeracy are aware of how they are negatively perceived by the more secure children, this is likely to further affect how they perceive themselves and their ability to complete the work.

*You get to year six and you’ve got a classroom set and there’s still one group of children that need resources to help their understanding. Whether the higher ability children look back and think ahhh, they need those. There is a little bit of that that creeps in, patronizing* (ME1: 10:535-541).

Through their experiences, mathematics experts had also become aware of gender differences in numeracy. These specifically related to making mistakes and how males were more likely to positively work towards overcoming their deficits in knowledge (Devine et al., 2012). Females were described as recoiling after making mistakes and having a negative perception of themselves, which may be exacerbated by males appearing to be unaffected by errors. Similarly, males were identified as thriving on the competition to complete numeracy work before anyone else, which may further affect the confidence of some females.

*If the girls don’t get it right, they do recoil, they do step back and don’t feel very good about themselves* (ME1: 7:381-8:386).

*Girls tend to be a lot more negative if they get things wrong; boys can just say, oh I got it wrong, so what, I’ll get it right next time* (ME1: 15:773-775).

*It’s about speed and the boys are a lot more competitive, they want to be the first one to answer* (ME1: 7:381).

Mathematics experts discussed maintaining a positive attitude towards numeracy, despite being aware that other children in their class were of a higher ability. This demonstrates mathematics self-efficacy and an optimistic explanatory style, shown to positively influence mathematical achievement (Yates, 2002). This phase of the discussion reflected the findings of Petronzi et al
(2012) as children were identified as comparing their numeracy ability against others. A negative outcome of this comparison resulted in a negative self-image, which can also further impact upon performance. Mathematics experts also discussed how children who are secure with their numeracy ability can appear to patronize children who struggle and require additional support. Again, if these children are aware of how others perceive them, their participation and performance may be further adversely affected. A gender difference was also discussed, with males being observed by the mathematics experts as more likely to accept and overcome errors and as also enjoying the competition to be the first to finish numeracy work.

3.6.10 Fear/Anxiety:

Mathematics experts discussed failure as a main component of the fear associated with numeracy. In some cases, they considered that children are unsure of what method to use and are fearful to write it down, with their uncertainty being further compounded by time restrictions (Wong & Evans, 2007). In other instances, in order for some children to hide their failings, mathematics experts had observed them sitting back in lessons and not attempting the work. In this case, the children have adopted the belief that the numeracy work is beyond their ability and choosing not to work is more self-preserving than to be stigmatised as failing (Chinn, 2012).

Because they can’t answer a question at the right time, quickly enough, they might not know the method and they might be scared at showing the method because they don’t know whether that’s correct (ME1: 12:611-614).

They don’t want to look like they’re failing and so they’d rather not do anything and sit back, and so their processes aren’t even being tackled because they just say to themselves, no I can’t do this (ME1: 12:617-620).

A fear of failure in numeracy was also attributed to the right or wrong nature of the subject (Chinn, 2012). If experience has taught children to be fearful of wrong answers, they are consequently less likely to attempt their numeracy work and disengage with the subject. As previously mentioned in comparison / competition, girls were observed by mathematics experts as particularly susceptible to experiencing a negative self-image if they provided incorrect answers.

I think people’s perception is that it is either right or wrong and there is a fear attached to not getting it right (ME2: 5:255-258).
Girls tend to be a lot more negative if they get things wrong; boys can just say, oh I got it wrong, so what, I’ll get it right next time (ME1: 15:773-775).

Speaking of their own experiences, a mathematics expert stated that their own fear in numeracy at school was induced during test situations, although they were generally very confident with the subject. This serves to demonstrate that children who are generally fearful of numeracy are further disadvantaged by their anxieties in test situations.

Anxieties would always come along in test situations, I think with the fear that you weren’t going to do very well in a test, and I think that’s there even if you do feel confident (ME2: 5:255-258).

Discussions revealed that mathematics experts considered failure in numeracy to be associated with fear. Their experiences had shown that some children considered their work to be wrong and feared showing their method, which could otherwise provide useful insight into their problem solving thought process. Their reluctance was reinforced by time restrictions that may cause an overwhelming situation for these children. Other children were discussed as not attempting work, presumably to avoid being stigmatised as failing, whilst others are assumed to fear the right or wrong nature of numeracy. To outline the fear experienced in test situations by children who are less secure with their numeracy knowledge, a mathematics expert revealed their own anxieties in test conditions, despite a general confidence in the subject at school.

3.6.11 Avoidance

Mathematics experts discussed in detail the numeracy avoidance behaviours that children have displayed. An initial point was that those who enjoy the subject are eager to make the teacher aware of this (Petronzi et al., 2012), whereas those that are not secure with their numeracy ability will attempt to hide their work from the teacher. If their work was incorrect, a mathematics expert stated that children would cry, and relates to the aforementioned theme of fear and failure.

I think the signs are that those who love maths will make you very aware of that. The ones that don’t just sit quietly with their heads down, they don’t put their hands up as often, they will put their hands over their work when you’re coming round to mark it in case they got it wrong...they do cry (ME1: 9:471-476).
This comment demonstrates that children, who want to avoid numeracy, have already developed a performance anxiety about the subject and have disengaged. Anxiety about working with numbers has been shown to disrupt working memory capacity in children, affecting cognition (Ashcraft & Krause, 2007). However, in relation to mathematics experts previously discussing that some children will not attempt work, others seemingly do, despite their difficulties, and risk the stigma of failure. Relating to children not attempting work, a mathematics expert directly stated that they had observed children whose difficulties in numeracy had developed to such an extent, that they refused to engage with the work. This relates to Baptist et al (2007) who considered early intervention for children early in education before mathematics anxiety becomes a rigid educational obstruction. Mathematics expert discussions have demonstrated that this is apparent in numeracy education, which they consider difficult to alleviate.

\[ I \text{ certainly saw evidence of children who'd already got to a stage where they were not prepared or they were reluctant to become engaged with problems to solve. There was a sense that they felt that they couldn’t do it and therefore, weren’t prepared to engage with it (ME2: 6:310-314).} \]

Mathematics experts also discussed extreme behaviours revealed by parents, that children would display at home to avoid doing numeracy work, such as tantrums, although these behaviours were not evident in the classroom. However, they revealed that some children would ask to go to the toilet when given numeracy work and others would simply begin to display negative behaviours and become disruptive as a form of avoidance. As children are avoiding work, the gap in concept knowledge and performance between them and other children widens, further reinforcing a negative attitude towards numeracy, e.g. (Chinn, 2012).

\[ Some \text{ of the parents have come in and said as soon as he gets some numeracy, it will be tantrums; I don’t see that in the classroom at all, but they put their hands up and ask to go to the toilet to avoid having to do the work and start messing around a little bit more (ME1: 11:558-563).} \]

For young children struggling to engage with numeracy or certain aspects, additional resources were made available to assist their understanding and involvement. However, mathematics experts stated that if the child has already disengaged from learning numeracy, they use the resources as a distraction and play with them instead.

\[ If \text{ with young children tactile resources have been made available to help them engage with a problem, to help them make sense of a problem and develop solutions,} \]
they often go off task and see the resource as something to play with (ME2: 7:346-350).

Children avoiding numeracy work was a main aspect of discussions with the mathematics experts. They initially noted that children secure with their own ability would make teachers aware of this, whereas those not secure with numeracy would keep their heads down and often hide work from the teacher. This is likely to avoid the negative consequences of failure that children responded to with crying. It had also been observed that come children’s disengagement with the subject had developed to the point that they would refuse to even attempt work, placing them at further risk of falling behind others. Parents had also revealed to the mathematics experts that children responded with tantrums to numeracy work at home, whilst in the classroom, they ask to go to the toilet or display disruptive behaviours to avoid numeracy work. Finally, children requiring additional support through the use of tactile resources saw this as an opportunity to play rather than engaging with their numeracy work. Children avoiding numeracy work are at risk of decreased performance and further becoming disengaged from their learning, referred to as a vicious cycle by Krinzinger et al (2009). However, cause or effect of avoidance and performance cannot be assumed.

3.6.12 Awareness of a hierarchy

Another main aspect of discussions focussed on children’s awareness of a hierarchy in numeracy. It was considered that anxiety may begin to develop after children have become aware of how they have been labelled in the classroom and in the same way, those initially secure in numeracy may begin to excel once they have been labelled as higher ability. It may be argued that children are not aware of the hierarchy in numeracy that is determined by ability groups, although a mathematics expert stated their certainty that children are aware of this.

*We try to do it so they don’t realise which ability group they’re in, but all children are aware, I promise you, and all the parents are aware, and I suppose that’s where it starts (ME1: 10: 526-528).*

The negative aspect of children becoming aware of an ability hierarchy in numeracy was discussed by considering that children in lower ability groups will socialise with other children in their class outside of school, and may be ridiculed. This may have a consequential effect on their self-esteem and they may further struggle with their numeracy work. A mathematics expert considered that
children develop a sense of each other’s ability during the early education years and are aware of a numeracy ability order by the age of seven.

It might be that when they go home, the children that they play with know they’re not in the higher ability set and might get teased about it (ME1: 12:628-630).

I think there is a journey children go on and by the time they’re seven, I think they become much more conscious of their own abilities within mathematics. I think by the time they’re age seven, children develop a pecking order (ME2: 6:276-283).

Mathematics experts also discussed how hierarchies in numeracy can be interpreted as defining an individual’s intelligence and believe that mathematics is generally perceived as for more academic individuals, although they do not agree with this. However, if children are aware of a hierarchy from an early age and realise that they are of lower ability, they may further develop the belief that they are not intelligent, which can decrease their motivation (Chinn, 2012).

I think there’s also a hierarchy within subjects often and I don’t agree with this, but mathematics is often seen as a subject that it more academic, that is high value and that is a subject for people who are bright (ME2: 9:488-10:491).

Relating to this, they consider that ability setting in numeracy, and not in other subjects, contributes to the perception that numeracy is exclusively measuring academic ability and intelligence.

In primary school they set as well, and again, that reinforces the idea of hierarchy and in primary schools, they would be set for maths but they won’t be set for history or geography, so again, that reinforces the point about this is more important as a subject (ME2: 12:604-608).

In some cases, children’s awareness of a hierarchy of ability could work in their favour, as mathematics experts had observed some children copying the work of those who were more secure with their numeracy ability. This reflects Petronzi et al (2012) who found that some children would use the more able children as a coping strategy for completing numeracy work. It was also noted that these children simply required an answer, so as not to present incomplete work. However, and as alluded to by the mathematics experts, if children who are not secure with their numeracy are copying work from more able children, teachers can often miss that they are having difficulties with the subject.
I think that there were some who were picking others out in the class as being the people who were good at doing those kinds of things and would tend to rely on those (ME2: 6:314-317).

Copying definitely goes on and so sometimes you get those invisibles that you think they’re doing fine and then when you get their mark, when you start looking at their work, you realise that they haven’t achieved (ME1: 11:577-580).

Children’s awareness of a hierarchy in numeracy was discussed as potentially leading to the development of anxiety, as they consider themselves to be of less intelligence than other children. However, although it could be argued that children in the early years of education are oblivious to where they have been grouped in terms of ability, a mathematics expert was certain that children and their parents know. For those children placed in lower ability groups, mathematics experts discussed how they may be ridiculed by other children, potentially causing a negative self-image. This notion seems supported by a mathematics expert discussing that children in the early years of education begin to understand their abilities and develop a “pecking order”. A hierarchy in numeracy was discussed as being important to children, as this is the basis of group setting that reinforces general perceptions of the subject as defining intelligence. Although negative aspects of a numeracy hierarchy were discussed, for children who are not secure with their ability, it is a system that helps them to determine who is most able in numeracy and then copy their work to provide complete work to the teacher.

3.6.13 Mathematics expert thematic maps: Figure 3.2

Representation of the discussion findings are detailed by the visual information of the mathematics expert thematic maps (figure 3.2). Each of the main themes discussed were initially extracted by the author who considered these as important, and were then supported by their frequency throughout the discussions. However, despite being inter-related to certain extents, an overarching title could not be provided to encapsulate the main themes identified by mathematic experts, as they implicated a variety of factors associated with how children experience numeracy. Identified themes were either discussed as positive or negative aspects in children’s numeracy experiences. These were therefore clustered under the titles of negative factors and positive factors, leading to two separate thematic maps, representing the thoughts and experiences of mathematics experts. Some themes raised by the mathematics experts were reflected in both a positive and negative light,
for example, parents and the influence of teachers. Thus, these were included as separate themes in their own right, within the corresponding thematic map.

The discussed main themes reflect the numeracy behaviours of children that mathematics experts have experienced and observed. Additionally, some of the themes reflect, though to a much lesser extent, mathematic expert’s numeracy experiences as a child and what they have observed in older students and teachers at the beginning of their careers. Their experiences as a child were included in the frequency of each theme, as they provided insight into the foundations of their current attitudes and career paths, and also to determine whether aspects of their own experiences are still observable in numeracy lessons today. Their current attitudes also influenced the numeracy experiences of children they have taught. Reference to older students was also included in the frequency of some themes, as they were discussed as having developed negative attitudes in their primary school years, which they had been unable to alleviate. Teachers in the early stages of their careers were further included in theme frequency, as they were discussed as underestimating the importance of understanding basic concepts, that directly affects the numeracy learning and experiences of children in early education.

As shown in figure 3.2, three discussed themes completed the cluster for positive factors, whilst ten themes completed the negative factors cluster. The formed themes of fear/anxiety and avoidance may have emerged due to the questions that primed this aspect of discussions, although all questions were open ended, and the sub categories that emerged within these themes, as shown in figure 3.2, were entirely driven by the mathematics experts. The additional themes that contributed to the negative factors cluster being more substantial than positive factors, emerged entirely from the thoughts and experiences of mathematics experts.

All three themes within the positive factors cluster were not exclusively positive, as they were also discussed in a negative light and are represented in the negative factors cluster. Each theme within the positive and negative factors clusters are presented to show that, whether to a more or lesser extent, discussions revealed them to be inter-related. However, it was indicated that avoidance was a consequence of fear in numeracy, and this is represented as a sub theme. Similarly, coping strategies were integrated into the theme of awareness of a hierarchy, as although discussed and considered important, the frequency was not enough to enable it to emerge as a theme in its own right.
3.7 Parents

3.7.1 Influence of primary adults - parents

Parents identified themselves as being influential in how young children experience numeracy. Parental involvement refers to motivational attitudes and behaviours that influence children’s well-being, and Christenson (2004) outlined this as a multidimensional and bidirectional construct. Dowker et al (2012) discuss how parents are conveyed as having a strong influence on their children’s educational attitudes, and suggest the importance of intergenerational transmission of mathematics attitudes. However, prior to discussing in detail the factors the parents in the current research related to their positive and/or negative influences on their children’s experiences and attitudes, some offered insight into their own relationship with the subject. One parent revealed that they were a primary school teacher and also married a mathematics teacher. They further stated that their career path demonstrated that their current feelings towards numeracy/mathematics were positive, although conceded that it was likely the result of understanding the contemporary teachings of the subject. This point will be expanded upon as the discussion turns towards parental concerns in their numeracy influences on their children.

I’m a primary school teacher and I’m married to a head in maths in a secondary school, so I guess I’ve got very positive feelings towards numeracy, but that’s probably just because I know how they’re doing it now (P1: 1:5-8).

Supporting a point raised with the mathematics experts, the same parent acknowledged that at the primary school level, it was important to understand all the basic concepts, although some early career teachers were discussed as underestimating this.

In primary school, you have to be able to teach everything anyway, and have the basic understanding (P1: 1:30-32).

Another parent who stated that they too had positive numeracy experiences in primary school, which influenced their career path towards banking, also considered that their early positive experiences in the subject set a positive trajectory through the remainder of their education. If their early experiences had been negative, they believed this would have had a negative effect on the remainder of their education (Witt, 2012).
I suppose yes, because they stayed positive. Had it gone the other way and been negative, then that perhaps would have had a knock on effect. For example, if I relate it to history, I had a few bad experiences and I only appreciate it now as an adult (P4: 3:76-82).

It was stated that some parents did not necessarily care about performance in numeracy and would therefore not encourage their child’s development in the subject. On the other hand, they considered that other parents would encourage their children to do numeracy, although this was also discussed as potentially placing pressure on the child (Krinzinger et al., 2009). An interesting point raised by the same parent, was the issue of higher ability children in a household where educational achievement was not given significant value (Fraser & Honeyford, 2000). In this case, it is likely that children will not perform to their true level in numeracy and may disengage from the subject if a negative attitude towards learning is transferred to them (Rossnan, 2006; Gunderson et al., 2012).

You’ve got your parents that don’t care and then you’ve got the other ones who want them all the time, and then you’ve got your parental pressures. The ones that can’t do their homework and ask mummy and daddy for help, they say, don’t worry about it (P5: 11:419-426).

This initial part of parent discussions demonstrated that early numeracy experiences are influential in the attitudes an individual will have towards the subject during the remainder of their education, supporting the views of mathematics experts. Further reinforcing previous comments by mathematics experts, a parent who is a primary school teacher, stated the importance of understanding the basic concepts. This is perhaps an attitude they had formed through their positive numeracy/mathematics experiences. In relation to being a parent, their position as a teacher and their understanding of contemporary numeracy concepts, placed their own children in an advantageous situation, as will be discussed in detail in the following section. Finally, as also discussed by mathematics experts, a parent considered the varying types of parental attitudes, including those who may not value numeracy and those that do, but place too much pressure on the child to a detrimental level.

3.7.2 Facilitate learning

This phase of the discussion included a number of aspects that gave parents an impression of being able to facilitate their own child’s learning in numeracy. Parents first discussed how their own parents had encouraged their numeracy learning as a child, and how this had been influential. A
parent stated that they were “lucky” to have a mother who was reasonably good at mathematics, reinforcing the concept of parents being a main influential factor in the development of children’s attitudes towards numeracy. Another parent recalled being introduced to the concept of money at an early age, due to their mother working in banks, which encouraged their numeracy learning through understanding how to budget. Similarly, another parent remembered watching their mother using workings out to manage money. Again, this reinforces the suggestion of parental careers influencing a child’s learning and also positive modelling of numeracy for practical reasons, i.e. money.

\[ I \text{ was quite lucky because my mum’s reasonably good at maths (P3: 4:149-151).} \]
\[ I \text{ have a few memories of family that worked in banks, my mum worked there and she was my biggest influence, in thinking about money from an early age and my maths came from there I suppose, that’s where it started (P4: 1:21-26).} \]

Based on positive numeracy experiences, a parent stated that they understood the value of good comprehension in the subject and were now passing on those values to their own child, as it is an important skill to have. Similarly, another parent recalled being very good at mental arithmetic, but was unable to show workings out when required by the teacher, and stated that their child also does the same. This demonstrates how certain numeracy abilities and behaviours can be transferred from parent to child, highlighting the importance of their influence.

\[ \text{Now knowing how important it is, I want to encourage my boy to enjoy it because it’s a great skill (P4: 2:35-37).} \]
\[ \text{I was good at doing it in my head and I’d write down the answer and then I’d miss out on all these workings out, and my boy seems to have the same tendency (P3: 2:41-43).} \]

The same parent explicitly alluded to the importance of parents facilitating children’s numeracy learning, and considered that without their help, the child is unlikely to achieve in the subject.

\[ \text{Learning is a lot to do with school, unless you’ve got parents doing things at home as well, you’re never going to get there are you? (P3: 6:208-209).} \]

This part of the discussion gave parents the opportunity to initially recall how their own parents influenced their numeracy learning. Some spoke of being exposed to money management from an early age, due to their parents professions in banking, and they stated that early development of this practical skill contributed to their appreciation of numeracy. Now as parents, they discussed
aspiring to teach their own children the importance of learning numeracy, which demonstrates that the attitudes parents have, can be transferred to their children. Additionally, a parent stated that methods they used at school were now being replicated by their child, further showing the influence of parental involvement in a child’s numeracy learning. This same parent went on to explicitly state that if a child’s parents are not facilitating their numeracy learning, then the child is disadvantaged, reflecting the findings of Petronzi et al (2012) and a discussion point raised by mathematics experts.

3.7.3 Areas of concern

Although parents acknowledged the positive influence that they could have on their own children’s numeracy learning, they also expressed a number of aspects about the subject that caused them concern. A main concern discussed by one parent in particular, was that they do not have an understanding of contemporary numeracy methods that their child is taught in school. This parent revealed feeling unable to help their child when they asked for help, which could lead their child to become frustrated and even angry. This parent further discussed attempting to explain contemporary methods to their child, despite having no knowledge of them at all, and eventually conceded that in order to give their child a sense of achievement; they reverted to their outdated method.

*My issue is the fact that there are two different maths and my boy, when he says, dad help me with my homework, I say I can’t because I don’t do it that way (P3: 1:31-33).*

*He gets frustrated that he can’t do it and he knows that if I could help him properly, we could probably do it (P3: 9:332-333).*

*I’ve never heard of a number line in all my life and I’m trying to explain to my son what a number line is having never seen one...in the end, I just have to tell him my way which I know is wrong, but it sort of gets him there (P3: 7:266-270 + P3: 9:337-340).*

This parent ended their contribution by stating that they would find it useful if the school provided information on how they would like children to be taught numeracy concepts and the methods they were currently using. This would provide consistency in a child’s numeracy learning and would also give greater confidence to parents, contributing to a positive attitude that can transfer to their children.
I think if parents are anxious, then it passes on to the children...you only need to say I hated maths at school once and a child will remember that won’t they, and take it and use it (P1: 8:279 + P1: 8:283-284).

Similarly, another issue raised by parents was that they felt as though their child’s school did not provide enough information or feedback on their numeracy progress. Parents discussed being kept up to date with their child’s reading and literacy, as they took a book home each day, although this was not the case in numeracy and information was only available at parents evening.

I know my daughter comes home with reading, but her maths, I don’t know anything about her maths...you don’t know how they’re doing until you get to parents evening (P1: 6:190-193 + 8:265-267).

If you’re a parent, you can’t come in and say, what are they doing in maths, and unless things get sent home, you don’t know what they’re doing (P2: 9:308-314).

Thus, if a child is struggling with numeracy at school, parents are likely to be unaware and unable to facilitate encourage and facilitate their learning at home with aspects they may be struggling with. However, relating to the previous point, even if informed that their child is struggling, parents may still face difficulties helping their progress if they too do not understand numeracy methods, demonstrating how factors can be inter-related. A parent revealed that they took the initiative to go their child’s teacher to ask for guidance on contemporary numeracy methods, although not all parents would do this, particularly if some do not place a high value on learning numeracy.

I went and said to the teacher, I don’t know how she does her maths, so she gave me a book and now, I know how to do their maths (P2: 7:228-231).

Indeed, without an understanding of the concepts, parents begin to feel as though their children have a greater understanding of numeracy concepts, which can perhaps be intimidating for them, particularly when their child requires help.

He knows things I don’t, he’s learning a lot better than I am and I never went that far in numeracy (P2: 2:71-72).

A further issue raised was parent work schedules and the impact this may have on children’s numeracy experiences at home. Specifically, it was discussed that if parents finish work late in the evening, they will simply not have the time to help their child with any numeracy homework they may have, which will not help their child’s progress. Additionally, if parents are feeling stressed from their working day, this will lead to a negative numeracy session for the child. Again, this
could contribute to a child developing a negative attitude towards numeracy, and in particular, feel as though they are unable to seek guidance.

Some parents who are working and not getting home until half six, they haven’t got the time to sit down and do homework...if they are stressed out and fed up, it’s not going to be a positive session is it (P3: 7:243-245 + 8: 285-287).

Specifically relating to transference of anxiety, a parent revealed that prior to attending the discussion group; she informed other parents of her participation who responded by stating their dislike for the subject, an attitude this parent felt could be passed on to children.

Some parents, after I told them I was coming to talk to you were saying, oh God, I hated maths, and their kids are going to think like that because they think like that (P2: 10:350-352).

During this phase of discussion, parents outlined a number of aspects of numeracy that personally caused them concern and talked about other issues that they were aware of generally. A parent revealed that they did not understand contemporary methods that are taught in numeracy and extensively discussed situations they had encountered with their own child, in which being unable to help them had caused frustration. In order to give their child a sense of achievement, they admitted to reverting to their own outdated methods, despite knowing it was wrong. Acknowledging that this was not ideal, they stated that parents would be better able to help their children if schools provided information on the current methods used. This would likely provide parents with greater confidence to facilitate their child’s learning in numeracy. Relating to this point, parents discussed a lack of information from schools regarding their child’s numeracy progress as a problem, as they were unaware of their ability and aspects of numeracy that they may require additional help with. Speaking generally, parents discussed work schedules as interfering with how children may experience numeracy at home, stating that if parents return home stressed and tired and need to help their child with numeracy work, the session would likely be negative. This may contribute to a child developing a negative attitude towards numeracy and fear seeking help. Specifically relating to transference, a parent held the belief that if parents speak negatively about their own numeracy experiences in the presence of their own children, then they are likely to adopt that same attitude.
3.7.4 Teachers

In the discussion of the influence of primary adults, the role of teachers was also implicated. Before discussing their influence in detail, some parents revealed their general feelings about their own primary school teachers. These were polarised as they were either very positive or very negative. A parent stated that at school, they had a general negative perception of mathematics teachers, whilst others discussed their teachers as contributing to a positive numeracy experience.

*Maths teachers were awful* (P2: 3:114)

*My recollection at primary school for maths was very positive, I had good teachers who made it interesting* (P3: 2:57-58).

Due to the divergence in how parents felt about teachers, this phase of the discussion naturally separated into positive and negative aspects of their influence.

3.7.5 Positive Aspects

Some parents discussed teachers as providing them with motivation in numeracy and helping them to overcome anxieties. A parent spoke of their early year’s experiences of numeracy and the importance of having a teacher that was approachable and who did not make them feel embarrassed for being unable to do work (Hadley & Dorward, 2011). They explained that this teacher could also explain numeracy concepts in a caring manner that provided a relaxed learning environment. This relates to the discussions with mathematics experts, who themselves aspired to create a happy and relaxed learning environment in numeracy, allowing children to feel comfortable to attempt work and learn from mistakes.

*In the earlier years, because he was approachable, then you didn’t feel embarrassed to put your hand up because you didn’t know the answer to a question, he’d explain it to me and it was that care and that being able to bring a laugh and a joke into it, it made it a little bit less serious* (P4: 2:48-54).

This same parent discussed the importance of being able to relate to their mathematics teachers in secondary school in terms of age, and this again allowed the learning environment to be relaxed, which further encouraged their learning. Again, this demonstrates the influence teachers can have
on a child’s learning by being accessible and the importance of teachers and pupils developing a positive working relationship.

At senior school, my numeracy teacher, because he was younger, he could relate to us, so because he could relate to us, he could bring fun into the lessons, and that encourages us (P4: 2: 39-42).

Another parent revealed that they were encountering difficulties with numeracy at an early age, although were fortunate to have a teacher that assisted them in overcoming their problems with the subject. They added that learning numeracy can be enjoyable if it is taught in such a way. Again, this places emphasis on teaching approaches and that some children may attain higher achievement in numeracy if it is made exciting and accessible, with encouragement and support.

I had to turn it around and luckily, I had a teacher that did it for me, I don’t think I would have done otherwise...it should be fun if taught in the right way (P1: 2:40-44 + P1: 8:261).

Parents discussed the positive influences of teachers who taught numeracy in a caring and relaxed manner. This was exemplified by one parent who described that in the early years of their numeracy education, their teacher was supportive, even when children were struggling with work. This encouraged them to seek guidance without a sense of shame. Additionally, being able to relate to teachers was discussed as influencing learning in the subject as this contributed to a positive teacher-pupil relationship, that was conducive to numeracy learning. Finally, a parent stated that for a time, they experienced difficulty with the numeracy, although they overcame this with support from a teacher. The attitudes and approaches of teachers were discussed as being highly influential and in this case, as supporting and encouraging learning. However, for some children, as found by Petronzi et al (2012), teachers are held in a negative light and as contributing to anxiety in numeracy learning.

3.7.6 Negative aspects

Although parents spoke of the positive influences of teachers, they also discussed aspects they considered as contributing to the development of negative attitudes in numeracy and children becoming disengaged from learning. Relating to a discussion point raised in Positive Aspects (2.7.5) a parent specifically outlined the significance of teachers and pupils forming a positive relationship (Mata et al., 2012). As their partner was a mathematics teacher, they discussed being
aware of parents who have sought private tuition for their child, due to their child not getting on with their class teacher. They add that in most cases, the child had good ability in the subject, but their learning was being affected by a negative relationship with the teacher. Similarly, a parent considered that if a child encountered a “bad” teacher in numeracy, they could become disengaged from the subject and possibly disruptive.

A huge amount of maths comes down to the teacher. My husband is a secondary school teacher but he does home tuition as well and there is a big number of people who phone and say, can you come and help my child, they don’t get on with the maths teacher. He goes and says that their ability is absolutely fine, it’s just they have this block on this relationship and it affects everything (P1: 2:62-69).

I feel that if you’ve got a bad teacher, it can disrupt you very quickly, and the reason you become disruptive is because you’re brain turns off and the teacher is not holding your interest (P3: 6:190-192).

Parents further implicated teaching methods as contributing to some of their own difficulties when learning numeracy. A parent stated that teaching methods and lesson structures contribute to a child’s trajectory through the subject, with another discussing their negative experience with certain types of teaching techniques in numeracy. If children struggle with certain methods, they may become dependent on friends who act as coping strategies, as also discussed previously by mathematics experts and Petronzi et al (2012).

I think it’s definitely the way you’re taught and the structure that you’re given and it sets you on the right path or not (P1: 2:56-58).

Mazzocco et al (2012) suggest that parents and teachers should provide children with feedback about the values of numerical and mathematical tasks that they are attempting, to help them form positive and accurate perceptions of their abilities and to value learning. Relating to teaching techniques, and in line with points raised by mathematics experts, a parent revealed that although they learnt to complete procedures such as percentages and probability, they never understood the logic. Again, if children are learning procedurally (Greenwood, 1984; Skemp, 1986) they may not necessarily appreciate the subject and its application to life, and this may lead some children to disengage and potentially transfer negative attitudes when they become parents. Teachers using basic methods in numeracy are considered to have a degree of mathematics anxiety (Aslan et al., 2013).
I can work out a percentage, I can work out a probability, but the logic behind it isn’t clear, I just learnt how to do it, I don’t really understand (P2: 1:32-35).

However, Lazarides and Ittel (2012) argue that consideration should be given to the individual differences of perceptions of instructional quality, as some children may consider teaching methods as appropriate for their needs. Parents discussed situations where they had struggled to complete numeracy work, and were not given help by the teacher. One parent then discussed that their inability to do their numeracy work eventually led them to fearing help, as they felt they would be punished by their teacher, which was again discussed in detail by Petronzi et al (2012) and also by mathematics experts.

I just sat there and if I didn’t figure it in my own head, in my own way from watching it at the beginning, I wasn’t getting anywhere (P3: 4:139-140).

I remember sitting there and getting upset; you think you don’t know how to do this and I can’t tell them because they’re going to get annoyed with me because we’ve gone through it and through it and I still don’t get it (P3: 3:85-87).

Parents discussed how teachers can have a negative influence on how children can experience numeracy, reflecting on their own experiences as a reference. Based on experience, the main issue raised focussed on the relationship between teachers and children, and how a poor relationship can eventually have an adverse effect on their learning in numeracy, even if they have an intrinsic ability in the subject. A poor relationship was discussed as potentially leading the child to disengage from numeracy and become disruptive. Parents further implicated teaching methods as contributing towards a child’s engagement with numeracy, considering that if they struggle with certain methods, they may begin to fall behind and become dependent on their friends as a coping strategy. Similarly, a parent stated that they had learnt numeracy as a procedural method, but had not understood the logic because of this. Referring to comments raised by mathematics experts who stated that some teachers underestimate the importance of the basic concepts in numeracy, if children are not learning these, not only will they struggle, but also fail to appreciate the wider application of numeracy. Finally, a parent stated that due them not receiving help from the teacher when they found numeracy work difficult, they eventually feared asking for help when unable to complete numeracy work. This phase of the discussion has further demonstrated the pivotal role of teachers in how children experience numeracy and the attitudes that they develop.
3.7.7 Low sense of ability

This aspect of the discussion formed the basis of the second thematic map, consisting of additional factors that parents considered as influencing children’s numeracy experiences in early education. A low sense of ability became the main factor, with other factors emerging and being discussed as an associate of this. Like mathematics experts, parents considered the causes and effects of a child’s low sense of ability in numeracy. Awanta (2000) considered that mathematics anxiety combined with a perceived lack of ability can hinder learning and performance. A parent raised the issue of assessments, believing that when a child becomes aware that their ability is being measured and they are not achieving to the level they should, a sense of low ability can begin to develop (Wong & Evans, 2007).

