The mathematical biographies of primary school teachers and how this may affect their teaching; a grounded theory study.

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Abstract

Improving numeracy skills in the UK population has been the aim of many different government education strategies over many decades. This piece of research uses grounded theory to explore the conscious psychological processes of primary school teachers when they are teaching maths to the children in their class. The question which is pursued throughout the study is how primary school teachers' own experience of learning mathematics are represented within those processes and how this may influence the way that they teach children in their class. The main form of data used in the study was the voices of ten different teachers in interview transcripts.

In the first chapter, a review of past and current legislation and government strategy as well as research and analytic literature is provided where mathematics education is discussed from multiple perspectives including temporal/historic, socio-economic, sociocultural and from the point of view of an individual's cognitive and emotional development. Chapter two deals with the methodology and the critical realist underpinnings. The main models of grounded theory are juxtaposed and considered in light of the author's critical realist ontological stance which is also explained. The third chapter presents the key findings before the analysis in the fourth chapter where the emergent core theory is first linked back to the reading and research in the introductory chapter and then taken further into fresh conceptual fields whereby it is seen as a broader set of re-enactment processes which are thought to take place in parenting and psychotherapy. The study's scope and limitations are dealt with before, finally, there is a short conclusion considering future research directions and the implications for education strategy, general education strategy, EPs, teachers and other stakeholders.

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To my husband and two children.

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Summary of tables and figures

Summary of abbreviations and acronyms

Abbreviation	Abbreviation/acronym in full
CPD	Continuing Professional Development
DfE	Department for Education
DfES	Department for Education and Skills
DfBEIS	Department for Business, Energy and Industrial Strategy
EP	Educational Psychologist
HCPC	Health Care Professional's Council
OFSTED	Office for Standards in Education
PGCE	Postgraduate Certificate in Education
SEN	Special Educational Needs

1. INTRODUCTION

1.1 Organisation of the chapters

This piece of research uses grounded theory to explore the psychological processes that influence primary school teachers when they are teaching maths. The main form of data used in the study was the voices of teachers in interview transcripts.

In the first chapter, a review of legislation, research and analytic literature is provided. Chapter two deals with the methodology used in this study, grounded theory, which involves the inductive generation of theory from the data as it is collected and analysed. The third chapter presents the key findings. This is followed by a second literature review, which forms part of the discussion chapter and here the emergent grounded theory is linked back to the reading and research in the introductory chapter and explored further in fresh conceptual fields. Finally, there is a short conclusion complete with recommendations and suggestions.

1.1.1. Introduction to the first chapter

The contextual analyses in the introductory chapter are shaped by ideas developed over many years through my own reading in a wide range of fields and discussions with colleagues prior, and during, the data collection. It has, therefore, played an important role in creating my 'theoretical sensitivity'. Although I took steps to enhance my neutrality and openness to the data, undoubtedly my reading in the field influenced my analysis of the data.

In this introductory chapter, my aim is to situate the teachers' voices within the contexts from which they have arisen. This involves discussing mathematical education from

multiple perspectives, including temporal/historic, socio-economic, sociocultural perspectives and from the point of view of an individual's cognitive and emotional development. First, I will provide details of how the author came to be interested in this area of research. I will then provide an historical overview of government guidance and legislation surrounding mathematics education in UK primary schools over previous decades focusing, in particular, upon the National Curriculum. A global-economic lens will then be applied and we will see how mathematics education is located within this macro-context. The scenario that is the central concern of this research is then brought into focus: the dyad of the child and the teacher in a mathematics lesson. I examine theory and research relevant to this scenario, initially looking at within-child factors, then working progressively outwards through the surrounding systems of family, school and society, incorporating the most recent national policy developments in education and teacher training. Finally, I will move back to the central scenario to look at the other member of the dyad: the teacher. I conclude the chapter by explaining the nature of the current research project and clarifying how the thesis has been organised to reflect the research process.

I have chosen to include an initial literature review within the introductory chapter and a second literature review after the results have been presented. The first is located in the introduction in order to place the research within a temporal socio-political context and to demonstrate that the study would be adding to the knowledge and understanding in the field. The second literature review is based on the outcomes of an inductive process of data analysis and theory generation. Here, the purpose will be to add density to the conceptual model emerging from the data by relating it back to a wider context of research so as to provide insights for future practice.

1.1.2 A note on style

I have used numbers and headings throughout my thesis. The numbers reflect the structure of the information that is presented, while the labels used for the headings are comments about the content and questions with the aim of enhancing the readability. Teachers are referred to as 'she' and pupils as 'he', unless the gender is denoted.

1.1.3. Definitions

There are varying definitions of numeracy. The Organization for Economic Cooperation and Development (OECD) is an international policy development forum where countries can bring together statistical data including educational data. The OECD defines numeracy as "the ability to access, use, interpret and communicate mathematical information and ideas, in order to engage in and manage the mathematical demands of a range of situations in adult life" (OECD, 2012, p34). This implies that the essential skills needed for engagement in mathematics are solving problems, processing information, making decisions and interpreting data. Being numerate is about appreciating number relationships and interpreting answers, not just about doing calculations. As the outcomes of OECD analysis have been instrumental in directing the UK government's educational policy and guidance, its definition will be adopted in this thesis.

Throughout this thesis, the word 'numeracy' will, for the most part, be used interchangeably with the word 'mathematics' and its abbreviation 'maths', although it is appreciated that there is an important distinction between numeracy and mathematics, which rests on the idea that numeracy goes beyond mathematics to include application

skills, such as solving problems, understanding and expanding solutions, and making decisions based on logical thinking and interpretation. However, in certain places, such as where I have explored the development of number sense in children, I have needed to re-draw the distinction between numeracy and mathematics in a very specific way for the purposes of my discussion.

1.2 The author's own mathematical biography

Mathematical biography is a term I coined during the project to describe a person's story of themselves both as a mathematician and as a learner or teacher of maths. The term will be developed over the course of this chapter. In this section, I recount my own mathematical biography for the purposes of transparency in terms of my personal interests and motivations in the research. My biography was shaped by many of the events discussed in the subsequent analysis of the history of mathematics education and highlights the affective aspects of learning mathematics, which are dealt with in the final section of this chapter.

I grew up and was educated in Scotland in the 1970s and 80s. Mathematics was a subject with which I had a problematic relationship. On the one hand, it was a high-status subject: I admired other children who were good at maths and yearned to be good at it myself. On the other hand, I soon discovered myself to be a failure at maths in terms of being unable to do what was required. My experiences of learning maths at school were imbued with a sense of failure and inadequacy.

My earliest memories of learning maths date back to primary school with a teacher called Mr Douglas. At that time in Scotland, teaching maths comprised the children individually

working through a set of workbooks at their own desks, progressing through different levels denoted by colours. Every now and again, Mr Douglas would call children out in groups to the front of the class to cover a teaching point. I remember that whenever Mr Douglas called me out to explain something, I simply could not comprehend it and as a result I did not learn any maths methods. In particular, I remember that I would experience a kind of mental paralysis whenever the long-division method was shown to me, a feeling which I associated with stupidity.

When I moved up to secondary school, I was put in the bottom group for maths. However, I enjoyed science very much and I was particularly good at physics, which increasingly involved maths. Despite being unable to learn mathematical methods in the classroom, I found that I could use maths without difficulty when I was doing physics as I simply developed my own methods for carrying out the calculations that were needed. The methods made perfect sense to me and flowed naturally from the structure of the physics problem I was trying to solve.

Later in life, I trained to be a teacher and studied for my PGCE at the Institute of Education (IOE) in London. This was in 2000, which was around the time the government introduced both the National Numeracy Strategy (NNS) and English and maths skills testing for primary school teachers. There was much anxiety among my peers about who would make the grade and we were encouraged to take practice tests before the real thing. When I did my maths practice test, much to my astonishment, I got a very high mark and was selected to be a peer tutor on my course, supporting other students who had failed the test. I was so proud of myself that I decided to take maths as my teaching specialism. The specialism on the IOE course was taught by Dr Tamara

Bibby who put together an extremely stimulating module. Each of the sessions began with a mathematics investigation that we usually carried out as a small group. I enjoyed these maths investigations immensely and it was during this time that I realized what an intuitive subject maths is. I often found that when the investigation was laid out, I would immediately have a sense of how I should start and became totally absorbed in the investigative process.

I then began my career as a primary school teacher and became the maths coordinator within the school. However, my newfound love of maths did not translate into being able to teach it well and I found myself struggling with the subject once again, only this time in terms of how I should present it to children.

While training to be an EP, I noted that children's difficulties with learning mathematics received scant attention compared to children's difficulties with learning literacy. As I learned more about psychological defences, I wondered if these may account for why mathematics is the poor relation to literacy, despite often being revered as one of the highest forms of learning, and returned to my contemplation of the teaching and learning of mathematics with a new set of questions. On occasion, I would be carrying out an observation of a child during a maths lesson, only to find myself drawn to the interaction in the classroom between the teacher and the children; I was struck by the differences between teachers' approaches to supporting children. It was through this that I began to wonder if our feelings about a subject influence the way that we teach this subject to others. I was also interested in understanding more about social and cultural influences on our experiences of different academic subjects.

Understanding the interplay between within-child factors and the learning environment is at the heart of the EP's work. With regards to maths, I studied how the idea of dyscalculia is socially constructed within the media, schools and online forums and how these representations compare with the definition constructed through the work of neuroscientists. I took an interest in what is known about the development of numerical cognition in young children and animals.

Models and algorithms of numerical reasoning are being developed to predict the choices that humans and animals will make when faced with a quantitative decision. Such models could have a range of application to every day life such as to help us make more effective decisions in regard to investments or purchases. To illustrate by way of an example, Strandburg-Peshkin, Farine, Couzin, and Crofoot (2015) studied the movements made by troops of wild baboons. They found that where there is a conflict in regard to the direction the troop should travel, rather than following the dominant baboon in the troop, the baboons' made a collective decision based on the comparative number of baboons that want to go in each direction i.e. the troop collectively went with the choice of the majority.

A further study using the baboon movement data gathered in the original study by Strandburg-Peshkin, Farine, Couzin, and Crofoot statistically tested different hypotheses to see how well they predicted the baboons' movements (Piantadosi & Cantlon, 2017). They found that the model which best accounted for the baboons' decisions was approximate-number comparisons rather than area or mass. By comparing their findings about the accuracy of baboon's numerical judgements with those of researchers studying numerical cognition in humans, Piantadosi and Cantlon

were able to estimate that the numerical sensitivity of wild baboons is comparable to that of 3-year-old human children (p468).

1.3 Mathematics Education in England: a historical overview of legislation

In this section, I will summarize the history of the national curriculum in England with a specific focus on how maths has been represented in it. This is relevant to the current study because it forms the historical and societal backdrop to the teachers' experience. As I was a primary school teacher myself during part of this period, it also forms the backdrop to my own experience and has played a pivotal role in shaping my reactions and interests, and thus my theoretical sensitivity. The data for the current study was collected between 2012 and 2016, a period of radical change in public services – the effect of which can be traced in the teachers' narratives about teaching maths in their classrooms. A focused analysis of this period in the third chapter, will provide a framework in which to present data.

1.3.1 Introduction of national standards

In 1988, the national curriculum was rolled out across schools in England, standardising the content taught and enabling the compilation of national assessment statistics. In the early 1990s, national testing was introduced for 7-, 11- and 14-year olds, with the data giving a picture of attainment throughout the UK. Although there was regional variation, overall the picture of national attainment showed that many pupils were not achieving at the level expected in the core subjects of mathematics, English and science. In terms of maths, only half of all Key Stage Two children (aged 7 to 11) were reaching the level expected for their age in mathematics.

1.3.2 International attainment surveys

The process of globalisation has created an international stage upon which governments around the world compete. The picture of poor national attainment was corroborated by the outcomes of a number of international surveys of maths achievement, in particular the Third International Maths and Science Study (TIMSS) in 1996, where it was found that English children were performing badly in maths compared to children in other countries. For example, Year Five pupils in England were shown by the TIMSS study to be "amongst the lowest performers in key areas of number out of nine countries with similar social and cultural backgrounds" (DfEE, 1998, p4). Coupled with this was the seminal piece of school effectiveness research published in the book *School Matters* (Mortimore, Sammons, Stoll, Lewis, and Ecob, 1988), which indicated that, at the time, educational factors affected children's performance in maths more than in other core subjects; the corollary of this being that the children's poor national performance in maths was more likely due to educational than socio-economic factors (Muijs & Reynolds, 1999). That is, poor pupil performance was a result of teaching and the curriculum, rather than pupils' family backgrounds.

1.3.3 Daily numeracy hour

Whether or not this was the case, politicians began the process of driving up standards in numeracy by taking control of the curriculum. This project was led by the Numeracy Task Force who set up the National Numeracy Project in 1996 which, in turn, led to the implementation of a National Numeracy Strategy (NNS) in 1999. The NNS was an offshoot of the national curriculum, which prescribed that maths was to be taught via a daily numeracy hour. This meant that one entire, unbroken hour of every school child's day would be spent learning maths directly: first, there would be a short session of oral maths and mental calculation; this would be followed by a direct teaching session

covering a particular aspect of maths; children would then practice independently; and finally there would be a short plenary or summary of the lesson. The design of the NNS was based on the outcomes of both American and British research into the effective teaching of mathematics, which indicated that a highly interactive and structured whole-class teaching style gave the best results (Brophy & Good, 1986). A similar project, the National Literacy Strategy, began at the same time as the NNS and was implemented to drive up standards in literacy.

Over the following two decades, the NNS followed a convoluted course of development, shaped by a wide range of different political interests and national objectives. In 2003, it was combined with the National Literacy Strategy to form the National Primary Strategy. In October 2006, the frameworks for teaching literacy and numeracy were renewed and issued in electronic form as the Primary Frameworks for Literacy and Mathematics and the original NNS and NLS ceased to operate in 2011. Throughout its evolution, the recipe for the educational dish that teachers were required to serve to children in their classrooms was increasingly controlled with tightly organised frameworks prescribing key learning objectives and termly planning grids, supplemented by examples of activities related to every learning objective for each year group.

1.3.4 National attainment

Figure 1: Percentage of children achieving level 4 and above in KS2 SATs
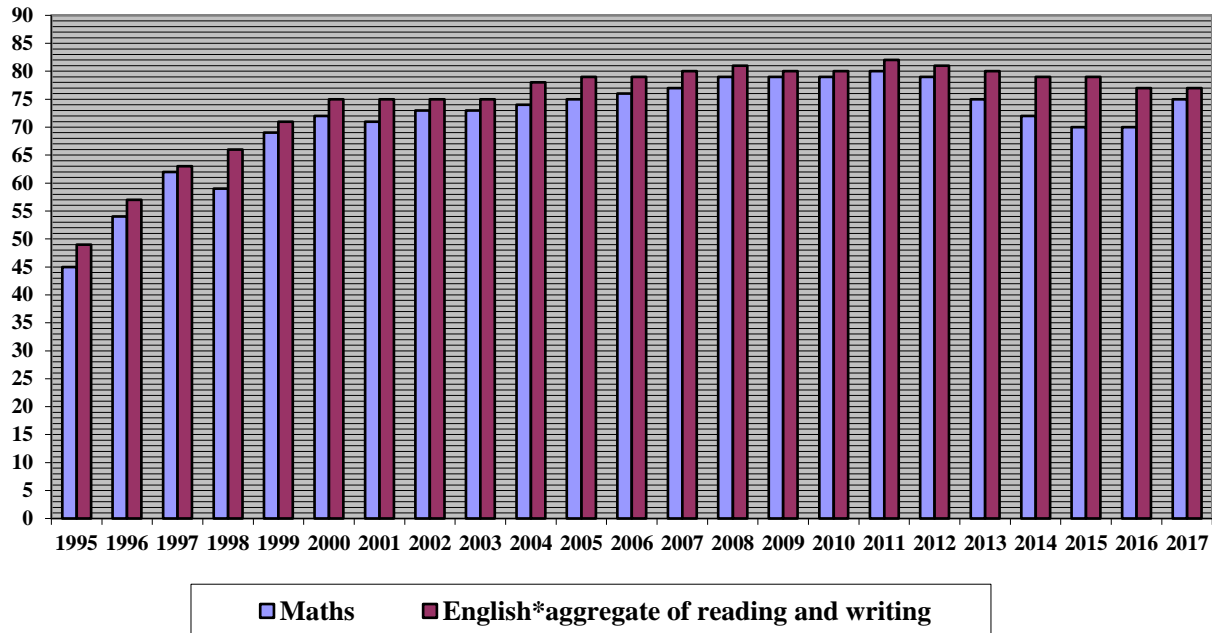
There was a mixed picture in terms of the results of the aforementioned initiatives. As can be seen in figure 1, substantial gains were made in both literacy and numeracy, with the percentage of children achieving the expected level 4 or above at the end of Key Stage 2 rising significantly and steadily. However, the figures consistently fell short of governmental targets. For example, the governmental target set for Key Stage 2 was that 85% of 11-year olds should achieve Level 4 or above in mathematics by 2006 and that this level of performance should be sustained until 2008. However, by 2008 only 79% of pupils had actually achieved this target. There was a similar picture in secondary schools, with only 47.6% of pupils achieving five or more A*-C in GCSEs compared to a target of 60%.

This generated debate nationally with regards to who was responsible for this failure. In 2008, OFSTED brought out a report, *Mathematics: Understanding the score (2008),* which was based on evidence from mathematics inspections from the previous three

years. Although this report was positive in many ways and praised the upward trend in the results across Key Stage 2, Key Stage 3 and GCSEs, OFSTED also outlined a number of concerns that were very much focused on the way in which the subject was taught, while the curriculum itself was considered to be developmentally appropriate. The OFSTED report highlighted widespread variation in the quality of mathematics teaching and stated that too much mathematics teaching focused on learning disparate and abstract facts for the purpose of passing tests rather than on developing children's conceptual abilities and application.

The next major political event to affect the mathematics curriculum and educational landscape came in 2010 when the Coalition Government was formed in England and began an extensive reform of the education system. The then-Education Secretary, Michael Gove, published a series of highly controversial drafts and proposals for a new national curriculum, slimming down the content and ostensibly reducing prescription. This generated strong feeling among stakeholders with criticism directed, on the whole, towards the new curriculum prioritising facts over method and understanding. There were also questions raised about whether the new curriculum was developmentally in tune with children and if it expected 'too much too young' (*The Independent*, 20 March 2013). A final curriculum was published in September 2013 and Programmes of Study for English and maths, followed a year later in September 2014.