As soon as they start being assessed and they realise that they are not hitting where they should be, because everyone wants to be top don’t they, that’s when you realise you’re not there (P3: 11:414-416).

Another parent reflected on their own situation in school, in which they were initially considered to be of lower ability by the teacher and thus placed in the appropriate numeracy group. However, despite subsequent achievement, the teacher failed to acknowledge this and the parent remained in the numeracy group they were initially placed in. This is a scenario that can still take place, with children first considered to have low ability in numeracy, remaining in the lower groups, despite progress. If a child has invested effort into improving in numeracy and this is unnoticed by the teacher, their motivation may decline.

I just accepted that. I wonder when teachers do that, there’s never any movement from there, they’ve decided they’re going to be there and when they don’t realise to move you if you’ve done any better (P3: 5:167-169).

Parents further reflected on their time in school, and some discussed developing their own low sense of ability in the subject, stating that this affected their schooling and they did not develop a level of confidence with numeracy until adulthood. This demonstrates that whether justified or not, a low sense of ability can lower achievement in numeracy. A parent also revealed that a form of punishment (having to stand on a chair in front of the class in a wrong answer was provided) reinforced some children’s low sense of ability, closely linking this belief to punishment in numeracy (Petronzi et al., 2012).

I knew I was never very good at it. That was that (P3: 1:26).
That affected me a lot in my schooling, thinking I wasn’t good enough. It was only in my adult years that I realised I could do it (P1: 9:297-300).

Finally, a parent discussed typical behaviour of children with a low sense of ability in numeracy, expecting them to withdraw from work or to present as not caring, also relating this belief to avoidance.

Perhaps they withdraw from their work, perhaps making a joke about it or perhaps doing things slowly (P4:5:153-154).

Assessment in numeracy was initially considered as contributing to the development of a low sense of ability, particularly when a child felt that they were under achieving in comparison to others. In addition, a scenario was discussed, in which children who are initially placed in lower numeracy groups may remain there indefinitely, even if they have invested effort into improving. This scenario reflected a similar experience of a parent in the discussion group, who also became resigned to the fact that they would be permanently in the lower group, regardless of their efforts. A further reflection on their own school experiences demonstrated that punishment in numeracy can reinforce a low sense of ability and subsequent withdrawal from the subject is closely related to avoidance.

3.7.8 Comparison/competition and an awareness of a hierarchy

Comparison and competition in numeracy was discussed in detail by parents who considered varying aspects of numeracy as reinforcing a competitive element. Parents first discussed the emphasis on speed and how this can often distract from the essential aspect of numeracy; to have knowledge of concepts and be able to problem solve. This is a valid point, as once time restraints are introduced; numeracy ability and performance may become secondary to evaluation anxiety that will reduce working memory resources. Evaluation anxiety is considered to be inherent to human beings and all emotions that encapsulate this, such as embarrassment and ridicule are experiences most attempt to avoid (Donaldson et al., 2002). Negative evaluation is considered to be dreaded from an early age (Beck, 1989) and this anxiety reflects the cognitive and behavioural responses induced when an individual is concerned about negative consequences of their evaluation (Donaldson et al., 2002). Expanding on this point, a parent spoke of times table awards that children work towards in school, although this gives rise to competition with peers and places emphasis on speed. Again, a parent considered that if a child has the knowledge but is naturally not
as quick as other children, this is acting as a punishment for something beyond their control. They deliberated that some children require longer for reading and processing information, whereas others have the ability to do this faster in comparison. This reflects the issue of mental arithmetic that mathematics experts and parents also encountered.

*The speed that children can do it, I think too much emphasis is put on that. They can work it out, they’ve got the knowledge and the skills to work it out, and then I don’t think speed is as important as it’s made out to be (P1: 4:127-128 + P1: 130-132).*

*It’s things like tables, math’s awards that they do and if you’re not quick but you’ve got the knowledge, then that’s not your fault and it might take some children longer to read the question and not everybody can look at a question and just know (P1: 4:133-139).*

As mathematics experts alluded to in the theme of an awareness of a hierarchy, parents also acknowledged that children begin to compare themselves against their peers and can often feel inadequate (Mutodi & Ngirande, 2014). Parents discussed that their children often talk to them about the abilities of other children and how others had received different work and achieved awards, considering that this may contribute to uncertain feelings in numeracy.

*I think they start to notice the abilities of other children…she knows she may have got something different to somebody else and I think that might be where it starts to creep in (P1: 8:286-290).*

*A lot of it is achievement, a lot of what I’ve gathered and what my daughter has said and that some get a smiley face and you’re bound to feel inadequate if you’re not (P1: 11:375-377).*

Similarly, one parent stated their own awareness that children’s daily performance in numeracy is displayed on a chart in the classroom, increasing a sense of competition and scope for negative evaluation from peers (Ashcraft et al., 2007). For children who are less secure in their numeracy, confidence and motivation will likely diminish if they are consistently displayed as being at the bottom of the chart, or never feature at the top. Further reflecting the views of mathematics experts, a parent stated that competition in numeracy could lead those who are secure in their ability to ridicule peers who are less secure.
It goes up on the board and at a glance; you can see who has done well that day (P1: 11:381-384).

Because they notice, kids are sharp aren’t they and they’re quite harsh with it (P3: 11:387).

Some parents went on to reveal that they too compared themselves with others in numeracy, particularly family members and considered that it is not only peers that children are competing with in numeracy.

I always lived in my sister’s shadow (P1: 9:303).

I knew I wasn’t as good as my sister or my dad (P2: 3:106).

Comparison and competition in numeracy directly related to an awareness of a hierarchy, as children who were less secure in their numeracy ability began to realise that some of their peers were more able in the subject. Parents discussed children being aware of why they are separated onto different tables and that no matter how the teacher attempts to disguise this, children acknowledge that there is a top group and children of higher ability. For some children, particularly those of medium ability, this may not be an issue. However, children in the lower ability groups may lose motivation and develop an anxiety about their performance in the subject.

I think they do realise they are separated into tables (P3: 5:163-165).

No matter how the teachers do it, the children always refer to them as the top group and they know, even though it’s not actually said, which is the brightest table and which ones need more help (P1: 8:291-296).

Mathematics experts alluded to the subject as being perceived as determining intellect and attributed this as a reason why people are anxious about working with numbers. Reinforcing this point, a parent stated that they believed numeracy was acting as a guide to intellect and this demonstrates how children may also develop this perception of the subject and may choose to withdraw if they consider it beyond their ability. Vukovic et al (2013) consider that as a performance orientated anxiety disorder; mathematics anxiety evokes a physiological response, negative cognitions and avoidance behaviours.

I think they use it as a guide to intellect, is my personal view (P3: 5:152-156).
Comparison and competition in numeracy were discussed by parents, who considered that an emphasis on speed was contributing towards a competitive edge in the subject and undermined the essential aspects of knowledge and problem solving. A focus on speed introduces evaluation anxiety, which like numeracy apprehension will reduce working memory resources. As discussed, children were also encouraged to compete for awards in numeracy, and those who needed more time to process information were indirectly being punished. Parents revealed that their own children acknowledge the abilities of their peers and are aware when different work has been set for different groups. They considered this as an origin of uncertainty in numeracy. Similarly, parents stated their awareness that children’s daily performance in numeracy was displayed on a board in the classroom, again reinforcing competition and comparison. Children who are less secure in their ability in numeracy and who do not feature at the top of this chart are at risk of ridicule, previously reinforced by mathematics experts and by a parent who stated that children can be “harsh”. Parents further considered that comparisons can be made to family members, as well as peers, with one revealing that they felt in the shadow of their sibling. Competition and comparison in numeracy appeared to be a key theme, reflecting the views of children aged 4-7 (Petronzi et al., 2012) and was related to an awareness of a hierarchy. Parents believed that children understand why they have been separated onto tables and know that children are of higher ability, regardless of how the teacher attempts to disguise this.

3.7.9 Stigma

Stigma was closely associated with an awareness of a hierarchy in numeracy, as children are likely to begin to feel the shame of being of lower ability in comparison to peers and requiring additional help. Parents acknowledged this and considered situations where children may feel stigmatised, such as asking for help with understanding a question in a test. A parent also revealed that their niece struggled with numeracy and was unable to seek help from the teacher due to shyness, which relates to stigma and a potential fear of the teachers reaction (Whyte & Anthony, 2012).

Having to put your hand up and ask the teacher to read something out for you in a test, you know it’s the stigma thing isn’t it (P1: 7:244-246).

My niece has just had her parents evening and she really struggles in maths and the maths teacher said she is so shy and she won’t say that she’s struggling (P1: 3:95-100).
A parent made a contribution that suggested the stigma associated with ridicule from peers may be a reason why some children will withdraw from numeracy, rather than continue to attempt work and fail. Continued efforts may be futile and the child is only serving to preserve their status of being of lower ability in numeracy, which, as discussed, is highly contested. This further reinforces a discussion point raised by mathematics experts, in which children may become disruptive to mask their difficulty in the subject.

“You can’t tell me that children want to be preserved as being, for want of a better term, thicker than their mates, because that’s the sort of term they’ll be using, you’re a thicky and it does have a stigma in it, it’s difficult for them (P3: 10:369-371).

The stigma associated with difficulty in numeracy was discussed by parents who considered how children struggle, perhaps due to shame, to seek guidance when encountering difficulties with their work. Children may also withdraw from numeracy to detach themselves from the stigma associated with a status of being of lower ability. Stigma has previously been discussed by mathematics experts and can further contribute to a negative attitude towards numeracy, particularly if a child is the subject of ridicule.

3.7.10 Difficulty

Relating to the difficulty of numeracy, parents recalled their own experiences and also shared behaviours they had noticed in their own children when numeracy had become challenging, as well as speaking in general terms. Mental arithmetic was discussed as a main source of difficulty in numeracy and was a view shared by a number of parents. This was also the view of mathematics experts, as aforementioned, and supports that mental arithmetic, particularly under a time constraint, is especially difficult (Wong & Evans, 2007).

I can do it quickly on paper but the mental arithmetic is what I struggle with the most (P4: 3:72-73).

I don’t have a great confidence in mental arithmetic (P2: 1:8-9).

Like the mathematics expert, a parent also stated that they could do numeracy work on paper, but struggled with mental arithmetic. If a child is successful with a method or believe that they are dependent on this, such as a pen and paper, then the removal of this method could induce anxiety, reducing working memory resources dedicated to the numeracy task. However, reflecting current research, some individuals’ neurons may naturally move in a less synchronised manner than others,
and thus be less effective and efficient when doing mental arithmetic, that is more challenging and complex (Krause, Marquez-Ruiz & Kadosh, 2013). If this is the case, individuals could benefit from appropriate training to improve the efficiency of neurons when working with numbers. Variations in working memory capacity should also be considered as this will influence the complexity of calculation strategies. Despite mental arithmetic being highlighted as a difficult aspect of numeracy, it did not deter effort in the subject, as parents and the mathematics expert who raised this point, already felt assured of their ability in the subject. This may suggest that in schools, children are able to use methods to assist their numeracy learning in most cases.

Parents also considered that fear and anxiety will develop if children are having difficulties in understanding numeracy work. They believed that if they persistently struggle to understand work, their experience of numeracy becomes more adverse as they cannot complete their work. This lack of understanding was also discussed as placing pressure on the children, which, as mentioned by mathematics experts, diminishes a child’s capability in solving numeracy problems. A parent also spoke of worded numeracy problems as causing problems for some children, particularly those who already have difficulty in reading. In this case, a deficit in literacy also becomes a deficit in numeracy, and can further cause anxiety. Vukovic et al (2013) state that children who can solve a whole number arithmetic question may be unable to solve a worded problem with the same digits, as they lack a conceptual understanding of the underlying mathematic concept.

_I think the biggest fear comes from not understanding, simple as that. It’s like with anything, and when you into that rut of not understanding something, it gets worse and worse and the higher you go up, the harder it seems (P2: 10:344-347)._

_When it’s a written problem that’s sort four or five lines long that can take a child with difficulty in reading a long time to comprehend what they’re asking (P1: 7:240-243)._ 

After speaking about the possible consequences on a child’s learning, a parent revealed that their child would display frustration and anger when numeracy became difficult, as well as going through phases of being quiet and crying. This parent believed that once a child is behind in their understanding of numeracy concepts, they begin to feel the stigma associated with this that can manifest as anxiety.

_He gets angry when he can’t do it...he also gets frustrated, and if he gets pressured in his frustration, he gets angry (P3: 9:329-330 + P3: 11:396-397)._
We could have crying or being quiet because you still don’t understand (P3: 11:398).

Reflecting the view of mathematics experts, parents also identified the right or wrong nature of numeracy as contributing towards its perceived difficulty. The required accuracy of working with numbers can ultimately lead a child to feel anxious about the subject, particularly if they have previous experience of producing incorrect work. This is particularly crucial for children in early education, as their success rate can contribute towards the attitude they develop towards numeracy.

Math is absolutely right or absolutely wrong. Even if it’s one out, it’s wrong. I definitely think that’s got a lot to do with it (P2: 10: 360-362).

When you’re learning the basics of it, it’s either right or wrong and there is no middle (P4: 6:203-204).

The difficulty of numeracy was discussed in a number of aspects by parents. Like mathematics experts, they implicated mental arithmetic as problematic. The removal of methods to work out problems or the expectation of encountering difficulty with mental arithmetic could cause anxiety, and reduce working memory resources dedicated to solving a problem. Parents also considered a deficit in concept understanding as leading to consistent failure to complete work and highlighted worded numeracy problems as being problematic for those with reading difficulties. Difficulty and pressure was exemplified by a parent who referenced their own child, revealing that they became frustrated and angry, and would sometimes go quiet or cry. They believed that once a child is behind, they begin to feel the stigma associated with this and can lead to a further decline in numeracy performance. Finally, the right or wrong nature of numeracy was associated with difficulty in the subject, due to the focus on precision.

3.7.11 Avoidance

Avoidance of numeracy was discussed by parents as they considered the responses of children. Parents revealed that children would refuse to do their numeracy work as a form of withdrawal and often avoid eye contact as they became disinterested. Parents also noticed that children would shut their book when struggling with numeracy work and would not ask for guidance and attempt to improve the situation. This was thought to relate to a lack of confidence in facing an issue and Bibby (2002) relates to shutting off as ‘mental absconding’.
My kids just shut off and refuse to do it, they roll their eyes and won’t look at you (P2: 10:368-369).

They just try and avoid it, they don’t come and say, mummy I’m worried about maths. They would just shut the book and not look for a way to get better at it (P2: 11:399-402).

Vukovic et al (2013) consider that when an individual is unable to escape or avoid the negative situation, there are deficits in performance. It was further discussed by parents, that children may avoid numeracy by completing their work as quickly as possible, with little regard for the quality and accuracy of their work. Parents also believed that some would joke about their difficulty or use tiredness and problems with their equipment as a distraction. Using humour to mask difficulty relates to parents previous comments about children wanting to avoid the stigma associated with failure. Additionally, a parent stated that their child claimed to feel sick when numeracy became difficult; a physiological response to anxiety.

He always tries to avoid doing his homework. He’ll do it quickly (P4: 4:134-135).

Perhaps they withdraw from their work, making a joke about it or perhaps doing things slowly (P4: 5:153-154).

As previously discussed, parents also felt that children would become disruptive in numeracy to disguise their difficulty with the work, attempting to create the visage that they have chosen not to engage. This method of avoidance can minimise the chances of ridicule from peers, who may not consider that they are unable to do the work. A parent raised an interesting point relating to children who are not appropriately challenged becoming disinterested as their underlying ability is not being nurtured. In this situation, a child with an initial ability in numeracy may withdraw or become disruptive as they are not working to their appropriate level.

They’ll be disruptive or they’ll disengage (P3: 12:428).

...or they’ll make some mischief (P4: 5:159).

Sometimes, it’ll be that this is too easy and so I’m just not going to bother (P4: 4:124-125).

The desire to avoid numeracy is a typical response of children who are encountering difficulty with the subject or who have feelings of apprehension towards it. Parents acknowledged this and considered a variety of response behaviours that children display. It was discussed that some may refuse to do work and close their books at the point of being unable to complete a numeracy
problem, becoming disinterested and showing no desire to overcome the issue and improve knowledge. This was linked to low confidence, as some children may already experience a stigma associated with a need for additional help. Consideration was also given to children completing work quickly as a form of avoidance, showing no regard for the quality of their work. Again, relating to stigma, parents believed that some children would dismiss their inability to do their numeracy work with humour, helping them to maintain a positive sense of themselves by avoiding the ridicule that some children may be exposed to by peers. A response of feeling sick was also revealed by a parent, whose child may have a developed anxiety about numeracy. Other parents considered that children may become disruptive in class when unable to complete their numeracy work, reflecting the views of mathematics experts. Finally, if a child is given work that is beneath their capability, some parents felt that this may lead them to disengage and avoid doing work as they are not being sufficiently challenged.

3.7.12 Failure in numeracy

Failure in numeracy was discussed by parents, who indicated causality in terms of children's confidence deteriorating due to unsuccessful results, leading them to give up. A parent also considered that some children may lose confidence in all other subjects as a consequence of failure in numeracy, affecting their overall academic achievement and, ultimately, career opportunities (Hadley & Dorward, 2011).

*If you keep getting it wrong, you’ll lose interest and lose your confidence; if you put your hand up and you’re getting the wrong answer, you’ll stop putting your hand up* (P3: 13:493-495).

*It’s a bit soul destroying isn’t it…I think it just destroys their confidence in everything, not just in numeracy* (P1: 10:373 + P3: 11:390-391).

A parent considered falling behind in the subject as a prerequisite to failure, as children who do not fully understand certain concepts cannot build on their knowledge and attempt more complex processes. This further relates to comparison / competition and stigma, as children who are less secure with their numeracy ability, will be aware of their deficit in comparison to children who are secure with numeracy work. This can lead to the development of negative attitudes and withdrawal. This was considered as an issue specifically relating to numeracy, due to the nature of concepts
building on the foundations of another. Parents felt that in other subjects, children would manage to find a way through difficulty.

*I think to miss something or not get something in maths can have such a knock on effect, compared to other subjects, you could probably muddle through it, but if you’ve missed a vital part in numeracy, you’re not going to get a lot of it (P3: 3:94-96).*

Parents also believed that some children vary in their response to failure in numeracy, referencing their own children’s behaviour. A parent stated that their child would initially demonstrate a negative reaction and walk away from the work, but soon return with a desire to complete the numeracy work. This reflects the views of mathematics experts, who through their primary school teaching experience, identified differences in how children managed failure, either withdrawing from the work, or demonstrating a determination to understand a concept and complete the work.

*I know my son likes to get things right, and if you say it’s not quite right, then he’s not happy and then he goes off for five minutes and then comes back (P4: 6:187-189).*

Failure in numeracy and its consequences was discussed by parents, who specifically indicated a causal relationship between failure, diminished confidence and giving up. Parents also considered that failure in numeracy may lead to low confidence that is transferred to other subjects, compromising a child’s general academic achievement and opportunities. Falling behind in the subject due to difficulties understanding concepts was further considered as a pre-requisite to failure, as children who struggle to comprehend certain concepts, will be unable to build on their knowledge. This was an issue attributed exclusively to numeracy, due to the progressive nature of the basic concepts. Parents further discussed variations in children’s responses to failure, and like mathematics experts, considered that some would show a determination to understand and complete work, whereas others would withdraw.

### 3.7.13 Parents thematic maps: Figure 3.3

Representation of the discussion findings are detailed by the visual information of the parents thematic maps (figure 3.3). As with the themes determined through mathematics expert discourse, conversations with parents led to the extraction of main themes, initially considered as important and subsequently justified by frequency. The main themes that emerged from the data could not be
represented in a single thematic map, as issues raised by parents indicated two central aspects that influenced children’s early numeracy experiences. Parent’s experiences as a child were also included in the frequency of some themes, as they provided insight into the foundations of their current attitudes, career paths and whether their child had developed similar attitudes or traits in learning numeracy. Two individual thematic maps were developed to represent the identified central aspects and the associated main themes.

A phase of the discussions focussed in detail on the influential role of parents and teachers on children’s numeracy experiences, and was encapsulated under the thematic map title of ‘the influence of primary adults’. This was sub-divided into parents and teachers, as parents focussed and reflected on the role they and teachers played in children’s numeracy experiences. Through discussions, it became apparent that parents considered themselves to be both a positive and negative influence on their children’s numeracy experiences in relation to certain aspects. Parents perceived their positive influence as facilitating numeracy learning, yet also expressed a concern of being unable to help their child in certain respects, for example, having limited to no understanding of contemporary numeracy methods. Similarly, aspects associated with the influence of teachers were divided into positive and negative aspects, although parents specifically detailed issues that they considered as contributing towards child negativity in numeracy and those that positively influenced their experiences. For both parents and teachers, the aspects associated with their negative influence on children’s numeracy experiences were more substantial than the positive. As with the mathematics experts, the author reiterates that the factors attributed to each theme emerged entirely from the thoughts and experiences of parents. Additionally, it may be perceived that a theme relating to the role of parents was an inevitable emergence. However, the factors that form the themes of Facilitate Learning and Negativity and Areas of Concern, arose independently through discussions.

As shown in figure 3.3, the second thematic map encapsulated a number of negative themes that were discussed by parents as relating to a child’s low sense of ability in numeracy. Thus, the thematic map was formed around a low sense of ability, as the themes that emerged through conversations were indicated to be associated with this perception by parents. However, the author is not suggesting that a low sense of ability has a causal relationship with the factors represented within this second thematic map. As awareness of a hierarchy was not discussed to a large extent, it was instead integrated into comparison/competition, as children were discussed as being aware of peers with good ability in numeracy and that divisions in the classroom were based on ability level.
3.8 Teachers

3.8.1 Influence of primary adults - parents

Discussions with groups of teachers revealed a number of factors that they believed, based on experience, to influence children’s early numeracy experiences and learning. The role of parents was considered by both groups, although predominantly in a negative light. Teachers reflected upon conversations they had during some parents evenings and revealed that when told that their child was struggling in numeracy, parents responded by stating that they often told their child that they were of low ability in numeracy. If children are told by their parents that they are incapable of doing numeracy work, many will withdraw and reduce their efforts (Gunderson et al., 2012).

We get parents who tell their children they can’t do maths and on parents evening, you might say, your child struggles more with maths and they’ll say, I know, he’s terrible at maths, I keep telling him he’s no good at maths (T1: 1:34-35).

As previously stated during parent’s discussions, teachers admitted that some children’s numeracy learning is not being reinforced at home, and report that it’s because they also encountered difficulty with the subject at school. Similarly, and in line with previously discussed parental concerns, teachers were aware that some parents felt incapable of helping their children with numeracy work, as they do not understand the contemporary methods. Relating to the findings of Petronzi et al (2012), this reinforces the confidence in numeracy revealed by children aged 4-7 years, whose parents worked with mathematics. This phase of discussions reinforced that parents facilitating learning is a main contributing factor towards numeracy success, relating to Vukovic et al (2013). However, early negative numeracy experiences can remain an issue into adulthood.

Some parents say, I couldn’t help with their homework because I was no good at maths at school (T1: 5:182-183).

That’s another thing parents say, we don’t know how to help them because it’s different from when we did it (T1: 6:201-202).

Teachers revealed that due to being told that they are of low ability in numeracy and that their parents did not achieve in the subject, children’s attitudes begin to reflect this in the classroom. Teachers discussed how children would imitate their parents to justify their reduced efforts, also stating that numeracy is beyond their ability, demonstrating transference of attitudes (Gunderson et
al., 2012). This is particularly crucial, as a child may have an underlying ability in the subject, but due to accepting a belief of low ability by parents, their efforts will deteriorate and they will not reach the educational potential.

*They are already saying that maths is beyond them and I’m bad at maths because my mum and dad were bad at maths (T1: 5:184-185 + T1: 5:187-188).*

An interesting part of this discussion phase related to teachers stating that some children will confide in their parents about difficulties and worries they are having in numeracy, which the teacher only became aware of at parents evening. The teacher raising this point added that they had not considered the child to be anxious or having any difficulties, demonstrating how anxiety in numeracy can often be overlooked.

*Some children will say things to their parents that they won’t say to us and on parents evening, the parents say that the child is worried about their maths in school. I would not say that the child is apprehensive, but they obviously have been as they’ve gone home and talked about it (T1: 6:224-228).*

This also suggests that the child’s performance had not been affected by their anxieties as the teacher was oblivious, suggesting that friends may have been used as coping strategies to get through numeracy lessons. Additionally, parents previously stated that information is only made available to them at parent evenings and a teacher also discussed only being made aware of a child’s difficulties at the same time, suggesting that more frequent numeracy progress updates are required between parents and teachers.

The phase of discussion that focussed on the influence of parents on how children experience numeracy, revealed a number of negative aspects. Initially, teachers reflected upon experiences of parent’s evenings and that some parents had admitted to telling their child that they are “terrible” at numeracy. This is likely to have a detrimental effect on their sense of ability and numeracy work ethic, as they consider any effort as futile. Teachers also felt that children’s numeracy attitudes were detrimentally affected when hearing their parent’s state that they too could not do numeracy at school (Erden & Akgul, 2010). A teacher recalled occasions when children directly stated that they could not do their work because their parents could not do it either, reflecting transference of attitudes and potentially damaging any underlying ability in the subject. Witnessing negative comments may further undermine the value of numeracy comprehension. Similarly, teachers stated that parents had admitted to not being able to help their children with numeracy work, as they did not understand contemporary numeracy methods. Finally, in some instances, children may be
anxious about numeracy and discuss any concerns with their parents, yet teacher may not be aware until parents evening, suggesting that more frequent contact is required between parents and teachers.

3.8.2 Teachers

Following the phase of discussion relating to the influence of parents on children’s numeracy learning, both groups of teachers focussed on their own influence and experiences, offering detailed insight into the teacher perspective of numeracy in the classroom. However, teachers first began by offering some background as to their own numeracy and mathematics educational experiences, with some revealing that they encountered difficulty with the subject and in some cases, only just managed to achieve or did not achieve the equivalent of a contemporary ‘A Level’ award. A teacher also stated that negative experiences with their teacher contributed to their difficulties, stating that they felt unable to seek guidance. This further reinforces the importance of a positive teacher and student relationship, as previously discussed.

*I just scraped my O level; but I think it was because of the teachers (T2: 2:69-71).*

*I felt I couldn’t ask a question, so consequently, I didn’t get my O level (T2: 2:74-75).*

Interestingly, another teacher stated that they would not have chosen a career that involved a high level of mathematics. This may reflect the views of mathematics experts, who suggested that some teachers underestimate the basic concepts and that some teachers hold anxious feelings towards the subject. If this is the case, particularly with inexperienced teachers, they may be inadvertently transferring anxiety to children.

*I would never have chosen a career that involved a lot of maths, never in a million years (T2: 2:42-44).*

Based on experience, mathematics experts discussed the importance of contemporary teaching methods, as if they are engaging and informative, children are more likely to develop a positive attitude to learning numeracy concepts. The lack of concept understanding was alluded to by a number of teachers, who recalled memorising concept methods, without understanding its application. Skemp (1986) discussed the learning of numeracy rules and the manipulation of numbers with no meaning as more challenging for a child to learn. Teachers also felt that numeracy was previously taught without adapting to the learning styles of children, who all process and retain
information in different ways, either through a visual; auditory; tactile or kinaesthetic learning style. Further reflecting on school numeracy experiences, teachers recalled lessons being regimented, leading them to stop their mathematics education when it became an optional subject. Again, this reinforces the importance of creating a positive experience for children in numeracy lessons, and providing interesting activities to encourage their learning.

I couldn’t understand it and it just felt we had to learn by memorising the method, but I didn’t really understand what I was doing (T2: 3:86-87).

It didn’t matter if your learning style was totally different to everyone else, there was no differentiation (T2: 3:91-92).

Further demonstrating the effect of teachers on how children experience numeracy, a teacher discussed children feeling positive and wanting to succeed in subjects if they considered the teachers to be good, and disliked subjects if the teacher was perceived negatively. Teachers then considered that some children would give up in numeracy without an enthusiastic teacher to help them through their difficulties and that negative numeracy experiences can be overturned through the positive influences of teachers.

The subject I was keen on were the ones where I had a really food teacher and the subjects that weren’t so good were the teachers that everybody thought were not quite so good. Teachers can bring that success and they influence how you feel about that subject (T1: 2:72-75).

I think the child would give up if they didn’t have the teacher with enthusiasm to show them how to do it (T1: 6:219-220).

Following a reflection on their own numeracy experiences, teachers discussed the current numeracy strategies used in primary schools and felt that teaching of the subject had improved as a consequence of the national Teaching Strategy. Specifically, they considered the strategy as providing clear guidelines and methods on how to teach numeracy topics and also how to progress these. Teachers linked this improvement to the implementation of technology in the classrooms, which has made the subject more exciting and engaging for children.

Teaching numeracy now is so much better and I think so much of it comes down to the National Teaching Strategy...it has helped us as teachers because it tells us exactly where to go and the progression to follow (T1: 1:6-7 + T1: 1:9-11).
Despite the belief that teaching in numeracy has improved, there is, to an extent, disparity between views of teachers, parents and children. Children have previously evidenced through discussions, that a large proportion in early education are already encountering difficulties and anxieties with the subject (Petronzi et al., 2012). This would counter teacher beliefs that numeracy teaching has improved. However, it is essential to acknowledge that a multitude of factors are involved in numeracy experiences and children’s anxieties may be caused by other issues, leading them to also hold negative perceptions of teachers and methods. The cause of anxieties will vary and range in severity for each child with negative feelings towards the subject, and thus, a child’s response to teaching methods in just one of a pool of influencing factors.

Teachers initially discussed their own numeracy experiences and some revealed that they only just managed or did not manage to achieve their A Level awards, in which enduring a negative relationship with numeracy teachers and being unable to seek guidance was outlined as a cause. Some teachers stated that they would not have chosen a career that involved a lot of mathematics, evidencing a degree of anxiety that could be transferred to children and an underestimation of the importance of the basic concepts at primary school. Teachers also discussed numeracy teaching methods as not adapting to the learning styles of children, who all process information in different ways. Teachers felt that children would strive for success in numeracy, if they felt that their teacher was good, and believed that they would otherwise give up and withdraw, again highlighting the importance of a positive teacher-pupil relationship. Finally, teachers discussed the National Teaching Strategy and believed that it has improved numeracy teaching, although this belief does not necessarily reflect the views of all parents and children.

3.8.3 Anxiety

Relating to teachers discussing their difficulties at primary school; only just managing or not being able to achieve their A-level awards in mathematics and avoiding the subject in their career choices, they further revealed the extent of their anxieties. In general terms, teachers stated that if currently given a GCSE mathematics question, they would be unable to attempt this as a consequence of their anxieties. As previously discussed, if teachers are anxious about the subject they teach, this may transfer to children and affect their learning. Eden, Heine & Jacobs (2013) found that female
elementary school teachers, who are themselves anxious about mathematics, can transfer their negative attitudes to their students.

*If someone gave me a GCSE question the shutter would come down. I would be bothered and frightened and thinking I couldn’t work it out* (T2: 1:6-10).

Reflecting the views of parents, who stated discomfort and uncertainty with contemporary numeracy methods, teachers also held the same negative feelings. Teachers revealed that in order to ensure that they are teaching the subject and concepts correctly through the use of modern methods, they first have to work out numeracy problems through their own methods. This again demonstrates an element of anxiety in their numeracy ability and reinforces that parents, who have no training in how to use modern methods, struggle to understand these, particularly in pressure situations when their child is requiring help with homework. Teachers also spoke of their anxiety when in a parental role, and stated that they now struggle to help their own children with their secondary school homework.