1.3.5 Recent developments

The mathematics Programme of Study lays out a rigorous set of demands in regard to acquiring number fact, developing fluency in the use of mathematical operation and the

ability to reason mathematically. The government claims that these targets are consistent with the expectations in the high-performing educational jurisdictions of countries such as Singapore and Hong Kong. In a recent white paper, *Educational Excellence Everywhere* (2016), Michael Gove's successor, education secretary Nicky Morgan, affirmed the role of the government as being to set the bar of accountability for schools by stating that teachers must ensure their children achieve "what needs to be achieved for the public money invested in education" (p9). On the other hand, she points out that the government does not dictate how these outcomes should be achieved and gives schools autonomy in regards to the methods they use. The whitepaper also announces the government's intention to introduce measures to support teachers in particular curriculum areas, such as maths, and states that school-led maths hubs have been established around the country to act as expert leaders in mathematics pedagogy in the curriculum. These hubs, known as Mathematics Education Strategic Hubs (MESH) are to disseminate pedagogic practice gleaned from local exchange programmes and exchange programmes with the Far East and specialist Continuing Professional Development providers.

A final point that should be made in this politico-historical introduction is that the most recent developments to the curriculum have been made within the context of the government's strategy of converting schools into academies (DfE, 2016). Although academies have a statutory duty to provide broad and balanced learning experiences for their pupils, they do not have to follow the national curriculum for programmes of study, even for the core subjects. What the future English education system will look like and what we should expect pupils to learn and experience should they attend school in England is currently uncertain and a matter of intense speculation.

1.4. Mathematics Education: A socio-economic overview

Mathematics education is a key area of interest for the government (Smith, 2017). In the next section, I explore the reasons why this should be the case.

1.4.1. The benefits of numeracy

The application of maths is ubiquitous and is thoroughly necessary for our daily personal and professional lives. Maths is used by individuals from all walks of life to carry out basic calculations, from counting the change received when shopping through to developing the latest technology for telecommunications.

In the government's *Plan for Growth* (2011), it is recognised that access to a workforce with science, technology, engineering and mathematics skills is vital for a number of sectors identified as being key drivers of economic growth. Furthermore, this is a developing picture, with many of the employment sectors dependent on mathematics emerging at an exponential rate (DfBI&S, 2016). So much so in the UK, it is estimated that for every £1 invested in mathematics and the sciences, £9.6 is generated in return, which represents nearly a ten-fold return on investment (Department for Business, Innovation and Skills, 2016). It is also estimated that research into mathematical sciences generates £208bn in the UK, equating to 16% of the overall the grade point average (GPA) of the entire UK. It is, therefore, unsurprising that it remains a key objective to increase the number of graduates, postgraduates and researchers in the mathematical sciences to meet current and future industry needs by maintaining and improving the UK's economic status on the world stage.

Maths achievement has been positively correlated with socio-economic productivity. The British Cohort Study (BCS) tracked a cohort of individuals born in a specific week of 1970 through their lives extracting from it, at different points, a wide range of standardised measures and ethnographic data with a view to illuminating possible links between later outcomes in the individuals' lives and differences that existed between them earlier in childhood. Researchers Vignoles, Coulon and Marcenaro-Gutierrez (2008) used BCS data to look at variance in certain measures such as salary at the age of 35 and achievement in a standardised maths test taken at the age of ten. They found that each standard deviation (approximately 15 points in the maths test) correlated with earning around 10% more as an adult after controlling for characteristics such as family background, early cognitive ability and education level.

Subsequent data from the BCS was followed up by researchers at the Institute of Fiscal Studies, Crawford and Cribb (2013) who found that by the time the cohort were aged 42 each standard deviation in the maths test at ten correlated with earning around 11% more. Although correlation is not evidence of causality, and it does not necessary follow that increasing a child's maths attainment when they are younger, results in higher earnings later in life, findings in this vein influence government policy and provides an overriding imperative and a clear mandate to generate a sufficient number of trained mathematicians to meet the demands of both academia and industry.

1.4.2. The cost of numeracy

The other side of the coin is the damaging impact that an adult population with substandard numeracy skills may have on the economy. Those with substandard numeracy skills earn less, spend less, are less likely to have a job and are more likely

to be in trouble with the law (Parsons & Bynner, 2005). Central estimates consider costs to individuals, employers and the government as around £20bn a year (Pro Bono Economics, 2014). This is for a number of reasons, the main ones being: first, low levels of numeracy affect an employee's ability to perform his/her job effectively, resulting in lower turnover and profits for firms. Second, as people with low numeracy are likely to earn less, there is a cost to the state in terms of lost national insurance contributions, income tax and pension contributions. Third, when significant factors, such as gender and socio-economic status, are controlled, people with low levels of numeracy are more likely to be on jobseeker's allowance (Grinyer, 2005) resulting in a cost to the economy in terms of benefits paid out and loss of income tax revenue.

1.4.3. Numeracy and England: 'The British maths problem'

The need for more qualified mathematicians is not restricted to the UK; A report predicting requirements for 2025, published by the American National Academy of Sciences stated: "Mathematical sciences work is becoming an increasingly integral and essential component of a growing array of areas… crucial to economic growth, national competitiveness and national security" (National Academy of Sciences, 2013, p1). However, concerns held by the UK Government about specific challenges in addressing the country's target are outlined in the *Plan for Growth* document where it is stated that between the years of 2000 and 2009, the UK fell in the OECD's Programme for International Student Assessment rankings from 8th to 28th for mathematics despite the numeracy strategies put in place. The publication of the government-conducted survey *Skills for Life* (DfBIS, 2012) showed that, based on a large sample size of approximately 7,000 adults aged between 16 and 65, numeracy skills are currently lower than they were in 2003, with 22% of the population working at or below the level expected of a

nine-year old. This compares with 26% in 2003. Elsewhere, it is noted that nearly three in five people in higher managerial and professional occupations in the UK do not have mathematical skills equivalent to A to C grade at GCSE (Bakhshi & Windsor, 2015). This has been labelled by some commentators as the British 'numeracy problem' (National Institute of Adult Continuing Education, 2011, p3).

To summarise, multiple interventions put in place by the government to improve the teaching of maths do not appear to have had the desired outcomes and governmental concern about standards of numeracy in England show no signs of abating. When these concerns are coupled with the analysis of the potential gains and losses presented above, it is easy to see why comprehending the reasons for these perceived failures is a major ongoing governmental objective.

1.5. The teaching and learning of maths within the ecological systems framework
Let us consider the scenario that is central to this thesis: the child with his teacher learning maths in the classroom. This scenario is also the concern of public bodies, such as OFSTED, and is being researched by academics from a wide range of theoretical orientations, such as social constructivist, psychoanalytic, meta-cognitive, neuro-cognitive and Marxist.

These commentators make different attributions as to the causes of perceived problems within the central scenario, which depend on their particular perspective and orientation. They seek to investigate the problem of numeracy failure and develop solutions from their own particular vantage point. Broadly speaking, causes are located in either the individual child or within one or more of the multiple sociocultural contexts

in which learning takes place: for example, in the family, where there may be poor attitudes to maths; or the school, where there may be deficiencies in resources, such as in the teaching methodologies and equipment available. There may also be deficiencies in the teacher where progress might be hindered by a variety of factors, such as insufficient subject knowledge or technical expertise with executing or selecting appropriate teaching methods; interference arising from a teacher's own problematic emotional relationship with mathematics or with learning in general shaping her pedagogic practices.

The wide range of potential causation is represented in figure 1 below in an eco-systemic model of maths education showing the influence of key factors from the child, teacher, home, school, national and global spheres. These factors converge on the child/teacher dyad and go some way to determining the types of interactions about that place in the mathematics lesson which are the interest of this study and ultimately the maths attainment of the child. There is also a retrospectives dimension on the diagram which shows that the teacher herself is influenced by a similar set of factors from the past when she was herself a learner of maths in school. This is the teacher's mathematical biography.
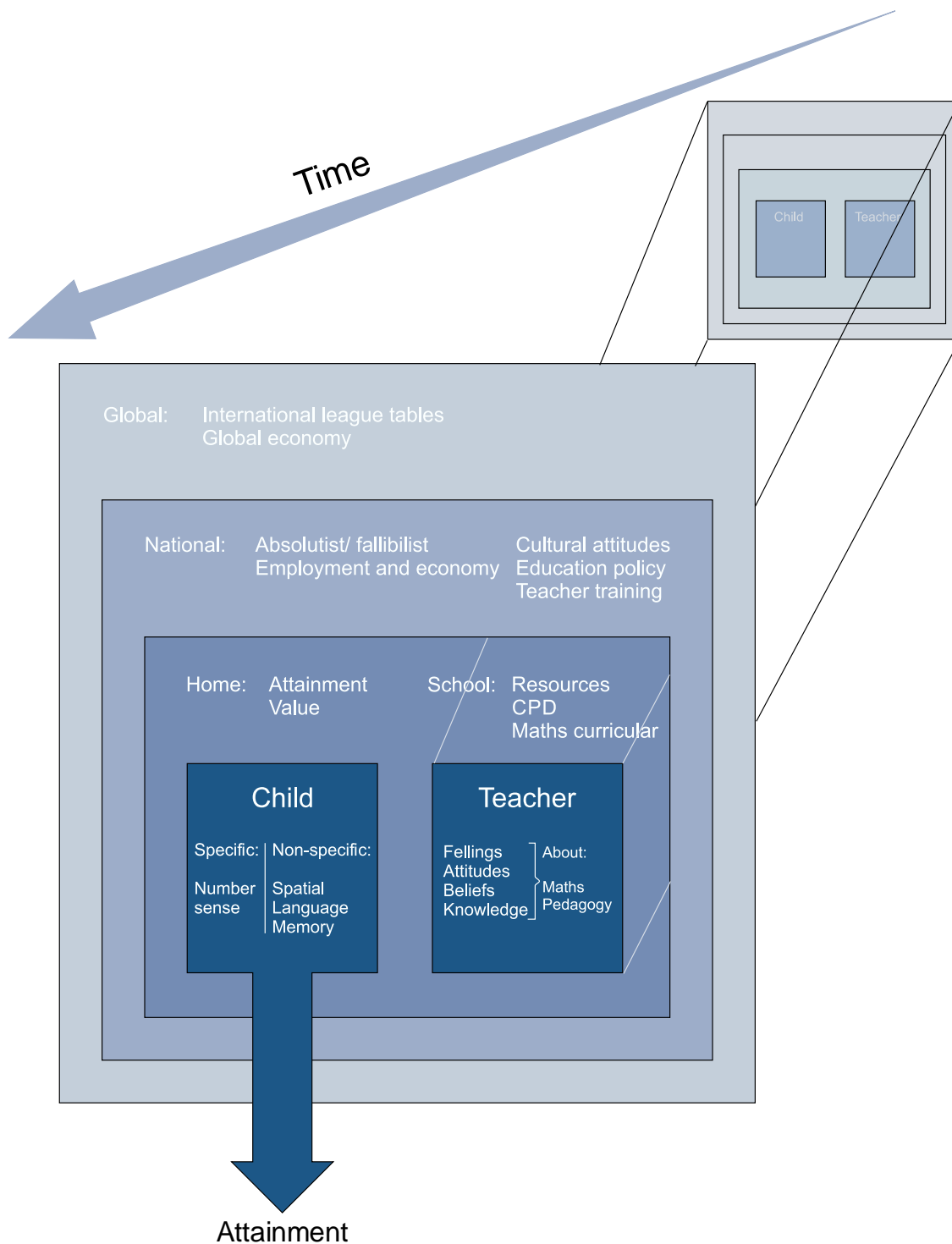
Figure 2: **Eco-systemic model of maths education**

As the government is highly instrumental in determining educational policy, both in terms of the curriculum and teacher training, its analysis of the causes of poor numeracy skills is vital as it determines the direction of travel. We have already seen how successive

governments have taken a narrowly defined stance on the barriers to improving standards in numeracy, looking mostly at educational factors, such as the curriculum, the methods used and the teachers. Here, there has been a tendency to draw on selected pieces of evidence, in particular the findings of OFSTED. One such assumption has been that teachers' subject knowledge is a key culprit of this national malaise, which has led to the implementation of increasingly rigorous testing of trainee primary school teachers to ensure their numeracy skills are at the level now required for entry into the profession (p32, DfEE, 2016).

The influence of the teacher is the key concern of this study. However, the research has at its heart a critical realist ontology where phenomena are conceptualised as having multiple causation and existing within complex, open systems. As such, it is accepted that all of the aforementioned factors have a bearing on how a person's numerical skills develop and there now follows further exploration of the various descriptions of the central scenario given by the different commentators. First, I will look at what psychologists often refer to as within-child factors. I will then consider the surrounding systems, represented in the diagram, before returning to within-teacher factors. The logic of progressing the analysis in this way – starting with the child, moving out to surrounding systems and then to the teacher – is that it is congruent with the circular nature of experience and resonant with the transmission of culture: the teachers were once children themselves and had direct experiences within the central scenario. They then trained to be teachers and were subject to the government policy of that day. These experiences, among others, comprise the teachers' mathematical biography and the experiences are described and reflected in their interviews.

1.5.1. Individual cognitive factors

In recent years, neuroscientific research has given insights into the role of brain mathematical development (Butterworth, 2005) and these are relevant to the current study as the insights have informed both teacher training and the design of the mathematics curriculum. It should be pointed out here that the research is premised on one important distinction: mathematics does not have to involve numbers, for example, when children are working with shape in geometry and when they work with symbols in algebraic equations.

1.5.1.i Specific and non-specific factors

This is illustrated in the following example, which is the kind of maths problem that might commonly be posed to a 9-year old.

John's birthday is on 17th April. If today is 3rd April, how many weeks does he have to wait for his party?

When we consider what is needed to solve this problem, we see the multiplicity of skills that the subject entails. These include non-specific abilities, such as working memory, understanding of language and spatial ability, and specific abilities, such as familiarity with the number system and the capacity to apply the right procedure in the right context. Given the complex range of skills that come into play, it is not surprising that some children encounter difficulties when learning mathematics.

1.5.1.ii Specific factors; number sense

Neuroscientific research has shown that number work – whether it be pure number work, such as calculation, or embedded number work, such as in real-life or educational tasks – relies on the mastery of a core set of skills. This begins with the ability to perceive quantity as a real property of the world around us, just as we may perceive colour. This capacity is known as number sense. Evidence from controlled experiments suggests that number sense is an innate capacity with which we are born, and that neonate babies have awareness of quantity (Donlan, 1998). There is also evidence that animals and insects have the innate capacity to be aware of quantity (Agrillo, Piffer, Bisazza & Butterworth, 2012).

Number sense allows us to carry out actions such as subitising, which is the automatic enumeration of small sets of up to 4 objects, and, as we grow older, estimating, which is the ability to, for example, look at a jar full of sweets and make a sensible guess at how many sweets are inside. This kind of numerical processing was recently found to be an efficient predictor of arithmetic skills in children (Jordan & Levine (2009); see also Jordan, Glutting, & Ramineni (2010); Geary (2011). Children are exposed to and are aware of numerosity from the very early stages of life. The second step in numerical development involves developing and formalising this innate capacity of number sense through mediated learning experiences into number knowledge and counting skills. Gelman and Gellistel (1978) identify principles that underlie accurate counting and are mastered by most children by the age of five. Finally, children must learn how to combine and transform numbers using the skills of calculation. Dowker (2004) states that there are three elements of calculation: retention and recall of number fact, knowledge of

mathematical procedures, and understanding of the way number operates (number sense). Different views of mathematics education have placed varying emphasis on the three elements at different times. For example, in the current curriculum programme of study there has been an emphasis on the first element, learning number fact, while in the previous national strategy the focus was more on the second element, learning different kinds of methods. Number sense has been poorly represented in traditional curricula.

1.5.1.iii Dyscalculia

Brain imaging and brain damage studies have revealed that there is a part of the human brain that is specifically used for processing number and underpins all the core number skills discussed above. When this part of the brain is underactive or damaged, the person's number sense is impaired. Over the past 10 years, the term developmental dyscalculia has entered the educational arena to describe a person who has a specific difficulty with learning number as a result of poor number sense.

Developmental dyscalculia (DD) is estimated to affect between 5% and 7% of the population (Butterworth, Varma & Laurillard, 2011). It is mentioned in the SEND Code of Practice (2014) and is defined as "a condition that affects the ability to acquire arithmetical skills". There are diverging opinions as to the causes of DD, which makes diagnosis and the formulation of valid remediation programmes problematic (Gillum, 2012); it is not certain what DD is and whether it can be treated. Furthermore, we could reason that DD is unlikely to account solely for the large proportion of the adult population with poor numeracy skills revealed by the Skills for Life survey; the estimated incidence of DD is similar to its literacy counterpart, dyslexia (McCandliss & Noble, 2003)

from which we would predict similar levels of underachievement in both literacy and numeracy rather than the actual discrepancy in attainment between the two subjects.

1.5.2. Systemic factors

Over recent decades, the reach of contemporary social theory has become wider, which has seen a greater emphasis placed on understanding the social and cultural aspects of mathematics and education as contextual influences on learning (Atweh, Forgasz & Nebres, 2001). Although not reflected in mathematical policy documents, it is widely acknowledged that mathematics teaching and learning does not take place in a rationalist vacuum as would traditionally be assumed in what Freire describes as a banking model of education (Freire, 1986). It is instead socially situated and subject to multiple influences from the surrounding sociocultural contexts in which it occurs. This includes not just the immediate context of the group and classroom but also the broader influence of culture, family and society (Lerman, 2006).

1.5.2.i Families and maths

Parsons and Bynner (2006) found that parents' performance in literacy and numeracy assessments correlated with the performance of their children. Analysis of the results of their experiment showed a statistically significant relationship between poor basic skills performance by parents and poor test performance by their children. A more recent controlled study has found strong evidence of an intergenerational numeracy effect (Mallows, 2013).

1.5.2.ii Cultural attitudes towards maths

Ernest (2008) describes the absolutist view of mathematical knowledge, which claims that mathematics is made up of certain unchallengeable truths and represents a unique realm of certain knowledge. At the beginning of the 20th century, mathematical theorists discovered contradictions and paradoxes that weakened the absolutist view, and a second view of maths, known as the fallibilist view, emerged where mathematical truths are seen as fallible and open to correction and revision. This view was supported by the Russian psychologist Vygotsky's theory of learning, which rejects the notion of fixed ability and sees intelligence as fluid and extendable, through social interactions, across the 'zone of proximal development'. The learner realises his mathematical potential through formative and developmental experiences that develop the mental processes used in mathematical problems.

Different views on the nature of mathematical knowledge has implications for the way in which it is taught. If mathematics knowledge is viewed as laws and facts, as from an absolutist perspective, then this implies a transmission model of teaching where the purpose of education is to convey these unquestionable truths into the heads of learners and, since they are unquestionable truths, there is no need for the learner to ask questions or consider alternatives. By contrast, in the fallibilist perspective, ability develops through socially mediated experiences and, therefore, the cognitive level of the student's response is not determined by his fixed ability but by the skill with which the teacher is able to engage the student in mathematical activity. This involves the development of mathematical activities that are sensitive to and relate to the student's interests and culture.

Freire has suggested that the transmission model of teaching, coupled with the absolutist view of maths, has become an instrument of social control used by those in power to inculcate the younger generation into existential oppression as illustrated by the following example. In a school mathematics lessons, questions are always asked in a particular sort of way and in the curriculum, particular areas of mathematics are favoured, such as those that are more easily tested. This is referred to by Brown (2007) in Marxist terms as a 'commodified' (p227) version of mathematics. It is also proposed that alternative versions of mathematics are possible. Any 'version' of reality, especially one that has been forced upon us, such as in a curriculum, shapes the person who encounters it. We respond to it and it makes a unique imprint upon us. For example, a survey of 2,000 adults carried out by YouGov (2012) revealed that eight in 10 adults would feel embarrassed to tell someone they were bad at reading and writing. But only four in 10 people would suffer the same embarrassment over poor numeracy. A different version of mathematics and mathematics education would require a different response and possibly the imprint made on those surveyed would have been different.

Although the absolutist view of maths remains the dominant layman's discourse, critiques, such as those of Brown and Freire, are important because they allow us to ask questions about the versions of mathematics that become institutionalised, the reasons why these have been favoured over others, and whose interests these choices may be serving. It also opens up new and radical possibilities of what mathematics education could be. Some maths educators are beginning to explore the use of critical pedagogy and what this means for the practical teaching of mathematics (Stinson, Bidwell & Powell, 2012; Gonzalez, 2009).

1.5.2.iii Education policy

In the current landscape of teaching, teachers have been caught within the political and policy flux arising from the centrally driven educational reforms (Furlong, 2005 & 2013), which were described in the previous section of this chapter – *see section, 1.3.1 Introduction of national standards, p6.* Since the advent of the national curriculum, education has been seen as of vital significance as both a social and economic tool, and was described by former prime minister Tony Blair as 'the best economic policy we have' (Blair, *The Guardian*, 1999). By this, he is referring to international competition and the potential for education to secure a nation's comparative success, via the means of an education service that the government has been able to measure, in precise terms, using the mechanisms of school assessment and reporting national data and international surveys. However, there is reason to believe that this intense focus on education policy has become a problem in itself due to the impact that it has had on schools and teachers.

Ball (2003, 2010 & 2013) argues that globalisation has led to an emphasis on competition as a lever for ensuring greater public service efficiency and quality in the delivery of services and as a means of securing innovation. This influence permeates through to activity in schools, as well as universities that offer initial teacher training, which ultimately comes to bear on how teachers plan and teach mathematics. He states that a culture of 'performativity' has taken a grip of schools and, as shall be explored further below, this is increasingly dominated by the impact of local interpretations of what inspectors, led by OFSTED, are looking for.

Jones (2013) argues that the influence of education policy in schools is complex and that the current performance-driven culture in schools cannot simply be seen as the direct consequence of governmental policy. She argues that although education policies are controlled by government, during their dissemination they become saturated by the values of those who have a direct influence on practice. Local interpretations of policy by school communities, teachers, school leaders and parents are influenced by the values that characterise these communities. Furthermore, teachers are more likely to implement teaching practices that are deemed valuable by their superiors because they are perceived to have helped raise standards in another setting. So, the way the policy develops in action within schools is complex and cannot be viewed as a direct consequence of government education policy.

1.5.2.iv Teacher selection, training and development

The processes involved in selecting and training teachers will, by default, shape the interactions that take place between teachers and children within the central scenario. The content of teacher education was once only broadly prescribed by government-training providers and was based on a common set of standards and procedures built through collaboration between the Training and Development Agency for Schools and the national inspectorate, OFSTED. However, international reports identifying teachers to be key resources in ensuring the global competitiveness of each nation state's education service (Barber & Mourshed, 2007; OECD, 2005; Rizvi & Lindgard, 2009) meant that the way teachers were selected, prepared and developed over their careers became essential concerns for national education systems.

Governmental mechanisms of control were needed and, in the case of England, this began in the 1990s by creating a competitive marketplace for teacher education through the establishment of alternative schemes run by schools themselves, such as the School-centred Initial Teacher Training programme. The potential to play the different schemes off against each other as they vied to secure funding gave the government leverage to intervene in defining what teacher education and professional practice should be. Teacher training became a target-based system, comprising lists of teacher standards linked to the standards of the national strategies, which were, in turn, key components of OFSTED inspections. Alongside increasing competition, another key trend was to challenge traditional notions of teachers having individual professional autonomy and to make them more accountable to their schools, parents and communities and, above all, to the government (Hursh, 2005). In 2002, a mechanism for increasing teacher quality was introduced by recruiting highflyers into the profession with the establishment of the Teach First initiative.

Most recently, the radical policies of both the Coalition Government (2010-2015) and subsequent Conservative Government (2016-2017) have taken a different direction and have sought to provide a better quality of public service, including education. It has also rolled back state involvement to enable a wide variety of agencies to deliver state services via diversified market provision, which is underpinned by even more rigorous accountability structures (Burgess, Wilson & Worth, 2010). These principles have had a drastic effect on all public services in England, including educational psychology services (Al-khatib & Norris, 2015). Within teaching, there have been far-reaching implications for the way in which professionals are trained to operate effectively within this new marketplace. For example, one of Michael Gove's flagship policies was the

development of Free Schools as independent, state-funded schools. Neither Free Schools nor Academies are required to employ qualified teachers and instead are free to employ anyone they want to teach children. A complementary policy has been the expansion of the Teach First scheme and the Teach Next scheme, which are a new entry route to career changes, including men and women returning from the armed services. The government is also making use of a national bursary scheme to increase the number of graduates with excellent degree results, focusing on subjects where there is a shortage of teachers, such as science and maths.

However, possibly the most controversial move has been to allow and encourage individual schools and chains of academies to become accredited providers of initial and in-service training, which other schools can purchase. This unprecedented move puts schools in direct competition with universities and appears to downgrade the contribution that universities can make to teacher education in terms of their unique role in being able to offer research-informed practice. It suggests that this can be replaced by practice based on what works in local schools and culturally reproduced by teachers from school to school, while being overseen by institutions, such as the maths hubs described in Nicky Morgan's white paper. Some analysts have described this as isolating teachers: on the one hand, giving them autonomy, while on the other, increasing their sense of being constantly judged for what they do with that autonomy in a variety of ways and according to different criteria, through different agents and agencies (Ball, 2013).

These initiatives are accompanied by a new set of teacher standards, issued in 2012, and are intended to provide a framework of clearly defined minimum standards against

which both trainees and experienced teachers' performances can be judged. Astonishingly, these standards have been reduced from 150 pages (DfES, 2012) to just 3.5 pages. The espoused rationale for these changes is removing red tape and giving the providers of teacher training the flexibility to design the programs that best meet the needs of their schools. However, a secondary effect of making what is expected less defined within the context of increased scrutiny and surveillance could be making teachers feel insecure about whether they are doing enough or whether they are doing the right thing and comparing themselves to others to see whether they are fitting in and doing as much as others and as well as others. The result is teachers who are continually striving to improve and be better, but as they are judged upon the end outcomes rather than the means and processes used, this may result in them achieving success by any means possible (Ball, 2013).

For example, teachers are required 'to demonstrate good subject and curriculum knowledge when teaching early maths through a clear understanding of appropriate teaching strategies.' (DfE, 2012, p16) As a trainee teacher, or teacher, one might be left wondering what the definition of 'an appropriate teaching strategy' for maths is. Presumably, this may be open to a very wide range of interpretations and were you to be judged on your teaching of mathematics, you may want to ensure that the teaching strategy used was 'appropriate' in the eyes of your appraiser. This puts enormous power in the hands of those who judge teachers, and means that ostensibly they can control the way teaching takes place. What is sinister, is that criteria through which control is exercised are opaque and not open to scrutiny or even debate. Also, the wide range of different possible interpretations may have a bewildering effect on a teacher and engender a sense of learned helplessness and dependency.

1.5.3. Within-teacher factors

In the preceding sections, within-child factors were discussed, followed by how the systems surrounding a child and maths teacher in the classroom, in varying degrees and at different moments, shape what happens in that classroom. I now return to consider the teacher and individual factors which might be described as internal to them, such as subject knowledge, attitudes, beliefs and feelings. We will consider how within-teacher factors may be seen as a distillation of all of the individual, within-child and systemic factors previously discussed which will be uniquely manifested within each individual teacher depending his/her own upbringing, educational experiences and life journey. We will introduce the term 'mathematical biography', which starts as nascent mathematical ability – an internal lump of clay, which is then moulded and continues to be moulded within the teacher. We will examine the relevancy of the teacher's mathematical biography to the child's learning with the teacher and how it shapes interactions through which the child's own mathematical biography grows.

As discussed, we are born with an innate capacity to apprehend number in the world around us (Dehaene, Dehaene-Lambertz & Cohen, 1998). This perceptual interest is the initial prism through which we take in experiences that might be defined as mathematical. These experiences are assimilated inside us and, as our faculties develop, they are elaborated on and combined with the product of other experiences into a complex internal network; such interacting psychic locations are referred to by psychoanalyst Christopher Bollas as meshworks (2008, p28). Within the meshworks might lie number sense; culture-specific mathematical knowledge; feelings and beliefs about mathematical knowledge and its place in the world; and memories, thoughts and

feelings about ourselves when engaged in acts that we define as mathematical. These meshworks might be thought of as our own personal mathematical biography, primarily forged via educational experience and to some extent through experiences at home and with play. Our mathematical biographies are essentially the crystallisation of our experience of the sociocultural factors, described above, combined with our innate capacities.

If we were to consider a teacher's mathematical biography, there would be the additional context of their teacher training, both generally and in regard to the teaching of maths, as well as their professional experience of teaching maths to children. The latter must be added as further factors that will also have left their trace, inscribing themselves in some way on an individual's mathematical biography and, in turn, having an influence on the teaching itself.

Bibby (2010) applies the feeding metaphor, created by Winnicott, to the experience of teaching and learning of mathematics and describes how it is the social and emotional environment created in the lesson that mediates the extent to which pupils can, through engagement, take in and digest the content of the (mathematics) lesson. In much the same way that a mother or carer supports an infant with feeding by providing the right amount of food at the right time, understanding the problems that may occur during the process and picking up the signals that the infant has had enough, it is the teacher who is responsible for creating a similar experience for the pupil, but with the food in this scenario being the content of the lesson. As with feeding and eating, the symbiotic processes of teaching and learning can be difficult and engender feelings of frustration, shame and inadequacy for both the teacher and pupil. The feeding analogy brings the

importance of the teacher's mathematical biography into relief and provides a possible mechanism of influence through which it may operate. It is the teacher's capacity to recognise, tolerate and contain her own difficult feelings about the metaphorical 'food' on offer and the feeding process itself that is most vital for the process to take place adequately.

A further crucial role of the mother or carer identified by Winnicott is to present the world to the baby in much the same way the teacher presents the curriculum to the pupil. If the teacher has a traumatic relationship with any subject matter and has strong psychic defences in order to cope with this, it is reasonable to suggest that this might affect the way she presents mathematics to her pupils: a teacher's biography might then be defined as an element of 'the hidden curriculum' (Jackson, 1968). This is the case if we ascribe to Dewey's conception of learning as the product of the interaction between the learner and the environment and Vygotsky's idea that a teacher's dialogue and interaction with her pupils makes up the social environment. Essentially, this means that, when learning, children introject their teacher and are imprinted upon through this. That is to say, if an entity were to be grown within a container, the growth of that entity would be influenced and shaped by the container itself.

1.5.3.i. Teacher beliefs

I shall now consider in more detail some teacher-specific factors along with a review of pre-existing research in each of the areas. The intention, here, is not to give a reductive account of the factors as it is accepted that teachers' beliefs, emotions, attitudes and knowledge are intimately interconnected (Lerman, 2002; Forgasz & Leder, 2008).

It is acknowledged that there is widespread ambiguity about how to define the word 'beliefs' and that no consistent definition exists. For the purposes of this thesis, when I am dealing broadly with the notion of beliefs, I adopt Schoenfeld's (1992) assumptions that beliefs encompass attitudes, emotions and conceptions and that these can be consciously espoused or unconsciously held and, in turn, shape the way an individual conceptualises and engages in behaviour. It is also assumed that attitudes and beliefs are not necessarily pre-constructed and may be constructed during the process of telling, such as during an interview (Ricoeur, 1981). However, I am working within a critical realist epistemological paradigm, which suggests a connection between the subject's espoused beliefs and the 'real' truth, which is always veiled from the subject and the researcher (Bhaskar, 1989) . More specifically when thinking about a teacher's beliefs about the nature of mathematics expressed in the interviews, I have adopted Thompson's (1992) definition of beliefs as 'conscious or subconscious concepts, meanings, rules, mental images, and preferences concerning the discipline of mathematics' (p132).

Teachers' beliefs about a subject are of significance to both educators and governments because they may affect the degree to which curriculum reform can be put into place, as well as the way the teaching takes place. In his book *The Philosophy of Mathematics Education* (2002), Ernest outlines two major views of maths, which can be seen as two opposing ends of the construct 'nature of mathematics'. The absolutist view sees maths as a static, unified body of knowledge. The constructionist view sees maths as a social construction, with human language playing a key role in establishing and justifying the truths of mathematics. Table 2, *below,* summarizes the characteristics of the two views with regards to educational dimensions.

	Absolutist	Constructionist
View of Maths	Instrumentalist Prescriptive Objective Truth	Relativist Descriptive Subjective Fallible
Teaching	Transmission orientation	Connectionist and discovery orientation
Approach and Methods	Drill Chalk and talk	Drawing out the connections between mathematical ideas and developing understand through discussion style activities

Table 1: Characteristics of two educational views of maths

Askew et al (1997) found that effective teachers of number were characterised by the constructivist set of beliefs which, in turn, led to a corresponding set of teaching

approaches. Studies into beliefs about mathematics held by teachers suggest that many have instrumentalist, absolutist views of the discipline, where maths is conceptualised as a utilitarian subject focused upon number (Handal, 2003). This was reflected in a study of the beliefs of trainee teachers by Brown & McNamarra (2011). However, as this study followed the teachers over a five-year period, from the start of their university course right through to the end of their first year in a teaching post, the researchers were able to track changes in the trainees' beliefs about mathematics and were able to show that there was some shift towards more relativist conceptions of mathematics. Swars, Smith, Smith & Hart (2009) found that teacher education that promoted constructivist ideology also had success in transforming traditional mathematics related beliefs and Philipp, Ambrose, Lamb, Sowder, Schappelle, Sowder, Thanheiser & Chauvot (2007) found the use of reflective practice to be effective. However, the rate of success was improved through the inclusion of direct educational experiences for trainee teachers designed to create dissonance between the absolutist and constructivist views of maths. My own personal experience of this was the mathematical experiences provided on the PGCE maths specialism module at the Institute of Education, which was indeed transformative in terms of my beliefs about maths.

1.5.3.ii Teacher emotions and maths

Although emotions are subsumed into the specific definition of teachers' beliefs given above, I have included a separate section on emotion as it is of particular relevance to the findings. Mathematics appears to be a subject that evokes strong emotions and the concepts of maths anxiety, first conceived by Dreger and Aiken in 1957, has now grown to have a firm footing within maths education literature. Maths anxiety is defined as feelings of tension and anxiety that interfere with the manipulation of numbers and the

solving of mathematical problems in a wide variety of ordinary-life and academic situations (Engelhard, 1990). Although no prevalence rates are available, a number of studies have found that maths anxiety operates to a greater or lesser degree as a significant number of both pre-service and qualified teachers (Brady & Bowd, 2005; Idris, 2006). Research suggests that mathematics-anxious teachers can have a negative effect on learning (Gresham, 2007).

In her paper entitled *Shame: an emotional response to doing mathematics as an adult and a teacher*, Bibby (2002) comments on themes elucidated in an earlier grounded theory analysis of transcripts from interviews she conducted with generalist primary school teachers about their experiences of learning mathematics and the affect aroused when tackling mathematical problems they perceived as difficult. She identifies shame, arising from fear of social humiliation, as predominating the experience of these teachers, caused by traumatic experiences of learning mathematics while at school as children themselves. She discusses the ways in which this shame is defended against through distancing, shutting off and self-denigration (pp715-716). Bibby comments that as shame appears to be a common response evoked in primary school teachers when engaged in performing challenging mathematical tasks as adults, there is a need to change this relationship, although she does not directly discuss the processes by which shame or mathematical biography might influence pedagogic practice. Although no practical recommendations are made by Bibby, her work in this area appears to suggest that teachers should take steps to identify and resolve any problematic relationship that they may have with mathematics.

1.5.3.iii Teachers' subject knowledge

Throughout the period described above, where maths education has been high on the government's agenda for improving educational standards and performance, teachers' subject knowledge has been identified as the key culprit by a number of governmental administrations (DfE and Employment, 1997). This was reflected in the introduction of numeracy skills testing in maths in 1996 which has continued to the present day. The tests are seen by some commentators as another instrument of governmental control and influence over teacher training. The evidence is mixed in terms of whether better content knowledge leads to more effective teaching of mathematics. Although there is a range of studies that link teacher effectiveness with the level of their subject knowledge, such as Goulding, Rowland and Barber (2002), other studies suggest that increasing a teacher's subject knowledge does not necessarily mean better teaching and even that some aspects of higher-level mathematics training may be counterproductive (Ball, 1990; Jayanthi, Gersten, Taylor, Smolkowski, & Dimino, 2017). A comprehensive meta-review considering studies over a number of decades found no statistical correlation between the two constructs (Lipsey & Wilson, 2001). However, the authors of the meta-review highlight issues with the validity of the two key constructs, 'teacher's subject knowledge' and 'effective teaching', which are often defined by researchers in conflicting and unclear ways.