*Things have changed from when I was taught and I have quite often ensured that I am teaching the children correctly by first working it out in my old fashioned way* (T2: 1:11-14).

*My children are now at secondary school and I find that I really can’t help them with their maths at that level* (T2: 1:25-26).

Adding to the anxiety in the numeracy classroom, a teaching assistant added that working in a primary school is now much harder due to the change in numeracy methods, further revealing that this has negatively impacted their ability to help children in lesson, as they are now hesitant. If children are struggling and teachers and teaching assistants who are often assigned to certain groups are also uncertain about methods, children will not receive the necessary help and encouragement that they require. This same teaching assistant also stated that they would panic if told in the morning that they were required to cover a numeracy lesson. As they would be anxious whilst delivering the lesson, negative feelings may transfer to the children, and Vinson (2001) suggests that mathematics anxiety may stem from mathematics anxious teachers, as one contributing factor in a combinational effect. Similarly, Maloney and Beilock (2012) further suggest that exposure to mathematics anxious teachers will likely contribute to the development of mathematics anxiety. Additionally, some mathematics anxious teachers may teach the subject with reliance upon
traditional instructions, insistence upon a single solution to a problem (Shields, 2005), use algorithmic teaching and neglect cognitive thought processes (Karp, 1991).

I think it’s got harder working in school as the methods have all changed and I find I’m a bit hesitant about helping children sometimes, because I’m not sure I’m doing it the way they’ve been taught (T2: 1:21-23).

Teachers also discussed the anxiety they experience when teaching numeracy and also in a parental role when attempting to help their children. Teachers spoke generally and put their anxieties into perspective, by stating that they would currently be unable to complete a GCSE mathematics question, due to feeling frightened and “the shutters coming down”. This demonstrated that teachers were experiencing a level of anxiety that could potentially be transferred to children. Teachers also revealed that they, like parents, struggle with modern numeracy methods and stated that they first need to work out concepts with the methods they used at primary school. Again, this reinforces the concerns of parents and also suggests that children may encounter difficulties with numeracy concept due to teachers not being able to appropriately explain methods. When discussing their parental role, teachers spoke of being unable to help their children with secondary school mathematics and would be too anxious to sit with them and work it out. Finally, teaching assistants were also experiencing anxiety and admitted to being hesitant to help children in numeracy lessons, due to uncertainty about the methods they were using. Thus, children who are struggling with numeracy work and are reliant on additional support may not necessarily receive this. Similarly, teaching assistants spoke of panic and anxiety when told in the morning that they were required to cover a numeracy lesson. If they deliver a numeracy lesson with uncertainty and anxiety, children may also feel uncertain and potentially disengage, affecting their learning experience.

3.8.4 Difficulty

Although teachers had chosen to work with numbers through their career choice, they revealed that at some stage in their primary schooling, they encountered difficulty with numeracy and also discussed the issues they had observed children encountering. A teacher stated that numeracy work became too difficult for them and attributed this to “a lack of thinking time and strategies for how to work it out”. These are issues that are still relevant today. As discussed with mathematics experts and parents, a teacher also revealed that their difficulty with numeracy at school was mental arithmetic, and through discussions, this aspect of numeracy had been highlighted as a particular
issue. Another teacher indicated feeling anxiety and pressure when attempting mental arithmetic in front of friends.

Mine was mental maths (T1: 2:61).

I am quite anxious if I'm in a situation with friends, and they can obviously work out mental maths much quicker than me and when I was younger, I just used to stand back (T1: 4:153-155).

Teachers went on to discuss the issues encountered by children in their classes and acknowledged that some are very able in numeracy, and can complete multiplication and division, although struggle to apply this to a problem. This again demonstrates that children may be learning numeracy in a procedural manner and are lacking in application skills. This relates to another issue raised by teachers, who have observed that some children struggle to solve problems, due to difficulties with reading and understanding the question, as their English skills are weaker in comparison. This is another factor that influences how children experience numeracy, as previously discussed by mathematics experts. A teacher reflected on their own experiences, and also recalled encountering difficulty with written numeracy questions, that required strong reading and comprehension skills.

I think they find the problem solving aspect very difficult, they might be able to do the multiplication and division, but it’s applying it to a problem (T2: 5:188-190).

We get quite a lot of children that are actually quite good at maths but can’t deal with reading and breaking down the problem because their English skills aren’t as strong (T1: 7:255-257).

Again, as discussed with mathematics experts and parents, teachers considered that numeracy being right or wrong contributed to the difficulty that some children face with the subject. Teachers further acknowledged that for those who consistently provide incorrect work, the experience of numeracy becomes increasingly negative, leading them to develop a low sense of ability and to withdraw.

Especially if you always get it wrong, it’s very negative (T2: 6:212).
Varying aspects of numeracy that contribute to the subject being perceived as difficult were discussed by teachers, who also reflected on their own childhood experiences. Teachers stated that numeracy work became a challenge for them at school when they had minimal thinking time and few strategies for how to work out numeracy problems. A teacher also stated that they struggled with mental arithmetic at school reflecting the discussions points of mathematics experts and parents, highlighting this aspect of numeracy as a common issue. Turning attention to their observations as teachers, they revealed that some children, although able to complete multiplication and division, struggle with applying this knowledge, demonstrating procedural learning. Mathematics experts identified procedural learning as an issue, as children are not learning the relevance of numeracy and its application to real life. Similarly, teachers felt that a difficult aspect of numeracy for children was reading and comprehending written problems, particularly if their English skills were weaker in comparison to their numeracy ability. Finally, concurring with the views of mathematics experts and parents, teacher considered that the right and wrong nature of numeracy contributed to the perceived difficulty of the subject. If children are persistently providing incorrect work, this will promote numeracy as a negative experience and they may eventually withdraw from the subject.

### 3.8.5 Negative aspects

Teachers went on to discuss a variety of additional factors that contributed towards a negative experience of numeracy for children in early education. Teachers, like mathematics experts and parents, considered the consequences of failure at an early age, stating that numeracy work increases in difficulty as anxiety sets in. Another teacher supported this view and believed that when a child persistently fails in numeracy, they are likely to withdraw, as they are not experiencing a sense of encouragement that comes with success. Dowker et al (2012) acknowledged that poor mathematical attainment can lead to anxiety and a vicious cycle may ensue, with anxiety and performance negatively affecting each other.

I do think that if you start failing at a very young age, it sets you up to fail later on. It gets harder because the anxiety comes in (T1: 4:146-148).

Although teachers could not give an indication of causality, they revealed an awareness of avoidance behaviours in children who were not secure in their numeracy ability (Dowker et al., 2012) and stated that they would often sharpen pencils or copy their friends work. It is beneficial for teachers to be aware of children who are displaying avoidance behaviours, as this may act as an
indication that they are struggling with their numeracy work, and additional support can be provided.

A teacher also commented on perceptions of numeracy and mathematics as reflecting an individual’s intelligence, as alluded to by mathematics experts and parents, who felt that children became aware of an intelligence hierarchy in numeracy lessons. For those that are placed in lower groups, a sense of low ability may develop, which could ultimately lead to withdrawal from the subject.

*I think people’s perceptions are that maths is the sign of intelligence (T1: 3:95-97).*

During the discussions, teachers considered the self-esteem of children, and that some will respond more positively to difficulty in numeracy and will not be adversely affected by failure, instead attempting the work again. Children with greater confidence may be those with parents who can facilitate their learning and have thus avoided the negative consequences of failure. Additionally, in some cases, children may be intrinsically motivated to succeed in numeracy, although teachers felt that if they attempt to answer questions by raising their hand and were not chosen, they too, can begin to question their efforts and withdraw. It may be that teachers focus on children who are more reluctant to volunteer an answer, and thus inadvertently affecting the motivation of those who are more secure with their numeracy ability. Additionally, teachers attempting to obtain answers from less forthcoming children may be causing anxiety through pressure and doing numeracy in front of others.

*Some children just have a low self-esteem for whatever reason and the slightest difficulty becomes a huge thing for them whereas other children with more confidence will just think, I don’t understand that, but I’ll just carry on (T2: 6:197-200).*

*Children that put their hand up in the class but are never asked and then start thinking, why do I bother? (T2: 6:201-203).*

In relation to individual differences in children that contribute to their numeracy experience, teachers additionally considered that some children would not approach them for additional support, due to concerns about how their peers would perceive them. This again relates to a fear of ridicule and being perceived as less intelligent.

Teachers discussed additional factors that contribute to children’s negative numeracy experiences. A main consequence of persistent failure was considered as leading to anxiety, which would
increase the difficulty of numeracy work for children who were less secure in their ability. Teachers were also aware of avoidance behaviours in numeracy, and noted that some children would copy the work of their friends. It is advantageous for a child’s numeracy experience if a teacher becomes aware of avoidance behaviours, as additional support can be provided to facilitate their learning. The perception of numeracy and mathematics as defining intelligence was also considered by teachers as negative aspect of the subject, whilst others felt that some children had lower self-esteem than others and were thus less able to manage difficulties. Finally, and relating to comparison in numeracy, teachers discussed that some children would not seek guidance when struggling with work, due to fear of how they would be perceived by their peers.

3.8.6 Teachers thematic map: Figure 3.4

The findings from the discussions with teachers are visually represented in the thematic map of figure 3.4. Themes that were initially considered as dominant were maintained due to their frequency throughout the discussions. The dominant themes that emerged from the data were represented in a single thematic map, as teachers raised issues that centred on the influence of parents and themselves, in regard to the numeracy experiences of children in early education.

These issues raised in the discussions were categorised under the main theme title of ‘the influence of primary adults’. This was sub-divided into parents and teachers. Through discussions, teachers focussed on negative behaviours of parents that could adversely affect their children’s numeracy experiences. It became evident that teachers were aware of negative statements made by parents in front of their children, relating to numeracy, and that a negative attitude was transferring to children. Teachers also revealed their awareness that some parents do not understand contemporary numeracy methods, and thus were unable to facilitate their child’s learning at home. Additionally, teachers stated that children will often confide in parents about their struggles in numeracy, although this is not made aware to them until parents evening. This and the issue of unfamiliarity with contemporary methods suggests that more frequent communication is needed between schools and parents, to monitor child progress and for parents to access additional support.

Although teachers focussed on parental behaviours, their own influence on children’s numeracy experience was discussed in greater detail. These were discussed in the main theme of teachers, which included negative and positive aspects. When speaking of their influence, teachers also reflected upon their childhood numeracy experiences and the relationships they had with their teachers. Discussions moved towards the anxiety that teachers experience themselves, particularly
in relation to contemporary methods, which relates to the concerns of parents. Anxiety was consequently a subordinated theme of teachers that also included teaching assistants revealing that they are hesitant in helping children in numeracy and panic when asked to cover numeracy lessons at short notice. Difficulty of numeracy was an additional subordinated theme of teachers, as they discussed the aspects of numeracy that they considered to be challenging for children, and from a personal perspective. A final subordinated theme of teachers was titled ‘negative aspects’, as this theme encapsulated multiple factors that negatively impact on children’s numeracy experiences. The factors identified were not discussed with a high frequency, but the author chose to collate these into a single theme as they relate to the previous comments of mathematics expert and parents, and offer additional support. The inclusion of these factors demonstrates that certain issues were considered by all three groups, and are therefore of importance.

During discussions, teachers focussed more on negative influences than positive. The author reiterates that the factors attributed to each theme emerged entirely from the thoughts and experiences of teachers. Additionally, it may be perceived that a theme relating to the role of teachers was an inevitable emergence. However, the subordinated themes that were discussed directly related to the experiences of teachers.
3.9 Reflexivity: a background to the author

3.9.1 Introspective

Introspection can be regarded as the process of reflecting upon and consciously making sense of our own thoughts and feelings. With regards to the method of interviews and focus groups that centre on interaction as the basis of gathering data, it is essential to consider how the author as a person, and their experiences, contributed to and influenced the process.

The author’s own negative childhood experiences of numeracy acted as a motivational force to conduct the current study. In hindsight, the sense of dread and fear experienced when working with numbers during numeracy lessons reflected the established definition of mathematics anxiety, although at the time, it seemed an inexplicable and uncontrollable emotional response. The author began primary school with considerable success in all areas and a deficit in numeracy did not become apparent until the age of 5-6 years, when in year one. Negative feelings towards numeracy emerged at this time in particular response to the class teacher refusing to acknowledge completed numeracy work when the author sought their approval, rather than staying sat. The author recalls that this led to questioning the purpose of completing numeracy work with great effort, as it would not be acknowledged and was instead met with punishment in the form of being told to sit down. This resulted in reduced effort and the author’s numeracy performance began to decline. By year two (aged 6-7 years) the author recalls a degree of avoidance of numeracy work and particularly struggled with multiplication, relative to peers. This was a considerable issue in test situations and the sense of fear and panic remains a very clear emotion when reflecting upon this time. However, as the author’s difficulties were highlighted during a parents evening, the author placed considerable effort in attempting to overcome these difficulties, with support at home. Yet, when successful in a test condition, the teacher was not convinced that the work had been completed independently and so gave the author six weeks’ worth of numeracy worksheets to complete over the summer holiday period. The use of numeracy and mathematics as a form of punishment led to negative feelings and attitudes towards numeracy and remained throughout the author’s educational career. It could be perceived that the author’s numeracy difficulties and negative emotions could have influenced the direction of the research with more emphasis being placed on other children’s negativity. This may be perceived more in relation to qualitative analysis of discussions with children (MPhil) and when interpreting the discussed observations of primary care providers. However, over the years and prior to the commencement of this PhD, the author learnt to appreciate the value of numeracy and mathematics through their experience of being a teaching assistant.
Their own negative experiences inspired a desire to ensure that other children experience positivity in the numeracy classroom and this research is an extension of wanting to make a positive contribution. Thus, the author reiterates that the studies comprising this body of work were data led to ensure that children’s experiences were accurately reflected and that a valid measure could be developed to support the assessment of those at risk. Furthermore, this PhD was inspired by a mathematics anxiety lecture as a second year undergraduate student, and since this point, the author has endeavoured to explore and understand how children experience numeracy in the early years and determine the factors that contribute to the development of mathematics anxiety.

The author's experience as a higher level teaching assistant, working with children from reception (ages 3-4) to year seven (ages 11-12) and with complex difficulties, revealed that from an early age, children hold and express thoughts and feelings that relate to a variety of school and life aspects. The author also acknowledges that young children are perceptive, intuitive and have an understanding of educational systems i.e. their knowledge of an intelligence hierarchy in numeracy. Thus, the author maintains the stance that young children can provide insightful information and accounts of their experiences. This is reinforced by the author encountering negative and self-critical discourse in numeracy lessons, as well as witnessing attempts to avoid numeracy work, either physically or mentally absconding (Bibby, 2002).

Previous data obtained with young children is discussed here, as it contributes to PhD study 2 in the same manner as the current research. In previous qualitative research with children, the author considered that the experience of working with children in a primary school setting may have impacted on data extraction, by selecting discourse that related to observations of negative numeracy experiences in the classroom. This may have also contributed to the development of the extracted four main themes, which may be argued to give a more negative representation of children’s numeracy experiences. However, following discussions with mathematics experts, parents and teachers, the author felt that the numeracy experiences described by the young children had been reinforced, as adults discussed similar issues and reported observations of children’s behaviour that were in line with children self-reports and statements. Focus groups with adults also gave a more negative representation of mathematics, and the factors involved in the development of attitudes. Additionally, due to the previous experience of discussing numeracy attitudes with children, the author was able to relate more to the comments made by adult participants, with increased understanding and can be regarded as ‘overlapping’ of data. This was considered to have contributed to the in depth discussions.
In relation to working in schools, the author also gained experience in addressing large groups of people and leading a group discussion, often through contributing in hosting and speaking in meetings with multiple agencies, for example, children and mental health services, behavioural support and educational psychologists, teachers and parents. This developed the author’s communication and speaking skills with adults, taught how to engage in professional discussions and to listen, respect and respond to the views of another.

Further demonstrating the ability of the author and thus, increasing the quality of the research and analysis procedure, they have current experience of working with autistic children and young people in a residential setting. Due to the social and language deficit of this developmental disability; communication, and the understanding of behaviour and anxieties often relies upon interpretation, and has allowed the author to improve interpretative skills.

An understanding of appropriate communication has been established through the author’s experience of working with parents, teachers and academics, enabling the author to create a relaxed atmosphere, and encourage a more natural discussion. Again, through working and research experience, the author has also developed confidence and techniques of engagement when leading groups of adults. The authors felt that this enabled them to form a rapport with all participants that encouraged a relaxed environment and honest discussions. It was observed that all participants contributed to the discussions. Teachers, who stated some degree of anxiety relating to mathematics, appeared to have accepted this as the norm and when parents spoke of the issues they faced with supporting their children, a degree of frustration was evident. Due to the frustration felt by parents, the author supports the U.K. adopting a similar to scheme to that of Singapore that aims to improve the numeracy skills of parents and teach them contemporary methods so that they can facilitate the learning of their children.

### 3.9.2 Methodological: discussions and analysis

The implementation of qualitative methodology resulted from the acknowledgement that interviews and focus groups would enable exploration and direct insight of the attitudes and experiences of mathematics experts, parents and teachers and their observations of children’s behavioural responses. The author had developed an appreciation for both quantitative and qualitative methods, without preference, and chose the method that was most appropriate for the research question. Additionally, it was considered by the author, that previous mathematics anxiety rating scales have typically been developed solely from a quantitative perspective and through adopting scale items
from previously validated scales. Thus, to develop a novel and comprehensive numeracy apprehension rating scale for young children, focus groups were utilised. These were acknowledged as the most suitable to provide the in-depth data relating to factors influencing children’s thoughts and feelings in which the scale items could be based upon. Thus, a positive interaction between quantitative and qualitative methods was accepted. The author had previously established that children hold positive and negative perceptions of numeracy, that are obtainable through speaking to them. However, children in reception typically provided simple answers, either one word or a short statement, in comparison to children in year one and year two, who were able to elaborate descriptions of their experiences and feelings. Nonetheless, reception children were still able to indicate whether they enjoyed numeracy or not.

Thematic analysis was the chosen analysis method, as the author intended the data to naturally drive the development of themes, rather than being based on pre-determined categories. This gave credibility to the research data, particularly as the themes that emerged reflected previous psychological research data and assumptions. In addition to thematic analysis, the use of content analysis allowed the quantification of naturally occurring themes. This filtered the data, after naturally emerging through the thematic procedure, until the most frequent phrases and themes within the discourse were categorised. Content analysis was implemented to incorporate rigour into the analysis process and to lessen the dependence on interpretation, leading to the final thematic maps that encapsulate the findings. The author determined that the implementation of thematic and content analysis to develop the main themes was beneficial. If a point of discussion, initially considered to be of interest, was unsupported by its frequency throughout the focus groups, then it could be omitted. This gave consistency to the analysis procedure and also limited the chances of themes developing and remaining, based on over-interpretation by the author. Thus, if the author judged a point of discussion as holding a deeper meaning, the lack of frequency would prevent this from developing into a key theme that could have misrepresented the data. However, due to the elaboration of all participant groups, the discourse spoke for itself and further assisted in limiting the reliance upon the author’s interpretation. The single use of thematic analysis in the author’s previous qualitative research was judged as a potential limitation due to interpretative bias, and so this was accordingly addressed in PhD Study 1. Had the element of frequency not been included in the analysis process, the formation of themes based on data with primary caregivers could be judged to have been made to fit the themes that formed following discussions with children. The use of frequency in the current study suggests that the previous interpretation of child discourse was
representative and limited in bias. This is supported by similarities between children’s and primary care givers discourse.

However, in the author’s previous research, the author acknowledged that their own previous difficulties with numeracy and mathematics may have influenced the interpretation of the data by seeking confirmatory negative thoughts and comments. Yet, the current research was conducted with mathematics experts, parents and teachers, and thus, they were able to provide more detailed explanations of their feelings towards and experiences of numeracy/mathematics. This naturally reduces the opportunity for interpretation error or bias. Still, the author relied upon interpretation of children’s feelings and observed behaviours from mathematics experts, parents and teachers, and whilst accurate accounts were provided, there are some instances in the data that may not necessarily reflect negativity towards numeracy. An example is perhaps evident in a parental observation that their child would refuse to do their numeracy homework as a form of withdrawal when struggling with numeracy, though this behaviour may reflect tiredness and have no relation to numeracy apprehension. In contrast, it should be considered that this account, as an example, was provided by a parent who is likely to be aware of their child’s numeracy attitudes, ability and response behaviours. Thus, a parent stating that their child closes their book when struggling with numeracy work can be considered as a reliable observation.

Participants were directed through discussions with questions relating to their own numeracy/mathematics experiences and behaviours they had observed in children. The questions were judged to have acted as a clear and consistent guide for the focus groups and interviews, as each instigated an insightful discussion and led to interesting and detailed findings. The questions also maintained the central topic and direction of discussions, enabling redirection when a discussion point had been exhausted, whilst enabling participants to have freedom in the points they made. Participants seemed comfortable with all the questions, and when focus groups included parent couples, the questions relating to their child often encouraged debate and a considered an honest reflection of their numeracy behaviours. In situations when participants began to discuss numeracy and mathematics aspects that did not relate to the listed questions, the author would explore their thoughts further with novel questions. All focus groups and interviews took place in quiet areas of each school and at the University of Derby, and no disturbances or interruptions occurred.

The use of qualitative methods was beneficial to the aims of the research, as the author began the process of scale development by obtaining data directly from the target population and their primary
care providers. Due to the novelty of the scale, based on its use with children aged 4-7 years, the author could not simply adapt items from scales that had been validated with older populations, traditionally in the US. Instead, it was necessary for the items to accurately reflect the numeracy experiences and influential factors of children, and qualitative methods allowed for this.

3.9.3 Epistemological: researcher approach to understanding numeracy attitudes

Throughout focus groups and analysis, the author maintained a critical realist epistemological stance, and considered the data as providing insight to wider and complex knowledge of early numeracy experiences. Individual meanings of school and current mathematics experiences were provided by mathematics experts, teachers and parents, who also gave accounts of observed children’s behavioural responses and experiences. To respect the individual meanings of discussed mathematics experiences and observations, the author presented a variety of detailed extracts, to disseminate the social reality constructed through the language of participants.

Through being in an academic position, the author has adopted a philosophical perspective that advocates intervention and alleviation of numeracy/mathematics anxiety. This is centred on positively contributing to children’s lives, by aiming to improve the educational experiences of those at risk of emotional responses to numeracy that can misrepresent ability. The data found from interviews and focus groups with mathematics experts, teachers and parents, and also previously in focus groups conducted with young children, will contribute to fulfilling the author’s philosophical perspective of intervention. This will be achieved by the data acting as an item pool to form the basis of a numeracy apprehension rating scale (see PhD study 2). It is hoped that this scale, once developed, will aid the identification of children at risk of numeracy apprehension, enabling early intervention to be provided. The current research has reinforced the negative statements, feelings and experiences that children revealed about numeracy in the authors previous study, and suggests that negativity towards numeracy continues to be a widespread educational obstruction. Additionally, study 1 found that parents and teachers are positively and negatively influential in a child’s development of attitudes towards numeracy and the development of numeracy apprehension has an association with a number of sub-factors relating to these primary care providers.

A social constructionist paradigm relates to the current research linguistically exploring mathematics experts, teachers and parent’s personal mathematics thoughts, feelings and experiences and those they have observed in children. This paradigm acknowledges that perceptions and
experiences are specific to each individual and that a single truth is unattainable, as there will always be contrast in people’s attitudes, and how they think and react. The paradigm further relates to the authors own views by acknowledging the influences of culture. Through working and research experience in a number of schools, the author has become aware of adults trivialising their poor mathematics ability with humour. The National Institute of Adult Continuing Education has suggested that a culture of taking pride in poor mathematics ability has emerged in the U.K. (BBC, 2011). However, a social constructionist paradigm places emphasis on nurture as influencing human behaviour, overlooking biology. Whilst the author encountered a high frequency of discourse that centred on the participants recalling the mathematical influences of their parents and family, the author ultimately considers that human behaviour results from the complex interaction between biology and experiences.
3.10 Discussion

The focus group discussions of the first study provided detailed insight regarding factors that may influence the numeracy experiences and performance of children aged 4-7 years. Ramirez, et al (2013) emphasised the need to consider the importance of addressing mathematics anxiety at the earliest age possible, to prevent a “snowball” effect of dislike, anxiety and avoidance of mathematics. Yet, the emergence of mathematics anxiety has not typically been a research focus (Mazzocco et al., 2012; Ramirez, et al., 2013). However, the current findings have built on previous qualitative research (Petronzi et al., 2012) to further rectify shortcomings of psychological research and to increase our understanding of influential factors and interactions in the development of numeracy attitudes.

A range of factors i.e. stigma and peer comparison were discussed by mathematics experts, parents and teachers in relation to children’s numeracy experiences in the classroom. Although individual themes emerged, these often had an association with others, for example, failure and avoidance. This reinforced the complexity and interaction of factors that have an association with the development of numeracy attitudes.

Children’s anxiety was discussed by mathematics experts, who recalled their own numeracy teaching experiences and observations of other classrooms. Children who had been identified as anxious were discussed as simply looking at their work and stating that they could not and would not do it, evidencing the “no-attempt” error. Parents considered that numeracy had an association with difficulty, as when a child is persistently wrong, they are likely to lose interest and confidence, referring to this as “soul destroying”. A parent stated that avoidance of numeracy is perhaps amplified, as one concept is usually the foundation for another, leading to further difficulties. This places an importance on the early years of education and understanding what factors contribute to positive and negative experiences. As stated by a mathematics expert, failure seems to have an association with a low sense of ability, with children believing that they are unable to complete numeracy work and thus, are not prepared to engage with it. Repeated failure may have led children to internalise the negative feedback associated with this, leading to feelings of inadequacy (Mutodi & Ngirande, 2014). In contrast, children described as having a high sense of ability were regarded as being more secure in making mistakes and more persistent, reflecting Yates (2002) who found optimism to have an association with higher mathematics performance. This further supports self-efficacy theory (Bandura, 1986), as despite making mistakes, some children remain engaged.
due to a belief in their ability. Such children are less at risk of developing anxiety (Zimmerman, 2000). However, an assessment tool to identify children at risk of numeracy apprehension remains to be developed, placing further importance on the current research findings.

A factor particularly associated with anxiety was children being asked for an answer in front of their peers, causing pressure and potential embarrassment if unable to answer correctly. In these situations and others where children could not complete their work, mathematics experts discussed witnessing children “burst into tears”. This reinforces the emotionality of apprehension (Luo et al., 2009) and is an example of helplessness (Lundberg & Sterner, 2006) at an early age of education. Again, this seems to mandate an identification measure for children aged 4-7 years, as mathematics experts reinforced that children in the early stages of education are susceptible to anxious feelings and worrisome thoughts in numeracy. This can adversely affect their participation and performance and places them at a distinct disadvantage. It seems that this is the stage where identification and intervention could be most effective. In addition, their observations had revealed that males present as more confident and resilient in numeracy and willing to make mistakes and build on these. This is in contrast to females, whom mathematics experts noted as being more reluctant to attempt an answer and to change their behaviour in pressure situations – suggesting a degree of discomfort. Despite this observation, there remain inconsistencies in research evidence based on gender differences in numeracy and mathematics, as previously discussed (Beilock et al., 2010; Devine et al., 2012). However, this offers further insight into how some males at an early age deal with the challenges of numeracy.

The difficulty associated with numeracy was represented as a theme in each discussion group. Mathematics experts discussed that the perception of difficulty can often influence anxiety, particularly in cases when an individual is already feeling unsuccessful. Applying this to some children in general and perhaps those who have been placed in pressure situations and been incorrect, they are likely to develop the perception of numeracy being difficult. This can have an association with avoidance and subsequently performance, and will be discussed later in this section and further demonstrates a combination of influential factors.

All focus groups identified mental arithmetic as being particularly problematic. A mathematics expert conceded that they had always struggled to solve mathematical problems without the use of strategies, suggesting that for some, an initial difficulty can remain into adulthood. This again points to the importance of numeracy assessment in the early years of education. Moreover, some
parents discussed their low confidence with mental arithmetic, which could transfer to their children. However, it also became apparent in discussions that some teachers posed a risk of transferring their own anxieties, as some stated that they too struggled with mental arithmetic (Vinson, 2001; Maloney & Beilock, 2012; Aslan et al., 2013). Despite experts, parents and teachers discussing difficulties and anxieties with mental arithmetic, children are assessed on this skill throughout their education. If primary care providers encounter difficulties with this aspect of numeracy and mathematics, it is thus understandable that some children may develop anxiety, with mental arithmetic at the core. Recent research now suggests that a deficit in mental arithmetic may relate to an individual’s neurons being inefficient and moving in a less synchronised manner (Krause, Marquez-Ruiz & Kadosh, 2013). Therefore, in some cases, a child’s deficit in mental arithmetic may have a neurological basis, placing them at a disadvantage. Although such individuals could benefit from appropriate training, an assessment scale would still be of worth for children in early education, as anxiety inhibits working memory resources required for task completion. Thus, the identification of those at risk would be a starting point for overcoming a deficit in mental arithmetic.

The right or wrong nature of numeracy was discussed as a key difficulty, with mathematics experts considering that this can induce anxiety. A parent supported this assumption and discussed how their child became angry, frustrated and cried when unable to achieve the correct answer. A mathematics expert and teachers considered that a key difficulty resides in moving on to worded problems, where children are required to apply their knowledge of a concept. This phase, along with moving on to teen numbers, subtraction and division were also discussed by experts as potentially causing anxiety and giving children a sense of being unable to do their work, reflecting the findings of Chinn (2012). The anxieties and issues that some students have at mathematics undergraduate level were described as rigid and as having been “brought along” from their earlier years of numeracy and mathematics education. Again, this suggests that the early years of numeracy education are key in the development of either positive attitudes or anxieties and worrisome thoughts. According to a mathematics expert, a deficit in applying knowledge to a problem rests with procedural teaching (Skemp, 1986; Chinn, 2012). It is this style of instruction that induces anxiety, as they considered that children complete methods without a core understanding. Indeed, this relates strongly to teachers themselves, which emerged as a main theme throughout all discussion groups.
Parents also recalled being taught concepts at school, such as percentage and probability, but not understanding the logic to the method. This suggests that the same issues affecting their own learning are still present in modern numeracy and mathematics lessons. As an underlying problem of numeracy education, a mathematics expert believed that some pre-service teachers underestimate the importance of basic numeracy and mathematics concepts and how to apply this knowledge in a classroom setting. Yet, a parent who was also a primary school teacher stated that it is essential to be able to teach all concepts and have a basic understanding. Thus, if teachers are inadequately prepared and do not have the core concept knowledge, children will also struggle to understand. This may have an association with observed issues when children attempt to apply knowledge to a problem. Moreover, children’s numeracy learning may also be affected by teachers with low confidence using incorrect vocabulary, potentially causing confusion i.e. referring to calculations as ‘sums’ rather than addition. This was again the view of a mathematics expert, who discussed children as learning the incorrect terminology and becoming confused.

Teachers who are not prepared with the knowledge of basic concepts, lack confidence and have their own anxieties, can transfer worrisome thoughts to children, subsequently affecting their own performance. However, some teacher anxieties may relate to contemporary methods, as discussions revealed that some needed to confirm the correct teaching of a concept with a new method, against outdated methods they were comfortable with. Supporting this view, a teaching assistant stated that due to their uncertainty surrounding contemporary methods, they were hesitant to support children who were struggling. This demonstrates that children at an early age, who encounter difficulty with numeracy, may not always receive the support they require due to teacher anxieties and uncertainties. Thus, a child may not resolve their difficulty and fall behind, which can have an association with worrisome thoughts, anxiety, avoidance and low performance. This shows the pivotal role that teachers play in the early years of numeracy education, and that exposure to anxiety can have an influence on the attitudes towards numeracy that children develop. Indeed, a teacher stated that children would “give up” without an enthusiastic teacher to support them, yet if a teacher is anxious, they are unlikely to be enthusiastic about numeracy, relating to a point raised by Mazzocco (2007).