1.5.3.iv Pedagogic content knowledge

Pedagogy is the science of formulating content or subject matter for the purposes of teaching. Pedagogic content knowledge is different from subject content knowledge in mathematics as it involves the repackaging of mathematics by teachers in a way that makes the ideas comprehensible to all children, such as through representations, illustrations, examples, explanations and analogies (Shulman, 1986). The link between

pedagogic content knowledge and effective teaching is far clearer than for subject content knowledge. Hill, Rowan and Ball (2005) investigated the importance of teacher's pedagogical content knowledge in mathematics and found the difference between high- and low-scoring teachers was associated with more than a month of additional learning for students in a year.

1.6.1. What is the focus of the study and how did you arrive at this?

In the preceding sections of this chapter, I have explored a set of diverse factors that most likely set the context and conditions for learning mathematics in English classrooms and shape this journey over time. I have conceptualised the factors of within child, sociocultural or within teacher, although it is recognised that this is a simplification, that the factors are not static and will most likely exert their influence in a manner that is highly complex, dynamic and overlapping, and that the factors will be shaped by each other. For example, I have touched on innate mathematical ability, but recognise that this is not a fixed quantity and that the expression of an individual's innate abilities, and the developmental course, will be determined largely by the contexts. It is also acknowledged that all of the factors covered in the introductory chapter are undoubtedly worthy subjects of study; however, as an EP my particular interest is in the psychology of mathematics education, and as I have a strong consultative focus I most commonly work with individual teachers. It is therefore the within-teacher factors that I used as my starting point in this study. Namely, what influences come to bear on teachers; what thoughts, feelings and memories are evoked when teaching mathematics; and how do these shape pedagogic practice and interactions with children? This study builds on previously undertaken research into the emotional lives of teachers and the affective aspects of learning and engaging in mathematics. However, the research aims to extend

beyond this by investigating links between biography and pedagogic practice within mathematical contexts.

The research is exploratory and explanatory. It explores the descriptions that teachers give of themselves as both learners and teachers of mathematics, as well as the descriptions they give of mathematics as a subject. It is explanatory in that I am looking for patterns within these narratives, and seeking to explain any mechanisms that function to connect these patterns to the context of teaching maths. The purpose of the study is to develop a deeper understanding of a small aspect of the multidimensional process of primary school mathematics education through the search for pattern and concept, which may play some part in organising the actions of primary school teachers. A similar study was carried out with trainee teachers where their mathematical identity was explored in relation to their experiences on the training course (Brown & McNamara, 2011) however, these researchers found that the trainees were not able to articulate themselves or the rationale underpinning their actions within the limitations of the research project and the researchers concluded that the trainees lacked the discursive skills required to engage in mathematically orientated discussions in relation to their classroom practice. The present study worked with a different group of participants, in the form of experienced teachers, using the methodology of unstructured interviews, so as to allow flexibility in regards to the questions and dialogue with the participants. A further aspect of the current study that differed from the McNamara and Brown study is in terms of the research-participant relationship. Both of the researchers were university teachers teaching directly on the trainees' course, which may have reduced their neutrality in the eyes of the trainees. In the current study, I took steps to ensure a

distance was maintained between myself and the participants, which will be described in more detail in the second chapter.

1.6.2. What research questions did you want the study to answer?

The question presented in my research protocol was: how do teachers' mathematical biographies influence their pedagogic practice? This is the question that was stimulated through my original readings and discussions in the field. However, in the first interview I found that by using this question as a basis for the interview agenda, I was organising and controlling the participant to an unsatisfactorily high degree by leading them into talking about their experiences of learning maths in school. I did not feel that I was asking effective questions and the dialogue in the interview had a stilted and uncomfortable quality. Through reflection in research supervision, I realised that I needed to both widen the lens of the research question and adjust the angle to ask a question that was more open and neutral. In light of this, the reformulated question became: What influences come to bear on primary school teachers when teaching mathematics to children in their class? As a set of influences came to light I subsequently, became interested in how these factors interacted with each other.

As the data collection and inductive analysis progressed, and I became more confident in the process, a multitude of further questions emerged and were used both to interrogate the data and to inform the agenda within the interviews. Some examples of the questions are given below.

-Do you think teaching maths is different to teaching other subjects? How?
-How do your maths lessons differ from your other lessons? Why?

-How do you organise your maths lessons? Why?

-What do you think are the most important things to remember when teaching maths?

-What were your own experiences of learning maths?

-Do you think these have shaped the way you teach maths?

1.6.3. The relevance of this study and the potential impact

A multiplicity of factors come to bear on a teacher's actions in the mathematics classroom. Some of these factors may lead to more effective teaching of maths, while some may be detrimental. Policies designed to weed out substandard mathematicians assume that, by increasing primary school teachers' subject knowledge, they will become better teachers of the subject. Alternative and additional hypotheses are of course also possible. For example, the hypothesis that mathematics is a subject that evokes strong emotions capable of mediating the dissemination of the teacher's subject knowledge in the classroom (Bibby, 2002); or that working with what mathematics signifies for a teacher may transform the way she teaches maths. This study aims to shine a light on the interaction between these factors and to conceptualise this interaction, putting forward a tentative hypothesis for further study.

This study will be relevant to those involved in teacher education and in researching teacher education as it might be useful for them to have a deeper understanding of the mechanisms that contribute to teachers' decision-making within and around the mathematics classroom. There may be interest in researching the broader relevance of the findings to look at whether these mechanisms for decision-making in teaching are not only exclusive to the mathematics classroom and may come into play in other subjects or situations. The study may also be of interest to teachers themselves in terms

of making sense of their own experiences of teaching maths to children. Finally, the results will be disseminated to EP colleagues, as teachers are a professional group with whom we work closely especially within the context of consultations with children who are not making progress. If the area of concern is a child's progress in mathematics, then awareness of what may be shaping a teacher's approach to teaching that child mathematics and shaping the teacher's conceptualisations of the child's problem provides an additional dimension for the EP to explore with the teacher, possibly leading to an enriched formulation of both problem and solution.

2. METHODOLOGY

2.1 Introduction to the second chapter

This study is based on a critical realist ontology/epistemology and uses grounded theory, as described by Glaser and Strauss (1967), to identify and understand some of the processes and mechanisms that act within teachers when they are teaching maths to children. The chapter comprises four subsections, which aim to provide a clear and complete description of what I did, how I did it and the rationale behind these choices and actions. The first section sets the broad frame by looking at critical realism, epistemology and ontology. The second section considers the methodological approach that was employed and why it was an appropriate framework for answering the research questions. The third describes the combined process of data collection and analysis; while the final section examines the trustworthiness of the study.

2.2. Epistemology and ontology

Ontology refers to the nature of reality, while epistemology is a related term that is concerned with knowledge about this reality (Robson & McCartan, 2016). A number of different ontological and epistemological positions are available to social science researchers, such as myself. One such stance is critical realism, which was developed the by philosopher Bhaskar (1989) in collaboration with a number of British social theorists and in recent years has emerged as the dominant discourse in the social sciences (Sayer, 2000). It is a framework with which I align myself and that forms the central theoretical perspective of the current study.

2.2.1. Philosophies of science; the three traditions

In this section, I look at three traditions that have framed the debate about method in the social sciences: positivism, interpretivism and constructionism. This analysis serves to situate critical realism within a modern philosophy of science and shows how it has been able to resolve the dilemmas of the three traditions; it, essentially, subsumes them into one coherent metatheory of science, which accounts for the activities of both natural and social scientists. Although these traditions are not the only schools of thought, most social scientists and researchers position themselves methodologically in relation to them. Each tradition proposes a very different social ontology, i.e. theory of social reality, and each has a different view on the relationship between the objects of science and the practice of science.

2.2.1.i The positivist method

Positivist social scientists believe there is a single scientific method, modelled after the natural sciences, which is the means for accumulating objective knowledge about the social and political world. It considers itself neutral and, through its methods, excludes morals and evaluations about the social world projected onto the knowledge by each individual researcher. Positivism assumes that scientific knowledge is expressed in the form of general laws: universal statements allowing us to predict and control events. Positivists do not draw any ontological distinction between natural and social entities; both are seen as 'phenomena' or 'objects of experience'. Positivist science is hypothetico-deductive, which means that it starts with the theory, makes a hypothesis from this and then constructs experiments, the results of which either confirm or disconfirm the hypothesis. The grand theory may then be adjusted in light of this.

2.2.1.ii The interpretivist method

Interpretivist social scientists draw a line between the two domains; they see social and political reality as distinct from physical reality and argue that it is linguistically constructed (Geertz, 1973; see also Winch, 1958). The positivist account of natural science is accepted, but its application to social sciences is refuted. Interpretivists insist that natural life is governed by laws, whereas social life is governed by meaning. The aims and methods of interpretivist social science are radically different from those of the natural sciences. Rather than general laws, the interpretivist social scientist seeks to generate ideographic, symbolic knowledge by hermeneutic means. They do not attempt to explain what happens in the social world, rather to find what meaning a certain action or event has for actors. The emphasis on meaning rather than cause implies that social behaviour is constructed like a text that needs to be interpreted, rather than an object of scientific and technological understanding. In this respect, interpretivists hold that the study of social life is more akin to the study of literary texts than to the objective study of physical objects or biological processes, and that any interpretation of social life has a moral dimension to it.

2.2.1.iii The constructionism method

Constructionist go further than the interpretivist: extreme proponents see the physical sciences as being linguistically constructed as well as the social and political domain (Feyerabend, 1975; see also Rorty, 1979). For example, Potter (1996), who is a social constructionist, argues that "the world is constituted in one way or another as people talk it, write it and argue it" (p98). For them, the natural sciences are simply a further realm of social life, which is linguistically constituted or 'constructed', and therefore governed by 'discourses' and 'powers'. Within this view, there is no real difference

between sociological theory, quantum physics and religion; all are simply a set of stories with no 'real' basis. Both interpretivism and constructionism methods are inductive and flexible in that there is no requirement of pre-determined theory to collect data and information; the researcher has a research question and uses their observations to reach a tentative hypothesis, which is defined by the original question(s) (Mertens, 2008).

After many decades of intense debate about which stance is the most credible, there is now a growing awareness that none of the three positions can offer the answer. This is because none is ultimately defensible or gives a realistic description of the activities of social scientists, such as myself. Considering the positivist ideal of general laws in relation to social laws, the explanation of which is the aim of social science, it is preposterous to think of the social explanations given by social scientists as general universal laws. Rather, they are better conceived of as causal models of social processes that produce certain outcomes in certain contexts. As social events take place in the real world and are subject to multiple, confounding influences, it has simply not been possible to find any perfect correlation between two variables that would allow scientists to specify the exact, numerical likelihood of a certain event. Even if this were possible, it would have limited utility in predicting the outcomes of social events as these take place in the field where they would be once again subject to confounding influences.

In regard to the interpretivist ideal of being able to understand the original and true meaning of a certain social event through making interpretations, as social science aims to interpret or understand social agents' thoughts and actions, there is necessarily a

subjective perspective (Yoshida, 2014). The researcher must interpret elements of the study and, in doing so, they integrate human interest into their analysis, which means that there is great room for bias on behalf the researcher. Since both the data collected and meaning given are heavily affected by personal viewpoint and values, no claim to 'truth' can be made. Lack of reliability and representativeness severely comprises the generalisability. However, in reality, this is not how social science works. The findings of social science studies, including those with an interpretivist stance, are generalised as they give us useful, often powerful, explanations and theories, otherwise arguably there would be no point to social research. Furthermore, the distinction between the social and physical word is untenable.

Constructionists, ultimately, are saying that reality is only constituted by language, and language is a medium of power. Taken to its logical consequence, constructionism, ultimately, leads to the conclusion that both social and natural reality are a fantasy constructed by human language. Furthermore, the meaning of the construction of 'power' is unclear and appears to have ethereal connotations. These conclusions undermine the entire constructionist project: if it were true that reality is purely socially constructed, and that my reality is so entirely different from another person's reality that no parallels can be drawn, then why would anybody study it? Also, if no external reality exists, how could one account for the products of technology, such as medicines that cure us and bridges that are constructed so that we can drive safely over them?

2.2.3. Critical Realism

The preceding analysis establishes the need for a better description for the activities of social scientists. This has been achieved through the writings of Roy Bhaskar (1989)

whose ideas have been labelled as critical realist. In his early writings, Bhaskar begins by addressing the true nature of all empirical science – by which he means the systematic collection of data. Both positivist and interpretivist visions of social science share the common assumption that natural science has as its main aim the discovery of general laws. However, Bhaskar argues that this is in fact fallacy as, in reality, even the physical sciences do not actually produce 'general laws' (Cartwright 1983). Bhaskar also refutes the stereotypic notion that scientific knowledge is gained through passive observation of empirical events as in reality all observations require an instrument and instruments, whether they be the human eye, a psychometric testing kit or a microscope, and have their own form, which shapes and organises the data-collection process and which, therefore, becomes imbued within in the final observations themselves. Instead, Bhaskar argues that what the natural sciences mostly do is isolate causal mechanisms by means of active interventions into the world (experiments) that produce indirect observations of the world and that they do this via instruments (p31, Hacking, 1983). Bhaskar explains that positivist social scientists are thwarted in their attempts to produce general laws because they cannot achieve a closed experimental system. Also, social and manmade phenomena vary to a far greater degree than physical structures and phenomena because they are dependent upon human activity and culture, which is in a constant state of flux. Finally, social phenomena have what Bhaskar calls 'emergent properties', which cannot be reduced to their individual elements. An example of this in relation to the physical sciences is that water has the property of putting out fire, but it is made up of hydrogen and oxygen, which both inflame fires. A parallel example in regard to social phenomena is that of an iPhone, which has the property of connecting people via communication, however, the constituent metallic parts are inert.

Critical realism holds that there exists a knowable, mind-independent reality, while acknowledging the roles of perception and cognition in shaping the experience and therefore 'knowing' of this reality. Critical realism's ontological stance is that the world is taken to consist of structures and mechanisms that have powers to generate events that actually occur and make up our experience of reality. The structures, however, are distinct from the events that they generate and, although the events occur at a particular point in time, the structures themselves endure and go on to create the events in interaction with each other. The claim is that both nature and, by default, our knowledge of it, is stratified and interconnected. It recognises that observation is fallible and theory laden. It revises the positivist-science goal from knowing the truth to getting as close to this stratified objective reality as possible, even though we can never truly achieve that goal. It emphasises the importance of triangulation of data sources and multiple-perspectives in achieving objectivity within research.

Critical realism suggests that the outcomes of scientific research are characterised by the equation: context(s) + mechanism = outcome. Research within a critical realist ontological perspective seeks to answer the question "what works for whom in what circumstances" (Pawson & Tilley, 1997 p109). In regard to the current study, the phenomena being studied is the mathematical biography (beliefs, understandings, memories and meanings) held by primary school teachers, which is observed via interview. The aim of the study is to build thorough inductive, comparative analysis of the interview data, an understanding of the mechanisms by which these phenomena may operate and interact within the context of teaching children, and to postulate the possible outcomes that will be generated.

2.3. Grounded theory

2.3.1. Grounded theory and the research questions

Critical realism does not concern itself greatly with method; the ontology may underpin empirical work irrespective of whether it is qualitative or quantitative (Grix, 2010). However, as its main aim is to understand reality, some proponents advocate greater reliance on qualitative methods. In recent years, approaches such as grounded theory, the approach taken in the current study, have been shown to be highly compatible with critical realism (Oliver, 2012) even though the authors of grounded theory do not concern themselves with describing the ontological underpinnings of the approach.

As described above, positive social science is deductive, beginning with a theory, such as behaviourism, and constructing experiments to explore how the theory works in different substantive areas of the social world, for example, the use of rewards in maths classrooms. Grounded theory, on the other hand, involves building theory inductively from the analysis of data, which is gathered in the field. Grounded theory was originally developed by Glaser, a quantitative researcher, and Strauss, a qualitative researcher (Glaser & Strauss, 1967). Grounded theory was selected for the current study because of its suitability for exploring contexts of social life where there has been little previous exploration of the factors coming to bear on the individuals' lives (Crooks, 2001). In grounded theory, there is an implicit assumption that the social data that is being systematically gathered and examined is generated by the structures of external reality, which exist independently from the researcher and the research participants. Constant comparison of the data allows the researcher to gradually detect and describe patterns that appear to be operating within this data; these are nuggets of the objective reality

and can be used to explain and understand what is happening for these participants in this situation, and which may then be generalizable to others who share the characteristics and contexts of the research participants. This notion is congruent with the author's critical realist ontological position, as described above.

This study was investigating how factors influence pedagogic practice. The key word within the research question at the outset is 'how' as this requires not only a description of the autobiographies and the influences but also an explanation i.e. theoretical model to explain how the influence of the autobiographies might take place specifically. I therefore, wanted a methodology that enabled me to conceptualise and build explanations from the data. Although the research question(s) was refined and became more specific in light of what emerged from the data, fundamentally it remained as a question that required an explanation. Had I used a different qualitative methodology, such as Interpretive Phenomenological Analysis, it is likely that I would have gained a rich understanding of the 'lived experience' of each participant but a reduction in the transferability of the new knowledge to other contexts. Grounded theory enabled me to focus on the meaning for individuals whilst at the same time inductively generate a theory or concept that has the power to explain the participants' experience.

2.3.2   Versions of grounded theory

Grounded theory has evolved since first being discovered in 1967 (Glaser & Strauss, 1967), and there are now many versions, which differ both in terms of their epistemology and their methodological techniques (McCallin, 2004). As grounded theory was applied for different purposes, it became clear that it could be interpreted in different ways.

Glaser and Strauss themselves began to disagree about the nature of the method and how it should be practised, and eventually diverged into different camps. The field of grounded theory is dominated by three different versions: the classical version associated with Glaser (Glaserian); the more structured approach associated with Strauss and Corbin (Straussian); and the constructivists' version developed by Charmaz (2006). The debates surrounding grounded theory appear to converge a number of issues.