In addition to the influence of teachers, the role of parents was also discussed by all groups and was a key area of discussion. There appeared to be a shared consensus that whilst children can benefit from support at school, the facilitation of numeracy learning in the home environment is just as influential (Dowker et al., 2012). A mathematics expert believed that if a child is surrounded by
people confident with numeracy and mathematics at home, then this benefits their own learning as they receive the necessary support and encouragement. This reflects the view of Mazzocco (2007) who considered educated parents in the household as an important factor to avoiding anxiety. Crucially, and perhaps in contrast to children who persistently struggle with numeracy, it was considered that if those with home support have any weaknesses in numeracy, these can quickly become resolved. This seemingly limits any negative feelings towards numeracy, whereas those with little to no support at home have persistent negative feelings. Again, an assessment scale could incorporate completing numeracy at home to determine whether a child has any concerns, and appropriate support can be provided.

When parents discussed the influence of themselves and other parents on numeracy education, they revealed more specific insight as to the variances in how parents approach their children’s education. It was discussed that whilst some place significant expectation and pressure on their children to perform at a high level (Yuksel-Sahin, 2008; Krinzinger et al., 2009), others may not value mathematical achievement, and transfer this attitude to children (Fraser & Honeyford, 2000) whose participation and performance will decline. This relates further to a parent stating that some will tell their children to not worry if they cannot do their numeracy homework. Parents in the discussion group also recalled learning the benefits of numeracy and mathematics from their own parents who, for example, worked in a bank. It seems that children are more likely to appreciate the value of numeracy if their parents have a job role that involves a degree of mathematics (Ashby, 2009). A mathematics expert stated that this is typically the father figure and in previous qualitative research (Petronzi et al., 2012) it was found that children stated an enjoyment of numeracy and acknowledged that they would be supported, as their parent also worked with numbers (a father working at British Aerospace and another as a teacher). This discussion point further reinforced the importance of parental involvement in children’s education and attitudes towards numeracy.

Demonstrating transference, one parent discussed how they are able to solve a mathematical problem, but typically miss showing all workings out, stating that their child now has the same tendency. Erden and Akgul (2010) also believe transference of attitudes to children can take place when parents state that they found numeracy/mathematics difficult at school. This is seemingly supported by discussions with teachers, who revealed that some parents on parents evening have acknowledged their child as being “terrible” at mathematics. Similarly, a mathematics expert described negative parent numeracy attitudes as being “beaten” into children to the point that they believe they lack any ability, again leading to avoidance. Additionally, teachers stated that children
in their numeracy lessons have claimed an inability to do the work because their parents were bad at it. This clearly demonstrates that the transference of an attitude is acting as a participation and motivational deficit in numeracy, even in cases when a child is capable of achieving. A parent also considered that anxious parents will likely cause anxiety in their children, particularly if they state that, “I hated mathematics at school”. In most cases, it seems likely that parents are not intending to deter their children from numeracy education with such statements, and are unaware of the profound negative affect that this can have on their children. It would perhaps be advantageous for schools to collaborate more with parents and to suggest that such comments are not made due to the transference of attitudes and children using this as justification for low motivation and performance.

The Mathematical Association (2012) stated that parents are struggling to facilitate children’s numeracy and mathematics as most do not understand modern methods and the research discussions supported this. A parent stated that he had encountered difficulty supporting his child with numeracy due to not understanding the modern methods and strategies, such as a number line, causing frustration for both. Based on the discussions, it appears that a child’s numeracy progress is not communicated between parents and teachers to the same extent as their reading progress. Demonstrating this point, a teacher stated that it is only at parents evening that they are made aware of a child’s concerns in numeracy, as they have only informed their parents, who have waited until that moment to raise their concerns. In contrast, a parent discussed that they are unaware of their child’s numeracy progress unless information is sent home, but in an instance when they approached the teacher for information, they were provided with a book of the contemporary numeracy methods. Again, this suggests that increased communication is required between parents and teachers, and that schools could promote sessions in which parents can learn about the contemporary methods used in numeracy lessons.

As identified in the author’s previous qualitative work with children aged 4-7 years (Petronzi et al., 2012) mathematics experts considered that some children are likely to develop a sense of their peers developing and advancing more quickly than themselves. Children making comparisons and an awareness of a hierarchy were discussed to a large extent by mathematics experts, based on their experiences and observations. From an early age, they considered that children acknowledge ability groups and in some cases, those of lower ability may be ridiculed, further causing negativity in numeracy. Another mathematics expert outlined the age of seven as when children are most likely to have become aware of their capabilities and when a “pecking order” begins to emerge. This suggests that numeracy comparison is evident from an early age and places pressure on performance. Those that struggle are thus likely to also experience a low sense of ability, fear of
failure and avoidance of work. Whilst this further highlights a key factor in the development of numeracy attitudes, it also supports an assessment scale that gauges how children feel in relation to their peers in numeracy. If a child compares themselves unfavourably, their numeracy participation and performance may be at risk.

Mathematics experts discussed the common perception of numeracy and mathematics as being a more academic subject and suited to those who are more intelligent. They discussed children as also acknowledging this, as did parents. Children who are not secure in their ability were said to begin to identify those who are capable and became dependent on them e.g. copying work. Again, this was a key finding with children aged 4-7 years in previous research (Petronzi et al., 2012). This suggests that due to anxieties and worrisome thoughts, children have become reliant on others and are no longer learning for themselves. An assessment scale may support in identifying children who are at risk of apprehension. Interestingly, dependence on others was referred to by a mathematics expert as leading to “invisible” children, who seem to be coping with work, but in actual fact, are not independently learning numeracy concepts and may be highly anxious. As stated previously, if children fall behind in numeracy and do not learn key concepts, they will encounter significant difficulty in learning and applying more advanced concepts.

At the point of a child developing dependence on other children, they have become avoidant of any issues they have with numeracy and do not have the confidence to attempt to solve them. This may relate to, for example, their perceptions of the teacher and believing that they would be punished (Petronzi et al., 2012) or through fearing stigma in the classroom. In other instances, mathematics experts had observed avoidant children as sitting quietly, covering their work and not participating in class discussions and work. Children were further described as being more likely to become disruptive, and those provided with tactile resources to support them, instead played with them. Thus, it seems that some children at an early age have already disengaged from numeracy, due to multiple factors that ultimately have an association with avoidance. Supporting the observations of mathematics experts, parents revealed that in some instances, numeracy homework had led to “tantrums” at home.

The qualitative discussions of study 1 revealed a number of factors that can be judged as having an association with the numeracy experiences and attitudes of children aged 4-7 years. The participation of mathematics experts, parents and teachers allowed for the comparison of insight and provided a range of views on many factors that, in most cases, supported and reinforced those of another. Interestingly, many of the key themes to emerge through discussions were similar to those that emerged following analysis of the author’s previous discussions with children aged 4-7 years.
(Petronzi et al., 2012) e.g. difficulty of numeracy, awareness of a hierarchy, pressure and numeracy in public, stigma and failure. This suggests that the information and experiences described by children was, to an extent, an accurate reflection of the typical experiences of contemporary numeracy education in the classroom. This also supports subsequent research in holding discussions with younger children, as in light of the current findings; they have been shown to have provided insightful information. Although the key themes of parents and teachers were also present in the previous research and study 1 of this PhD thesis, it should always be anticipated that as primary care providers, they will typically have the largest influence on children’s experiences and attitudes, whether positive or negative. Whilst the research findings can be compared to other qualitative data, and quantitative findings with older populations, some of the discussion points provided further insight beyond the child, but which still impacts on their education. For example, the apparent lack of communication and updates between teachers and parents with regards to children’s numeracy progress, and also that parents struggle with contemporary numeracy methods. A particularly advantageous suggestion based on the research findings centres on schools adapting a numeracy progress diary to be sent between home and school, something which the discussions suggest that parents would appreciate and welcome. Further to this, schools could also implement and promote sessions for parents to learn the contemporary numeracy methods that are taught in the classroom, so that they are able to adequately and consistently support children in their learning and to minimise the confusion and frustration when outdated methods are used as a last resort.

Although qualitative research, the author acknowledged limitations of the study and considers that the findings could have been more representative, and possibly contrasting, if more schools (parents and teachers) with more ethnic diversity and from a wider area had participated. Thus, replication of this research would be particularly beneficial, as this would either offer support for the themes interpreted by the author, or introduce additional factors that have an association with numeracy attitudes and performance for children aged 4-7 years. As alluded to, the themes were interpreted by the author and thus can be judged to be a subjective representation of the data. However, whilst thematic analysis was implemented to extract initial points of interest, content analysis was then employed to minimise the subjective nature of interpretation and to include some rigour in the process of theme selection. This incorporated a quantitative perspective, allowing for the frequency of key words, phrases and concepts to determine the nature of the findings. This also phased out any points of interest that had been selected through over interpretation.

Whilst the research results would be further supported by the participation of more parents, teacher and mathematics experts, the results can still be judged as providing depth and detail, achieving the
aims of qualitative research. Due to the novelty of the proposed Numeracy Apprehension Scale, it was essential to gain insight from all involved in children’s education. The research findings, along with those of the author’s discussions with children aged 4-7 years (Petronzi et al., 2012) would provide an item pool for the initial version of the Numeracy Apprehension Rating Scale and is discussed in detail in chapter 4 of this body of work.

Validation of a numeracy apprehension assessment measure using qualitative methods, addresses the traditional issue of scales being developed solely from a quantitative perspective. The Numeracy Apprehension Rating Scale will be developed for children aged 4-7 years, based on children’s insight and also that of their care providers. Whilst this is a foundation for validity, appropriate quantitative implementation and analysis is required to appropriately determine this. However, if a scale for young children is developed, consideration must be given as to whether honest answers will be provided by children if administered by teachers and if copying of answers will take place if completed as a class. Thus, independent administrators may be required to complete scales where necessary on a one-to-one basis. Quantitative development of the numeracy apprehension rating scale may reveal that some factors identified in the literature may in fact, have low impact on children’s numeracy attitude formation.

The first study within this body of work indicates a need for psychology to progress with exploratory research with children and their primary care providers, in order to develop a broad perspective of influential factors in early numeracy experiences and attitudes. Indeed, the findings suggest that numeracy apprehension is an educational concern and that some children are at risk. This can have a profound affect throughout their educational careers. Thus, the findings from discussions with children (Petronzi et al., 2012) and the first study will be the basis for items on the initial iteration of the Infancy Numeracy Apprehension Rating Scale that will subsequently be implemented with children aged 4-7 years. The ground-up and all-encompassing development of the NAS is a key strength. The scale will undergo factor analysis to remove items that do not significantly reflect the numeracy experiences of children, further providing insight as to which factors are most influential and can be compared to previous research with older children and populations. This will also be the first scale with the intention of assessing numeracy apprehension in children, addressing the current limitation in psychological and educational research, as well as the educational system.
4 Development of the numeracy apprehension rating scale

4.1 Introduction

This chapter introduces the development and initial validation phase of the Numeracy Apprehension Rating Scale, of which the author’s previous qualitative research with children (Petronzi et al., 2012) and the first piece of research acted as an item pool. The use of qualitative methods to produce an item pool for scale development is advocated by Mahoney, Thombs and Howe (1995). The research process is discussed in detail in the following method section.

4.2 Summary and outline of study 2

As discussed, assessment scales have traditionally been developed based on other previous scales, typically adapting items for the experiences of the target population. However, to correspond with contemporary development expectations, scales should ideally be created using both methodologies. Mathematics anxiety scales would further benefit from focusing on potential key factors that have been revealed in qualitative data. To adhere to this and to rectify a limitation in the field of mathematics anxiety research – that a U.K. scale does not exist for the assessment of children in the early years of education, focus groups were conducted with the target population (children aged 4-7 years) (Petronzi et al., 2012; chapter 2). Additionally, in the second empirical study within this body of work, primary care providers also provided insight and details of their observations of children’s numeracy behaviours. Children in the U.K. and in the early years of education should have a specifically designed scale, to assess for early numeracy difficulties and anxieties. This is a beneficial alternative to adapting items from scales that have been validated with older populations in the US. Indeed, some factors discussed by children in the author's previous qualitative research i.e. worry, positive effect towards mathematics, success and teacher anxiety. This therefore suggests that underlying issues that influence the onset of mathematics anxiety may stem from the early years of education. Again, this reinforces the need for an assessment scale that was addressed by the current study.

Acknowledging the potential methodological issues of utilizing a scale with children aged 4-7 years, the author aimed to minimise limitations by neutrally wording terms so that children were not
guided into a particular response or misled. Also, emoticon faces were used to simplify the response process and to minimise the eventuality of some children not being able to read to the questions. Further applying the knowledge learned from the implementation of previous mathematics anxiety scales, the NAS used appropriate sample size for the items to be tested following item redundancy and a re-test was conducted in the third empirical study, and will be discussed later in this PhD thesis. Additionally, in the third empirical study, construct validity was tested through giving children numeracy problems to complete along the scale to determine whether a correlation between NAS scores and performance scores was evident.

Ecological validity is often regarded as a strength of qualitative research, and a weakness of quantitative methods. However, this study, to a certain degree, transcends this as the extensive scale development process has first “captured the daily life conditions, opinions, values and attitudes of those to be studied” (Bryman, 2004: 29). Despite this, the author acknowledges the unnaturalness of expressing feelings through quantifiable methods that can result in limited ecological validity. Nonetheless, the NAS (relevant to everyday numeracy experiences) was administered to children in schools, in their numeracy classrooms (their natural setting).

This PhD thesis will present the results of the subsequent factor analysis of empirical studies 2 and 3, following scale administration with children aged 4-7 years. The author will also acknowledge limitations in methodology that naturally exist within the scope of a PhD (e.g. sample size) whilst suggesting improvements for subsequent research to further validate the numeracy apprehension rating scale. In the second empirical study, the numeracy apprehension rating scale was developed based on an item pool of items created by previous qualitative data, and was implemented with children aged 4-7 years and analysed using exploratory factor analysis.
4.3 Method

4.3.1 Design

The study employed a quantitative cross-sectional design to determine the reliability and validity of a numeracy apprehension rating scale (NAS), a 44-item scale consisting of statements that describe day-to-day numeracy lesson situations for U.K. children.

4.3.2 Participants

Participants for the research were recruited through opportunity sampling from four state primary schools, dispersed across the East Midlands region in the U.K. The demographics of the four schools were similar, each with a catchment of predominantly white, middle class families, as informed by the head teachers. In total, 307 children between the age ranges of 4 and 7 participated in the research. A total of 72 girls (52.6%) and 65 boys (47.4%) participated from school one, accounting for 44.6% percent of the overall sample size. In school two, 33 girls (57.9%) and 24 boys (42.1%) participated and accounted for a total of 18.6%. The third school consisted of 38 girls (58.5%) and 27 boys participants, accounting for 21.2% of the total sample size. Finally, 26 girls (54.2%) and 22 boys (45.8%) participated in school four, accounting for 15.6% of the overall sample size. Significantly more participants were obtained in school one, due to it being larger and having more children in the research age range. The children were pupils in either reception (age 4-5 years), year 1 (age 5-6 years) and year 2 (age 6-7 years) and learning at the level of key stage 1. The U.K. education system regards children between the ages of 3 and 4 years as the early years of education and the ages of 4-11 as primary education. One hundred and thirty seven children participated from the first school: 46 from reception (33.6%); 35 from year one (25.5%); 56 from year 2 (40.9%). Fifty-seven children participated from the second school: 11 from reception (19.3%); 26 from year one (45.6%); 20 from year 2 (35.1%). Sixty-five children participated from the third school: 15 from reception (23.1%); 31 from year one (47.7%); 19 from year two (29.2%). Finally, 48 children participated from the fourth school: 10 from reception (20.9%); 16 from year one (33.3%); 22 from year two (45.8%). The participants in the first school accounted for 44.6% of the total number, the second accounted for 18.6%, the third accounted for 21.2% and the fourth school accounted for 15.6% of participants. Across all schools, a total number of eighty two of participating children were in reception (26.7%), one hundred and eight were in year one (35.2%) and one hundred and seventeen were in year two (38.1%). See table 4.1.
The sample size of the research (n = 307) can be regarded as sufficient and acceptable (DeVellis, 2003; Comrey 1973). With a total of 44 items, the current research was judged to have a ratio of 7 participants per item (7 x 44 = 308), therefore adhering to the outlined guidelines.

4.3.3 Materials

A letter was sent to prospectus schools that sought to obtain participation and gave an outline of the research. (appendix vii). A following consent letter was sent to parents through each school (appendix viii) accompanied by a letter written by each of the head teachers, with the intention of further reassuring parents that the research was fully supported by the school (appendix ix). A script for children was also created (appendix x) to introduce the author, to standardise the explanation of the research and to ensure that the style of language used was consistently appropriate for the age range. This was corroborated by teachers from a primary school where the author had previously worked. The details from participation return slips were transferred to a standard participation sheet (appendix xi) that was created for each school, allowing the author to record all essential participant details and scale score on a single document.

4.3.4 The Numeracy Apprehension Scale

The scale initially consisted of 97-items. Twelve of the items were adopted from the author’s undergraduate 13-item mathematics anxiety rating scale (α = .8) (Petronzi & Staples, 2009), that had been developed with 20 primary school children, adapting items, from the Mathematics Anxiety Scale for Children (MASC) (Chiu & Henry, 1990) and the Abbreviated Mathematics Anxiety Rating Scale (Alexander and Martray, 1989).

Fifty-three items of the initial 97-item NAS, developed in this piece of research, were formed from an item pool, based on the author’s previous qualitative research with children (aged 4-7 years), mathematics experts, teachers and parents. An additional nine items were adapted from mathematics anxiety literature, and, for example, included statements that would ask children to consider how they felt when asked to answer a numeracy question in front of the class or when doing column addition.

Thirteen-items of the 97-item NAS were based on Newstead’s (1992) Mathematics Anxiety Questionnaire and a further 10 items were included from the Mathematics Anxiety Questionnaire
for Children (Chiu & Henry, 1990). These were selected as the items most relevant to children. The terminology of these items was adjusted to match the language of which U.K. primary school children are familiar with. The items adapted from the MASC were not the same items adapted for the creation of the author's original MARS. Together, these items were randomly ordered to form the initial 97-item NAS, which was refined to 44 items following item redundancy.

4.3.5 Item Redundancy of the NAS

Item redundancy of the NAS was completed by a total of 9 professionals: 2 mathematics experts; 2 mathematics anxiety researchers; 2 key stage one primary school teachers; 1 primary school special educational needs co-ordinator (SEN); 1 educationalist and 1 primary school head teacher. Each was provided with a 97-item version of the NAS and asked to identify which items in their current state were appropriate to the experiences of children aged 4-7 years. Each was asked to adjust item terminology and structure for those that were fundamentally appropriate; to indicate which items were not focussed on numeracy and to identify items to be removed and to provide a reason for this. For example, some items were similar to others or potentially confusing to children. Others were identified as not being a differentiator between numeracy anxious and non-numeracy anxious children, i.e. if I have to do numeracy work at break time, I feel…The feedback stated that most children would dislike having to do work during their break and relates more to enjoyment. Another removed item example relates to data obtained in the author’s previous research and attempting to understand whether children make a connection between their parents enjoying numeracy and their own feelings. However, feedback advised that children aged 4-7 years would not understand this, and so it was removed. Once all item redundancy feedback had been completed, this was collated by the author. A majority of the items that were removed followed consensus amongst professionals. However, in instances where there was not unanimous agreement, if at least 5 professionals had suggested the removal of an item, this was adhered to. For items to be maintained, the author adjusted terminology and statement structure where advised.

The 44-items related to, for example, teachers; peers and friends; difficulties with work and receiving help or not etc. Children could respond using an emoticon three point Likert-scale, with a face representing ‘happy’, another signified uncertainty and the other represented feeling ‘sad’. Children responding to images on questionnaires has been assessed by the Koala Fear Questionnaire (Muris, Meesters, Mayer, Bogie, Luijten, Geebelen, Bessems & Smit, 2003). This was implemented with children aged 4-12 years and was found to be a valuable instrument for
clinicians and researchers. The images used to represent the three emotions were simple and clear, as also corroborated by teachers, mathematics anxiety researchers and mathematics experts. The same facial images have been consistently used by the author since the original undergraduate research which was the origin of the concept of a psychometrically developed scale for numeracy apprehension.

### 4.3.6 Research Procedure

Prior to data collection, permission to conduct the research was sought from head teachers of schools that had previous connections with the University of Derby and personally with the author. Once head teachers had expressed interest in the research, a meeting was scheduled to enable the author to discuss the research in greater depth and to demonstrate the materials and ensure suitability. Following these meetings, the research within each school was authorised and subsequently, consent forms were left with reception, year one and year two teachers to distribute to children to give to their parents. A response time frame of two weeks was implemented. After this period had elapsed, the author returned to the schools to collect the returned consent slips, so that participant data could be entered onto a participation sheet. All consent slips were locked in a filing cabinet in a postgraduate office in the University of Derby.

For each school, data collection was spread over a number of days, although children in all schools only participated in the mornings. No data was collected in the afternoons, as children’s attention can diminish towards the end of a school day. For each research group, children in reception, year one and year two were taken to a separate and quiet area of the school to avoid extraneous distractions and to encourage concentration. For children in reception, the author limited the group size to a maximum of three, as previous research experience had taught that, although emotionally aware, younger children can struggle to understand the response procedure for scales, and require assistance. A small group size enabled the author to ensure that all children responded to the appropriate statement. For children in year one and two, the maximum group size was increased to between six and eight, as the author had previously found that children in these years were able to understand and follow the response procedure with minimal assistance. Once children had sat down in the research area of the school, introductions were made and children were given time to talk generally, helping to create a relaxed atmosphere. The author used this time to record their names, age and year group on a participation sheet. Following this, the author redirected the children’s attention to the research. A standard introduction to the research was read to each group
and had been written at an age appropriate level. Children also had the opportunity to ask any questions, raise any concerns and were informed that they could stop whenever they liked, which referred to their right to withdraw. Children in all groups were also kindly asked to not discuss their statement responses with each other, as the author’s previous research experience had shown that some children, who initially indicate anxiety, can alter their response if others are expressing confidence. All children were provided with a copy of the 44-item NAS and given a pencil for circling the appropriate emoticon that reflected their feelings. Each group was informed that the author would read each statement to the group and then time would be given for their response. For each scale statement, the author read the statement twice to ensure understanding. Once all children had responded, the author moved on to the next statement. Once the NAS had been completed, the children were thanked for their time and they were each given a sticker, before being taken back to their classroom.

**4.3.7 Ethical Consideration**

The research was cleared through the University of Derby Psychology Research Ethics Committee and adhered to the British Psychological Society ethical guidelines. Consent letters were sent home to parents through the school, outlining the research in a question and answer format, informing of right to data withdrawal and anonymity. This provided them with the opportunity to make an informed decision regarding their child’s participation and included on the letter was a guide for generating a unique reference code, to write on a returnable slip. Participation return slips were subsequently locked in a filing cabinet in the University of Derby, in which only the author had access to. As all research aspects were detailed in the consent letter, debrief at the completion of the study was unnecessary.

**4.3.8 Analysis**

An exploratory factor analysis (EFA) was used to determine the factor structure of the NAS for children aged 4-7 years. This analysis is appropriate for a developing scale, as it evaluates inter-item correlations and enables identification of groups of items that are strongly correlated with each other, which represent a psychological dimension (factor) (Furr, 2011).
4.4 Results

Table 4.1 - Summary of the participant demographics from study 2 for each school

<table>
<thead>
<tr>
<th>Groups</th>
<th>Reception</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Size</td>
<td>82</td>
<td>108</td>
<td>117</td>
<td>307</td>
</tr>
<tr>
<td>School 1 (Males = 65 &amp; Females = 72)</td>
<td>46</td>
<td>35</td>
<td>56</td>
<td>137</td>
</tr>
<tr>
<td>School 2 (Males = 24 &amp; Females = 33)</td>
<td>11</td>
<td>26</td>
<td>20</td>
<td>57</td>
</tr>
<tr>
<td>School 3 (Males = 27 &amp; Females = 38)</td>
<td>15</td>
<td>31</td>
<td>19</td>
<td>65</td>
</tr>
<tr>
<td>School 4 (Males = 22 &amp; Females = 26)</td>
<td>10</td>
<td>16</td>
<td>22</td>
<td>48</td>
</tr>
</tbody>
</table>

4.5 The 44-item NAS

Item redundancy led to the 44-item version of the NAS and was subsequently given to the head teacher and SEN co-ordinator who participated in the redundancy phase, to judge the appropriateness of the items. They deemed all items as appropriate. The 44-item version of the NAS consisted of: 12 items from the authors original MARS (1 item removed through feedback); 19 items from the author’s previous two qualitative research (34 items removed); 5 items from previous mathematics anxiety literature (4 items removed); 4 items from the mathematics anxiety questionnaire (9 items removed) and 5 items from the mathematics anxiety scale for children (5 items removed). The 44-item NAS was subsequently accepted as appropriate by the four head teachers of each participating primary school.

The numeracy apprehension rating scale (NAS) was implemented in the research, with 44 items relating to general thoughts and feelings about numeracy and typical day-to-day numeracy experiences.
4.5.1 Internal reliability and exploratory factor analysis of the 44-item NAS

The exploratory factor analysis was carried out. An initial Cronbach’s Alpha was conducted on the 44 scale items to estimate the internal consistency associated with the scores that could be derived from the scale, representing the variability of a composite score. Cronbach’s alpha was sufficiently high ($\alpha = .905$) as Kline (2000) suggests that a Cronbach’s alpha of .80 is an appropriate value for cognitive tests, and Lacobucci and Duhachek (2003) state that an alpha value of .70 may not be an acceptable reliability level. Additionally, Rattray and Jones (2005) suggest Cronbach’s alpha should exceed .70 for a developing scale. The calculated alpha value of .905 provides a .19 error variance in the scores ($0.90 \times 0.90 = 0.81$; $1.00 - 0.81 = 0.19$) and due to the high estimate of reliability, there is a decrease in the test score that can be attributed to error. However, Tavakol and Dennick (2011) suggest that some items may be redundant if the alpha value is too high, recommending that the alpha value should not exceed 0.90, though the current alpha value does. As this was just over .9, this was regarded as acceptable at this stage.

Standard deviations were therefore assessed to determine whether any items should be removed. A threshold of .6 was implemented and any items below this value were to be removed. Items 1; 12; 15 and 40 were below the value of .6 and would be deleted from the scale.

A Cronbach’s alpha was run again with the items identified by the standard deviations removed. The scale then consisted of 40 items. Cronbach’s alpha for the 40 item scale was .896 and remained sufficiently high. Additionally, this value complied with the criteria outlined by Tavakol and Dennick (2011). However, continuing with the threshold of .6 for standard deviations, item 35 was below this value and would also be removed. Implementing a more robust item total-correlation significance threshold of .35 resulted in items 3; 6; 19; 20; 21; 28; 29; 35 loading beneath this value and would therefore be removed from the data set and a Cronbach’s Alpha was run again. As reported by Field (2009), Stevens (1992) states that factors should load above .0512 for a sample size of 100 and 0.364 for a sample of 200. Given the sample size of the current study ($n = 307$) a minimum required factor loading threshold of .35 was implemented to ensure statistical significance (Shevlin & Miles, 1998; Furr, 2011; Bertsch, 2012).

Had a .4 item-total correlation been implemented, rather than .35 at this stage, only 3 further items would be removed (32, 4 and 9). However, these items are removed later in the validity and reliability phases. Thus, a .4 threshold was not chosen.
A subsequent Cronbach’s alpha was run with the items (<.35) removed. The scale consisted of 32 items. Cronbach’s alpha for the 32 item scale was .912 and had increased with the omission of the previous 8 items. However, this value was in excess of the ideal value outlined by Tavakol and Dennick (2011). All item standard deviations were above the threshold of .6. Again, all items loaded above the more robust .35 minimum statistical significance threshold and so all items were maintained.

A limitation of Cronbach’s alpha is that an acceptable value does not necessarily imply unidimensionality of a scale, and exploratory factor analysis was used to determine the factor structure of the scale and which items loaded to a determined factor. Accordingly, exploratory factor analysis (EFA) was employed on the remaining 32 items, using the extraction method of principal axis factoring (PAF). This views scale item responses as arising from underlying psychological variables (Furr, 2011) with participants indicating apprehension in situations that evoke numeracy apprehension.

Bartlett’s Test of Sphericity was significant (p < .01) and indicated that factor analysis was possible. However, as this is sensitive to sample size, it is necessary to consider the more discriminating index of factor analyzability of The Kaiser-Meyer-Oklin measure of sampling adequacy (KMO). A value of .898 is greater than the recommended values of 0.6 (Pallant, 2001) and 0.7 (Collins, Gomez, Hill, Milliken, Goff & Gregory, 2013) indicating that there are sufficient items for each factor.

Kaiser’s criterion (eigenvalue >1) and the scree test were used to determine the number of factors emerging from the data. An estimate of variance of a factor is demonstrated by this criterion, with a value >1 showing more than average variance (Rattray & Jones, 2005) which is visually represented in the scree plot. An initial PAF revealed the presence of 7 components with eigenvalues exceeding 1 and explained 54.21% of the variance. However, Costello and Osborne (2005) state that the eigenvalue guideline is not as accurate as the scree plot method for determining which factors to retain.

However, the scree plot representation indicated either 1 or 2 factors, with all 32 items loading above the imposed threshold of .35 on the factor matrix for factor 1 and 3 items loading onto factor 2.
With the scree plot and to an extent, the factor matrix suggesting 2 factors, factor extraction was again conducted (PAF) and Kaiser’s criterion was replaced with 2 fixed factors. An oblique rotation method (promax) was used to produce factors that may be correlated with each other. A factor correlation matrix value of .577 demonstrated that factors are not orthogonal and analysis should continue with an oblique rotation.

The pattern matrix was used to determine the strength of items loading onto factor 1 and/or 2. Fifteen items (item: 44; 41; 31; 42; 14; 27; 36; 11; 18; 43; 5; 7; 38; 2; 32) loaded above the minimum threshold (.35) for factor 1 and 12 items (item: 24; 13; 23; 30; 26; 10; 17; 8; 25; 37; 16; 39) loaded above this threshold for factor 2. Items 33; 4; 34; 22 and 9 did not load onto either factor. These items were therefore removed from the scale and a Cronbach’s alpha was re-run.

The identified items were dropped from the scale, as suggested by factor analysis, leaving 27 items. Cronbach’s alpha was run again and produced a value (α = .900) that fit the criteria of Tavakol and Dennick (2011). All item standard deviations were appropriate (> .6) and corrected-item total correlations showed that all items, except item 32, loaded appropriately (> .35). Item 32 was therefore removed from the scale and Cronbach’s alpha was re-run.

Cronbach’s alpha was run again on the 26-items and produced a sufficiently high and acceptable value (α = .899). All item standard deviations were above .6 and corrected item total correlations showed that all items loaded above the minimum statistical significance threshold (.35).

Exploratory factor analysis was again employed, using principal axis factoring. The Kaiser-Meyer-Oklin value was sufficiently high (.895) and Bartlett’s test of sphericity remained significant (p < .01). Principal axis factoring revealed the presence of 5 components with eigenvalues exceeding 1. However, the scree plot indicated 2 factors, with all 26 items loading above .35 for factor 1, and 3 items loading for factor 2.