Firstly, grounded theory was developed as a reaction to the positivist paradigms of hypothesis testing and the application of existing theories to new data. It was intended to minimise the imposition of the researcher's own categories of meaning upon the data during the research process. However, Straussian grounded theory involved the production of a detailed, step-by-step guide to the method. For example, the inclusion of a specific coding paradigm ensures that the researcher will be looking for the manifestation of particular patterns in the data. This means that instead of taking the data as the starting point, the data is explored in light of pre-set dimensions. Glaserian grounded theorists are concerned that this deductive element undermines the original purpose of grounded theory and its creative potential. Glaserian grounded theory has at its heart the constant-comparative method, which requires the researcher to be continually asking questions of the data and for them to be led through the research process by the data itself. It is highly flexible and not prescriptive in terms of what constitutes data and how data should be considered, although transparency and the theoretical sensitivity of the researcher are important.

Secondly, there is debate over the use of the words 'discovery' and 'emergent' as these suggests that the researcher uncovers something that is already there which, in turn, has the effect of playing down the creative role of the researcher in the research programme process. The notion that theories can emerge from data and that it is possible for the researcher to avoid imposing meaning onto the data, reflects the belief that phenomena create their own representations, which can be directly perceived by observers – an assertion that has been refuted (Charmaz, 2006). In its place, has come the notion of researchers investigating social life are theory laden, bringing with them their own lens and conceptual networks and that it is not possible to drop these (Kelle, 1995 see also Mcleod, 2011).

Each version of grounded theory takes a different stance in regard to the role of the researcher in generating the grounded theory. Charmaz, who takes a constructionist stance, argues that the theory does not emerge from the data, but is instead constructed by the researcher through interaction with the data. According to this version of grounded theory, the research process consists of discovering the ideas of researchers about the data after interacting with it (Charmaz, 1990, p1169) which leads on to the confusing and unsatisfactory conclusion that the same set of data could give rise to multiple grounded theories. However, these dilemmas are resolved by the critical realism stance, which accepts that the data in any research project can, and will, be read in different ways by different researchers and that the reading is shaped by each researcher's personal and professional background. However, through the processes of empirical science, such as systematic data collection and analysis, triangulation and peer review, the researcher is able to minimise his/her assumptions and be objective enough to develop a theory which goes beyond the bias of the researcher and is

generalizable. The processes advocated in Glaserian grounded theory help the researcher to be close to the data, but at the same time remain open and receptive to what is found there.

With regards to the current study, I found the ideas of grounded theory helpful as they gave me a theory base of frameworks with which to articulate the research process and relate this to other research. As a novice in the area of grounded theory, I found comfort in the prescriptive approach of Strauss and Corbin. I familiarised myself with the techniques and determined to use their step-by-step model where coding is structured and staged. However, I had read that it is not necessary to adhere religiously to any one of the three versions and, instead, that the strategies and ideas could be used flexibly (Strauss & Corbin 1998). This was a relief, as I soon found that after starting the interviews, I was already beginning to link codes and develop meaning, so I reverted to a more flexible Glaserian style, proceeding in an iterative fashion by constantly comparing codes from one interview with codes from the next interview to develop concepts, then returning back to the data with the concepts to look for further instances, negative cases or new ideas.

2.3.3. The key elements of grounded theory

Grounded theory is an analytic technique which is most commonly used in conjunction with qualitative data. It is an inductive approach, which aims to derive theoretical understandings about the data from the data itself, rather than from either confirming or disconfirming prior theories and preconceptions: 'A grounded theory is one that is inductively derived from the study of the phenomena it represents' (Strauss & Corbin, 2008, p23). Ground theory has evolved to fit a variety of purposes and can be conceived

in different ways, according to a researcher's ontological stance. Most usefully, it can be thought of as a set of procedures for gathering and comparing data, remaining open to different possible theoretical understandings of the data and developing tentative interpretations of the data. This, in turn, allows the researcher to engage in a close and detailed analysis of research materials to stimulate and discipline the theoretical imagination (Pigeon & Henwood, 1997, p255).

Grounded theory key elements can be summarised as:

-aimed at discovering social and psychological processes.

-simultaneous data collection and analysis

-inductive rather than deductive

-theory led sampling

-moving from descriptive codes to more analytic accounts.

These core elements of a grounded theory are akin to critical realism, which also places great importance on conceptualisation, 'thick' description, field work and stratification. These key elements are elaborated further and, together with other methodological considerations, woven through the next sections to describe the process of data gathering and data analysis. I have chosen to describe the process in a series of stages, first looking at participant selection, then data gathering and finally data analysis. However, these stages are for the purposes of readability and do not reflect the reality of data gathering and analysis, which was iterative rather than linear.

2.4. Data collection

2.4.1. Sample composition and participant selection

A total of ten primary school teachers were interviewed and the transcripts coded for the purposes of the grounded theory. Eight of the ten participants were women and two of them were men. Seven of the participants described themselves as 'White British', two described themselves as 'mixed White/Asian' but did not specify further and finally one of them was 'White Australian'. Six of the ten participants had between 2-5 years of teaching experience and four of them had between 5-10 years teaching experience.

Selection of participants involves different criteria depending on the researcher's ontological stance and the style of the research. In this section, I will describe my approach to selecting participants in relation to the broad frames of the research paradigms and with particular regard to sampling techniques that were employed.

2.4.2. Sampling techniques

The research question in the current study can broadly be described as 'phenomenological' as it is asking general questions such as: 'What is it like...?' and 'What does it do…?' (Giorgi, 2009; see also Spradley, 2016) compared to general quantitative question, such as 'how much/many/often'. This fundamental difference means that statistics will not be involved in the evaluation. In other words, the intention of this research is not to make generalisations through statistical inference, which would require the random selection of units from the population to create a sample using a probability sampling technique. Phenomenological research is not primarily interested in knowing how many have had a particular experience, although such information may be described and may become important at a later stage. Therefore, non-probability

sampling techniques were drawn from a group known as purposive sampling (Patton, 1990).

The main objective of purposive sampling is to select information-rich cases for in-depth study, focusing on particular characteristics of the population that are of interest and will best enable the researcher to answer her research questions and to have a relevant grounded theory. The aim was to learn more about primary school teachers hence a typical-case sampling technique was employed, which involves identifying inclusion and exclusion criteria based on a sample of what one would call typical, normal or average for a particular phenomenon. Table 1 below lays out my inclusion and exclusion criteria and the respective rationale. The criteria were, in part, determined at the pre-interview conversations and pilot-interview stages, which focused my mind on the importance of getting participants who would be able to give me the most relevant data.

Inclusion/exclusion criteria	Rationale
A fully qualified primary school teacher	Primary school teachers are generalists and must teach many different subjects.
Attended school themselves, rather than another arrangement, such as being home educated.	This was to ensure that there was some equivalence in regard to their mathematical biography.
Have more than two years' teaching experience.	This was to ensure that the participants would have had a rich and varied experience of teaching maths to children.

Table 2: Exclusion/inclusion criteria

2.4.3. Theoretical sampling

As theories begin to emerge from the data analysis process, 'theoretical sampling' involves checking these against reality and collecting further data in light of the ideas. This process is central to theory generation and development and yet little guidance is available to researchers in regard to the methods they might use (Breckenridge & Jones, 2009). In a review of published grounded theory studies, Draucker, Martsolf, Ross & Rusk (2007), found that the majority of researchers used participant selection, modification of the interview schedule and adding data sources as methods of theoretical sampling. The main method of theoretical sampling used in the current study was continual adaptation of the interview schedule so as to explore particular areas in more depth. Literature searches and informal discussion with teachers and other EPs about the emergent findings also shaped the ideas.

2.4.4. Sampling context

The impact of my role as EP, was a potentially confounding factor that I needed to work around in my strategy for participant selection. I was aware it was not possible to eliminate this dynamic altogether, as this would have involved concealing my professional identity from participants, which is not ethical. However, I wanted, as much as possible, to separate myself from the role of EP and make myself as neutral an object as possible, as I felt it had the potential to skew the content of the interviews. I had worked in one local authority for many years and was well known by most of the schools. One way of distancing myself was to obtain a sample of teachers from schools in other boroughs where neither the school nor the teachers knew me as a psychologist. I had

talked frequently about my research to family, friends and colleagues throughout the course of my doctorate so, at the recruitment phase for my study, I used an opportunistic-sampling strategy, by alerting this network of people to the fact that I was looking for teachers to interview and my inclusion criteria. Whenever a potential candidate was identified, I asked my contact to obtain initial permission from the candidate for me to contact them. I then spoke to candidates on the phone, explained the project to them and confirmed that they met the inclusion/exclusion criteria. If the candidate felt they would like to participate, a date was arranged for the interview, and a follow-up email was sent containing the consent form.

I only interviewed one teacher from each school in accordance with a further purposive strategy known as maximum-variation sampling which aims to gather as much variation within the sample group as possible (Guest, Bunce & Johnson 2006). I was able to recruit ten teachers in this way, all of whom were class teachers from inner-London state primary schools. One of the schools was a primary academy, the other nine primary schools were maintained by their local authorities. All the teachers were full-time class teachers. The age groups of children that these teachers taught varied.

2.4.5. Informed consent

Informed consent was obtained through a number of processes. Following the initial telephone call, where a brief verbal description of the research was given, an information and consent form was emailed to the participants (see appendix 2). I asked participants to read the information and arranged a follow-up phone call, during which I would be able to answer any questions they might have before asking for their consent in writing and making the appointments for the interviews. It was made clear to teachers that the

data would be anonymized and that they were able to withdraw their data up to the end point of the data analysis. It was also made clear to teachers that their contributions may not necessarily form part of the research should theoretical saturation be reached. All of the teachers with whom I made initial contact agreed to take part. Teachers were given a further opportunity to ask questions prior to commencing the interview, and they were all given my contact details should they wish to get in touch at a later date.

2.4.6 Method of data collection

Although Glaser (1978) states "All is data." and asserts that many different sources of data can be used in a grounded theory research study, interviews are the most common method. Another reason for using interviews as the method of data collection is that the current study aims to identify and explore the experiences, beliefs and motivations of participants in a specific area where not very much is already known. Interviews provide the opportunity to garner rich information about social phenomena, leading to more detailed insights into the study phenomenon than can be obtained from quantitative methods, such as questionnaires.

The teachers' spoken accounts of their experiences in learning maths and teaching maths formed the raw data for my study. I needed to prepare this in a manner that made analysis feasible. I gained consent from the participants to audio record the interviews and have them transcribed. Although I was, at times, interested in how participants said things, I opted for a standard transcription method rather than the Jefferson transcription method which captures not just what was said but also the way in which it was said. This was because, once I received the transcriptions, I listened to the audio recording at the

same time as carrying out the manual coding. I found that this multisensory method of interacting with the data enhanced my theoretical sensitivity (Glaser, 1998).

2.4.7. Ethical consideration

Prior to beginning my data collection, I had secured ethical approval through the Tavistock and Portman ethics committee (appendix 3). The study had been designed using the guidance of the BPS Ethical Code for Research with Human Participants (2010).

I applied this ethical code in the data-collection process through some of the measures described above; measures such as providing the participants with an information sheet, which I talked through with them, giving them the opportunity to ask questions. This was to ensure that the participants understood the purpose of the research and the process of data collection.

The confidentiality of the information generated through the study was a critical ethical consideration, both in terms of respect and anonymity but also the ethical principle of minimising harm. All audio files and transcripts were stored in password-protected, electronic folders, with codes for the names. Any other information in the transcripts that could lead to a participant being recognised, such as the name of the school, was also replaced with a code. The codes were logged in a book, which is kept in a locked cabinet and is available only to me. The book will be shredded, along with all the other data, on completion of this thesis.

2.4.8. Interviews

Research interviews involved talking to participants of the study about a certain phenomenon, and varied in their degree of formality and structure (Fontana & Frey, 2005; see also Bailey, 2008). Although the depth of exploration in all interviews is dependent on the knowledge and skill of the researcher (Klenke, 2008), unstructured interviews allow the researcher to address any or all of a given number of topics that may be of interest to the research. Unstructured interview were the method of choice in the current study as they afforded the flexibility required for theory generation. In unstructured interviews, questions, and their order, are not fixed and are allowed to evolve during the interview process. Here, comparability and ease of analysis and quantification are secondary to obtaining rich, salient data from each individual, using open-ended, rather than forced-choice questions. Interviews, as with all research methods, are open to a number of biases and shortcomings, the most critical of which in regard to unstructured interviews, is the difficulty of achieving reliable and valid results.

There are various existing definitions of an unstructured interview, with general agreement about the basic characteristics (p104, Rubin & Babbie, 2016). Firstly, the researcher comes to the interview without a predefined theoretical framework, thus no hypothesis, and without predefined questions about the social realities under investigation. Rather, the researcher has conversations with the participant and generates questions in response to the interviewee's narration. As a consequence, each unstructured interview might generate data with different structures and patterns. The intention of an unstructured interview is to expose the researcher to unanticipated themes and to help him develop a better understanding of the interviewee's social reality

from the interviewee's perspective. Although unstructured interviews do not use predefined questions, the aim is to gain insight into people's lives and, therefore, the interviewer requires detailed knowledge and preparation (Patton, 2002). Fife (2005) advises that the researcher keeps in mind the study's purpose and the general scope of the issues that he/she wishes to discuss in the interview. In the case of the current research, this initially involved holding in mind my background, reading and ideas that I had developed in my research diary prior to the collection of data. As the interviews progressed, my ideation increasingly stemmed from what was emerging through the constant comparative-coding process.

It can be argued that an unstructured interview can result in more valid data (Corbin & Morse, 2003) as the data is generated by allowing participants to follow what is called the natural path of free association. The discourse of each participant varies, meaning the interviewer must change the wording to meet the understanding of each individual participant: "Although my questions mostly followed the interviewee's narration and were generated spontaneously, based on my reflections on that narration, the structure of each interview was loosely guided by an agenda" (McCann & Clark, 2005). An interview agenda is a broad guide to topical issues that might be covered in the interview, rather than the actual questions to be asked. It was a mechanism for theoretical sampling as it was continually adjusted from interview to interview to include emerging concepts. Although I used the agenda as an aide memoir, I aimed to phrase questions in the most open-ended way possible to enable and empower the participants to shift the direction of the interview and to bring up unanticipated information.

2.5.9. Conducting the interviews

I offered participants a choice of where to conduct the interviews. Either, I could visit them at their school or, should they prefer a different venue, I could have made arrangements for a more neutral setting. All of the participants opted to have the interview carried out at their schools. The interviews were carried out in a quiet, undisturbed room and varied in length from 28 minutes to 46 minutes, with the average interview lasting 36 minutes. My data collection activities spanned a period of 37 months and was recorded in a Gantt chart which is given in Appendix 4.

The research diary was made use of frequently while I conducted the interviews as a means of supporting myself in role and to enhance the trustworthiness of my research.

2.6 Data Analysis

2.6.1. Initial coding

Coding is a heuristic process closely associated with grounded theory; it is a technique that is used to break up data into units and, in doing so, highlight connections between the units and patterns. Different schools of grounded theory follow different coding systems and nomenclature. Initial line-by-line coding, or open coding, as it is also known, generally takes place near the beginning of the data-gathering process; it involves going through the data, in this case the transcripts, and labelling chunks of the text by applying codes that denote the possible meaning. Here, the researcher needs to be as neutral as possible, but he must also shift from a merely descriptive approach to a more analytic and theoretical prescription, which describes motivations and intentions.

In table 3, I present some extracts from the interviews, along with the open codes that I ascribed to them to give a flavour of this process.

Participant's words	Open code
'I would sit next to x because she always knew the answers and so when the teacher asked a question I would be less likely to be noticed because X always had her hand up.' (Teacher B, 10.07.13)	Exposure
You know when they just sit there and you know they don't get it. I think with maths they either just get it or they don't.(Teacher E 10.05.14)	Get it or they don't'

Table 4: Excerpts of coded interview

As can be observed, the data was fractured into sections for closer scrutiny and subsequently assigned labels – synonymous with the creation of the code. These labels consisted of a participant's actual words, for example, 'get it or they don't' or words that reflected my understanding of the data.

My personal technique for initial coding was to read the transcripts multiple times while listening to the audio recordings of the interviews. The transcripts were coded manually,

and the codes were then transferred to a computer file using Microsoft Word. Coding the transcripts by hand rather than through a computer application on screen had the advantage of facilitating a microanalysis, allowing more of the data to be seen and codes to be assigned simultaneously, which resulted in better consistency.

2.6.2. Constant comparison

Constant comparison is a key element of grounded theory. It involves comparing the initial codes emanating from interview 1 with what then unfolds in interview 2, for example. Through this process of comparison, the researcher begins to build a more abstract set of concepts in order to explain the similarities and differences in the accounts of participants operating in the same area. The constant comparison allows the researcher to determine where to go next in the data-gathering process. In the case of my study, constant comparison directed the areas and style of questioning. Intra-code comparison was also used as a way of maintaining a connection between the codes I already had and the data I was looking at. This meant that every time a new passage appeared to be about a topic I had already identified through coding, I would look back and compare the way I had done it previously; each time I evaluated whether or not I had been consistent and considered any differences. The coding system was adjusted in light of this.

2.6.3. Memo writing

In grounded theory, the researcher is required to maintain written records of theory development which, in this case, involved justifying the coding labels, tracing the relationships between codes as they emerged, and keeping a record of the progressive integration of higher- and lower-level categories. These are called 'memos' and are

important because they show up changes of direction in the analytic process and how these relate back to the original research questions. The use of memos was a key part in supporting the constant comparison of what I was coding.

As I carried out my grounded theory analysis manually, my memos were also kept as handwritten notes. These were either on small pieces of paper that I could move around with the coding labels, or they were annotations on the interview transcripts themselves. I also made voice memos and notes on my mobile phone; this was the best way to capture thoughts as I would constantly ruminate over the data. My research diary also contained memos.

Initially, I felt self-conscious when using memos. Often, they were incomplete and consisted of only one word, a phrase or a picture, which signified my thinking at a particular time. I was aware that these would not make much sense to anybody else. Over time, I relaxed and allowed myself to be messy with my use of memos. This was about having trust in the process and faith that clarity would come.