With the scree plot and, to an extent, the factor matrix suggesting 2 factors, factor extraction was again conducted (PAF) and Kaiser’s criterion was replaced with 2 fixed factors. An oblique rotation method (promax) was used. A factor correlation matrix value of .54 demonstrated that factors were not orthogonal and analysis should continue with an oblique rotation, to determine the factor structure of the scale.
Factor extraction was conducted (PAF), Kaiser’s criterion was replaced with 2 fixed factors and an oblique rotation method was used. The factor pattern matrix was again used to determine the strength of item loading onto factor 1 and/or factor 2. All 26 items loaded. 14 items (item: 44; 41; 31; 42; 14; 27; 36; 11; 18; 43; 5; 7; 2; 38) loaded onto factor 1 and 12 items (item: 24; 13; 23; 30; 26; 10; 17; 8; 25; 37; 16; 39) loaded onto factor 2, and can be seen in table 4.2. Factor 1 related to Prospective Numeracy task Apprehension and factor 2 related to On-line Number Apprehension.
Table 4.2 - Factor Loadings of Items for the Numeracy Apprehension Scale (.35 threshold)

<table>
<thead>
<tr>
<th>Item</th>
<th>Prospective Numeracy Task Apprehension</th>
<th>On-line Number Apprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q44: Listening to the teacher in a numeracy class makes me feel…</td>
<td>.780</td>
<td>-</td>
</tr>
<tr>
<td>Q41: Walking into the numeracy class makes me feel…</td>
<td>.742</td>
<td>-</td>
</tr>
<tr>
<td>Q31: When I read questions in numeracy, I feel…</td>
<td>.673</td>
<td>-</td>
</tr>
<tr>
<td>Q42: Starting a new topic in numeracy makes me feel…</td>
<td>.592</td>
<td>-</td>
</tr>
<tr>
<td>Q14: When I practise numeracy, I feel…</td>
<td>.567</td>
<td>-</td>
</tr>
<tr>
<td>Q27: If I have to do numeracy work in my head, I feel…</td>
<td>.547</td>
<td>-</td>
</tr>
<tr>
<td>Q36: When I watch or listen to my teacher explain a numeracy problem, I feel…</td>
<td>.533</td>
<td>-</td>
</tr>
<tr>
<td>Q11: When my teacher wants me to do numeracy at home, I feel…</td>
<td>.533</td>
<td>-</td>
</tr>
<tr>
<td>Q18: If I have to finish all my numeracy work in lesson, I feel…</td>
<td>.487</td>
<td>-</td>
</tr>
<tr>
<td>Q43: Thinking about numeracy outside of class makes me feel…</td>
<td>.477</td>
<td>-</td>
</tr>
<tr>
<td>Q5: When I explain how I got my answer to my teacher, I feel…</td>
<td>.410</td>
<td>-</td>
</tr>
<tr>
<td>Q7: When I am asked to do lots of numeracy in class, I feel…</td>
<td>.393</td>
<td>-</td>
</tr>
<tr>
<td>Q2: When I see lots of numbers, I feel…</td>
<td>.381</td>
<td>-</td>
</tr>
<tr>
<td>Q38: When I have to explain a numeracy problem to my friends, I feel…</td>
<td>.368</td>
<td>-</td>
</tr>
<tr>
<td>Q24: If I am the last to finish numeracy work on my table, I feel…</td>
<td>-</td>
<td>.711</td>
</tr>
<tr>
<td>Q13: If I answer questions and get them wrong, I feel…</td>
<td>-</td>
<td>.643</td>
</tr>
<tr>
<td>Q23: If I think I can’t do my numeracy work, I feel…</td>
<td>-</td>
<td>.640</td>
</tr>
<tr>
<td>Q30: If other children finish their numeracy work very quickly, I feel…</td>
<td>-</td>
<td>.618</td>
</tr>
<tr>
<td>Q26: If I make a mistake in numeracy, I feel…</td>
<td>-</td>
<td>.594</td>
</tr>
<tr>
<td>Q10: If I don’t finish my number work in class, I feel…</td>
<td>-</td>
<td>.586</td>
</tr>
<tr>
<td>Q17: When I can’t do my numeracy work, I feel…</td>
<td>-</td>
<td>.577</td>
</tr>
<tr>
<td>Q8: When my friends finish their numeracy before me, I feel…</td>
<td>-</td>
<td>.551</td>
</tr>
<tr>
<td>Q25: If other children know that I find numeracy hard, I feel…</td>
<td>-</td>
<td>.501</td>
</tr>
<tr>
<td>Q37: When I have someone watching me while I do my numeracy, I feel…</td>
<td>-</td>
<td>.416</td>
</tr>
<tr>
<td>Q16: If I have to tell the teacher that I don’t understand my numeracy work, I feel…</td>
<td>-</td>
<td>.397</td>
</tr>
<tr>
<td>Q39: When I have to explain a numeracy problem to my teacher, I feel…</td>
<td>-</td>
<td>.390</td>
</tr>
</tbody>
</table>

Values signify rotated factor loadings – all values below .35 were omitted.
4.6 Discussion

The quantitative results of study 2 satisfied the aims and objectives of applying qualitative findings from primary care providers and children and producing an item pool to develop and test the Numeracy Apprehension Rating Scale with children aged 4-7 years.

Factor analysis of the 44-items implemented with children and then reduced to 26-items, indicated a two-factor structure. Since the implementation of the original MARS which assumed the unidimensionality of mathematics anxiety, subsequent factor analysis studies have produced evidence to suggest that a range of factors have an association with mathematics anxiety. Despite a significant variance in the target population, the results of the current factor analysis were consistent with this, identifying a factor relating to prospective numeracy task apprehension (factor 1) and another that related to apprehension when completing a numeracy task (factor 2). Items that loaded onto factor one seemed to have an association with participating in numeracy tasks i.e. having to finish all numeracy work in lesson time and explaining an answer to the teacher. Moreover, this factor seemed to be related to prospective numeracy tasks i.e. seeing lots of numbers, walking into a numeracy lesson and when thinking about numeracy outside of school time. The second factor was strongly associated with feelings in situations that could arise on a daily basis when completing numeracy tasks i.e. making mistakes, friends finishing work after others and explaining a numeracy problem to the teacher.

The factor analysis in this study maintained items that relate to underlying factors of mathematics anxiety, as shown in research with older populations. For example, the MAS-U.K. (Hunt, Clark-Carter & Sheffield, 2011) identified evaluation anxiety as a factor with an undergraduate population and the post factor analysis NAS has maintained item 37, that relates to being observed when performing a numeracy task. This shows a similarity between mathematics anxiety in older populations and numeracy apprehension in children aged 4-7 years. In addition to this, many of the items maintained in the NAS relate to worry, including children perceiving that they cannot do their numeracy work and thinking about numeracy outside of the classroom environment. These findings also reflect the discussions of study 1, suggesting that the development process of the Numeracy Apprehension Rating Scale had been based on detailed and relevant insight from primary care providers. Worry was a key factor identified by Kazelskis (1998) when testing the RMARS, the Mathematics Anxiety Scale and the Mathematics Anxiety Questionnaire with older populations. This again demonstrated that factors that are influential in later years, are also evident in the early
education years and reinforce the development of an assessment measure. Moreover, items that related to teacher anxiety were also maintained in the NAS, suggesting a degree of validity as this had been a key point raised in the discussions of study 1. These items included listening to a teacher in a numeracy class, explaining a numeracy problem to the teacher and a child having to tell them that they do not understand their work. Teacher anxiety was a main factor identified by Chiu and Henry (1990) using the Mathematics Anxiety Scale for Children for ages 9-14 years. Again, this suggests that factors in the later years have their origins in the early years of education, based on the factor analysis of the NAS. Moreover, the implementation of an assessment measure of numeracy apprehension in schools was again reinforced. Similarly, Chiu and Henry (1990) and also Alexander and Martray (1989) using the Revised Mathematics Anxiety Rating Scale (undergraduate population) identified evaluation anxiety and concern with mathematics evaluation. Likewise, Hunt et al (2011) found evaluation anxiety as a factor associated with undergraduate student anxiety. This further corresponds with the remaining items of the NAS, for example, providing an incorrect answer, being the last to finish numeracy work on the table and having someone watch during a numeracy task. These suggest that the underlying factors that can negatively influence the mathematics experiences of older populations are also experienced by children aged 4-7 years. This suggests that mathematics anxiety may stem from the initial development of numeracy apprehension and is based on consistent negative experiences throughout an educational career. The maintenance of items relating to factors identified in older population with regards to mathematics anxiety indicates the necessity for the current research and supports the author’s theory that numeracy apprehension is a foundation phase of mathematics anxiety.

The Numeracy Apprehension Rating Scale also produced a high internal consistency value ($\alpha = .899$) and exceeds the value of .70 which Lacobucci and Duhachek (2003) considered to be an unacceptable reliability value and which Rattray and Jones (2005) suggested a developing scale should exceed. The internal reliability of the Numeracy Apprehension Rating Scale also compared favourably with previous mathematics anxiety scales, particularly those that have been implemented over a number of studies and adapted from other validated measures. For example, the MARS-A produced an internal reliability value of .89 – 0.96 (Suinn and Edwards, 1982) and the MARS-E with an internal reliability value of .8 (Suinn, Taylor and Edwards, 1988). However, whilst the internal reliability can be regarded as a strength of the NAS, the loading thresholds do not yet reflect those of the scales predecessors. A minimum statistical loading threshold of .35 was reinforced by Stevens (1992) who stated that factors should load above .0512 for a sample size of 100 and 0.364 for a sample of 200. Considering the sample size of study 2 ($n = 307$) a minimum
required factor loading threshold of .35 was acceptable. Despite this, the factor structures of previous scales have been statistically supported by higher loading thresholds than the NAS. For example, Bai (2011) found items of the Revised Mathematics Anxiety Scale to load between .67 and .89 whilst Hunt et al (2011) initially found a majority of items of the MAS-U.K. to load at .45. Yet, with regards to Bai (2011) it can be argued that a higher loading threshold was required due to a lower sample size \((n = 78)\) in comparison to the NAS in this study \((n = 307)\) and significantly less items \((14\)-items\). As can be seen in table 4.2, four items loaded above .4; ten items loaded above .5; four items loaded above .6 and three items loaded above .7. Thus, if for example, a .5 threshold had been in place, the NAS after factor analysis would still have comprised of 17-items. The four items that loaded above .6 were all associated with making mistakes, getting answers wrong in numeracy, peer comparison and reading numeracy questions. This reinforces that failure in numeracy has a significant association with apprehension for children in the early years of education and that comparison against peers is evident. Similarly, the items that loaded above .5 relate to not finishing work, other children being aware of their difficulties and being asked to complete a numeracy task at home. The .5 threshold also included the item that relates to mental arithmetic, supporting previous literature and the discussions groups of study 1 and further demonstrating the children aged 4-7 years share similar experiences with those of older populations. The three highest loading items above .7 related to walking into a numeracy lesson, listening to the teacher and being the last to finish a numeracy task on a group table. The results are also significant in that they highlight apprehensive feelings, simply from the expectation of a numeracy lesson, which extends to the instruction provided by the teacher. This demonstrates that children who are apprehensive at the start of a lesson will likely encounter difficulties in concentrating on the introduction to the numeracy task by the teacher and be unable to follow guidance. This seemingly relates to the high loading of the item that corresponded with being the last to finish a task, as children may simply not know what to do. This will also implicate evaluation anxiety, which has been the strongest factor found in previous studies assessing the dimensionality of mathematics anxiety.

Initially 44-items, the factor analytic process of study 2 reduced the NAS to 26-itmes. Traditional mathematics anxiety measures have typically implemented a significantly larger number of items for older populations i.e. 98-items (MARS) (Richardson & Suinn, 1972) and 69-items (RMARS) (Alexander & Martray, 1989). However, scales intended for age ranges more close to that of the NAS have comprised of item totals that reflect that of the current measure (26-items) i.e. 26-items (MARS-E, ages 9-12) (Suinn et al., 1988) and 22-items (MASC, ages 9-14) (Chiu & Henry, 1990). This is particularly advantageous for the target population of the NAS, as a high number of items
can become cumbersome for young children, particularly those aged 4-5 years in reception. Children may become bored and fatigued with the repetition of completing a measurement scale, and thus provide responses that are not true reflections of their feelings and experiences. The 44-item iteration of the NAS implemented in study 2 with children aged 4-7 years was found to be at the threshold of attention for children aged 5-7 years, whilst those aged 4 required additional support and encouragement. This is perhaps associated with less advanced reading skills. Thus, these children were more dependent on support from the author with regards to reading questions and understanding how to answer appropriately. To control for this, group sizes in reception were kept to a maximum of three, so that the author could provide sufficient support to each of the children and ensure that they understood the question. In contrast, based on previous scale research, the author was aware that older children are able to read and understand the items and follow the response procedure. Therefore, group sizes maintained between six and eight participants, and still enabled the author to provide support or clarification.

In the author’s previous qualitative study with children, an insight was obtained following focus group discussions in relation to how children’s responses to questions can be influenced by the author. Children’s knowledge of basic emotions typically develops by the age of three, enabling recognition of happy and sad, though at this stage, they are continually learning social emotions such as shame and guilt (Izard & Harris, 1995). Ackerman and Izard (2004) report that children’s expression knowledge enables them to identify subtle facial indications of emotions of other people, including fear. Based on the emotional expressions of others, Ackerman and Izard (2004) additionally state that children are also capable of using verbal labels in memory associated with emotional cues. Thus, when responding to scale items that relate to specific numeracy situations and which could be regarded as intrinsically negative i.e. when not being able to complete numeracy work, the author read each item neutrally and without any suggestive expression, either verbally or facially. Again, this was particularly the case with the children in reception, as they required items to be read to them. However, the author’s awareness supported the independent responses of the children. Relating to this, the items were also neutrally termed and did not lean towards either a positive or negative effect (Black, 1999) thus allowing the children to respond as they felt.

The validity and reliability of the research could be increased through the inclusion of a more diverse population and from a larger range of schools. The participants in the current research were predominantly white, middle class children in one region of the U.K. However, the NAS would be
more representative if implemented across a wider cross-section of the country and in schools ranging from rural areas, to inner-cities. This could be a focus for research with the aim of further developing the NAS, as the author acknowledges this research as development of the NAS and further testing and analysis is required. A replication of implementing the 44-item iteration of the NAS would be beneficial, as it would demonstrate whether the same or similar items were maintained and if these suggested similar factor structures.

Nonetheless, this research has gone some way to rectifying the limitations of previous mathematics anxiety research. The development of an initial iteration of the NAS and the subsequent results after implementation with children aged 4-7 years has further supported that a state of apprehension emerges as an origin of mathematics anxiety, reflecting the same view as Mazzocco et al., (2012) who considered mathematics anxiety to be rooted within the early years of education. Mazzocco (2007) and Ashcraft and Moore (2009) stated that the appropriate tools have not been developed in order to examine anxiety and those at risk of mathematics difficulties in early education, but this has, to an extent, been addressed by the initial development of the NAS. The factor structure that emerged following statistical analysis reflects those of similar assessments measures implemented with older populations, again suggesting that mathematics anxiety is closely associated with the early years of education. In this same way, the 26-items maintained on the NAS show similarities to previously validated mathematics anxiety scales and highlight associations with, for example, teachers; evaluation anxiety, observation anxiety and failure. These items also directly relate to the qualitative findings of study 1 and previous research (Petronzi et al., 2012) that relates to Morse (1994) who considered qualitative research to be at the core of important work and to lay the theoretical foundations for quantitative methods to test.

A direct comparison cannot be made between the NAS and other mathematics anxiety assessment measures, as the NAS was developed specifically for the numeracy experiences of children aged 4-7 years and to the author’s knowledge, remains the only scale to do so. Some measures have been developed, in which children in the older years of primary school can respond, i.e. children aged 9-10 years can complete the MARS-E (Suinn et al., 1988) and the MASC (Chiu & Henry, 1990) can also include children aged 9-10 years. Yet, this remains beyond the age range of the NAS and can be considered as not addressing the early educational years, as the NAS has demonstrated that children from the age of 4 years can develop apprehensive feelings towards numeracy.
Despite the NAS addressing a limitation of psychological research in the area of the development of mathematics anxiety, the scale requires further implementation and analysis before it can be considered as a valid and reliable measure of numeracy apprehension. Thus, in study 3 of this PhD thesis, the 26-item iteration of the NAS was implemented with children aged 4-7 years.

To summarise, the NAS demonstrated that it can be a valid measure of numeracy apprehension in children aged 4-7 years and was able to identify 2 underlying factors of children’s numeracy experiences. These related to items that were supported in the discussions of chapter 2 (Petronzi et al., 2012) and in study 1, whilst also reflecting previous empirical data with older children and populations. It can therefore be assumed that some children in the early years of numeracy education are at risk of apprehensive and worrisome thoughts, and that an assessment measure could prove valuable to teachers. The data reinforces continued development of the NAS, to strengthen validity and reliability. This would determine whether the NAS could be a predictor of numeracy performance, and in study 3, the scale was completed alongside a numeracy task to measure construct validity.
CHAPTER FIVE

5 Further development of the numeracy apprehension scale

5.1 Introduction

As discussed prior to this chapter, many scales have and continue to be developed for the assessment of mathematics anxiety in older populations. These scales have progressively identified a large number of varying underlying mathematics anxiety factors, although these cannot be directly related to the experiences of children aged 4-7 years. The previous study of this PhD thesis went some way to rectifying criticisms that appropriate assessments have not been developed to support the identification of children at risk of numeracy difficulties, including apprehension.

This chapter introduces the final stage of development of the NAS – within the scope of this PhD. Following study 2, the NAS consisted of 26-items and were associated with either factor 1 (Prospective Numeracy Task Apprehension) or factor 2 (On-line Number Apprehension). However, the scale required further development with the same age range (age 4-7 years) to increase the statistical robustness. Simultaneously, the construct validity of the scale was tested by comparing scale scores against numeracy performance.

Numeracy apprehension has been suggested as a foundation phase of mathematics anxiety and has been considered as distinct from other dimensions (Kazelskis, 1998). This is based on the identification of number anxiety as an underlying factor by assessment scales. As highlighted throughout this PhD thesis, a number of factors may influence the development of apprehension that relate to mathematics anxiety. These factors include: negative evaluation from peers and teachers (Beck, 1989; Ashcraft & Krause, 2007); pessimistic attitudes (Al-Minshawi, 2006); low confidence (Harari et al., 2013); low self-efficacy (Meece et al., 1990); a resignation to failure (Ashby, 2009); worry relating to performance (Hachey, 2009); reduced motivation (Anthony 2000; Tella, 2007; Zakaria & Nordin, 2008) and avoidance of perceived complex tasks (Chinn, 2012). Norwood (1994) and Hadfield and McNeil (1994) considered that mathematics anxiety is a product of multiple factors, rather than one influential cause. The authors suggest that an interaction exists between various factors and numeracy attitudes in early education, such that an association exists between negative experiences and lower performance.
However, due to the limited research focus in early education, the influence of such factors could only be applied to the experiences of children aged 4-7 years through assumptions and speculation alone. Although there is now emerging research in this area of mathematics with a focus on the primary school years (e.g. Mizala, Martinez & Martinez, 2015; Ramirez et al., 2013; Harari et al., 2013) the author’s previous qualitative research went some way to addressing this and identified factors in the early years of mathematics education. In addition, this research also presented factors that may have previously been underestimated or not considered as influencing early numeracy attitudes. Study 2 of this PhD thesis used the qualitative data item pool to form the initial version of the Numeracy Apprehension Rating Scale. To the author’s knowledge and at the time of writing, this scale is the first in the U.K. to quantifiably measure the numeracy experiences and reactions of children aged 4-7 years.

5.2 Construct validity and the current study

Study three endeavoured to expand on the findings of the previous implementation of the NAS. The 26-item measure was completed by a replication sample to further refine the scale items through statistical rigour. In conjunction with this, the children completing the NAS would also be required to complete an intermediate difficulty numeracy task, relative to their year group. This was used as a measure of construct validity and would yield whether the scale scores had an association with numeracy performance.

Construct validity is a key aspect of psychological research and is the basis of research in which a measure, such as the NAS, is implemented to study a variable that is not observable, including mathematics anxiety and numeracy apprehension. In other words, construct validity is the extent to which items on an instrument relate to the relevant theoretical construct (Parsian & Dunning, 2009). Construct validity is typically established by presenting correlations between a measure of a construct i.e. the NAS, and other measures that should be associated with it, i.e. numeracy performance scores (Westen & Rosenthal, 2003). The measure and variables should correlate in a theoretically predictable manner. In the case of this research, the prediction would be that children who score higher for apprehension on the NAS will have lower scores on a numeracy task.

Construct validity has been tested for in previous mathematics anxiety research in which a scale has been utilised. Measures of construct validity have typically varied. For example, the construct validity of the MARS (Richardson & Suinn, 1972) was assessed through determining differences in
scale scores prior to, and following an intervention. Results showed that scale scores remained higher for those that did not receive mathematics anxiety intervention, thus assuming a degree of construct validity through an association with the MARS measure and the mathematics anxiety construct. Alternatively, Suinn and Edwards (1982) determined the construct validity of the MARS-A by comparing grade averages against scores on the MARS-A. The results indicated an association between higher anxiety scores and lower mathematics grade averages, suggesting construct validity of the scale. Similarly, Suinn et al (1988) correlated children’s SATs scores with their scores on the MARS-E, in which a relationship was found. Again, this supported construct validity of the MARS-E. Chiu and Henry (1990) determined construct and convergent validity of the MASC by comparing participant’s scores against the shortened version of the MARS, their most recent mathematics results, scores from completing the Test Anxiety Scale for Children (Wren & Benson, 2004) and the School achievement Motivation Rating Scale (Chiu, 1997). This method for assessing construct validity can be considered as more rigorous, as the MASC was not only compared against performance scores, but also previously validated assessment scales. To summarise, the examples of construct validity testing in mathematics anxiety research demonstrate some of the methods in which this can be assessed. However, evidence of construct validity in a single piece of research does not ascertain that construct validity exists.

In the final study, following the statistical refinement of items in study 2, the 26-item NAS was administered to another sample of children aged 4-7 years, to further test the validity and reliability of the items through subsequent factor analysis. This would further determine whether the prevalent items are those that relate to previous mathematics anxiety rating scales and the author’s qualitative data with children aged 4-7 years. Additionally, a key point of interest was whether two distinctive factors would again be identified, or if further factors would emerge. In the case of a single factor, that would presumably represent numeracy apprehension, it would be assumed that the remaining items related to the key influences in how children experience numeracy in a negative fashion. Children responding to the NAS would also complete a numeracy task in order to test the construct validity of the scale, through determining whether a relationship between scale and numeracy task scores was evident. Unlike some previous research, this was the single measure of construct validity as a comparison scale for mathematics anxiety in children aged 4-7 years has, yet to be developed, to the author’s knowledge. The hypothesis for this research was that there would be an association between numeracy apprehension scores and performance, such that those who report higher apprehension should demonstrate lower performance.
5.3 Method

5.3.1 Design

The study employed a quantitative cross-sectional design to further determine the reliability and validity of a numeracy apprehension rating scale (NAS), in its 26-item iteration following factor analysis. Numeracy performance was the dependent variable in the research, whilst school, gender and scores on the NAS were the independent variables. The scale consisted of statements that describe day-to-day numeracy lesson situations for U.K. children aged 4-7 years. To begin testing the construct validity of the NAS, the children participating in the research were also required to complete a numeracy task to determine if performance scores have an association with numeracy apprehension scores, as measured by the NAS.

5.3.2 Participants

As in study 2, participants for the research were recruited through opportunity sampling from two state primary schools, separated by a distance of roughly 45 miles across the East Midlands region in the U.K. The demographics of the two schools that agreed to participate were similar, each with a catchment of predominantly white, middle class families. In total, 163 children between the age ranges of four and seven participated in the research. A total of 39 males (23.9%) and 36 females (22.1%) participated from school one, accounting for 46% of the overall sample size. In school two, 51 males (31.3%) and 37 females (22.7%) participated and accounted for a total of 54% of the sample size. The children in the research were pupils in either reception (age 4-5), year 1 (age 5-6) and year 2 (age 6-7) and learning at the level of key stage 1. Seventy five children participated from the first school (19 reception (25.3%); 36 year one (48%); 20 year two (26.7%)) and 88 participated from the second school (40 reception (45.4%); 21 year one (23.9%) and 27 year two (30.7%)). Across all schools, a total number of 59 children were in reception (36.2%), 57 children were in year one (35%) and 47 children were in year two (28.8%). Again, reflecting on the guidelines of Tinsley and Tinsley (1987) who suggest a ratio of 5 to 10 participants per item, the sample size of the research (n = 163) can be regarded as sufficient and acceptable, as this equates to roughly 6.27 participants per item (26 items) \((6.27 \times 26 = 163.02)\), therefore adhering to the guidelines.
5.3.3 Materials

A letter was sent to prospective schools to obtain permission to recruit pupils that gave an outline of the research. (appendix xii). Following permission from the head teacher, a consent letter was sent to parents through each school (appendix xiii). A script for children was also created (appendix xiv) to introduce the author, to standardise the explanation of the research and to ensure that the style of language used was consistently appropriate for the age range. This had been corroborated by teachers from a primary school in which the author had previously worked. The details from participation return slips were transferred to a standard participation sheet (appendix xv) that was created for each school, allowing the author to record all essential participant details and scale score on a single document.

5.3.4 The Numeracy Apprehension Scale

The numeracy apprehension rating scale (NAS) was implemented in the research and consisted of 26 statements. These were randomly assigned from 1 to 26, and related to general thoughts and feelings about numeracy and typical day-to-day numeracy experiences, that related to, for example, teachers; peers and friends; difficulties with work and receiving help or not etc. Following factor analysis, the items fell into either factor 1 (14-items; prospective numeracy task apprehension) or factor 2 (12-items; on-line number apprehension) and provided a sufficiently high and acceptable internal consistency (α = .89). As in study 2, children could respond using an emoticon three point Likert-scale, with a face representing ‘happy’, another signified uncertainty and the other represented feeling ‘sad’. The same facial images have been consistently used by the author since the original undergraduate research which was the origin of the concept of a psychometrically developed scale for numeracy apprehension.

5.3.5 The Numeracy Task

A numeracy task that was implemented with children in reception, year one and year two was the same task that had previously been used in the author’s undergraduate research. Teachers of reception, year one and year two were asked to create a set of intermediate numeracy problems that were age appropriate (appendix xvi - xvii). These same problem sets were used again as they had been successful in the previous research and were created utilizing teacher expertise and understanding of children’s abilities in each year group. The numeracy task for reception children
is more pictorial based and called upon a knowledge of shapes, addition, subtraction, missing numbers and visual identification of more and less. For year one and two children, the numeracy task included longer addition, money, division, multiplication and using numbers to make a specified value. A time limit was not enforced when children were completing the numeracy task, as the intention was to measure their ability without a pressure situation acting as a confounding variable. However, the children were asked to do their own work, to complete as much of the task as possible and to hand it in when they had finished – to whatever extent that may be. To avoid children becoming anxious when asked to do their own work, they were informed that the task was not a test and that the teacher would not see their answers. Reception children could achieve a maximum score of 18, whilst year 1 and 2 children could achieve a maximum score of 20. However, these scores were converted to percentages.

5.3.6 Research Procedure

For the most part, the research procedure replicated that of study 2. Prior to data collection, permission to conduct the research was sought from head teachers of a number of schools in the East Midlands region. Once head teachers had expressed interest in the research, a meeting was scheduled to enable the author to discuss the research in greater depth and to demonstrate the materials and ensure suitability. Following these meetings, the research within each school was authorised and subsequently, consent forms were left with reception, year one and year two teachers to distribute to children to give to their parents. A response time frame of two weeks was implemented. After this period had elapsed, the author returned to the schools to collect the returned consent slips, so that participant data could be entered onto a participation sheet. All consent slips were locked in a filing cabinet in a postgraduate office in the University of Derby.

For each research group, children in reception, year one and year two were taken to a separate and quiet area of the school to avoid extraneous distractions and to encourage concentration. For children in reception, the author again limited the group size to a maximum of three, as previous research experience had taught that, although emotionally aware, younger children can struggle to understand the response procedure for scales, and require assistance. A small group size enabled the author to ensure that all children responded to the appropriate statement. For children in year one and two, the maximum group size was increased to between six and eight, as the author had previously found that children in these years were able to understand and follow the response procedure with minimal assistance. Once children had sat down in the research area of the school,
introductions were made and children were given time to talk generally, helping to create a relaxed atmosphere. The author used this time to record their names, age and year group on a participation sheet. Following this, the author redirected the children’s attention to the research. A standard introduction to the research was read to each group and had been written at an age appropriate level. Children also had the opportunity to ask any questions, raise any concerns and were informed that they could stop whenever they liked, which referred to their right to withdraw. Children in all groups were also kindly asked to not discuss their statement responses with each other, as the author’s previous research experience had shown that some children, who initially indicate anxiety, can alter their response if others are expressing confidence. All children were provided with a copy of the 26-item NAS and given a pencil for circling the appropriate emoticon that reflected their feelings. Each group was informed that the author would read each statement to the group and then time would be given for their response. For each scale statement, the author read the statement twice to ensure understanding. Once all children had responded, the author moved on to the following statement. Once the NAS had been completed, the children were thanked for their time and then returned to their class. The NAS was completed prior to the numeracy task, so as to avoid response bias.

All participating children completed the numeracy task as a large group, although this was on a separate day to avoid fatigue. It was explained to the children that this was not a test and that they should complete as much of the task as possible. They were also informed that there was no time limit, and that they did not need to rush their work. The class teacher assisted in overseeing the completion of the numeracy task and to ensure that children completed their work independently – although they were given assistance in reading the questions, particularly children in reception. Following the completion of the numeracy task, these were collected and matched up to each child’s completed NAS.

5.3.7 Ethical Considerations

The research was cleared through the University of Derby Psychology Research Ethics Committee and adhered to the British Psychological Society ethical guidelines. Consent letters were sent home to parents through the school, outlining the research in a question and answer format, informing of right to data withdrawal and anonymity. As all research aspects were detailed in the consent letter and children were thanked for their time and effort upon completion of the scale and numeracy task.
5.3.8 Analysis

An exploratory factor analysis (EFA) was again conducted to determine the factor structure of the NAS. Exploratory factor analysis is frequently used to validate a measurement model, for example, Zhu and Kraemer (2005) tested the robustness of a measurement model using EFA and, relating to the current research, Koh, Ang and Straub (2004) selected EFA to assess construct validity. This analysis remained appropriate as the NAS was a developing scale and construct validity was tested in this piece of empirical research. This analysis enabled the removal of scale items that did not meet the minimum statistical threshold for internal reliability. In addition, bivariate correlations were conducted to demonstrate whether any associations existed amongst the predictor variables and the criterion variable (numeracy performance score). Furthermore, multiple regression was implemented using the enter method and subsequently, the stepwise method, to determine if the criterion variable (numeracy performance scores) could be predicted by any of the research variables, that included primary school (2 levels), gender (2 levels) and the 19-item NAS scores following exploratory factor analysis. The variables in the research were a combination of categorical and continuous. The stepwise method highlighted the research variables that best predicted numeracy performance scores. Finally, linear regression and curve fit were conducted to further verify which research variable was the best predictor of the criterion variable.
5.4 Results

5.4.1 Participant demographics

The demographic table 5.1 presents the ages and gender of children from each year group and school.

Table 5.1 - Summary of the participant demographics from study 3 for each school and overall

<table>
<thead>
<tr>
<th>Groups</th>
<th>Reception</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Size</td>
<td>59</td>
<td>57</td>
<td>47</td>
<td>163</td>
</tr>
<tr>
<td>School 1</td>
<td>19</td>
<td>36</td>
<td>20</td>
<td>75</td>
</tr>
<tr>
<td>School 2</td>
<td>40</td>
<td>21</td>
<td>27</td>
<td>88</td>
</tr>
<tr>
<td>Overall Age (Mean = 5.6 &amp; SD = .88)</td>
<td>(4-5)</td>
<td>(5-6)</td>
<td>(6-7)</td>
<td>0</td>
</tr>
<tr>
<td>Age 4</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Age 5</td>
<td>46</td>
<td>24</td>
<td>0</td>
<td>70</td>
</tr>
<tr>
<td>Age 6</td>
<td>0</td>
<td>33</td>
<td>16</td>
<td>49</td>
</tr>
<tr>
<td>Age 7</td>
<td>0</td>
<td>0</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>School 1 Males</td>
<td>8</td>
<td>19</td>
<td>12</td>
<td>39</td>
</tr>
<tr>
<td>School 1 Females</td>
<td>11</td>
<td>17</td>
<td>8</td>
<td>36</td>
</tr>
<tr>
<td>School 2 Males</td>
<td>22</td>
<td>13</td>
<td>16</td>
<td>51</td>
</tr>
<tr>
<td>School 2 Females</td>
<td>18</td>
<td>8</td>
<td>11</td>
<td>37</td>
</tr>
<tr>
<td>Overall Males</td>
<td>30</td>
<td>32</td>
<td>28</td>
<td>90</td>
</tr>
<tr>
<td>Overall Females</td>
<td>29</td>
<td>25</td>
<td>19</td>
<td>73</td>
</tr>
</tbody>
</table>

In Table 5.1, it can be seen that the total number of participants in each year group did not vary greatly, with the largest group being reception, followed by year one and then year two. The difference between the largest overall group (reception) and the smallest group (year 2) was 12 participants. Again, the table shows that there was not a large variation in the total number of participants from school 1 and school 2, with the difference being 13 participants. Breaking this
down further, for the reception group, it can be seen that roughly double the participant number was obtained in school 2, and is thus accountable for a larger proportion of the overall reception results. In contrast, the overall group size for year one is more attributable to school 1, which provided 15 more participants than school 2. Finally, the overall group size for year 2 children was fairly similar across the two schools, with only a difference of 7 participants, again in favour of school 2. In terms of age, the age of 4 was the least represented due to this being the lowest age and only in one year group, whilst age 7 was the next lowest, due to this age also being in year 3, and not a part of this research. On the other hand, children aged 5 and 6 typically occupy two year groups within the scope of this research, thus accounting for larger group sizes. The most represented age group was age 5, which was significantly larger than age 4 and age 7. Children aged 6 were the second highest represented age group, and seemingly mid-way in terms of group size, between the highest and next lowest age groups. As can also be seen from table 1, males were overall more represented in the research than females, although not by a significant margin, with a difference of 17 participants. Interestingly, the total male and female numbers in reception were almost identical, with only a small difference in year 1, and a slightly larger difference in year 2. Overall, in each year group, male participants outnumbered female participants. Looking at this in more detail across the two schools, it can be seen that more males were obtained in school 2 than school 1, whereas an almost identical number of female participants were obtained in each school, with a difference of 1 participant. The largest female group was reception in school 2 with the lowest being equally year 2 in school 1 and year 1 in school 2. The largest male group was also reception in school 1 and the lowest being reception in school 1.

5.4.2 Tests of normality

Tests of normality indicated that the frequency distributions for the NAS scores were normally distributed with skewness of \( z = -1.25 \) (SE = .190) and kurtosis of \( z = -1.69 \) (SE = .378) and for the numeracy scores, the frequency distributions were not normally distributed for skewness \( z = -4.28 \) (SE = .190) but kurtosis was normally distributed \( z = 0.32 \) (SE = .378), and so, transformation was not necessary. A majority of the tests suggested that the data was normally distributed and Norris and Aroian (2004) found that neither Cronbachs alpha or Pearson correlation showed a difference between original data and after it had been transformed.
5.5 Exploratory factor analysis

A Cronbach’s alpha was conducted on all 26 scale items to estimate the internal consistency, representing the variability of a composite score. Cronbach’s alpha was sufficiently high (α = .890) (Kline, 2000; Lacobucci & Duhachek, 2003 and Rattray & Jones, 2005). This is further consistent with the criteria of Tavakol and Dennick (2011) who recommend that the alpha value does not exceed 0.90.

Standard deviations were therefore assessed to determine whether any items should be removed. All item standard deviations were above the .6 threshold, with the exception of item 6. Prior to checking correct item-total correlations, a Cronbach’s alpha was again run, with the identified item removed.

Item 6: When I read questions in numeracy, I feel...

Item 6 was dropped from the scale, leaving 25 items. A Cronbach’s alpha was run again and produced a sufficiently high and acceptable value (α = .888). All item standard deviations were appropriate (> .6). With the exception of item 2, all item-total correlations exceeded .35. This item was therefore removed from the scale and a Cronbach’s alpha was run again.

Item 2: When I am asked to do lots of numeracy, I feel...

Item 2 was dropped from the scale, leaving 24 items. A Cronbach’s alpha produced a sufficiently high and acceptable value (α = .886). All item standard deviations were above .6. Corrected item total correlations showed that all items, except items 5 and 7 loaded appropriately. These items were therefore removed from the scale and a Cronbach’s alpha was re-run.

Item 5: If I have to do numeracy work in my head, I feel...

Item 7: Starting a new topic in numeracy makes me feel...

Following the removal of items 5 and 7, the scale consisted of 22 items. A Cronbach’s alpha was run again and produced a sufficiently high and acceptable value (α = .883). All item standard deviations were appropriate (> .6), although items 12 (.63), 15 (.62) and 16 (.62) were marginally
above the statistical threshold. Corrected item total correlations showed that all items loaded appropriately (> .35). However, items 9, 16 and 20 were the only items to load beneath .40.

Thus, the scale remained as 22 items. Bartlett’s test of sphericity was significant (P < .01) indicating that factor analysis was possible. The Kaiser-Meyer-Oklin measure of sampling adequacy (KMO) of .868 was greater than the recommended value of 0.6 (Pallant, 2001). Exploratory factor analysis (EFA) was employed, using the extraction method of principal axis factoring (PAF).

An initial PAF revealed the presence of 5 components with eigenvalues exceeding 1. However, the scree plot representation indicated 1 factor, with all 22 items loading above the imposed threshold of .35 on the factor matrix for factor 1 and only item 24 loading onto factor 2.

As the scree plot suggested 1 factor, the author chose to explore a 1 factor model. Principal axis factoring was conducted and Kaiser’s criterion was replaced with 1 fixed factor. Rotation was not required for a 1-factor model. The factor matrix showed that all 22 items loaded above the minimum threshold for statistical significance (> .35).

5.5.1 Justification for a .40 statistical threshold

As can be seen in table 5.2, item 20, was the only item that did not load above .40. In addition, although items 9 and 16 were maintained following EFA, they had previously been identified in the analysis as not loading above .40, and so this was explored further. Throughout the initial phase of analyses, it became evident that .40 was a more appropriate minimum statistical threshold. A majority of the items were found to load above this. Thus, in order to make the scale more statistically robust, a threshold of .40 was subsequently implemented for scale items and a further exploratory factor analysis was conducted. As can be seen from the following factor analysis using a .40 threshold, a further 3 items were removed from the scale (items 9, 16 & 20) than when using the less robust statistical threshold of .35. This served to refine the scale further, without omitting a large number of items.
Table 5.2 – Single factor loadings of items for the Numeracy Apprehension Scale (.35 threshold).

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: When my friends finish their work before me, I feel…</td>
<td>.504</td>
</tr>
<tr>
<td>Q3: If I am the last to finish numeracy work on my table, I feel…</td>
<td>.549</td>
</tr>
<tr>
<td>Q4: If I make a mistake in numeracy, I feel…</td>
<td>.536</td>
</tr>
<tr>
<td>Q8: When I can’t do my numeracy work, I feel…</td>
<td>.517</td>
</tr>
<tr>
<td>Q9: When I have someone watching me while I do my numeracy, I feel…</td>
<td>.409</td>
</tr>
<tr>
<td>Q10: When I have to explain a numeracy problem to my teacher, I feel…</td>
<td>.487</td>
</tr>
<tr>
<td>Q11: If I think I can’t do my numeracy work, I feel…</td>
<td>.590</td>
</tr>
<tr>
<td>Q12: When I see a lot of numbers, I feel…</td>
<td>.481</td>
</tr>
<tr>
<td>Q13: When I have to explain a numeracy problem to my friends, I feel...</td>
<td>.480</td>
</tr>
<tr>
<td>Q14: If I have to finish all my numeracy work in lesson, I feel…</td>
<td>.555</td>
</tr>
<tr>
<td>Q15: Listening to the teacher in my numeracy class makes me feel…</td>
<td>.456</td>
</tr>
<tr>
<td>Q16: When I practise numeracy, I feel…</td>
<td>.419</td>
</tr>
<tr>
<td>Q17: If I answer questions and get them wrong, I feel…</td>
<td>.590</td>
</tr>
<tr>
<td>Q18: If I have to tell the teacher that I don’t understand my numeracy work, I feel…</td>
<td>.507</td>
</tr>
<tr>
<td>Q19: If other children know that I find numeracy hard, I feel…</td>
<td>.607</td>
</tr>
<tr>
<td>Q20: Thinking about numeracy outside of class makes me feel…</td>
<td>.396</td>
</tr>
<tr>
<td>Q21: When I watch or listen to my teacher explain a numeracy problem, I feel…</td>
<td>.435</td>
</tr>
<tr>
<td>Q22: If I don’t finish my number work in class, I feel…</td>
<td>.596</td>
</tr>
<tr>
<td>Q23: If other children finish their numeracy very quickly, I feel…</td>
<td>.570</td>
</tr>
<tr>
<td>Q24: When I explain how I got my answer to my teacher, I feel…</td>
<td>.446</td>
</tr>
<tr>
<td>Q25: When my teacher wants me to do numeracy at home, I feel…</td>
<td>.474</td>
</tr>
<tr>
<td>Q26: Walking into the numeracy class makes me feel…</td>
<td>.530</td>
</tr>
</tbody>
</table>

*Item 20 is the only item to not load above .4
5.5.2 Exploratory factor analysis – 1 factor

(Loading Threshold of .40)

A Cronbach’s alpha was conducted on all 26 scale items to estimate the internal consistency. Cronbach’s alpha was sufficiently high (α = .890) (Lacobucci & Duhachek, 2003 and Rattray & Jones, 2005). This is further consistent with the criteria of Tavakol and Dennick (2011) who recommend that the alpha value does not exceed 0.90. Standard deviations were therefore assessed to determine whether any items should be removed. All item standard deviations were above the .6 threshold, with the exception of item 6. Prior to checking correct item-total correlations, a Cronbach’s alpha was again conducted with the identified item removed.

Item 6: When I read questions in numeracy, I feel...

Following the removal of item 6, the scale consisted of 25 items. A Cronbach’s alpha was run again and produced a sufficiently high and acceptable value (α = .888). All item standard deviations were appropriate (> .6). Corrected item total correlations showed that all items, except items 2, 5, 7, 9 and 20 did not exceed the value of .40. These items were therefore removed from the scale.

Item 2: When I am asked to do lots of numeracy, I feel...
Item 5: If I have to do numeracy in my head, I feel...
Item 7: Starting a new topic in numeracy makes me feel...
Item 9: When I have someone watching me while I do my numeracy, I feel...
Item 20: Thinking about numeracy outside of class makes me feel...

Items 2; 5; 7; 9 and 20 were removed from the scale, leaving the 20 items. A Cronbach’s alpha was run again and produced a sufficiently high and acceptable value (α = .880). All item standard deviations were appropriately (> .6). Corrected item total correlations showed that all items, except for item 6, loaded above the minimal statistical significance threshold (.40). However, item 21 was only just above this threshold (.404). Item 16 was removed from the scale and a Cronbach’s alpha was re-run.

Item 16: When I practise numeracy, I feel...
At this point, the scale consisted of 19 items, following the removal of item 16. A Cronbach’s alpha was run again and produced a sufficiently high and acceptable value (α = .877). All item standard deviations were appropriate (> .6). Corrected item total correlations showed that all items, loaded above .40.

The scale remained as 19 items and exploratory factor analysis was employed, using the extraction method of principal axis factoring. Bartlett’s test of sphericity was significant (p < .01); again indicating that factor analysis was possible. The KMO value was also sufficiently high (.870) (Pallant, 2001).

An initial PAF revealed the presence of five components with eigenvalues exceeding 1. However, the scree plot representation indicated 1 factor, with all 19 items loading above the imposed threshold of .40 on the factor matrix for factor 1.

As the scree plot suggested 1 factor, the author again chose to explore a 1 factor model. Principal axis factoring was conducted and Kaiser’s criterion was replaced with 1 fixed factor. Rotation was not required for a 1 factor model. The factor matrix showed that all 19 items loaded above the minimum threshold for statistical significance (> .40). This led to the final iteration of the NAS within the scope of this PhD thesis (appendix xix).
Table 5.3 - Factor loadings of items for the Numeracy Apprehension Scale (.40 threshold).

<table>
<thead>
<tr>
<th>Item</th>
<th>On-line Number Apprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: When my friends finish their work before me, I feel…</td>
<td>.499</td>
</tr>
<tr>
<td>Q3: If I am the last to finish numeracy work on my table, I feel…</td>
<td>.535</td>
</tr>
<tr>
<td>Q4: If I make a mistake in numeracy, I feel…</td>
<td>.539</td>
</tr>
<tr>
<td>Q8: When I can’t do my numeracy work, I feel…</td>
<td>.527</td>
</tr>
<tr>
<td>Q10: When I have to explain a numeracy problem to my teacher, I feel…</td>
<td>.498</td>
</tr>
<tr>
<td>Q11: If I think I can’t do my numeracy work, I feel…</td>
<td>.593</td>
</tr>
<tr>
<td>Q12: When I see a lot of numbers, I feel…</td>
<td>.476</td>
</tr>
<tr>
<td>Q13: When I have to explain a numeracy problem to my friends, I feel…</td>
<td>.478</td>
</tr>
<tr>
<td>Q14: If I have to finish all my numeracy work in lesson, I feel…</td>
<td>.533</td>
</tr>
<tr>
<td>Q15: Listening to the teacher in my numeracy class makes me feel…</td>
<td>.450</td>
</tr>
<tr>
<td>Q17: If I answer questions and get them wrong, I feel…</td>
<td>.607</td>
</tr>
<tr>
<td>Q18: If I have to tell the teacher that I don’t understand my numeracy work, I feel…</td>
<td>.515</td>
</tr>
<tr>
<td>Q19: If other children know that I find numeracy hard, I feel…</td>
<td>.612</td>
</tr>
<tr>
<td>Q21: When I watch or listen to my teacher explain a numeracy problem, I feel…</td>
<td>.435</td>
</tr>
<tr>
<td>Q22: If I don’t finish my number work in class, I feel…</td>
<td>.593</td>
</tr>
<tr>
<td>Q23: If other children finish their numeracy very quickly, I feel…</td>
<td>.581</td>
</tr>
<tr>
<td>Q24: When I explain how I got my answer to my teacher, I feel…</td>
<td>.446</td>
</tr>
<tr>
<td>Q25: When my teacher wants me to do numeracy at home, I feel…</td>
<td>.470</td>
</tr>
<tr>
<td>Q26: Walking into the numeracy class makes me feel…</td>
<td>.525</td>
</tr>
</tbody>
</table>
5.5.3 Factor labelling

Items that loaded onto the single observed factor appeared to have a strong association with feelings and situations arising in the moment of completing numeracy tasks i.e. explaining an answer to the teacher, being the last to finish numeracy work, making mistakes and getting work wrong. This factor was thus named, ‘On-line Number Apprehension’, maintaining the factor 2 name from study two. This factor consists of merged items from the initial factor 1 and factor. In study 2, the item, ‘walking into a numeracy class makes me feel…’ was observed in factor 1 – ‘Prospective Numeracy Task Apprehension’. However, it could be argued to also be on-line numeracy apprehension as it has an association with the impending numeracy tasks. Indeed, the entire numeracy lesson could be viewed as being an on-line task, as it requires the learner to not only complete work, but to observe and listen closely to instruction – something the high anxious children may encounter difficulty with. This would seemingly relate to the item, ‘when I watch or listen to my teacher explain a numeracy problem’, which was also observed in factor 1 (prospective numeracy task apprehension) in study 2 of this PhD thesis.

The single factor observed in study 3 was not termed ‘Numeracy Apprehension’, as it is acknowledged that the scale items require further validation and analysis, and so the 19-item NAS is recognised to not be the final version of this measure.

5.6 Correlational analysis

Bivariate correlations were conducted in order to investigate whether there were any associations amongst age, gender, numeracy score and the 19-item NAS scores after Factor Analysis. The results demonstrated that there was a strong negative correlation between scores on the numeracy problems and NAS \( (r(163) = -.620, p < .001) \) as shown in figure 5.1. However, no significant correlations were found between NAS scores and age \( (r(163) = -.095, p = .229) \) or gender \( (r(163) = .104, p = .188) \) as shown in table 5.4. Moreover, there were no significant associations between numeracy problems scores and age \( (r(163) = .151, p = .054) \) or gender \( (r(163) = -.064, p = .415) \).
Table 5.4 – A table showing the correlation and significance values for numeracy performance scores, age and gender with numeracy apprehension scores (N = 163).

<table>
<thead>
<tr>
<th>Numeracy Apprehension Scores</th>
<th>Numeracy Performance Scores</th>
<th>Age</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>-.620**</td>
<td>-.095</td>
<td>.104</td>
</tr>
<tr>
<td>Significance Value</td>
<td>.001</td>
<td>.229</td>
<td>.188</td>
</tr>
</tbody>
</table>

Figure 5.1 - Graph showing the correlation between numeracy problem scores and the NAS.

The correlation graph shows a negative association between high numeracy apprehension scores on the NAS and lower performance on the numeracy task. The association is significant, but the correlation graph visually demonstrates that not all participant scores closely followed this trend. Despite some children scoring 100% on the numeracy performance task, it can be seen that they
also provided a high numeracy apprehension score. In contrast, other children who obtained lower performance scores also scored lower for numeracy apprehension. Despite this, an association is evident from the scatterplot, which also clearly shows that those who scored the lowest on the numeracy task also obtained some of the highest apprehension scores on the NAS.

5.7 Analysis of variance

Table 5.5 - The means and standard deviations for age and gender in comparison to numeracy apprehension scale scores (19-items).

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Male</td>
<td>34.78</td>
<td>7.87</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>34.50</td>
<td>10.47</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>34.70</td>
<td>8.29</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>35.73</td>
<td>7.63</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>35.16</td>
<td>8.90</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>35.43</td>
<td>8.27</td>
<td>70</td>
</tr>
<tr>
<td>6</td>
<td>Male</td>
<td>32.56</td>
<td>9.17</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>37.25</td>
<td>7.44</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>34.86</td>
<td>8.61</td>
<td>49</td>
</tr>
<tr>
<td>7</td>
<td>Male</td>
<td>32.52</td>
<td>7.16</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>33.50</td>
<td>7.48</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>32.77</td>
<td>7.14</td>
<td>31</td>
</tr>
<tr>
<td>Total</td>
<td>Male</td>
<td>33.93</td>
<td>8.00</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>35.63</td>
<td>8.30</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>34.69</td>
<td>8.16</td>
<td>163</td>
</tr>
</tbody>
</table>
Table 5.6 - The means and standard deviations for age and gender in comparison to numeracy performance scores (%).

<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Male</td>
<td>66.00</td>
<td>26.30</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>68.00</td>
<td>24.22</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>66.62</td>
<td>24.67</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>Male</td>
<td>68.52</td>
<td>19.47</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>72.51</td>
<td>22.52</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>70.63</td>
<td>21.08</td>
<td>70</td>
</tr>
<tr>
<td>6</td>
<td>Male</td>
<td>76.80</td>
<td>26.14</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>68.75</td>
<td>23.56</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>72.86</td>
<td>24.98</td>
<td>49</td>
</tr>
<tr>
<td>7</td>
<td>Male</td>
<td>81.30</td>
<td>17.53</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>71.88</td>
<td>21.87</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>78.87</td>
<td>18.83</td>
<td>31</td>
</tr>
<tr>
<td>Total</td>
<td>Male</td>
<td>73.83</td>
<td>22.19</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>70.96</td>
<td>22.48</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>72.55</td>
<td>22.29</td>
<td>163</td>
</tr>
</tbody>
</table>

A two-way independent analysis of variance (ANOVA) was conducted to explore whether numeracy apprehension scores were affected by age and gender. The results showed that there was no significant main effect of age and numeracy apprehension scores (19-items), $F(3, 155) = .527, p = .66$, or gender and numeracy apprehension scores, $F(1, 155) = .522, p = .47$. There was also no significant interaction between age and gender on numeracy apprehension scores, $F(3, 155) = 1.042, p = .38$.

An additional two-way independent ANOVA was conducted to explore whether performance on the numeracy task was affected by age and gender. The results showed that there was no significant main effect of age and numeracy performance scores, $F(3, 155) = .644, p = .59$, or gender and numeracy performance scores, $F(3, 155) = .97, p = .41$. There was also no significant interaction between age and gender on numeracy performance scores, $F(3, 155) = .97, p = .41$. 
5.8 Moderation analysis

A moderation analysis was conducted to determine whether the relationship between numeracy apprehension scale scores (19-items) and numeracy performance scores, were dependent on gender, reception data and year 2 data. Initially, it was found that numeracy apprehension rating scale scores, gender and reception children’s data explained a significant amount of the variance in numeracy performance scores ($F(5, 157) = 20.42, p < .001, R^2 = .39$). However, there was no effect on numeracy performance between numeracy apprehension scores and gender, $F(1, 157) = .60, p = .44$, and numeracy apprehension scores and reception children, $F(1, 157) = 1.21, p = .27$. There was also no significant interaction between numeracy apprehension scores, gender and reception children on numeracy performance scores, $F(2, 157) = 1.16, p = .32$.

When considering year 2 children, numeracy apprehension rating scale scores and gender, it was found that these explained a significant amount of the variance in numeracy performance scores ($F(5, 157) = 22.28, p < .001, R^2 = .42$). However, there was no effect on numeracy performance between numeracy apprehension scores and gender, $F(1, 157) = .79, p = .38$ and numeracy apprehension scores and year 2 children, $F(1, 157) = 3.46, p = .065$. There was also no interaction between numeracy apprehension scores, gender and year 2 children on numeracy performance scores, $F(2, 157) = 2.25, p = .109$.

5.9 Correlational analysis – reception and year two

A bivariate correlation was conducted to determine if there were any differences between the two populations of reception and year 2 children on numeracy apprehension scores and numeracy performance scores. The results demonstrated that there was a strong negative correlation between numeracy apprehension scores and numeracy performance scores ($r(47) = -.807, p < .001$) such that this negative association was stronger for year 2 children, than those in reception.

5.10 Multiple regression – enter method

The enter method of multiple regression includes all predictor variables to identify to what extent each of these can predict numeracy performance. A subsequent stepwise method regression was conducted to only include the variables that are good predictors of numeracy performance. A
multiple regression was conducted using primary school (categorical), gender (categorical) and 19-item NAS scores to analyse whether these predicted numeracy performance scores.

An analysis of standard residuals was carried out on the data to identify any outliers. The standard residual minimum was -.352 and exceeded -.329, suggesting outliers in the data, although not by a significant amount. The standard residual maximum was acceptable, with a value of 2.19 and did not exceed .329. Despite the minimum standard residual value indicating data outliers, participant data was not removed as the full data had been subject to factor analysis and thus, data could not be removed for subsequent analysis.

Tests indicated that multicollinearity was not a concern (Primary School, Tolerance = .99, VIF = 1.00; Gender, Tolerance = .99, VIF = 1.01 and the 19-Item NAS Scores, Tolerance = .98, VIF = 1.01).

The data also met the assumption of independent errors (Durbin-Watson value = 1.85) (Ayyangar, 2007).

The histogram of standardised residuals indicated that the data contained approximately normally distributed errors, and this was also evident on the P-P plot of standardised residuals.

**Figure 5.2** - Histogram of standardised residuals.
The scatterplot of standardised predicted values, showed that the data met the assumptions of homogeneity of variance.

Figure 5.4 - Scatterplot of standardised predicted values.
The data also met the assumption of non-zero variances (Primary School, Variance = .25; Gender, Variance = .25; Numeracy Scores %, Variance = 496.99 and the 19-Item NAS Scores, Variance = 66.57).

Using the enter method, it was found that primary school, gender and the 19-item NAS scores explained a significant amount of the variance in numeracy performance scores ($F(3, 159) = 36.43$, $p < .001$, $R^2 = .41$, $R^2_{Adjusted} = .40$). Thus, this demonstrates that approximately 41% of the variance in numeracy scores can be accounted for by the variables.

The analysis shows that primary school did predict numeracy performance scores, $Beta = -.153$, $t(159) = -2.49$, $p < .01$, showing that numeracy performance scores were lower by 6.81 in school two, in comparison to school one. In addition, gender was not a significant predictor of numeracy performance scores, $Beta = -.008$, $t(159) = -.130$, $p = .90$. Finally, the 19-item NAS scores significantly predicted numeracy performance scores, $Beta = -.63$, $t(159) = -10.25$, $p < .001$, showing as NAS scores increased by one unit, performance decreased by 1.72 per cent.

5.10.1 Multiple regression – stepwise method

The enter method of multiple regression includes all predictor variables, but a stepwise method was also conducted to only include the variables that are good predictors of numeracy performance. Using the stepwise method, it was found that the 19-item NAS scores and primary school explained a significant amount of the variance of numeracy performance scores ($F(2, 160) = 54.97$, $p < .01$, $R^2 = .41$, $R^2_{Adjusted} = .40$). However, a significant amount of the variance can be explained by numeracy performance scores being predicted by the 19-item NAS scores ($F(1, 161) = 100.47$, $p < .01$, $R^2 = .38$, $R^2_{Adjusted} = .38$).

When only implementing the 19-item NAS as a predictor variable using the stepwise method, the analysis again shows that NAS scores are the best predictor of numeracy performance scores, $Beta = -.62$, $t(161) = -10.02$, $p < .01$. When considering primary school and the NAS 19-item scores together, primary school was again not as significant as NAS scores, $Beta = -.15$, $t(160) = -2.49$, $p = .14$ When included with primary school, the 19-item NAS results closely resembled those of when considered as a single predictor of numeracy performance, $Beta = -.63$, $t(160) = -10.35$, $p < .01$, suggesting that the 19-item NAS is the best predictor variable of numeracy performance scores.
5.11 Curve fit

A curve fit was conducted to again verify the association between the 19-item NAS scores and numeracy performance scores. The curve fit scatter plot shows the distribution of scores and includes a line of best fit that can be used to predict one score in comparison to another. The scatter plot shows that whilst a proportion of scores follow the line of best fit, others are quite distant, representing a less apparent association between the 19-item NAS scores and numeracy performance scores. For instance, a distinct outlier can be seen, showing a 19-item NAS score as slightly above 20 (representing low anxiety), but with a low numeracy performance score, at roughly 30%. However, for the most part, the data follows the association that children with low 19-item NAS scores generally demonstrated better numeracy performance and high scores on the 19-item NAS were generally linked to lower numeracy performance scores.

**Figure 5.5** – Curve fit scatter plot showing numeracy performance scores and numeracy apprehension rating scale scores.
5.12 Discussion

Until recently, psychological literature has traditionally provided empirical evidence for the existence of mathematics anxiety in older populations, with only theoretical attention given to the early years of numeracy education. Thus, knowledge has been limited with regards to the onset of mathematics anxiety and whether factors in the early educational years have an association with this. Building on the research findings of study 1 and 2, the quantitative results further supported the notion of numeracy apprehension as a foundation phase of mathematics anxiety, developing between the ages of 4 and 7 years. In contrast to study 2, only a single factor relating to apprehension emerged. Moreover, this was found to have a negative association with numeracy task performance, and was stronger for year 2 children, than those at the beginning of school in reception. Addressing the aims of the research, the NAS was developed further to produce a 19-item iteration and a relationship was highlighted between numeracy apprehension scores and performance on a numeracy task.

The 26-item iteration of the NAS was again implemented with children aged 4-7 years (n =163) in their primary school setting, who also completed a numeracy task. The children were demographically similar to those in study 1 and study 2. Following factor analysis, the results indicated that a one factor solution was the most appropriate and maintained 19-items, omitting seven items that were not above a standard deviation threshold of .6. A single factor of numeracy apprehension was enforced by raising the minimum statistical threshold from .35 in study 2, to .40 in the current research. Throughout the initial phase of analysis using a .35 threshold for items, it became evident that .40 was a more appropriate minimum statistical threshold. A majority of the items were found to load above this. The scale could therefore be made more statistically robust by implementing a threshold of .40. Factor analysis using a .40 threshold, removed a further 3 items from the scale (items 9, 16 & 20) than when using the less robust statistical threshold of .35. This served to refine the scale further, without omitting a large number of items. Following analysis using a .35 threshold, item 20 was the only item to not load above .40 and although items 9 and 16 were maintained following EFA, they had previously been identified in the analysis as not loading above .40. Hence, this was explored further using a .4 statistical threshold for items. Again referring to Stevens (1992), factors should load above .5 for a sample of 100 and .3 for a sample of 200, the current study (n = 163) can be judged as between these values and thus, .4 was judged to be acceptable. A higher loading threshold was avoided, as further testing with 19-items could provide more insightful results, as for example, had a .50 threshold been enforced, the NAS would have
comprised of 11-items, omitting a further eight items. As a developing scale, it is advantageous to progressively remove items that are of low internal reliability through a number of replication tests. However, an 11-item NAS would still have compared favourably to previously validated mathematics anxiety scales, i.e. the 10-item MAS (Betz, 1978). In its current form, a 19-item measure of numeracy apprehension corresponds to the 22-item MASC (Chiu & Henry, 1990) and 26-item MARS-E (Suinn et al., 1988). Immediate comparison against these validated scales is justified, as like the NAS, they were developed for implementation with children, albeit somewhat older children. In terms of a practical application to classrooms, it is beneficial for the NAS to have fewer items, due to its intended lower age range, with issues surrounding attention and fatigue in younger children, particularly those in reception.

Six of the seven items that were omitted from the 26-item NAS had previously formed factor one (prospective numeracy task apprehension) in study 2. Specifically, these items related to reading numeracy questions; starting a new topic; practising numeracy; children completing numeracy in their head (mental arithmetic); thinking about numeracy when not in class and feelings when asked to do a lot of numeracy and when someone is watching. This does not mean to say that prospective numeracy task apprehension is not a factor in the numeracy classroom. Instead, the remaining items from this factor could contribute to the definition of a single and all-encompassing factor (on-line number apprehension) that encapsulates an entire numeracy lesson. This is detailed later in this discussion. Table 5.7 shows the comparison between the items maintained for the 2 factors in study 2 and the single factor of study 3.

The range of statistical loading for the six omitted items in the current research, ranged from .3 to .6 in study 2. However, a number of these items (reading questions in numeracy, starting a new topic and practising numeracy) had not been reinforced by previous mathematics anxiety research to the same extent as evaluation anxiety, failure and the influence of parents and teachers. Thus, it is perhaps understandable why these items became less associated with numeracy apprehension on the reduced 26-item NAS, in comparison to other more influential factors, such as making mistakes and peer comparison. Despite this, the omission of the item relating to mental arithmetic is somewhat surprising, particularly as previous research, i.e. Ashcraft (2002) and the discussion groups of study 1, indicated that this is a particularly difficult aspect of numeracy/mathematics, and may act as a key differentiator between numeracy attitudes. Yet when considering the participation totals of year groups in study 2 (reception = 82; year 1 = 108; year 2 = 117) and study 3 (reception = 59; year 1 = 57; year 2 = 47), a possible explanation can be afforded. In study 2, the reception year group was
significantly less represented than year one and two, whilst in study 3, the reception year group was the highest represented year group, albeit by only two participants. Nonetheless, at the age of reception, children are learning and practising calculations, becoming familiar with numbers and learning strategies to facilitate their learning. Thus, there is less emphasis on mental arithmetic, which becomes a more essential skill as children progress through education. Therefore, the removal of the mental arithmetic item may relate to it not being a particular issue for children in the most represented age group (reception) in study 3.
Table 5.7 – A comparison between the items maintained for the 2 factors in study 2 and the single factor of study 3.