Some coded examples from interview transcripts and my memos from my research diary are presented in table 4 below. Memoing was part of theory generation which in turn gave rise to theoretical sampling where, in the case of this study, aspects of the theory was taken back into the interviews and explored further with participants. Where relevant, I have also describe what action was taken in response to the memo to illustrate how it informed the research process.

Number and date of memo	Interview quote	Memo
Interview Memo 13 (13/06/13) Teacher A line 130	found it difficult at first. I would explain it and then say ok off you go and they would just sit there looking at me with blank faces. It was awful"	*I must say this connects with my own experience of teaching maths. There seems to be a gap or void between knowing and not knowing. I wonder what this is about?* Is this something to do with the zone of proximal development. It seems that the idea of scaffolding this void in the ZPD evokes anxiety. Why? What is the fear? Is there something about an idealised teacher-pupil relationship that needs to be maintained. If you explain it again and again, this relationship is compromised."
Action taken in response to memo	In the next two interviews I went on to explore teachers' feelings when they are faced with a child who does not

	understand and whether this affect has changed over time. This became the code of 'can do/can't do maths' in the category of beliefs about maths.	
Interview Memo 56 (14/01/14) Teacher C, line 10	"I felt like a total failure. I couldn't believe that she brought up how I had done it… taught time. Everyone was looking at me"	*"Total failure' highlights how desperate she felt and the word 'total' may indicate the feeling is absolute and she feels beyond help. Does this link at all to 'stupidity' feeling and exposure?* *"Also the 'Lacanian Mirror' and how feedback shapes the picture that we carry of ourselves."*
Action taken in response to memo	I read a chapter by Bibby (2013) on the Lacanian mirror in regard to teaching but chose not to incorporate this into the theory because the effect of feedback was not directly related to the research questions.	
Interview Memo 199 (26/09/14) Teacher H line 38	*"I know that now I can just give them time and that I shouldn't put myself under pressure; that really makes a difference"*	This reflects coming to terms with the dimensional aspects of teaching – importance of time and space, which could be acknowledging the power of

		the 'feminine/maternal containment' aspects of teaching rather than masculine' method/intervention structural aspects."
Action taken in response to memo	Reading on Winnicott's notion of containment and transitional space which was then developed in the second literature review as a possible process by which CPD mediates the effect of a teacher's autobiography.	

Table 4: Memoing examples

2.6.4 Developing codes

Strauss and Corbin talk about how codes can be 'dimensionalised': as the researcher collects data on what participants are saying about a particular phenomenon that he has coded in the same way, he will begin to see that there are differences between the data within the same code and these differences represent different properties of the code concept in the same way that colour has properties such as hue, tone and shade. The properties of each code can be further broken down into dimensions in the same way that the property of 'shade' has the dimensions of dark and light. An important aspect of the open-coding process is developing the dimensionality of the code by adding density.

In their guide Strauss and Corbin (1998) also suggest a number of techniques the researcher could employ during coding and memo writing in order to give the concepts greater density and dimension. These techniques were used to some degree in the current study and are described below.

2.6.4.i. Constant-questioning approach

While open coding is progressing, the researcher is encouraged to use a constant-questioning approach, whereby the data is continually interrogated through the use of questions involving: who, when, where, what, how, how much and why. This approach formed part of my analysis of the initial interview transcript, which was used to determine the direction of subsequent interviews. The formulation of open questions during the interviews themselves was premised on the constant-questioning approach, meaning that whenever the participants stopped talking, I was poised in terms of where I wanted to go next, although that did not necessarily involve asking another question. For example, on the topic of code 'exposure': Why does the participant feel exposed? Is it a good or bad thing, or does it depend on the context? And, if so, what are the conditions that determine whether it is good or bad. This illuminated the experience of teachers and allowed me to see that there were those who felt they had benefitted from and enjoyed exposure and those who did not enjoy exposure.

2.6.4.ii. Analysis of word or sentence

Corbin and Strauss suggest that the researcher may select a word or sentence to dwell upon and think deeply about what it means. One participant said: 'I **never** felt I could ask questions'. Here, I was struck by the word **never** which, after careful consideration,

I took to be a sign of the participant's feelings of terror as a child within the context of learning maths at school; she felt herself to be a totally passive recipient of teaching.

2.6.4.iii. Analysis through comparisons

Comparison of phenomena within a study is recommended as a way of bringing new insight and density to the concepts. Techniques such as 'flip flop' and 'what if' are ways of comparing extremes, and help you to think analytically rather than descriptively. Making a way-out comparison sheds light on aspects of the concept that you may have taken for granted. For example, I thought about the teachers' experiences of teaching maths to children and contrasted that with the idea of the same teachers turning up at the school, only to find that they had a class full of aliens. I asked the question: "how would this be different?" By considering this question, I developed the idea of malleability and boundaries, as I thought that the teachers would be exasperated if they had to teach aliens. They would say it is impossible and refuse to do their jobs. From this, I had the idea of teachers at this current time becoming malleable subjects with little sense of boundaries in their role, as a result of the context in which they had to work. From here, I went on to wonder why this should be so? What is it about these contexts, specifically, that create this malleability?

2.6.5. Coding structure

The aim of a grounded theory methodology is the emergence of theory to explain the main problem in the substantive area of study through coding which is the analysis of data. As discussed in section 2.3.2 different schools of grounded theory have different coding paradigms. Glasrian grounded theory, is vague in regard to how theory emerges; it is described as coming through the theoretically sensitive researcher coding and

memoing and whilst doing so constantly comparing and sorting these into a schematic model (Glaser, 2001, p 120). However, Straussian grounded theory, which is structured and prescriptive describes two further stages of coding which are achieved, in part, through the analytic comparative processes that have just been discussed. Firstly, there is axial coding which involves interconnecting the open codes after these have been obtained in order to explore the relationships between them. In doing so, the researcher attempts to build a theoretical model of the open codes by discovering the categories within which the phenomena occur, as well as the consequences of the phenomena which give rise to the dimensions of the categories. Straussian theory envisages a third stage of coding, selective coding, which involves being selective and picking certain core codes that you have decided are needed to develop the grounded theory. This is a concept or concepts that you believe have the power to elucidate much of the area of interest, around which a story can be constructed to explain the participant's experience. The core category is central: subsequent to this, all other categories become subcategories.

The current study is aligned more with a Glaserian approach as I found that categories, what those in the Straussian position may have called 'axial codes', and their dimensions began to emerge very soon after the interviews started and as they were used to shape my questions they become part of the data generation.

2.6.6. Theoretical saturation

Coding and memoing involves making progress towards saturation, which is a situation where you have looked, via constant comparison, for more examples or instances of the same thing happening in the same or different ways, but cannot find any new variation

that provides further insight into the open-code category. By this point, the categories have well-developed dimensions and properties. Theoretical saturation is of critical importance in the search for a grounded theory because it is at this stage that the researcher stops collecting data. Categories and subcategories that capture the bulk of the available evidence have been identified. Although saturation of categories is the aim of the data gathering, modification of the categories themselves or changes in perspective are possible at any point during the subsequent stages, and the researcher must always be alert to emerging perspectives and understand that their particular endpoints represent a pause in 'a never-ending process of generating theory' (Glaser & Strauss, 1967, p40).

Theoretical saturation determines the sample size of the project and the point at which saturation takes place. This is contingent on factors, such as how the researcher has defined the topic under investigation and how many kinds of variables there can be (Morse, 2000). The more variations there are, the more participants the researcher may need to interview, and the more settings they may need to visit. Another important factor in determining theoretical saturation and, therefore, sample size, is the sample that you are working with and whether this represents a heterogeneous tranche with a narrow set of criteria (p 77, Ritchie, Lewis, Nicholls, & Ormston 2013). There are no strict guidelines regarding the number of participants needed for a grounded theory study. However, Thomson (2004) found that published studies using a Grounded-Theory approach varied in sample size from five to 350. In the case of the current study, a very narrowly defined sample was used and although there was a degree of variation in terms of the dimensions of the constructs, teachers did think along similar lines. For these reasons, theoretical saturation was achieved after 10 interviews. Cross-checking and

intercoder checking were used to confirm that saturation had been achieved by looking back at the first pilot interviews to ensure that no new codes emerged (Curry, Nembhard & Bradley, 2009).

2.6.7. Theoretical sensitivity

The concept of theoretical sensitivity is key to grounded theory and, put simply, is the researcher's predispositions in relation to the data. In the grounded theory, it is accepted that the researcher interacts with the data, asking questions that are, in turn, modified by the emerging answers. Each concept or connection that emerges will inform the way the researcher subsequently looks at the data which will, in turn, modify the original construct. This becomes the process by which the researcher moves from the descriptive to the analytic level, and it may involve going back to the source to collect further data. In terms of what guided this interaction, I would align myself with Glaser in saying that my theoretical sensitivity was as a result of my reading of literature, personal experience and professional experience (Glaser 1978). Through my consultation work, in particular, I have become skilled in maintaining a neutral stance in relation to what my consultees may talk about, but I also draw on psychological frameworks to conceptualise and bring meaning to it. Making use of my countertransference is also a key strand.

2.7. Trustworthiness

All research is concerned with the search for information to fulfil some purpose. Within formal research, the quality of the information generated is of critical importance and, central to this, are the concepts of validity and reliability. The criteria for validity and reliability, used in traditional paradigms of research, usually involve strictly controlled

designs and quantitative measures of probability. It is contended that these criteria cannot be addressed in the same way in naturalistic, social science studies.

Although some researchers have attempted to incorporate measures that deal with these issues of validity and reliability directly (Pandey, & Patnaik, 2014 see also Silverman, 2016) while working within a naturalistic paradigm, other qualitative researchers have developed a parallel set of terminology to distance themselves from the traditional paradigms. The seminal work in regard to this was carried out by Guba (1981) who developed the concept of trustworthiness in research, and proposed four criteria that he believed should be considered by qualitative researchers: the dimensions of credibility, dependability, transferability and confirmability. As these are all entirely congruent with a critical realist paradigm of social science, which accepts the subjective aspects of all scientific endeavours, they have been adopted as the main framework for quality assurance within the current study.

A wide range of different and possible provisions can be made by a researcher to address the four criteria; indeed, many provisions will overlap and address more than one. In the following section, I will define the four criteria in turn, then describe how I have attempted to incorporate relevant measures in order to address them in my research construction and operations, so as to enhance the trustworthiness of my project.

2.7.1 Credibility

The key criterion that needs to be addressed in any empirical study is that of internal validity, where the researcher seeks to ensure their study measures or tests what it

actually intended to. Credibility is the equivalent of internal validity when conducting naturalistic research, which is commonly, but not exclusively, qualitative in nature. Lincoln and Guba (1985) assert that in order to ensure the credibility of the research and establish trustworthiness, the researcher should be able to explain and give a thorough account of why and how they believe they have accurately captured the phenomena that is purportedly under scrutiny. In the case of the current project, this would translate into questions which were asked to teachers in the interviews such as;

-Do you think that your experiences of learning maths in school affect the way you teach it?

-Is that different from the way you were taught?

-What other aspects of your school experience comes to bear on you?

-Looking back, what do you wish had been done differently when you were (learning maths) at school?

-What would an observer have noticed was different about your classroom following the course?

2.7.1.i Data-collection methods

Selection of the most appropriate method of data collection is essential for ensuring the credibility of the analysis. Credibility deals with the focus of the research and refers to how confident the researcher feels the data addresses the intended focus. Thus the researcher should give detailed consideration to how to collect the most suitable data for the analysis. This starts with ensuring that you have chosen the best data-collection method to answer the research questions of interest. In most grounded theory studies, the data is unstructured and gathered by methods, such as interviews, observations or

a combination of different methods. This is especially true where the aim of the research is to carry out an inductive analysis of the content leading to new insights and theory. In this case, it is important that the data are as unstructured as possible (p52, Neuendorf, 2002) and it was for this reason that unstructured interviews were used.

Furthermore, Lincoln and Guba (2005) recommend the adoption of research methods that are well established in qualitative investigations in general and, where possible, these should be derived from those that have been successfully utilised in previous comparable projects. In terms of investigating how individuals' prior experiences influence their reactions in the present, the work of Blase (1982), Cherubini, (2009) and Tidwell (2014) are noted as having effectively employed a strategy similar to the one in the current project.

Where verbal data, such as from an interview, is being gathered, further issues in regard to the credibility of the data collection arise during the collection phase itself, as the interview transcripts form the content for analysis. Here the researcher faces challenges with managing the requirements of the dual and often contradictory tasks of ensuring that a diverse and natural account of participants' experience is elicited while preventing interviewer bias, inherent within the questions asked, giving privilege to one type of information (Pyett, 2003). Patton (2005) recognises the importance of the researcher's background and experience in enhancing the credibility of the research; my training and experience in questioning skills as a psychologist was especially useful here, as the questions were in fact the major instrument of data collection and analysis. They needed to be well formulated in the moment. Also, I was proficient in the process of Reflective Practice (Kolb, 1984), which is akin to the continual active reflection required throughout

the interviews where I would ask a question, listen to and reflect upon the response and, from there, plan my next move in a systematic and empirical manner.

The use of the pre-interview conversations and the two formal pilot interviews were enormously helpful in refining the language and phrasing the interview questions so as to be suitable for obtaining rich data that addresses the research questions. After obtaining the transcripts for the first two interviews, I conducted a special exercise where I scrutinised my questions and the quality of participants' responses in terms of the richness of data. From this, I identified that the reflecting-back technique appeared to be a very effective tool for eliciting information from the participants with minimal researcher bias. Reflecting back is a technique drawn from Active Listening (Louw, Todd & Jimarkon, 2011), which involves summarising what somebody has said in words that are slightly different but stay true to the original meaning as possible. As well as minimising the effect of researcher bias, it has communicative and interpersonal value as it signals to the participant that you have been listening with interest to what they have said. It also allows the participant to listen back to what they have said, which affords them the opportunity to correct any misunderstandings or elaborate further should they wish. Following its identification, I made extensive use of the reflecting-back technique during the subsequent interviews.

2.7.1.ii. The researcher's reflective commentary

The lack of control in studies, such as the current one, brings the issue of a researcher's personal biases into stark relief, and demands that this issue is addressed explicitly throughout the research process. The inception of the project was a direct result of my own personal and professional interest in mathematics and was the main impetus in my

pre-research reading, which then formed the backdrop to the initial stages of the process, such as formulating the research questions. As the project progressed, it gathered more of its own momentum, however, my own professional role as an EP and, previously, as a primary school teacher with a specialism in maths, had the potential to play an active part in shaping the project. In order to document how my own perspective, beliefs, assumptions and experiences would influence my thinking when collecting and analysing the data, and in order to systematically examine my responses to the data, I kept a research diary, which I actively updated for more than two years especially at the times of the interviews. I found that my responses to the research did not arise in a linear or structured way and, for that reason, I kept my research diary with me at all times so that I could capture fragile thoughts as they arose in their raw form.

As a psychoanalytically informed EP, I used my research diary as a method of attending to my counter-transference and noting anxieties and defences that were aroused as an additional source of data, both about the participants' material and my own response to this. As I subscribe to the view that it is impossible to make the research process completely neutral (Sayer, 2010), my best hope was to make my responses to the data explicit. I, therefore, made process notes on my thoughts as I conducted the interviews. For example:

Research diary entry 22/09/13: I felt overwhelmed myself by a feeling of stupidity when she spoke about how hard it had been teaching her class to do subtraction. I couldn't think of what to ask her next or what to say in response. I felt awkward and paralysed about my role as the researcher. Should I ask more and if so more about what? The more I asked about one area, the more that became the focus, and what about if that

was not the teacher's focus. But the teacher expects me to be in charge so I can't stop to think or look unsure. This is so unbelievably hard.

I attempted to make sense of these process notes in light of the interview that was generated and made modifications to the questions that I used. Another way that I used the process notes in the research diary was to re-read these continuously and actively rationalise the anxieties and fantasies. For example, in the extract above, I recorded my notion in the moment that 'the teacher expects me to be in charge' and used questioning techniques from cognitive behavioural therapy which invite us to think about evidence for our thoughts and to consider alternative realities. I found that this process helped me to process the anxieties and stay in role as a researcher.

2.7.1.iii. Peer scrutiny

Peer debriefing involves sharing thought processes and ruminations that arise during the project with a disinterested peer (Lincoln & Guba, 1985). I have presented and discussed my research extensively throughout the process of the project, both with my fellow doctoral students and other professional colleagues. This has taken the form of formal presentations, such as at a service day and through regular research buddy meetings, through which my colleagues and I have sought to support each other by acting as a critical friend, asking probing questions to help uncover taken-for-granted biases, perspectives and assumptions on the research. As well as being supportive and motivating, this process has been of great help to me in gaining an awareness of my stance towards the data and the analysis, and helped me overall in my choice of project.

I have also used it as an opportunity to test and defend any urgent hypotheses in order to ascertain if they seem reasonable and plausible.

I also made an inter-coder agreement with a fellow doctoral student who looked at the first two interviews and at the coding system as it developed. This led me to make some changes to a number of codes. It also highlighted certain aspects of the transcripts that I had not noticed, which proved to be of great significance later in the process.

2.7.1.iv. Negative case analysis

Negative case analysis, recommended by commentators such as Lincoln and Guba (1985), involves searching for and discussing elements of the data that do not support or appear to contradict patterns that are emerging from a data analysis. Negative case analysis can take on a number of forms, but in the case of producing a grounded theory it involves the researcher looking for instances that do not fit the emerging categories or links between categories. As well as enhancing the credibility of the project, as negative case analysis is heuristic, it allows the researcher to elaborate on theory adding depth and density. Negative case analysis was a constant theme during the iterative cycle of simultaneous data analysis and data collection in the current study. For example, negative case analysis took place in the fifth interview, where a teacher talks about employing psychological ideas in his teaching, which he learned about in his initial teacher training. This led me to consider whether I should expand the area within which the substantive theory was operating to include teachers' initial training. However, I decided to think of CPD and initial teacher training as two dimensions of the axial category 'training'.