<table>
<thead>
<tr>
<th>Item</th>
<th>Study 2 Prospective Numeracy Task Apprehension</th>
<th>Study 2 On-line Number Apprehension</th>
<th>Study 3 On-line Number Apprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listening to the teacher in a numeracy class makes me feel…</td>
<td>.780</td>
<td>-</td>
<td>.450</td>
</tr>
<tr>
<td>Walking into the numeracy class makes me feel…</td>
<td>.742</td>
<td>-</td>
<td>.525</td>
</tr>
<tr>
<td>When I read questions in numeracy, I feel…</td>
<td>.673</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Starting a new topic in numeracy makes me feel…</td>
<td>.592</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>When I practise numeracy, I feel…</td>
<td>.567</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>If I have to do numeracy work in my head, I feel…</td>
<td>.547</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>When I watch or listen to my teacher explain a numeracy problem, I feel…</td>
<td>.533</td>
<td>-</td>
<td>.435</td>
</tr>
<tr>
<td>When my teacher wants me to do numeracy at home, I feel…</td>
<td>.533</td>
<td>-</td>
<td>.470</td>
</tr>
<tr>
<td>If I have to finish all my numeracy work in lesson, I feel…</td>
<td>.487</td>
<td>-</td>
<td>.533</td>
</tr>
<tr>
<td>Thinking about numeracy outside of class makes me feel…</td>
<td>.477</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>When I explain how I got my answer to my teacher, I feel…</td>
<td>.410</td>
<td>-</td>
<td>.446</td>
</tr>
<tr>
<td>When I am asked to do lots of numeracy in class, I feel…</td>
<td>.393</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>When I see lots of numbers, I feel…</td>
<td>.381</td>
<td>-</td>
<td>.476</td>
</tr>
<tr>
<td>When I have to explain a numeracy problem to my friends, I feel…</td>
<td>.368</td>
<td>-</td>
<td>.478</td>
</tr>
<tr>
<td>If I am the last to finish numeracy work on my table, I feel…</td>
<td>-</td>
<td>.711</td>
<td>.535</td>
</tr>
<tr>
<td>If I answer questions and get them wrong, I feel…</td>
<td>-</td>
<td>.643</td>
<td>.607</td>
</tr>
<tr>
<td>If I think I can’t do my numeracy work, I feel…</td>
<td>-</td>
<td>.640</td>
<td>.593</td>
</tr>
<tr>
<td>If other children finish their numeracy work very quickly, I feel…</td>
<td>-</td>
<td>.618</td>
<td>.581</td>
</tr>
<tr>
<td>If I make a mistake in numeracy, I feel…</td>
<td>-</td>
<td>.594</td>
<td>.539</td>
</tr>
<tr>
<td>If I don’t finish my number work in class, I feel…</td>
<td>-</td>
<td>.586</td>
<td>.593</td>
</tr>
<tr>
<td>When I can’t do my numeracy work, I feel…</td>
<td>-</td>
<td>.577</td>
<td>.527</td>
</tr>
<tr>
<td>When my friends finish their numeracy before me, I feel…</td>
<td>-</td>
<td>.551</td>
<td>.499</td>
</tr>
<tr>
<td>If other children know that I find numeracy hard, I feel…</td>
<td>-</td>
<td>.501</td>
<td>.612</td>
</tr>
<tr>
<td>When I have someone watching me while I do my numeracy, I feel…</td>
<td>-</td>
<td>.416</td>
<td>-</td>
</tr>
<tr>
<td>If I have to tell the teacher that I don’t understand my numeracy work, I feel…</td>
<td>-</td>
<td>.397</td>
<td>.515</td>
</tr>
<tr>
<td>When I have to explain a numeracy problem to my teacher, I feel…</td>
<td>-</td>
<td>.390</td>
<td>.498</td>
</tr>
</tbody>
</table>
In addition to this, the removal of the item corresponding to being observed when completing a numeracy task was unanticipated. Relating to evaluation anxiety, observation anxiety was strongly discussed in study 1 as being associated with worrisome thoughts, particularly by mathematics experts who had experienced this in a primary school classroom setting. Evaluation anxiety was also a main factor identified by Hunt et al (2011) in the development of the MAS-U.K., although relating to adult experiences. Yet, Newstead (1994) also found that children aged 9-11 years (U.K. years 5-6) found observation anxiety to be a key factor contributing towards anxiety. An explanation for the removal of this item may relate to the inclusion of the word ‘someone’ watching. This may be too ambiguous for children and was thus less influential than other items on the scale that more closely reflected their classroom numeracy experiences. Furthermore, this item previously loaded at .416, and was thus only previously above the .4 threshold following analysis in study 2.

With the omission of these seven items following factor analysis, the remaining items for factor one (prospective numeracy task apprehension) identified in study 2, became more associated with factor 2 (on-line number apprehension). The results of factor analysis supported this, as a one factor solution was shown to be the most appropriate. Of the 19-items that remained, 11 were maintained from the on-line number apprehension factor and it was thus preserved as the single dominant factor of the NAS. The additional 8 items were maintained from the prospective numeracy task apprehension factors. Collectively, the 19-items seemingly encapsulate a typical numeracy lesson, from feelings when walking into a numeracy lesson, to being unable or the last in a group to finish the work set. This also added to the validity of the scale. Items that relate to significant findings of previous research with older populations and the discussion groups of study 1 were maintained. In addition, items relating to factors that were anticipated as differentiators between children’s attitudes remained to be some of the highest loading items. For example, these items relate to being the last to finish; other children finishing their work quickly and having an awareness of someone struggling (failure and peer comparison); providing incorrect answers; making mistakes (failure and low self-efficacy) and holding the belief of being unable to complete work (low sense of ability and self-esteem). The statistical loadings of the majority of these items had the highest loadings of all items on the 19-item NAS. These also relate to quantitative mathematics anxiety research with older populations, suggesting that the early years of education may be the root of adult difficulties and negative attitudes.
Mutodi and Ngirande (2014) discussed repeated failure as negatively influencing mathematics achievement, whilst peer comparison has been addressed in a number of studies e.g. Erdogan et al (2011) and Mutodi & Ngirande (2014) and relates to self-assessment (Haase et al., 2012). Moreover, Meece et al. (1990) considered self-efficacy to be a crucial determinant factor of mathematics achievement. Low sense of ability, or a low self-concept has also been shown by Dowker et al (2012) to predict mathematical performance. Taken together, the NAS can be judged to be addressing a limitation in knowledge of children’s early educational numeracy feelings and suggests that apprehension relates to perceived ability level. The scale has also demonstrated a potential to not only be applied in psychological research, but in education, subsequent to further testing and analysis.

Notably, items relating to teachers, specifically, children telling them that they do not understand their numeracy work and explaining their answers, increased in their statistical loading. Again, this could be explained by these factors becoming more prominent on the 26-item NAS as opposed to the initial testing of the 44-item iteration. The statistical increase of items associated with teachers is further consistent with the qualitative findings of study 1 and previous literature and quantitative measures i.e. Chiu and Henry (1990). Again, the maintenance of such items demonstrates a degree of validity of the NAS, and that factors influencing children’s numeracy experiences are similar to those of mathematics anxiety, found in research with older populations. More specifically, the results suggest that numeracy apprehension may be the origin of development of mathematics anxiety.

Following factor analysis, the Numeracy Apprehension Rating Scale was shown to have high internal consistency (α = .877) (Lacobucci & Duhachek, 2003; Rattray & Jones, 2005) and is similar to that obtained in study 2 (α = .899). However, the value in the current study could be argued to be more ideal, as this is further from .90, which Tavakol and Dennick (2011) suggested a scale should not exceed, as this could indicate redundant items. An internal reliability of .87 can be considered a strength of the 19-item NAS, particularly in comparison to the previous 26-item iteration, although this should be accepted with caution, as further implementation and analysis is required.

The 26-item iteration of the NAS was implemented in conjunction with a numeracy task in order to determine construct validity. Correlational analysis and multiple regression was conducted using the 19-item iteration, following factor analysis and removal of a further 7 items. Correlational
results demonstrated a strong negative relationship between NAS scores and performance on the numeracy task, suggesting that the NAS can be a useful predictor of performance for children aged 4-7 years. This further demonstrated that numeracy apprehension in the early years of education may have a detrimental effect on numeracy performance and corresponded to the observational findings of mathematics experts, parents and teachers, who had observed apprehensive responses in children when completing numeracy work. Whilst the association between numeracy apprehension scores and numeracy performance scores was significantly large \( r = -.620 \) again, this should be viewed with a degree of caution. With scores visually plotted on a graph, it is evident that those scoring low on the numeracy task also obtained high apprehension scores. However, in some cases, children who obtained a high score on the numeracy task, also obtained a high score on the NAS. Whilst this may initially seem to be an anomalous finding, Ashcraft (2002) had previously found that despite some children insisting on mathematics problems related to anxiety, their competence scores remained unaffected. Previous to this, Ashcraft and Kirk (1998) found that an effect of anxiety only became apparent on certain mathematical concepts. Thus, it may be that the children were highly anxious, but were comfortable with the concepts on the numeracy task, and thus performance was unaffected. Ashcraft (2002) stated that researchers should always consider the competence-anxiety relationship, as the highly anxious may demonstrate increased competence in varying circumstances. This more recently reflects the findings of Chinn (2012). In contrast, another explanation for high numeracy performance and apprehension scores may relate to factors discussed throughout this PhD thesis, i.e. parental pressure to achieve in numeracy, fear of failure and a negative perception of teachers. Thus, if for example, parental pressure was the cause of apprehension, a child may still achieve in numeracy, but also have a degree of apprehension due to an expectation to achieve. However, for the most part, the data follows the association that children with low 19-item NAS scores generally demonstrated better numeracy performance whilst higher scores on the NAS were generally linked to lower numeracy performance scores. Witt (2012) stated that mathematics anxiety research has commonly identified mathematics anxious children and assumed that all others had no anxiety. Yet, when again viewing the plotted graph results, it can be seen that in the current study, a range of apprehension scores was evident, suggesting whilst some children had higher anxiety levels than others, they typically had a degree of apprehension. In summary, the strong negative association between NAS scores and numeracy task scores addressed an aim of the research; to demonstrate construct validity, and has shown that it can be an appropriate measure for early difficulties in numeracy (Mazzocco, 2007). Further to this, although study 3 tested performance effectiveness, the processing efficiency theory suggests that this is not always affected by anxiety. Attentional Control Theory (ACT) predicts that anxiety affects
performance by adversely effecting attentional control (Derakshan & Eysenck, 2009). The negative relationship between numeracy apprehension and numeracy performance relates to ACT, in that children with higher anxiety and lower performance were likely to show more attentional bias for threat related material i.e. the numeracy task, and were unable to disengage from thinking of the treat this posed (Derakshan & Eysenck, 2009).

Despite a significant correlation between NAS scores and performance, other correlations were not present between NAS scores and age or NAS scores and gender. The lack of a correlation between NAS scores and age can be viewed as beneficial, as this demonstrates that if the measure does not relate more to one age group than another, and was appropriate for all children aged 4-7 years. In addition, this results suggests that numeracy apprehension does not necessarily change with age.

Relating to gender, multiple regression results revealed that this was not a sufficient predictor of numeracy performance. As aforementioned, mathematics anxiety research has presented inconsistent results relating to the association between gender and mathematics anxiety, and this finding further adds to the ambiguity (Haase et al., 2012; Mata et al., 2012; Devine et al., 2012; Beilock et al., 2010; Mutodi & Ngirande, 2014). A similar number of males and females participated in the current study, and thus one gender was not significantly more represented than another. Similarly, age was unable to predict numeracy performance, demonstrating that the numeracy tasks created by teachers had been a consistent intermediate level measure of performance.

Whilst the NAS has been shown to be a predictor of numeracy performance, the author acknowledges limitations in the research. As a first consideration, the use of numeracy teacher assessment levels for each of the participating children would have been more beneficial as a measure of numeracy performance. The task implemented by the author consisted of 20 questions for year one and two children and 18 for reception, in which scores were then converted to percentages. However, the numeracy task is unlikely to give the same reflection of numeracy performance as teacher levels, due to this being limited to a certain number of questions and only briefly gauging certain key concepts. Moreover, factors at the time of completing the task, may have given unrepresentative performance scores, i.e. tiredness or mood. In contrast, teacher levels would take into account children’s performance on a number of numeracy concepts and modules.
A particular issue was further identified in the reception year group, with regards to the numeracy task. Although designed by teachers, when implemented in other schools, teachers stated that they did not focus on children practising concepts through recording answers on paper - in the manner in which the task attempted to gauge their understanding and performance. Instead, they advised that children learned numeracy only through practical tasks. Thus, children in reception required more help with the task than was anticipated, possibly improving their results and not providing an accurate account of this. Again, this further advocates using teacher assessment levels in subsequent research. Moreover, a wider range of schools, with varying socioeconomic status across a larger area of the U.K. would provide more representative results to children aged 4-7 years, and could be a primary focus for replication and further validation research using the NAS. Despite the 19-item iteration of the NAS, it would perhaps be advantageous to again test the 26-item NAS with a larger and more diverse sample. Following analysis, a comparison could be made against the results of this research, to determine whether the same items are maintained.

Nonetheless, the 19-item NAS has gone some way to addressing the scant research knowledge of factors influencing children’s numeracy experiences between the ages of 4-7 years and has demonstrated that children can suffer with apprehension in early education. This has contributed to a move beyond theorisation, to producing empirical results that reflect factors measured in older populations. This reinforces that the early years are the development grounds for mathematics anxiety. The development of the NAS is a positive response to Mazzocco (2007) and Ashcraft and Moore (2009) who stated that the appropriate tools have not been developed in order to examine anxiety and those at risk of mathematics difficulties in early education. Despite this, it is acknowledged that this research has been a development of the NAS, and that further implementation and analysis is essential. Rossnan (2006) argued that mathematics anxiety can develop at any age and the associated fear is deeply rooted within a child’s first experience of school mathematics. This research can now build on this, and state that prior to mathematics anxiety, a child is first likely to develop numeracy apprehension and a longitudinal study may be beneficial to further support this. Although in concurrence with Rossnan (2006), the results of this study and indeed this PhD thesis, support that the early years and experiences of working with numbers are critical. Mazzocco et al (2012) further considered that mathematics anxiety in older children may be rooted within the early years of education and that efforts should be made in early childhood to steer them away from negative outcomes, thus reinforcing the NAS and subsequent development beyond this PhD thesis. Furthermore, it is necessary for future researchers of numeracy apprehension to appreciate that a combination of identified influential factors adds to the
complexity of understanding the construct of mathematics anxiety and the foundation phase of numeracy apprehension. This should be considered when using an assessment measure such as the NAS, to quantify feelings and experiences.

Subsequent to the research conducted in this body of work, the NAS could undergo further validation testing and begin to be implemented with the testing of intervention strategies for children aged 4-7 years, using beginning of school year teacher assessments as a baseline measurement and comparing these against teacher assessments at the end of the school year. However, functional intervention techniques first need to be trialled with children of this age range, to ensure the efficacy of the strategies that may include the utilisation of games, mathematics resilience and promoting self-compassion.
CHAPTER SIX

6 Overall Discussion

6.1 Intentions of the research

The PhD thesis was based on the construct of ‘numeracy apprehension’; a postulated foundation phase to mathematics anxiety that is evident in some children in the early years of education. The research aimed to address the use of ‘mathematics anxiety’ when discussing children’s adverse emotional responses when working with numbers. Mathematics anxiety is a subsequent issue relating to more complex procedures, and it is unsuitable to associate this with children’s worrisome thoughts in numeracy.

As discussed in the introduction to this body of work, it has been suggested that a number of possible factors link to mathematics anxiety, for example: strained student-teacher relationships (Mata et al., 2012; Harari et al., 2013; Petronzi et al., 2012); a teacher’s own mathematics anxiety and the risk of transference to children (Vinson, 2001; Maloney & Beilock, 2012; Aslan, et al., 2013); children’s awareness of a deficit in their ability (Petronzi et al., 2013; Erdogan et al., 2011); avoidance (Brady & Bowd, 2005) and the role of parents (Vukovic et al., 2013). However, many factors have been based on research findings with adults, adolescents and older children, despite suggestions by psychologists (e.g. Rossnan, 2006) in the research area, that mathematics anxiety can develop at any age and is rooted within a child’s first experience of school mathematics.

The current research aimed to explore the numeracy classroom experiences of children aged 4-7 years and identify factors that influence their attitudes. The ages of 4-7 years mark the beginning of formal education in the U.K. and end of the infancy period following year two. Thus, this age range was maintained as the phase when early numeracy and educational attitudes and experiences would occur. Building upon the author’s previous focus group data collected from 4-7 year olds (Petronzi et al., 2012) insights were obtained from primary care providers including parents, teachers and mathematics experts using a combination of interviews and focus groups. The findings from the children and adults formed an item pool for the development of scale items for the Numeracy Apprehension Scale. This addressed a limitation in psychological research and has provided a measure for children at risk of negative feelings affecting performance. However, the author acknowledges that the NAS requires additional implementation and testing, subsequent to this PhD,
prior to being deemed as a valid and reliable predictor of numeracy performance. This is in part due to it still being in the development stages and the process of scale development should be lengthy and extensive, to avoid invalid measurements of constructs.

Again, this empirical research intended to explore whether numeracy apprehension was evident between the ages of 4-7 years through the development of the Numeracy Apprehension Scale. The intention of this scale further addressed a limitation in the research area, as various quantitative scales exist for the assessment of mathematics anxiety in older populations, as detailed in chapter one, but not for children aged 4-7 years. This overlooks a crucial point in education and limits the opportunity for intervention within schools, as at risk children often remain unseen.

6.2 Synthesis of the three studies

This PhD found a number of key factors relating to children’s experiences of numeracy and related to the direct findings obtained with children aged 4-7 years in the author’s MPhil research. This suggests that the information and experiences described by children was to an extent, an accurate reflection of contemporary numeracy education in the classroom and highlighted the issue of numeracy apprehension. Specific underlying factors were supported when the 26-items of the NAS related particularly to observation and evaluation anxiety, worry and teacher anxiety. These factors reflected those found in quantitative research with older populations, looking at the issue of mathematics anxiety. This demonstrated that the underlying factors that can negatively influence the mathematics experiences of older populations are also experienced by children aged 4-7 years. It could therefore be assumed that mathematics anxiety stems from the initial development of numeracy apprehension and is based on consistent negative experiences throughout an educational career. The empirical data reinforced the necessity for an assessment measure of numeracy apprehension and supports this as a foundation phase of mathematics anxiety. The final 19-item iteration of the NAS further supported observation, teacher and evaluation anxiety, as having an association with numeracy apprehension and again supported quantitative research results with older populations. A significant negative correlation was also observed between the NAS and numeracy performance scores, suggesting that educational attainment is adversely effected by anxiety at an early age and that the NAS has the potential to be a reliable assessment of children’s numeracy apprehension. The collective research conducted within this body of work has demonstrated a negative association between apprehension and performance, and produced a measure for early numeracy difficulties. This corresponds to the focus of emerging research within
the area of mathematics anxiety, that has occurred during the completion of this body of work and is discussed in chapter one.

6.3 Numeracy apprehension: support for a foundation phase of mathematics anxiety

Although mathematics anxiety research has shifted more towards the mathematics experiences of children during the completion of this body of work, there remains limited attention placed on the early school years. The findings from the current empirical work suggest that it is at this time when negative attitudes towards working with numbers first develop, and have an association with multiple factors.

The construct of ‘numeracy apprehension’ was proposed as a more age and experience appropriate term for children aged 4-7 years. The existence of numeracy apprehension as a foundation phase of mathematics anxiety was supported by the observations of primary care providers and subsequent scale implementation with children. The basis of the worrisome thoughts and avoidance that encompasses numeracy apprehension has been found to be a complex combination of related factors (Mutodi & Ngirande, 2014) in the current body of work. Indeed, as previously suggested for mathematics anxiety, the research within this thesis has demonstrated numeracy apprehension as being related to, for example: failure (Perry, 2004); dysfunctional beliefs about ability (Mazzocco et al., 2012); social phobia and embarrassment in front of peers (Hadley & Dorward, 2011; Vukovic et al., 2013; Mutodi & Ngirande, 2014); avoidance (Chinn, 2012); evaluation anxiety (Donaldson et al., 2002) and strained student-teacher relationships (Mata et al., 2012; Harari et al., 2013; Petronzi et al., 2012). As outlined in the introduction of this body of work, teachers and parents are influential factors in the formation of children’s numeracy attitudes and can have an association with other key factors, such as failure, avoidance and embarrassment. A main concern centres on children’s susceptibility to anxiety transference. In study one of this body of work, some teaching assistants stated an inability to help children with their numeracy work in the classroom, as they are uncertain of the correct method to use and fear causing further confusion to the child. Parents can further contribute to children’s numeracy negativity by placing too much pressure on their success (Krinzinger et al., 2009) and in contrast, can harm children’s participation by insisting that they lack ability in the subject (Gunderson et al., 2012). Parents can further and unintentionally cause frustration for children by attempting to facilitate their learning, even when they are unaware of how to use contemporary methods. Such occurrences place children at risk of learning anxiety when working with numbers, potentially affecting their participation and achievement. The extent
of parental and teacher involvement in the early education years implicates them as key factors in the development of numeracy attitudes.

The identified range of factors have been found to be present in the classroom during numeracy lessons, and are represented in the 19-item iteration of the numeracy apprehension scale. The items relating to these, form a one factor solution of ‘on-line numeracy apprehension’, and suggests that it is the numeracy lesson environment, from simply walking into the classroom, that induces anxiety. For the highly apprehensive children, the on-line element of numeracy does not only relate to the specific numeracy task, but managing all aspects of the numeracy lesson, including peers, teachers, incomplete work and intrusive thoughts that relate to their ability to complete a task. As these factors have been observed and measured in the early numeracy experiences of children, it can be posited that the origins of mathematics anxiety are based in the first years of formal education. Due to the similarities in observed influential factors between older populations and children aged 4-7 years, it can also be suggested with a degree of predictability that negative attitudes towards numeracy in the early years, will advance throughout a child’s educational career and negatively affect performance (Yates, 2002). It is the advancement of these attitudes that will develop into mathematics anxiety, particularly as the procedures increase in difficulty and complexity. Mathematics anxiety can also be regarded as a more rigid educational obstruction (Wigfield & Meece, 1988) than numeracy apprehension. Thus, it is the early years of education when assessment and intervention efforts will be most effective. Indeed, intervention efforts with teachers to alleviate anxiety and improve knowledge have been attempted, with limited benefits e.g. Hamlett (2007), whereas intervention efforts with children have often produced a reduction in anxiety and performance improvement e.g. Sheffield et al (2007).

As shown by the findings of the research in this body of work, the same factors afflicting achievement in mathematics in the later years, are the same factors, to a large extent, in the early years. The empirical evidence presented has demonstrated a negative association between numeracy apprehension and performance on a numeracy task, highlighting that the development of negative numeracy attitudes poses a notable risk to achievement, and relates to performance related research outlined in chapter one of this body of work e.g. Ashcraft et al (1998). This key finding not only reflects quantitative mathematics anxiety research results, but heightens the educational issue of numeracy apprehension. Indeed, like mathematics anxiety, this can be viewed as cyclic (Preis & Biggs, 2001; Ashcraft, 2002) as negative attitudes relate to avoidance and poor performance, that in turn, escalates negative feelings. The results from the research comprising this
body of work suggest that a child does not simply have or not have worrisome thoughts about numeracy, but rather, that most children have a certain degree of apprehension. For some, this is only minor and manageable and may only relate to a certain aspect e.g. division, whereas for others, apprehensive feelings have an adverse association with participation, perception and response behaviours in all regards. Witt (2012) was critical of previous mathematics anxiety research due to commonly identifying those with anxiety, and concluding that all others were entirely non anxious. Again, based on the current body of work, it can be suggested that the construct of numeracy apprehension exists as a spectrum, in which all children fall on. This is perhaps logical, as from the age of 4 years in the U.K., children begin attending school and continue along the maturation process, forming attitudes and determining likes and dislikes, as well as abilities in which peers are used as a gauge. Indeed, Nicolaidou and Philippou (2003) considered that children are intrinsically motivated to learn mathematics with positive attitudes, but begin to form attitudes, of which some may be negative and stem to factors, such as their teacher. As indicated by the research findings of this body of work, a clear separation between apprehension and no apprehension was not, and is unlikely to be found in children aged 4-7 years. However, a divergence is apparent and evidenced in the research, with an association to performance. This relates to the extent of the influence and impact of each of the key identified factors e.g. failure. For each child, there is a complex interaction of factors, and differences in personality should also be considered in terms of how these are managed and resolved, which implicates self-efficacy (Zimmerman, 2000; Kolacinski, 2003). Reinforcing the complexity of factors, Mohamed and Waheed (2011) considered the individual, the school and the home environment as the main areas associated with mathematics anxiety, and these have also been evidenced as relating to numeracy apprehension in the current research findings. However, this body of work has not addressed the thoughts of children under the age of 4 years, and non-verbal methods, such as pointing to an appropriate response, could be implemented in subsequent research to assess numeracy apprehension.

To summarise, the empirical research within this body of work has provided support for numeracy apprehension as a foundation phase of mathematics anxiety. Numeracy apprehension has been found to have an association with a combination of factors that have previously been linked to mathematics anxiety. Thus, as early negative attitudes often advance throughout a child’s educational career, numeracy apprehension can be argued to be the root of mathematics anxiety. It is therefore essential for assessment and intervention during the early years of education, as research has typically shown that children, more so than teachers for example, respond well to intervention efforts, also showing a marked improvement in performance. This is of further
importance, based on the current findings that children did not simply have or not have apprehensive feelings towards numeracy, but that all children reported apprehension to some degree.

6.4 Socio-economic status, culture and other forms of anxiety

Relating to the points of Mohamed and Waheed (2011), it is also necessary to consider the influence of socio-economic status and culture on mathematics performance and anxiety. Mazzocco (2007) discussed lower income as a mathematics education risk factor that specifically relates to limited resources in the form of a lack of intellectually stimulating environments and educated parents in the household. Therefore, children who are initially positive towards numeracy may begin to fall behind peers due to their social and economic situation. This relates to the point of Nicolaïdou and Philippou (2003) that all children start school with inherently positive attitudes towards mathematics, but are at risk from persistent failure and difficulties. Additionally, Chiu and Xihua (2008) found that socio-economic status of individuals and countries has an association with achievement in mathematics, although Dowker, Sarkar and Looi (2016) highlight that there is limited research that focusses on the specific association between socio-economic status and mathematics anxiety. Moreover, a higher socio-economic status does not inevitably result in parents placing significantly more value on numeracy and mathematics (Fraser & Honeyford, 2000) and in cases that they do, the child may perceive this as threatening (Krienzinger et al., 2009). This relates to cultural differences in attitudes towards mathematics performance and achievement. For instance, Korea and Japan have high achievement in mathematics, yet children were found to have higher mathematics anxiety than those in high achieving European countries (Lee, 2009). Although Tan and Yates (2011) attribute this difference to higher examination pressure in Asian countries, Dowker et al (2016) state that there may be further and as yet, unknown contributing factors and may relate to specific aspects of the educational systems. Despite some cross-cultural research in mathematics anxiety, the findings are limited, particularly in relation to generalizability (Ho, Senturk, Lan, Zimmer, Hong & Okamoto, 2002) and consistent results have not been achieved (Lee, 2009). The disparity between socio-economic and cross-cultural findings is yet another factor that complicates the understanding of mathematics anxiety and its association with performance.

Moreover, the finding that most children in this body of work were afflicted by a degree of numeracy apprehension, does not mean to say that other forms of anxiety did not contribute to the findings. Research has found mathematics anxiety to correlate with other forms of anxiety, and
have typically been identified using quantitative measures, as discussed in detail in section 1.8.2 in this body of work. As discussed in the introduction, Brown et al (1993) differentiate between general anxiety and mathematics anxiety, stating that the former is continuous worrying and tension relating to various aspects of life. Despite this, Hembree (1990) found mathematics to correlate with general anxiety (.35) and Ashcraft et al (1998) had shown mathematics anxiety to be related to other anxieties, particularly test anxiety, with a correlation of .3 and .5. Lee (2009) states that researchers have viewed mathematics anxiety as a subject specific form of test anxiety (Hembree, 1990). In contrast, Young et al (2012) have since demonstrated that mathematics anxiety has a distinct pattern of neural activity that is independent of anxiety, intelligence, reading ability and working memory. At the same time, Haase et al (2012) found that mathematics anxiety has an association with self-assessment in mathematics that in turn, has links with evaluation anxiety. Evaluation anxiety was also found to be an underlying factor of mathematics anxiety by Baloglu & Zelhart (2007) and Wren and Benson (2004), who also showed that those with mathematics anxiety score higher for test anxiety. However, Dowker at al (2016) highlight that anxiety exists in other subjects, particularly when performing in front of others, including foreign language learning, music performance anxiety and literacy learning for individuals with dyslexia. They further point to the research of Punaro and Reeve (2012) who found that whilst children aged 9-years had literacy and mathematics anxiety in relation to difficult problems in both subjects, mathematics elicited more intense worry that was related to mathematics performance. This suggested that whilst mathematics is not unique in causing anxiety, it may be the subject that elicits the most intense anxiety that is detrimental to performance.

In summary, areas of diversity including socio-economic status and culture have been shown to have a degree of involvement with mathematics performance and to a lesser extent, mathematics anxiety. In particular, socio-economic status is viewed as having a negative association with mathematics performance, although the limited and often divergent knowledge with regards to these factors presents an opportunity for further research. Moreover, when considering the influence of mathematics anxiety, research has evidenced that other forms of anxiety may also be involved, particularly evaluation and test anxiety. Therefore, mathematics anxiety may not influence performance and attitude in isolation, and again, further research would be of importance in this area, particularly with children aged 4-7 years.
6.5 Research limitations and future directions

Although the empirical research within this body of work has addressed a shortcoming in knowledge relating to the origins of mathematics anxiety, methodological limitations are acknowledged. With regards to the first piece of research, the findings could have been more representative, and possibly contrasting, with the inclusion of additional schools (parents and teachers) with more ethnic diversity and from a wider area. Thus, replication of this research would be particularly beneficial, and would either offer support for the themes interpreted by the author, or introduce additional factors that have an association with numeracy attitudes and performance for children aged 4-7 years. This limitation persisted in the second and third empirical studies, as schools that participated resided within the same region, and thus, the demographics of participants, including socioeconomic status, were similar. This could limit the application of the Numeracy Apprehension Scale. However, since the development of the 19-item iteration, it has been utilised in a student project in another region of the U.K. and was deemed to be successful in assessing for apprehensive feelings towards numeracy, in which an intervention was then based. Whilst this is only a single case of the NAS being applied beyond the region it was developed, the results were promising.

Reflecting upon the research process and responses in the second piece of empirical research, within the age range of this research, children’s memories continue to develop and are restricted in terms of the extent of information and experiences they can store in short term memory. This extends to long term memory and further restricts the encoding and storage of information (Croker, 2012). As some children may not implement information recall strategies, it may be that their responses on the NAS only partly reflect their reality. Indeed, this is a limitation of quantifying thoughts and experiences. To exemplify this point further, particularly in the case of the younger children in this research, it may be that a child responded to the items according to a bad experience in numeracy the previous day, yet a child who, for example, had an equally negative experience during the previous week, may have not stored this experience in their long term memory and thus provided more positive responses. Indeed, as discussed throughout this body of work, a number of additional factors can have an association with how children manage difficult experiences, including their self-esteem, parental support and teacher influence. Nonetheless, the memory capabilities of the younger children, particularly those aged 4-5 years, could have a further influence on the response process and could be considered further in subsequent research.
Despite the development of the NAS, the 19 items that comprise the scale are based on a .4 minimum statistical loading threshold, and are acknowledged to be in need of further implementation with children aged 4-7 years. The enforcement of a higher loading threshold for items may yield a change in a number of items that are included. In conjunction with this, the sample size in the third empirical study (n = 163) is further acknowledged to be less than ideal, although it can be justified as acceptable. Nonetheless, as this group of participants provided scale data and performance data in which a correlation was made – and is an important finding of this research – it would be advisable to repeat the third study with a larger sample size, and implement the 19-item iteration of the NAS. This would enable a comparison of the negative correlation between numeracy apprehension and performance, found in this body of work.

Further to this, a particular issue was identified in the third empirical study. This related to the reception year group and the numeracy task. Although designed by teachers, when implemented in other schools, teachers stated that they did not focus on children practising concepts through recording answers on paper - in the manner in which the task attempted to gauge their understanding and performance. Instead, they advised that children learned numeracy only through practical tasks. Thus, children in reception required more help with the task than was anticipated, possibly improving their results and not providing an accurate account of performance. Based on this limitation, teacher assessment levels could be requested as a more valid and reliable performance measure. This minimises the variability that, as found, can arise with the implementation of a single numeracy based task. These suggestions would improve the methodological approach of the third empirical study in this body of work, although the NAS remains part-validated.