2.7.2 Transferability

In empirical research studies, the concept of external validity relates to being able to demonstrate that the results of the research at hand can be applied to a wider population. In the instance of a drug trial, the researchers would be seeking to find out whether the effects of the drug scene in the sample population would have a similar impact when used on a wider population. In a qualitative study, which has as its focus obtaining rich and highly individual stories from participants, it would be impossible to demonstrate that the findings and conclusions were applicable to other situations and populations, as the content of the participants' stories draw directly from specific contexts in which they have occurred. However, Lincoln and Guba (2005) have developed the equivalent notion of transferability, which suggests that although each case may be unique, it is also an example within a broader group and, as a result, the prospect of transferability should be considered. Lincoln and Guba (2005) maintained that since the researcher knows only the context in which the data was generated, he or she cannot make the transferability inferences. However, ensuring that sufficient contextual information about the fieldwork site is provided enables the reader to make such a transfer.

2.7.3 Dependability

Dependability is equivalent to the positivist techniques for ensuring reliability, so that were the works to be repeated in the same context, with the same methods and with the same participants, similar results will be obtained. However, the changing nature of the phenomena scrutinised in qualitative, social-science research renders such measures problematic and ties researchers' observations to the situation of study (Marshall & Rossman, 1999). Lincoln and Guba (2005) stressed that there are close ties between

credibility and dependability, and argue that, in practice, a demonstration of the former would go some distance to ensuring the latter. In order to address the dependability issue more directly, the processes within the study should be reported in detail, thereby enabling a future researcher to repeat the work, if not necessarily to gain the same results. This kind of in-depth coverage also allows the reader to assess the extent to which proper research practices have been followed in regards to the research design and implementation, the operational data gathering and the reflective appraisal of the project.

Dependability was enhanced via the extensive account of the research and the methods used for the study presented within this thesis, along with additional details and primary data, such as the interview transcripts and the coding database provided in the appendices. The independent transcription of the interviews and scrutiny of the emerging coding system during research supervision acted as further evidence of dependability. Another key aspect of the research projects that is relevant here is the timeframe of data collection, which spanned two years. The first four interviews and the pilot interviews were collected between the end of 2012 and the middle of 2013. The final six interviews were conducted between mid-2014 and the start of 2016, and yet the categories that had emerged from the inductive data analysis were still fully present three years on.

2.7.4 Confirmability

For the qualitative investigator, the concept of confirmability is comparable to the quantitative investigator's concern with objectivity. Confirmability is achieved through active processes that ensure the findings reflect the experiences and ideas of the

participants, rather than those of the researcher. Many of the strategies discussed above are key strategies that improve confirmability along with an account of how the researcher's assumptions and predispositions may have lead them to favour one method or explanation over another. The author needs to demonstrate a recognition of the study's shortcomings and their potential effect – a matter that is dealt with in the final discussion chapters of this thesis. The role of triangulation in promoting confirmability is often emphasised. In the case of this study, it was achieved via site triangulation whereby I sought to work with teachers drawn from a different primary school each time, in a bid to reduce the effect of particular local factors that might be peculiar to one school (Dervin, 1997), such as leadership.

The auditability of the project is closely linked to its confirmability. This involves offering up for scrutiny all data, records, materials and instruments which support any conclusions and claims. This avoids one of the main criticisms levelled at grounded theory, in that it is not transparent (Melia, 1997). There needs to be an audit strategy in place throughout the research process. In the case of the current project, the raw data in the form of recordings and the author's research diary are available alongside all the annotated transcripts, codes and memos. At different points during the analysis, transcripts were formally shared with colleagues who were asked to code the data. The codes were then compared with my own codes of the same interviews and, through discussion with colleagues, I synthesised my codes with their codes, thereby increasing the density and richness of the concepts. I also discarded codes which, in light of the comparison, seemed to be more a result of my own predispositions.

3. FINDINGS

3.1 Introduction to the third chapter

In this chapter I will present the findings from interviews with primary school teachers. The interviews were focused at phenomena which affected teachers' choices when teaching. Although originally I had planned to look specifically at factors from the teachers' autobiographies, so much rich data emanated from the interviews with regards to wider factors that I broadened the analysis to look at what factors influence pedagogic practice and how these factors interact. The findings in regard to this are presented in three sections. First, I will summarise what was learned from the pilot interviews conducted at the start of the research process. Second, the main findings are presented in categories and dimensions, which are essentially the higher-order concepts that emerged from the processes of coding and memoing Throughout this second section, I will offer comment on how a grounded theory evolved from the constant comparison of the codes and memos across the different categories. I will also give accounts of theoretical sampling through which concepts were extended and refined. Finally, I present the main grounded theory, which was the one core concept which appeared to govern certain key aspects of the primary school teachers' choices when teaching maths to the children in their class.

3.2 Summary of pilot study interviews

The pilot study comprised pre-interview conversations with primary school teachers and the first two recorded interviews. These were useful in a number of ways: not only did they give rise to initial concepts and begin to shape my theoretical sensitivity, they also enabled me to develop a language for talking with the teachers about their experiences of learning and teaching maths.

My typical experience of speaking to teachers is in consultations, during which we discuss problems the teacher is experiencing, most commonly with a child. Here, my role as the psychologist is to offer help and be a change agent. My new role as research psychologist is quite different from this and I had not considered before beginning how difficult I would find this. I felt that the initial pilot interviews did not go smoothly as I struggled to formulate my questions well and felt uncomfortable when responding to teachers. For example, asking teachers about the 'methods' that they used, seemed to lead to a technical, dry content that felt disjointed from the teacher's feelings and beliefs about maths. At other times, my questions seemed to stultify the conversation. I also found that the teachers digressed into talking about individual children's problems learning maths, possibly because this is how they thought a conversation with an EP should go. Also, for myself, discussing children's problems was a well-worn and comfortable conversational tramline I could fall into. It is possible that the power dynamics that exist between an EP and a teacher and the current climate of frequent OFSTED inspections were a factor in this: teachers may have felt that they were having their subject knowledge and pedagogic knowledge tested by me.

Following this, I put into place a strategy for role management. This was to construct a short script addressing and making explicit the dynamics, which I then read out to the teachers at the beginning of the main interviews (please see appendix 1). Whether or not this made a difference to the teachers, I do not know. However, it certainly helped me to be more focused and clear about my involvement. I also found that by listening carefully to the recordings of the pilot interviews, I was able to determine where I had gone wrong in terms of closing participants down or eliciting overly long accounts of the methods used. I was able to think of questions and language that captured material that was relevant to and addressed the research questions, for example, how teachers make choices in the classroom when teaching maths, their own experiences of learning maths and how these experiences may link with or mediate their choices.

Although there could be debate as to how conscious we can be when making choices and around the extent to which people are able or willing to give clear accounts of their choices, I found 'choices' rather than 'methods' to be a helpful word to use in the subsequent interviews. The teachers to whom I spoke understood what it felt like to be faced with choices for dealing with situations, such as a child who comes to ask you whether or not she got the answer right or what to do if you ask a child a question and she doesn't answer. Should you continue to ask the child or should you ask somebody else? If so, who would you ask next? Five children have their hands up in the classroom. The rest have their hands down and some boys at the back are not even paying attention. Who do you ask? How do you ask? Why do only five children have their hands up? Do others know the answer but are too anxious to say publicly in case it is wrong? Through the idea of 'choices', which came directly from the pilot interviews, I was able to elicit scenarios like this and explore with teachers the thoughts, memories and feelings evoked in any instance and the ultimate choice they made.

3.3 Categories and codes

A further critical aspect of the pilot phase was that it gave rise to the initial categories within which the teachers appeared to be describing their choices in the classroom. These categories evolved over the course of the other interviews

Linking back to the critical realist ontological framework, I envisaged the categories to be the effects of the major 'real' mechanisms influencing the teachers' choices. I will now use these categories as a framework in which to present detailed observations from the main interviews. The dimensions of each category are delineated through exploring the nature and quality of the teachers' words when they were describing it and are presented in a coding paradigm in table 5 below.

Category	Code
Personal experience and background in learning maths	**Good at maths or bad at maths** **Groups equal ability** **Traumatic memories** **Rituals** **Pleasure** **Authority and power** **Panic**
Beliefs about maths	**Maths is something you can or can't do.**
	Practical maths is motivating and fun
Beliefs and values about teaching maths	**Abstract versus real life** **Attributes of mathematics teachers** **Peer learning** **Rote learning of maths is boring but necessary** **Foreign methods are better**
CPD	**Revising beliefs about maths** **Children's mathematical development** **Observing other teachers**

Curriculum	**Prescription of content**
	Emphasis on method
	Being told and conformity
Teaching choices	**Do it differently**
	Responding to errors
	Activity planning
	When children don't get it or don't get it

Table 6: Coding paradigm

3.3.1 Personal experience and background in learning maths

Many of the stories that teachers had to tell about their own experience of learning maths were affective accounts. When feelings about maths were explored, intense emotions were often expressed. However, the teachers' experience of learning maths at school were mixed; overall approximately 50% of the participants disliked maths or had found it a struggle. Irrespective of this, the following dimensions appeared to characterise experience within this category.

3.3.1.i. Good at maths or bad at maths

The language used by the teachers to evaluate themselves as mathematicians was, without exception, black and white. You were either 'good at maths' or 'bad at maths'. This is illustrated by the quotes below:

'I was pretty good at maths. In my school you were either one of the good ones or one of the ones who couldn't do it.' (Teacher D, page 3, line 14)

'I really felt rubbish at maths although that did change depending on the teacher that I got' (Teacher G page 4, line 12)

*'I think it depended on whether you were good at maths or bad at maths. I was one of the ones that was bad at maths. I really struggled.' (*Teacher A, page 6, line 10.)

This highlights how even as adults the teachers continued to attribute their performance in maths to fixed, internal factors rather than environmental factors, such as the teacher or the curriculum.

3.3.1.ii. Groups equal ability

This sense of how good or bad the teachers were at maths appeared to stem from how they compared to others. Linked to the concept of 'good or bad' were the key experiences relayed by the teachers in regard to grouping. Groupings appeared to have been pivotal in determining whether the teachers were either good or bad at maths, and the degree to which they were either good or bad.

 'I was always in the bottom group, right from when I can first remember…that really made me feel that I was not very good and it didn't seem to matter how hard I worked at it. I just got used to it in the end.' (Teacher E, page 8, line 2)

So as to ensure that I was addressing the research question of how teachers' autobiography influence their teaching choices, I updated the research agenda to remind myself to ask teachers about whether they used groupings in their own classes and how. When asked about this, teachers frequently stated that they did use ability

groupings for maths but that this was something that they had no control over as it was decided by the school. They just taught the group they were given. There was awareness of how putting a child in an ability group can be detrimental as it is giving him/her a label and connecting his/her experience of learning with this label. Yet as this vignette from my interview with Teacher F highlights, the teachers did not seem to feel that they could challenge this structural aspect of teaching within their school.

'They know what group they are in and I think it does get them down and mean that they maybe don't try so hard.' (Teacher F, page 14, line 10)

'And is that something that you have ever raised within your school with someone like the maths subject leader?' (Researcher)

'No because I don't really think that would go down well. I mean that's just the way it is done and it was the same when I was at school you were just put in a group.' (Teacher F, page 15, line 1).

3.3.1.iii. Exposure and shame

There were many incidents where teachers described feelings of shame as a child when they were exposed to not knowing things they felt they should know. Teacher B talked about being good at conceptual maths but not the quick-fire aspects of maths, such as times tables.

'*It was when we would do times tables that I would just know I was going to slip up and oh my god I used to get so scared. It was so embarrassing and everyone would laugh at you – awful really.*' (Teacher B, page 10, line 20)

I was interested in the choice of term 'slipping up' and the associations between this and shame. Teacher F recounted the following story about a practice in her class as a child.

'*We had to lay out our marked books on the table, so everyone could see if you had got it right or not. You could hear them all [other children in the class] laughing at you.*'
(Teacher F, page 15, line 7).

3.3.1.iv. Traumatic memories

As the quotations from the interviews below highlight, there was often a sensory quality to the teacher's language where they mentioned colours and sounds: the kinaesthetic aspects of their memories.

'*I remember the little red chairs we had to stand on.*' (Teacher E, page 8, line 19)

'*The sounds of those ticks on the page…I would look up at the ceiling and listen out for them and then I would know if I'd got them right. That was exciting but then sometimes of course…no ticks…and that was when the dread would start to creep in.*' (Teacher I, page 11, line 2).

'*She (the maths teacher) had these thick glasses and she would look so cross and slam the book on the table if you got it wrong.*' (Teacher C, page 9, line 23)

These kinds of vivid sensory impressions are the kinds of memories that are associated with traumatic events, such as car accidents, where the person has been exposed to an inescapably stressful event that overwhelms their coping mechanisms (Gunnar & Quevedo, 2007). When people become upset by their emotions, the fear of the memory prevents the synthesis of the traumatic event and splits the memories from the ordinary consciousness, leaving them to be organised as visual perceptions and potentially behavioural re-enactments. The memories cannot be transformed into a neutral narrative, where the emotional, sensory, cognitive and behavioural aspects of the traumatic experience are integrated, and instead the experiences become dissociated from each other.

3.3.1.v. Rituals

A ritual is a sequence of activities which are completed in a prescribed order. The memories with traumatic qualities, as described above, were often associated with teachers' descriptions of rituals in the maths classroom. For example, Teacher E, who is quoted above, described how he/she would have to stand on chairs and recite times tables. If you made a mistake you had to get off the chair. Teacher I, who is also quoted above, recalled how he/she would have to sit with his/her books open in silence and wait for his/her work to be checked.'

3.3.1.vi. Pleasure

As much as teachers talked about finding aspects of maths and the learning of maths very difficult, they all talked about topics or aspects of learning maths that they loved and appeared to get pleasure and a sense of empowerment from.

'I loved shapes and graphs and things that put pictures in your head'. (Teacher B, page 5, line 31)

'It was brilliant doing compound interest because I used to like working out how rich I could get by putting my pocket money in the bank.' (Teacher I, page 3, line 22)

It was not only the topic that teachers enjoyed but also the teaching method or activity that was employed. The phrase 'ticks on the page', was used by a number of teachers. Teacher I and Teacher B described doing worksheets of sums, which would then be marked by the teacher. Again, there was a sensory quality to the memories; Teacher I spoke about how she loved to 'hear' the ticks on the page, which was suggestive of a feeling of excitement.

3.3.1.vii. Authority and power

Teachers talked about how, as children learning maths, if they couldn't understand something, there was an expectation that you should just accept the way maths was:

'*They would explain it and if you didn't get it then, that's that, you just have to accept, like that's that. It's the way is is*'. (Teacher G, page 15, line 10)

Here, I was interested in the phrase 'that's that' and the consequence of that being that as 'you just have to accept <u>it</u>'. This suggests that, although there may be other possibilities, you are not going to be given a choice and must blindly accept, without

questioning, that this is what you must do, in much the way that a child must accept the authority of the adult or risk some form of punishment. Further incidents related to the dimension of authority, power and control within the category of learning mathematics arose:

'*You didn't really have any say in the methods and really they didn't make any sense anyway so I don't know how I could have asked to for a different way of explaining it or doing it.*' (Teacher A, page 12, line 36)

Teacher G expressed a sense of powerlessness when learning how to multiply fractions and stated that to this day she still does not have a method for multiplying fractions.

'*He would show us this method for multiplying fractions and I would try really hard to understand and remember it, but it just wasn't sticking in my head. I would ask him again to explain and he would show me and expect me to understand and I just couldn't see it. Then, because he had explained it again, he would expect me to understand and know how to do it and I couldn't get at it. I didn't want to disappoint him or for him to get angry with me, so I didn't ask again.*' (Teacher G, page 15, line 36)

The quotation from Teacher G highlights two issues. Firstly, she seemed to suggest an idealised teacher-pupil relationship with the main priority being to please the teacher rather than grasping the lesson. As a child, Teacher G felt that 'getting at the maths' meant compromising the pupil-teacher relationship. The second point is related to the reason why Teacher G had not understood and whether this was because the teacher did not explain it well or possibly did not understand the concept of multiplying fractions. One of the problematic aspects of the power dynamic in classrooms is that poor learning is usually always equated with a defective pupil rather than defective teaching. It seems

that this exchange had left a permanent imprint and deficit in the participant, and I wondered what that would mean if Teacher G had to teach her class how to multiply fractions.

3.3.1.viii. Panic

Panic was a word that was used during the interviews as teachers recounted some aspects of their experience of learning maths. Usually, this was connected to experiences of doing fast paced maths and also tests.

'Oh my god I used to panic so much in the tests. I would go totally blank and shaky but I remember one girl was even sick.' (Teacher I, page 4, line 25)

'By the time it was your turn..(to recite the times tables aloud)… the panic had truly set in.' (Teacher B, page 18, line 3)

Once again, there seemed to be a connection here between the chosen teaching methods and the emotions that were aroused in the person on the receiving end of the method. However, it is interesting that the emotion and the maths remain connected rather than the emotion and the teaching method. For example, the teachers did not talk about quick-fire teaching methods arousing panic in them, they talked about the panic they experienced while doing times tables.

3.3.2. Beliefs about maths

The dimensions within this category were developed towards the end of the process by looking back at incidents that had occurred over the entire sequence of interviews but which did not arise from the questions asked. I considered subsuming this category into

the 'personal experience and backgrounds' section as many of the ideas overlap, but when I looked across the colour coding of the transcripts I could see that 'beliefs and values about maths' appeared to be a 'real' mechanism in its own right and were weaved through the interviews, embedded, for example, in teachers' descriptions of teaching maths or their CPD experiences.

Furthermore, as the research questions evolved to focus on how certain attitudes and beliefs effect instructional practice, it seemed important to capture how teachers conceptualise maths and its significance to them, as well as what they believe it takes to be proficient in maths. To teach mathematics, teachers need to be able to recognise expressions of mathematical ideas in students and plan appropriate ways to respond. Inherent in the teaching of any subject are the teacher's beliefs about 'the horizon' of the teaching i.e. the utility, function and meaning of the subject to us as humans and where the teaching of it can lead the pupils. This notion can then be used to respond to pupils and provide for them, through appraising and adapting instructional material, representing content in accessible ways, planning and conducting lessons, and assessing and evaluating what they are learning.

3.3.2.i. Maths is something you can or can't do.

I have already discussed that a key dimension of the participants' experience of learning maths was being either 'good' or 'bad' at maths. Teachers also talked about the children in their class as being either 'able at maths' or 'not able at maths'.