Therefore, the validity and reliability of the scale would benefit from implementation across schools in different regions of the U.K. that cover a range of pupil demographics and socioeconomic backgrounds. Children’s scale responses could then be assessed against the levels they are given by their class teachers, providing more accurate correlational results. With increased validity and reliability, the Numeracy Apprehension Scale has the potential to become a standardised assessment measure in research and in the education system. More specifically, the NAS may be a valuable tool implemented by teachers to identify children at risk of numeracy difficulties. However, despite supporting the notion of numeracy apprehension between the ages of 4-7 years, it is still unknown as to which age this transitions into mathematics anxiety. Thus, subsequent research with children could enhance our understanding of this transitional phase, although emphasis should still be placed
on exploring the factors that children aged 4-7 years consider as influential in their numeracy attitudes and experiences. Functional intervention strategies could be developed based on discussion findings, and the trajectory towards mathematics anxiety can be stunted early in education. Early intervention is key, and the findings of this PhD thesis show that this is necessary between the ages of 4-7 years, due to the identification of negative attitudes and experiences that contribute to numeracy apprehension. The NAS holds the advantage of being relatively short, particularly for children aged 4 years and can also be administered to groups of children, rather than on a one-to-one basis. Indeed, intervention will not always be successful for some children, whom by the age of 8-9 years of age, may have become significantly withdrawn from and avoidant of numeracy and mathematics. However, future research that incorporates brief interventions could take the form of mathematics resilience, in which children are taught to concentrate on what they have achieved, rather than their deficits. The research could be longitudinal to measure children’s resilience levels over time and to also measure their mathematical attainment. Similarly, in other research, those identified with mathematics anxiety could participate in a self-compassion course to determine whether this intervention method can be effective in reducing anxiety. However, self-compassion can be anxiety provoking for some, particularly those that have established a negative self-concept in relation to mathematical achievement, and consideration must be given to this. Instead, revision podcasts could be incorporated as an intervention for mathematics anxiety, whilst for young children, numeracy computer games could be developed and utilised to promote numeracy indirectly and would counter the issue of avoidance.

The author’s research can be viewed as adding to knowledge with regards to age differences, although it would be of interest to determine whether similar findings would be obtained with a replication sample in other countries, including the US, Korea and Japan. However, as cross-cultural research in mathematics anxiety is limited, it would be beneficial for more data to be obtained relating to this construct, prior to studies that focus on numeracy apprehension. Similarly, as data is inconclusive regarding the correlation between mathematics anxiety and other anxieties, including general, test and evaluation anxiety, subsequent research could focus on children’s numeracy apprehension and whether this is associated with other factors. This could be achieved using the NAS and additionally, it would be of interest to obtain data to determine whether children between the ages of 4-7 years have other subject anxieties, particularly as they are still relatively new to formal education. The author would also endeavour to make a significant contribution in the area of gender differences in mathematics anxiety and would focus research on children aged 5 years, at the time of moving into a formal classroom setting. This would involve implementing the
NAS and obtaining teacher assessments over a one year period, to determine if there are changes between males and females as numeracy education increases in difficulty.

To conclude, based on the research findings of this body of work and that of emerging research which is placing emphasis on younger children, numeracy apprehension should be considered as a foundation phase to mathematics anxiety. The refinement and development of further assessment measures, such as the Numeracy Apprehension Scale, would prove beneficial and could begin to be implemented within schools, aiding teachers in identifying children who may be at risk. Intervention measures could then be implemented for these children, reducing the potential for the adverse effects on performance, as evidenced in this research.


Al-Ansari, B. (2003). Optimism and pessimism: There measurement and relationships with certain personality variables among Kuwait University students. Al-Resala, 192, 23rd Year Book, Scientific Publication Council, University of Kuwait, Kuwait.


Ayyangar, L. (2007). Skewness, multicollinearity, heteroscedasticity – you name it, cost data have it! Solutions to violations of assumptions of ordinary least squares regression models using SAS.


Department for Education (2012). Literacy and numeracy catch-up strategies.


National Numeracy (2012). BBC News Online, Poor numeracy ‘blights the economy and ruins lives’.


Olson, H. (N/D). Quantitative “Versus” Qualitative research: The Wrong Question, Canada: University of Alberta.


Appendix i – Letter to head teachers for study 1

Unique Reference Code………………………

Telephone:  07....
Email:  ...................

Dear ...........

Thank you for taking the time to read this letter. I am currently conducting research in the area of numerical apprehension in children between the ages of four and seven and I am seeking your permission to invite the teachers, parents and the children at your school to take part.

This research will aim to gain insight into the negative thoughts and feelings that some children experience towards number, something that research areas have often overlooked. To obtain a depth of insight, I will be holding discussions with teachers, parents and their children at various schools in your area. I would therefore like to take this opportunity to invite you and your school to participate.

If you are interested in taking part in this research and would like to know more about what is involved for the teachers, parents and children at your school, I will be contacting your school administrator on Tuesday 9th November to arrange a mutually convenient time for us to discuss this further. In the meantime, if you would like further details regarding the research, my contact details are:

Email:  D.............

I look forward to discussing this research with you in more depth in the near future.

Warm regards

Dominic Petronzi
PhD Student
Appendix ii – Study 1 consent form for study 1

Dear Parent/Guardian

Please find attached an invitation for you and your child to take part in a study that will look at thoughts, feelings and attitudes towards numeracy.

Apprehensive feelings towards numbers have been shown to impact negatively upon a child’s numeracy performance throughout their school careers. Many children suffer from such feelings, yet often remain unnoticed. There are existing scales designed to identify number apprehension in older children (7+), adolescents and adults, but a scale does not yet exist for children aged 4 – 7. Group discussions will therefore be taking place, allowing you, teachers and children to talk about numbers, providing information that can be used as part of this new scale. It is hoped that early identification can allow for early intervention, thus helping thousands of children overcome their numeracy apprehension, before it can develop.

This has received ethical clearance by the Psychology Research Ethics Committee.

Thank you for your consideration,
Yours sincerely,

Dominic Petronzi (PhD Student)

Please turn over
Q: Why should my child and I take part?

A: You and your child will be giving data that will be used to create a scale to help spot children that are nervous about working with numbers. Your input could benefit thousands of children, as they may receive early help to reduce fearful number feelings.

Q: What will we have to do?

A: You and your child will take part in a focus group, discussing numeracy attitudes and experience. There will be a group discussion for parents, a group discussion for children, and group discussion for teachers.

Q: What is a focus Group?

A: A focus group involves a small group of people openly discussing a particular topic of interest. I will be asking questions to find out opinions or reactions to numeracy issues. In your group, there will be between 10 and 12 participants.

Q: How long will it take and when will it be?

A: The discussion will last about 60 – 80 minutes for parents, and 30 minutes for children. Parents will be contacted for their availability, whilst discussions with children will take place during lesson time.

Q: What will happen to the data my child and I provide?

A: Discussions will be recorded so that what you and your child say can be later explored by me. Points of particular interest will be used to create statements for a numeracy apprehension scale. Your data will remain strictly confidential and whilst we will aim to keep you and your child anonymous, this cannot be guaranteed. However, you will be identified by an individual code, rather than your names.

Q: Why can’t anonymity be guaranteed?

A: Anonymity cannot be guaranteed as others in the group discussion will be aware what has been said and by whom. However, before starting, we will respectfully ask all those participating to not discuss anything that another person has said outside of the group.
Q: Who will be using the data?

A: Your data will be used only by the University of Derby for the purpose of this study alone. Data will be held in accordance with the Data Protection Act (1998) and will be kept in a lockable storage and on a password protected computer in an office in the University of Derby. The study may also be published at a later stage for others to read. All publications relating to this study will use arbitrary code numbers to refer to participants, rather than names. None of the data collected will inform my role and work at a school I am also currently employed at.

Q: What are the intended benefits?

A: As well as potentially helping thousands of children, your child’s school will receive a £75 book voucher for taking part.

Q: What are our rights as a research participant?

A: As participants, you and your child have the right to leave the research at any point you wish. You may also ask that the information about you and your child is not used. Should you choose to withdraw, the focus group discussions will still be used for analysis, but what you and your child have said personally will not be used. You can even request this up to 6 weeks after taking part in the discussion. Your child will always be reminded that they can stop whenever they would like and that they will not be in trouble for anything they say.

Q: What if taking part upsets me and my child?

A: Information on local sources of help will be made available, and pastoral support will, as always, be on hand should your child become worried during the group.

This is a consent slip regarding the numeracy discussions study. Please detach and return to school.

I would/would not like to take part in the group discussion.

I would/would not like my child, __________________________ to take part in the group discussion.
Your unique reference code is generated by the first and last name initials of your grandmother, and your own 6 digit birth date. For example, if your grandmother’s name is Mary Smith and your date of birth was 18/10/1982, your unique reference code would be MS181082. Please ensure that you also write your code on the space provided on the front page.

**My unique reference code**

__________________________

Contact Number  _____________________________

Signed parent/guardian ___________________________
Appendix iii – Teacher question schedule for study 1

Initially, some numerical problems and scenarios will be shown to the group, and they will be asked how each makes them feel.

Thoughts and Feelings Now:

1. Can you describe your feelings towards numeracy?
2. Did your attitudes towards numeracy influence your career choices in any way?
3. What situations set off yours feelings towards numeracy? Why?

Thoughts and Feelings as a child:

4. Do you think your feelings now were influenced by your own childhood experiences of numeracy?
5. What were those experiences? What were your numeracy teachers like?
6. Can you remember at what age any negative feelings started and why?
7. What did you find most difficult about numeracy?
8. Did your experiences affect your approach to numeracy throughout your school life?
9. Beyond the classroom, what other situations made you feel nervous about working with numbers?

Thoughts and Feelings of your Children:

10. How do your children feel towards numeracy?
11. Are you familiar with numeracy apprehension in children, in that they might fear and dread numeracy, negatively affecting performance?
12. Is this something you are aware of in the classroom?
13. From your observations and teaching experience, what do you think are the signs of children who might be numeracy apprehensive, and at what age do you think it starts?
14. How do they appear to cope with this? PROMPT do they employ avoidance tactics? Or do they rely on their friends for help?
15. What aspects of numeracy do children seem to struggle with? What aspects would provoke numeracy apprehension? (e.g. being asked to explain their answers) Why do you think this is?
16. Why do you think some children are more likely to develop apprehensive feelings towards numeracy than others?
17. What are the factors external to school? In what way?
18. Do you think children fail to see the application to real life of numeracy? Why is this hard for them?
19. Do you believe that being either right or wrong contributes to numeracy apprehension? Why?
20. Do children who are more often wrong lose interest and seemingly give up?
Appendix iv – Parent and mathematics expert question schedule for study 1

Initially, some numerical problems and scenarios will be shown to the group, and they will be asked how each makes them feel.

Thoughts and Feelings Now:

1. Can you describe your feelings towards numeracy?
2. Did your attitudes towards numeracy influence your career choices in any way?
3. What situations set off yours feelings towards numeracy? Why?

Thoughts and Feelings as a child:

4. Do you think your feelings now were influenced by your own childhood experiences of numeracy?
5. What were those experiences? What were your numeracy teachers like?
6. Can you remember at what age any negative feelings started and why?
7. What did you find most difficult about numeracy?
8. Did your experiences affect your approach to numeracy throughout your school life?
9. Beyond the classroom, what other situations made you feel nervous about working with numbers?

Thoughts and Feelings of your Children:

10. How do your children feel towards numeracy?
11. Do they ever display negative feelings? PROMPT - fear or dread of numeracy? Why do you think this is?
12. Do they ever seem to avoid working with numbers?
13. Why do you think some children are more likely to fear numeracy more than others?
14. What do you think are the signs of children who might be numeracy apprehensive?
15. What signs did you see in your children and when did they appear to start?
16. How do you think they would cope with this? PROMPT – do they avoid numeracy or rely on their friends for help?
17. Do you think children fail to see the application to real life of numeracy? Why do you think this is hard for them?
18. Do you believe that being either right or wrong contributes to numeracy apprehension? Why?
19. Do you think children who are more often wrong in numeracy lose interest and seemingly give up?
20. Do you think screening children early in life for negative feelings towards numeracy would be useful if help can be provided to make them feel better?
Appendix v – Researcher script for parents and teachers for study 1

First of all, I’d like to take this opportunity to thank you all for being here today. You really are going to contribute towards helping a lot of children who are fearful of working with numbers. I also appreciate that you are giving up your free time to take part in this discussion, and it is very much appreciated by the University of Derby and me.

So as you know, we are here to discuss feelings, thoughts and attitudes towards numeracy. Anything you say will be confidential, so please don’t hold back and share anything you wish. Just to remind you, this has received ethical clearance by the Psychology Research Ethics Committee.

I will be asking some questions, which the group can then elaborate on and discuss openly. I may ask further questions in relation to points and opinions you raise. However, this really is an open discussion, and you may say whatever you like whenever you like. Is that alright with everyone? However, before starting, we will respectfully ask that you do not discuss anything that another person has said outside of the group. Please keep all information about other group members confidential once the focus group is over.

Just to remind you, this discussion will be recorded, and you may leave whenever you like. Also, after completion of the discussion, if you later decide you would like what you have said to be taken out of the study, you may request this within 6 weeks. To do so, you will need to quote your unique reference number, which you wrote on the front page of the consent letter. Is that alright with everyone? Should you choose to withdraw, the focus group discussions will still be used for analysis, but what you have said personally will not be used.

At this point, some numerical problems and situations will be shown and discussed to allow them to focus in on their feelings relating to numeracy.

On Completion of the Focus Group:

- Thank everyone for their participation
- Remind them of their right to withdraw, and the children’s right to withdraw.
- Ask them to contact me should they have any further questions about the study.
## Appendix vi – Mathematics expert analysis table example

<table>
<thead>
<tr>
<th>Transcription</th>
<th>Question</th>
<th>Location/Data Extract</th>
<th>Coded For</th>
<th>Number of Apps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Expert 1</td>
<td>(1) Can you describe your feelings towards maths now?</td>
<td>1:16-17 - I do get a little bit of anxiety creeping in, in front of the students.</td>
<td>Negative Emotions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(8) Did you have any negative experiences at all, in school, for example...?</td>
<td>3:155-157 - I didn’t, but I saw negative experiences where children were put on the spot and I felt sorry for them because, half of me thought why don’t they know it because I do.</td>
<td>Pressure and Public Maths</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(13) Its kind of a similar reason coming out from the children that do like it, is that my daddy works with maths...</td>
<td>7:359-365 - Men, generally, are much more confident, and there also more confident at making mistakes, whereas the girls are a lot more reluctant to say the answer, and they’ll sit back, their body language changes and they actually physically recoil into their seats, thinking that you might ask them the question, and they’ll probably know the answer, but they’re not confident at relaying that answer.</td>
<td>Ability of Students</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2) Is that from just having to teach it or...feeling unsure about the concept yourself?</td>
<td>1:23-26 - I’m actually dealing with some students that have actually got A levels in maths and some of them have probably even got a degree in maths, the PGC students, so it’s a bit of both really.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix vii – letter to head teachers for study 2

Dear______.

Thank you for taking the time to read this letter. My name is Dominic Petronzi and I am a postgraduate psychology student, currently conducting research in the area of numerical apprehension in children between the ages of four and seven and I am seeking your permission to invite the children at your school to take part.

Apprehensive feelings towards numbers have been shown to impact negatively upon a child’s numeracy performance throughout their school careers. Many children suffer from such feelings, yet often remain unnoticed and so I endeavour to create an identification measure. This research will aim to gain insight into the negative thoughts and feelings that some children experience towards numbers, something that research areas have often overlooked. To identify the most influential numeracy factors, I will be asking children to respond to a variety of statements by circling one of three facial expression representations, at various schools in your area. I would therefore like to take this opportunity to invite you and your school to participate.

If you are interested in taking part in this research and would like to know more about what is involved for the children at your school, I will be contacting your school administrator on ___________ to arrange a mutually convenient time for us to discuss this further. In the meantime, if you would like further details regarding the research, my contact details are:

Email: D………..

I look forward to discussing this research with you in more depth in the near future.

Warm regards

Dominic Petronzi
PhD Student
Appendix viii – Consent letter to parents for study 2

Dear Parent/Guardian

Please find attached an invitation for your child to take part in a study that will look at feelings towards numeracy.

My name is Dominic Petronzi and I am a postgraduate research student currently researching children’s emotional responses to numeracy and aiming to create an identification measure for those whose worries prevent their full potential.

Apprehensive feelings towards numbers have been shown to impact negatively upon a child’s numeracy performance throughout their school careers. Many children suffer from such feelings, yet often remain unnoticed. There are existing scales designed to identify number apprehension in older children (7+), adolescents and adults, but a scale does not yet exist for children aged 4 – 7. Children are therefore being presented with the opportunity to respond to a variety of numeracy statements, by selecting one of three facial expressions, representing happy, unsure and sad. The information provided will inform of which statements to keep and which to remove. It is hoped that creation of a numeracy scale can allow for early identification and intervention, thus helping thousands of children overcome their numeracy apprehension, before it can develop.

This has received ethical clearance by the Psychology Research Ethics Committee.

Thank you for your consideration,

Yours sincerely,

Dominic Petronzi (PhD Student)
Q: Why should my child take part?

A: Your child will be giving data that will be used to create a scale to help spot children that are nervous about working with numbers. Your input could benefit thousands of children, as they may receive early help to reduce fearful numeracy feelings.

Q: What will my child have to do?

A: Your child will be given a sheet with a number of statements asking how they feel in certain numeracy situations. Each statement will be read to them and they will simply be asked to circle the face which is the same as how they feel in that situation.

Q: How long will it take?

A: Children will be out of lesson for no more than 20 minutes.

Q: What will happen to the data my child provides?

A: The information provided by your child will be added to information from other children to be analysed as one group. The information will remain strictly confidential. Your child will remain anonymous and will only be identifiable by a unique reference code, rather than their name.

Q: Who will be using the data?

A: Your data will be used only by the University of Derby for the purpose of this study alone. Data will be held in accordance with the Data Protection Act (1998) and will be kept in a lockable storage and on a password protected computer in an office in the University of Derby. The study may also be published at a later stage for others to read. All publications relating to this study will use arbitrary code numbers to refer to participants, rather than names.

Q: What are the intended benefits?

A: As well as potentially helping thousands of children, your child’s school will receive a £75 book voucher for taking part.
Q: **What are my child’s rights as a research participant?**

A: As a participant, your child has the right to leave the research at any point they wish. You may also ask that the information your child provides is not used. Should you choose to withdraw your child, the information they have provided will not be used. You can request this up to 6 weeks after their taking part in responding to numeracy statements. Your child will always be reminded that they can stop whenever they would like.

Q: **What if taking part upsets my child?**

A: Information on local sources of help will be made available, and pastoral support will, as always, be on hand should your child become worried.

This is a consent slip regarding the numeracy statements study. Please detach and return to school.

I would / would not like my child, ________________________________

to take part in responding to numeracy statements.

Your unique reference code is generated by the first and last name initials of your grandmother, and your own 6 digit birth date. For example, if your grandmother’s name is Mary Smith and your date of birth was 18/10/82, your unique reference code would be MS181082.

**Please ensure that you also write your code on the space provided on the front page.**

My unique reference code __________________________

Contact Number ________________________________

Signed parent/guardian __________________________
Appendix ix – Letter sent from schools to parents

Dear Parent

Please find attached a letter from Dominic Petronzi. He is a student at the University of Derby and we are supporting him with his research about maths. His letter outlines his research and what he will be doing in school.

We would really appreciate your support in allowing your child to take part in this project. If you have any questions please do not hesitate to contact me.

If you could return the permission slip to school by Friday 3rd May it would be much appreciated.

Many thanks,

Mrs.....................

Assistant Headteacher
Appendix x – Script for children in study 2

Hello everyone, my name is Dominic Petronzi and I am a student at university. I am here to ask you how you feel about doing numeracy when you are in school and at home. It would be absolutely fantastic if you and some of your friends will come and sit with me in a quiet area to answer some simple questions about numeracy.

Before I start, I want you to know that if you don’t want to do take part in this, it’s okay for you to say no. You will not get into trouble with either me or the teachers, and we really don’t mind. It’s important that you remember this. Does everybody understand so far? So we’re going to be looking at how we feel about numeracy, and to do this, I will read some questions to you and it would be very helpful if you could circle the face which shows how you honestly feel about that question. Does everybody understand?

Once ready to begin statement completion:

- Ask if they are feeling okay.
- Remind them that they won’t get in trouble for however they respond.
- Remind them that they can leave whenever they would like.
- Tell them that it should not take too long.

Throughout the task:

- Ensure that all children are still happy to respond to statements
- Remind them that they can leave whenever they like, and they will not be in trouble.
- Remind them that they should answer honestly.

On completion of response to statements:

Thank you all for all your time and for telling me how you feel in different numeracy situations. You have all been fantastic, and have helped me very much. So well done, you’ve all been excellent.
### Appendix xi – Participation sheet for study 2

<table>
<thead>
<tr>
<th>Child Name</th>
<th>Unique Ref Code</th>
<th>School Year Group</th>
<th>Age</th>
<th>Scale Score</th>
<th>Parent/Guardian Contact Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix xii – Letter to head teacher for study 3

Dear______,

Thank you for taking the time to read this letter. My name is Dominic Petronzi and I am a postgraduate psychology student, currently conducting research in the area of numerical apprehension in children between the ages of four and seven and I am seeking your permission to invite the children at your school to take part.

Apprehensive feelings towards numbers have been shown to impact negatively upon a child’s numeracy performance throughout their school careers. Many children suffer from such feelings, yet often remain unnoticed and so I endeavour to create an identification measure. This research will aim to gain insight into the negative thoughts and feelings that some children experience towards numbers, something that research areas have often overlooked. To identify the most influential numeracy factors, I will be asking children to respond to a variety of statements by circling one of three facial expression representations, at various schools in your area. In addition, the children will also complete a short numeracy task. I would therefore like to take this opportunity to invite you and your school to participate.

If you are interested in taking part in this research and would like to know more about what is involved for the children at your school, I will be contacting your school administrator on __________to arrange a mutually convenient time for us to discuss this further. In the meantime, if you would like further details regarding the research, my contact details are:

Email: D……….  

I look forward to discussing this research with you in more depth in the near future.

Warm regards

Dominic Petronzi
PhD Student
Appendix xiii – Consent letter to parents for study 3

Dear Parent/Guardian,

Please find attached an invitation for your child to take part in a study that will look at feelings towards numeracy.

My name is Dominic Petronzi and I am a postgraduate research student currently researching children’s emotional responses to numeracy and aiming to create an identification measure for those whose worries prevent their full potential.

Apprehensive feelings towards numbers have been shown to impact negatively upon a child’s numeracy performance throughout their school careers. Many children suffer from such feelings, yet often remain unnoticed. In this work, children are being presented with the opportunity to respond to a variety of numeracy statements, by selecting one of three facial expressions, representing happy, unsure and sad. The information provided will inform of which statements to keep and which to remove. It is hoped that creation of a numeracy questionnaire can allow for early identification and intervention, thus helping thousands of children overcome their numeracy apprehension, before it can develop.

This has received ethical clearance by the Psychology Research Ethics Committee at the University of Derby.

Thank you for your consideration,

Yours sincerely,

Dominic Petronzi (PhD Student)
Q: Why should my child take part?

A: Your child will be giving answers that will be used to create a questionnaire to help spot children who are nervous about working with numbers.

Q: What will my child have to do?

A: Your child will be given a sheet with a number of statements asking how they feel in certain numeracy situations. Each statement will be read to them and they will simply be asked to circle the face which is the same as how they feel in that situation. Children will also be asked to answer 20 numeracy problems, similar to those they complete in class.

When I do number work, I feel…

😊 😞 ☹️

Q: How long will it take?

A: Children will be out of lesson for no more than 30 minutes.

Q: What will happen to the data my child provides?

A: The information provided by your child will remain strictly confidential. Your child will remain anonymous and will only be identifiable by a unique reference code, rather than their name.

Q: Who will be using the data?

A: Your data will be used only by the University of Derby for the purpose of this study alone. Data will be held in accordance with the Data Protection Act (1998) and will be kept in a lockable storage and on a password protected computer in an office in the University of Derby. The study may also be published at a later stage for others to read.

Q: What are my child’s rights as a research participant?

A: As a participant, your child has the right to leave the research at any point they wish. You may also ask that the information your child provides is not used. You can request this up to 6 weeks after
they have taken part. Your child will always be reminded that they can stop whenever they would like.

Q: What if taking part upsets my child?

A: Although unlikely, should your child become upset, I will be able to offer reassurance and support due to having worked as a teaching assistant for 3 years and in a children’s care home for 1 year. They will be free to stop at this point and return to class where their class teacher will also be made aware, so that they can provide additional support. Your child will still receive a sticker or sweet for taking part. Pastoral support will, as always, be on hand should your child become worried and information on local sources of help will be made available.

This is a consent slip regarding the numeracy statements study.

Please detach and return to school by ..........................

I would / would not like my child, _________________________________________
to take part.

My child’s year group _______ and class teacher_____________________________

Your unique reference code is generated by the first and last name initials of your grandmother, and your own 6 digit birth date. For example, if your grandmother’s name is Mary Smith and your date of birth was 18/10/82, your unique reference code would be MS181082.

Please ensure that you also write your code on the space provided on the front page.

My unique reference code __________________________

Signed parent/guardian __________________________
Appendix xiv – Script for children in study 3

Hello everyone, my name is Dominic Petronzi and I am a student at university. I am here to ask you how you feel about doing numeracy when you are in school and at home. It would be absolutely fantastic if you and some of your friends will come and sit with me in a quiet area to answer some simple questions about numeracy.

Before I start, I want you to know that if you don’t want to do take part in this, it’s okay for you to say no. You will not get into trouble with either me or the teachers, and we really don’t mind. It’s important that you remember this. Does everybody understand so far? So today, we’re going to be looking at how we feel about numeracy and to do this, I will read some questions to you and it would be very helpful if you could circle the face which shows how you honestly feel about that question. Does everybody understand? On another day, we will do some numeracy questions that are just like the ones you do in class with your teacher.

Once ready to begin the task:

• Ask if they are feeling okay.
• Remind them that they won’t get in trouble for however they respond.
• Remind them that they can leave whenever they would like.
• Tell them that it should not take too long.

Throughout the task:

• Ensure that all children are still happy to respond to statements.
• Remind them that they can leave whenever they like, and they will not be in trouble.
• Remind them that they should answer honestly.

On completion of the task:

Thank you all for all your time and for telling me how you feel in different numeracy situations. You have all been fantastic, and have helped me very much. So well done, you’ve all been excellent.
**Appendix xv** – Participation sheet for study 3

<table>
<thead>
<tr>
<th>Child Name</th>
<th>Unique Ref Code</th>
<th>School Year Group</th>
<th>Age</th>
<th>NARS Score</th>
<th>Numeracy Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix xvi – Reception children’s numeracy task

Name: 

How many shapes in this picture?

○ = □
△ = □
□ = □
■ = □

Fill in the missing numbers:

1  2  ___  4  5  ___  7
5  6  7  ___  9  10  ___
10  9  8  ___  6  5  ___

Add the 2 numbers together...
find the answer:

2 + 3 = □
5 + 4 = □
Take 1 away:

\[ \begin{align*}
\text{🍎} & \quad \text{🍎} - 1 = \square \\
\text{スター} & \quad \text{スター} - 1 = \square \\
\end{align*} \]

Write F for full . . .
E for empty . . .

Full in the missing number:

10  20  30  _  50  60

70  _  90  100.  Well done! 😊
Appendix xvii – Year one children’s numeracy task

1) 3 + 4 = □

2) Double 2 = □

3) What is the difference between 3 and 9? □

4) 7 – 2 = □

5) □ + 3 = 8

6) 10 + □ = 12

7) 5 + □ = 7

8) 6 + 2 + 2 = □

9) 11p + 1p + 1p + 1p + 1p = □

10) 2, 4, □, □, □

11) 1, 3, 5, □, □

12) 6 − 2 = □

13) 8 - □ = □
14) $1p + 2p + 5p + 1p = \square$

15) $\square + \square + \square = 5$

16) $\square + \square + \square = 7$

17) Make 10 $\square + \square = 10$

18) Make 10 $\square + \square = 10$

19) Make 10 $\square + \square = 10$

20) Make 10 $\square + \square = 10$
Appendix xviii – Year two children’s numeracy task

1) $7 + \square = 10$

2) $1 + 9 = \square$

3) $\square + \square = 20$

4) $19 - 1 = \square$

5) $30 - 10 = \square$

6) $12, 14, 16, \square, \square, 22$

7) $20\text{p} + 10\text{p} + 5\text{p} = \square\text{p}$

8) $1\text{p} + 2\text{p} + 10\text{p} = \square\text{p}$

9) $6 + 9 = \square$

10) Double 3 = \square

11) Double 9 = \square

12) $\frac{1}{2}$ of 16 = \square

13) $7 + 3 + 5 = \square$
14) $19 - 8 = \underline{11}$

15) $23 - 4 = \underline{19}$

16) $10 + 10 + 10 + 10 + 10 = \underline{50}$

17) $4 \times 2 = \underline{8}$

18) $7 \times 5 = \underline{35}$

19) $3 \times 10 = \underline{30}$

20) $3 + 3 + 3 + 3 + 3 = \underline{15}$
Appendix xix – Numeracy apprehension scale (19-items)

NAME_______________________________________  Total Score________________________

NUMERACY APPREHENSION SCALE

The items in the questionnaire refer to day-to-day numeracy situations which may cause apprehension for children aged 4-7 years. For each item, children can place a circle around the face which describes how they feel in relation to the situation.

1. When my friends finish their number work before me, I feel...
   - Happy
   - Neutral
   - Sad

2. If I am the last to finish numeracy work on my table, I feel...
   - Happy
   - Neutral
   - Sad

3. If I make a mistake in numeracy, I feel...
   - Happy
   - Neutral
   - Sad

4. When I can’t do my numeracy work, I feel...
   - Happy
   - Neutral
   - Sad

5. When I have to explain a numeracy problem to my teacher, I feel...
   - Happy
   - Neutral
   - Sad

6. If I think I can’t do my numeracy work, I feel...
   - Happy
   - Neutral
   - Sad

7. When I see lots of numbers, I feel...
   - Happy
   - Neutral
   - Sad

8. When I have to explain a numeracy problem to my friends, I feel...
   - Happy
   - Neutral
   - Sad
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9.</td>
<td>If I have to finish all my numeracy work in lesson, I feel...</td>
<td>😊😊😊</td>
</tr>
<tr>
<td>10.</td>
<td>Listening to the teacher in my numeracy class makes me feel...</td>
<td>😊😊😊</td>
</tr>
<tr>
<td>11.</td>
<td>If I answer questions and get them wrong, I feel...</td>
<td>😊😊😊</td>
</tr>
<tr>
<td>12.</td>
<td>If I have to tell the teacher that I don't understand my numeracy work, I feel...</td>
<td>😊😊😊</td>
</tr>
<tr>
<td>13.</td>
<td>If other children know that I find numeracy hard, I feel...</td>
<td>😊😊😊</td>
</tr>
<tr>
<td>14.</td>
<td>When I watch or listen to my teacher explain a numeracy problem, I feel...</td>
<td>😊😊😊</td>
</tr>
<tr>
<td>15.</td>
<td>If I don’t finish my number work in class, I feel...</td>
<td>😊😊😊</td>
</tr>
<tr>
<td>16.</td>
<td>If other children finish their numeracy very quickly, I feel...</td>
<td>😊😊😊</td>
</tr>
<tr>
<td>17.</td>
<td>When I explain how I got my answer to my teacher, I feel...</td>
<td>😊😊😊</td>
</tr>
<tr>
<td>18.</td>
<td>When my teacher wants me to do numeracy at home, I feel...</td>
<td>😊😊😊</td>
</tr>
<tr>
<td>19.</td>
<td>Walking into the numeracy class makes me feel...</td>
<td>😊😊😊</td>
</tr>
</tbody>
</table>