'Once you have a new class and you have been teaching them for a few lessons you start to see the ones who are able and the ones who at not able (at maths)…It's pretty clear quite quickly who they are.' (Teacher H, page 14, line 2)

Connected to this was a black-and-white belief about maths as a body of knowledge described as though it were binary: either you 'get it' or 'you don't get it'. This belief gives rise to the implicit privileging of getting the answer that is found in classrooms where 'ticks on the page' were often the only tangible product and rationale for engaging in school maths. Here, we might think of the 'ticks on a page' described by Teacher I and Teacher B as a calibration that can be used as a measure and evidence of the extent to which a person can or cannot do maths.

3.3.2.ii. Practical maths is motivating and fun

Teachers talked about the need to contextualise maths in order to make it practical and relevant to children and the importance of making it fun.

'I always think that maths should be fun. It was so 'unfun' and boring when I learned it at school and so I think it should be fun and that means making it really practical and hands on.' (Teacher D, page 21, line 18)

Taken in the context of many teachers' difficult experiences of learning maths themselves, I was interested in this belief that 'maths should be fun' as it appeared to represent a diametric reaction to their own experiences. Teachers talked about how they believed that seeing the purpose or point of the maths was critical to the enjoyment of the subject.

'It is a waste of time to learn abstract maths because it is not something that you will ever use in your life. I mean I had to learn quadrilateral equations at secondary school and have I ever used quadrilateral equations again? I don't think so. So what is the point? It just wastes people's time. ' (Teacher E, page 14, line 12)

Here there is an assumption that quadrilateral equations have no significance to people's lives when in fact, they can be used to describe physical things and can be used in design. The problem seems to be that quadrilateral equations had been taught in a way that was devoid of context and as an end in itself rather than a means to an end. Through developing this dimension of teachers' beliefs about maths, I made further key connections leading me to the core grounded theory: I noted that teachers have a tendency to make assumptions about the needs of their learners, based on their own personal experiences, without seeing how, while her own personal experiences are valuable, they are specific and do not necessarily denote 'the truth'.

3.3.3. Beliefs and values about teaching maths

This category was distinct in that it pertained to comments made about the act of teaching mathematics as a subject rather than the subject itself. However, some of the codes were linked with the initial category of personal experience as the teachers were found to draw on their personal experiences, describing memories of their own education whenever a value or belief was discussed.

3.3.3.i. Abstract versus real life

There was the sense that as the teachers had progressed through the maths curriculum at school when they themselves were children, the maths that they were learning departed further and further from the real world and was increasingly abstract.

'I don't see why it had to become so abstract and like a thing in itself.' ' (Teacher F, page 8, line 31)

'I had a friend who did maths at uni and I can't imagine what he did in his maths degrees. I don't see how much more abstract it could get.' (Teacher B, page 21, line 18)

One teacher equated abstract with pointless and said that when teaching maths to children in her primary school class, she always wanted to make sure that children understood the point of the maths.

'I always start with some kind of practical activity or game through which they have to use the maths we are learning. It means that they will see how it fits and I think it helps them to remember it because they understand the point of it.' ' (Teacher G, page 25, line 3)

This was a new code and a pivotal moment in the analysis-collection process as the idea of teachers' unprocessed experience became a central organising idea, which I explored more and more through the interviews.

3.3.3. ii. Attributes of mathematics teachers

Teachers often talked about the attributes of the maths teachers that they had encountered in their own educational experiences and this seemed to be intrinsically connected to their enjoyment of the subject.

'He was the strictest teacher you could imagine. I don't think he shouted but he looked like he could. I just hated it so much and I don't think I will ever forget those horrible experiences because they really made me scared of maths and made me think I was not good and could never be good at it. ' (Teacher D, page 21, line 18)

There were narratives about teachers who were distant and unapproachable, creating traumatic and painful memories as a result of the kinds of ritualised humiliation they would use as part of their teaching approach. As pupils these teachers had participated in the lessons of these teachers in the hope of obtaining knowledge and understanding but this was not forthcoming and instead they were possibly damaged during the process.

'You would not dare ask a question because he looked so scary and he would shout at anyone who made mistakes or was messy laying out their work. It was actually really bad and you would never be allowed to be like that now. It was really bullying pupils into silence.' (Teacher D, page 21, line 18).

In contrast, there were positive memories from Teacher A and Teacher I of teachers who had been approachable, patient or humorous. They also identified teachers who would explain things over and over again until the children understood.

'I remember a teacher in year 6 called Mrs X, she was very lovely and so patient. She would spot if you didn't get it and then come to explain later.' (Teacher A, page 21, line 18).

'He was actually a really caring teacher and although I didn't always understand the lessons, he never gave anyone a bad time so at least you didn't feel bad about asking questions.' (Teacher I, page 21, line 18).

3.3.3.iii. Peer learning

Some teachers had salient memories about learning maths through other children. Teacher D in particular recounted how there had been a maths competition within the school where everybody was set an investigation. Teacher D, who described herself as being bad at maths and someone who never did her homework, approached another child and asked her to help with the investigation.

'She was one of the brainy ones at maths but she was quite naughty as well, a bit of a rebel, and I can't even remember how we got to look at it together, maybe I asked her to help or may be she offered, but I remember that we sat down the library and she opened her book and started with the problem. She did it step by step and explained each bit to me. I really don't know why but something about the way she explained it I found I just got it and from then on I knew the things I could do that I couldn't do before. Actually even talking about this makes me wonder why we don't let children talk more to each other. Why don't I do that? I guess with the weaker ones I would be worried that they might confuse each other.' (Teacher D, page 21, line 18).

This serves to highlight the value in peer teaching in mathematics and calls into question the consequences of ability grouping children in the subject thereby isolating children and reducing their access to thinking models. The vignettes highlights how the help and explanation that the other child offered transformed Teacher D's understanding and this led to a leap in her mathematical development. We can also see how evoking this memory has led Teacher D to reappraise the use of peer learning in her classroom.

3.3.3.iv. Rote learning of maths is boring but necessary

There appeared to be the belief that the only way of learning maths skills was through rote learning and repetitive practice, which was described as 'boring'. There was a double bind, here, as teachers believed that although learning in this way was boring it was also necessary if children are to develop the kind of quick-thinking mental agility that is so prized in maths and is often considered to be the same as being good at maths. Teachers talked about the government's intentions to re-emphasise the importance of rote learning of number fact and that this was not efficacious for all children. At this point, I often asked teachers if they had identified any other way of learning number fact and, indeed, if it was necessary to learn number fact at all. Each time, teachers responses indicated that it was necessary to endure and accept boring rote learning as through this it was possible to win a rites of passage and receive the prize of 'being good at maths'.

'Learning number fact is just one of those things that you got to do. It is boring but it's gotta be done…It's really the main way that you can get really fluent and secure. A bit like learning spelling lists although there are less of them.' (Teacher D, page 21, line 18).

'*I don't think you can get away without it. I can immediately recognise the children who don't have the basics in place.'*(Teacher D, page 21, line 18).

3.3.3.v. Foreign methods are better

Many teachers talked about other countries' methods of teaching maths, such as methods from Singapore, China and Hungary, which were mentioned in the introductory chapter. When I asked teachers if they felt these methods were better than British

methods, there appeared to be confusion about how we would know this, but that, potentially, there is a lot to learn from the way maths is taught in other countries.

'*I learned a bit about Singapore maths and, well, it was really interesting, but I wasn't really sure how it fitted with the other things that I did or where I would go to with it.*' (Teacher A, page 21, line 18).

3.3.4 Continuing professional development

Continuing professional development refers to training activities that teachers have undertaken once they have completed their initial training and are qualified. Not all teachers talked about CPD, but for those who did, it appeared that this had been a very critical influence on the way they taught children and, in some cases, the CPD had brought about a transformation in terms of thinking about how children learn maths, what their needs are and what the teacher's role is in relation to this.

3.3.4.i. Revising beliefs about maths

Teachers who talked about CPD had an overwhelmingly positive experience of it. Often, they talked about how they had encountered maths in a new way and this had caused them to see it differently.

'*It completely changed the way that I thought about maths and the way that I taught maths.*' (Teacher B, page 21, line 18).

One particular way in which CPD redefined maths as a subject was by giving teachers experience of mathematical processes through practical activity. This seemed to move teachers from the mindset of maths being a set of abstract, meaningless activities that you either can or can't do to it being something coherent and meaningful.

'*I realised that it doesn't matter if you don't get the answer as long as you can understand the process and then, eventually, you will come to an answer.*' (Teacher J, page 21, line 18).

'*I realised that by just having a go you, you learned and understood more than by being told.*' (Teacher D, page 21, line 18).

'*There are many different ways of doing maths. It doesn't have to be one way.*' (Teacher F, page 21, line 18).

Teachers described CPD as illuminating the connections between the learning experience of their pupils and their teaching choices.

'*My maths classes were never the same again after I did that course and, suddenly, I knew what to do with the ones who didn't know and I found it was ok if they didn't know as I could actually know how to teach them and bring them on.*' (Teacher D, page 21, line 18).

In this example, the CPD had acted like a bridge between the teacher and the pupils in her class, giving the teacher access to the internal resources she needed to tolerate children's struggles with learning – a concept that will be explored further in the next section.

3.3.4.ii Children's mathematical development

A further effect of CPD was to raise teachers' awareness of children's mathematical development. Teachers talked about the stages of development in children's counting and how this had been illuminating in terms of understanding children's errors and knowing what to expect from them when they were learning the subject. It also appeared to have made teachers interested in children's mathematical play and perhaps reframed maths in their minds as an intuitive, human social practice rather than an abstract, alien activity.

Teachers' previous experience of maths had been associated most commonly with a 'transmission' or 'facilitation' view of teaching, where the teacher either stands at the front of the class talking while the pupils listen passively and then work through pages of an exercise book, or when the teacher sits at the desk facilitating pupils in pursuing individualised programmes of work.

'*Before, maths was on the board and now it is actually working with blocks and things like that. I do find that more interesting and enjoyable.*' (Teacher J, page 21, line 18).

'*It helped me see maths as a practical subject, something that you do, not something where you just sat down working through pages and pages of a book.*' (Teacher G, page 21, line 18).

Here, again, it appeared that the CPD had enabled the teachers to rethink their role as facilitator in relation to children's mathematical development.

3.3.4.iii. Observing other teachers

Teachers talked about the value of observing mathematics teaching during CPD experiences as this gave them different perspectives on the teacher-learner relationship in the mathematics classroom. The teachers talked about garnering ideas from watching other teachers, then using these ideas in their own classrooms. However, what was interesting about this was that they were not talking about directly copying the ideas. It seemed to be more the principles underpinning the idea that teachers were then applying to their own situation.

'*I saw her do this brilliant lesson about money with piggy banks and then I saw that children really need a story to learn and so now I always have a story when I'm teaching maths. It seems to help it go into their heads better.*' (Teacher C, page 21, line 18).

So, here the teacher was describing how, from watching the lesson with piggy banks, she had developed a theory that giving children a story helps them to encode and assimilate ideas. However, prior to the observation, the teacher had not thought about

doing this in a mathematics classroom, possibly as a result of the abstraction and segregation of maths identified and discussed in previous sections of this thesis.

A secondary purported benefit of observation was that it prompted discussion of practice and through this the development of a pedagogic language to think about and articulate what you are doing in the mathematics classroom and why – giving a sense of agency as a mathematics teacher. This was especially the case when the CPD observations were followed up with mentoring arrangements.

'It was great because after the observations you could meet to discuss these with a mentor. I think it was in these discussions that I really got to unpick what had worked well and why. I really used things that were said in those discussions with my mentor when I taught. It was like what she said really stuck in my head.' (Teacher E, page 21, line 18).

Following her own positive experience of verbal mediation, Teacher B also described how she now encourages and builds in spaces for her pupils to talk to each other while they are learning maths to 'iron out glitches in understanding' as they go along.

'Actually after I had this, I started doing talk partners in my own maths lessons because I thought well if it works for me. I just stop every five minutes or so and get them to do a sum or say what they learned, what they didn't get. I think it irons out the glitches in their understanding as they go along.' (Teacher B, page 21, line 18).

3.3.5. The curriculum

The curriculum was frequently mentioned by teachers and appeared to act as a mediator of their classroom decision-making i.e. an intervening condition. Teachers described the

curriculum as though it were an external, independent entity that must be delivered to children, and as though it had authoritarian properties dictating both the content and the pace of their lessons.

'*We need to be sure that we are always delivering the curriculum and you have to keep going at the right pace.*' (Teacher G, page 21, line 18).

'*I mean there is just so much to get through it's quite scary. I don't know what you are meant to do with the ones who get left behind. You are just looking at them thinking, please get this, because there just isn't time to back over things. It's now or never.*' (Teacher H, page 21, line 18).

3.3.5.i. Prescription of pace

Teachers talked about the pace of the curriculum objectives, which are prescribed week by week as being far too fast, and said that it was simply not possible to cover them. There was the sense that the pace was far too fast and that children were left far behind with nothing.

'*It drives me crazy, it [the national curriculum] tells you to teach one method for subtraction one day and then the very next day you teach another method for subtraction and then another method and another method.*' (Teacher I, page 21, line 18).

'*There is not enough time to get into something with the children and it means that you feel they go away empty handed in the end.*' (Teacher B, page 21, line 18).

Teachers talked about needing a slower pace or perhaps no pace so that they could meander with children as they engaged with the objectives and make connections between them.

'*The problem is that children all learn at different paces and that's in all subjects. If you were to draw their learning on a graph, it would not be a straight line. Each one has their own individual line and sometimes they go back on themselves.*' (Teacher D, page 21, line 18).

Prescribed pace where everyone must move through something to cover a distance in the same time has connotations to the idea of marching. Once more there was the sense of teachers being required by the government to conform and the mechanism of control was the curriculum.

3.3.5.ii. Emphasis on method

Teachers perceived that there was an increased emphasis on teaching method and that method had become content, which had to be taught to pupils.

'*The aim is, I suppose, to teach them as many methods as possible so they can choose one that works for them. But it is too many methods and not enough on the practical application and the meaning.*' (Teacher F, page 21, line 18).

The teacher is describing presenting maths to children as a series of methods rather than as something with meaning.

3.3.5.iii. Being told and conformity

Numerous instances of the national curriculum being collated with the verb 'tell' were identified. The research aim is to explain how factors interacted to influence the

teachers' choices when teaching and here the curriculum was one such factor which appeared to have the effect of limiting these choices.

'In a way it's good that the national curriculum tells you what to do. So you know where your up to and what next. It means that it is all organised and decided for you so you have to think about actually delivering it.' (Teacher H, page 21, line 18).

'To be honest at the moment, I am spending most of my time just getting my head around the new Progamme of Study. It's enough just to work out how on earth I can fit it all in, never mind actually deciding the best way to teach it. In fact the best way to teach means the quickest way to teach it for me at the moment.' (Teacher J, page 21, line 18).

There seems to be a convenience in a highly prescriptive curriculum as it reduces the need to spend time reinventing the wheel. However, teachers seemed to be describing how this then meant that they were less likely to practise thinking and making choices, which are critical parts of dynamic models of reflective practice where a teacher would go through the phases plan, do and review to learn from experience, and gradually refine their skills and expertise.

Teachers described the mechanism of the national curriculum as having a shifting influence on their choices as they moved through their career and becoming more aware and reflective about their practice and its relation to exterior influences.

'It takes some time to not be feeling you are governed by the plan and realise that you can make your own choices.' (Teacher I, page 21, line 18).

'Over time you develop a feeling of confidence that you can go your own way with it but still covering the objectives.' (Teacher G, page 21, line 18).

3.3.6. Teaching choices

Throughout the course of the interviews, teachers talked about their work, both in the context of their current or previous classrooms. They described the interactions and their reasoning and decision-making, their choices among alternative courses of actions and how these were affected by the perception of the teaching situation they were in, such as the particular school, the likelihood of an OFSTED inspection happening or the requirements of the curriculum. Pre-lesson decisions included objectives, content, methods and materials. The kind of decisions that were made within lessons typically included such things as implementation of pre-lesson decisions, use of language level, giving examples, error correction, motivating pupils and managing relationships. I gave the category name 'teaching choices' to dimensions that pertained to decisions made by teachers about how to teach maths, either before the lessons or within the lessons. This category has a particular status as it denotes the effects of other categories, such as teachers' previous experiences.

3.3.6.i. Do it differently

As I explored, during the interviews, the choices teachers made and related these to other codes, it became clear that at certain times teachers were actively making choices in relation to their own autobiographical experiences. In fact, 'do it differently' is an *in vivo* code, which was spoken by Teacher E in the fifth interview:

'I encourage the children to come and ask me questions and tell me when they don't understand because I always felt afraid to do that and felt I couldn't do it. I want to do it differently from that.' (Teacher E, page 6, line 15)

I returned to the scripts of previous interviews with the novel idea: that the impetus behind some choices was a desire to 'do it differently' from the actions that led to their own negative experience. I found that there were multiple incidents in all of the interviews of teachers describing what they themselves were/were not allowed to do and what they had to do when they were children learning maths and subsequently a desire to make different choices and create a different set of experiences and hence memories for their pupils.

In the next few interviews, I included this concept in the interview agenda and asked teachers directly about the concept through questions such as 'Do you ever feel that you try to teach maths differently from the way it was taught to you?'. Although there were teachers who didn't feel that they did this so much anymore, it was certainly recognised by them and proved a fruitful line of enquiry through which I was able to find out more about teachers' desire to 'do it differently' and examine the conditions, consequences and properties of this phenomenon.

'Yes I definitely do that. I definitely think about the bad experiences I had and want to do it in my own way. I don't know why I do that actually coming to think about it but I guess I would feel really bad about myself as a teacher if I felt I was doing the same things' (Teacher F, page 4, line 38)

'It's sort of like a way of proving those teachers wrong and showing that actually maths can be fun and it doesn't have to be boring.' (Teacher G, page 8, line 18)

'I don't know if I do that quite so much now to be honest I am so busy I don't usually even have time to think back to what happened to me. I'm just focused on delivering my

plan really. But I do know what you mean and I think naturally you want to emulate the good experiences but not the bad ones' (Teacher I, page 10, line 24)

The desire to 'do it differently' was consistently in response to a traumatic or bad memory of their own learning experiences as children. By this I mean, a negative experience as a child seemed to evoke this desire. The course of action taken by the teachers was diametric to how they perceived their original experience and in this sense it was like that concept of 'do it differently' had the property of direction to it. It was also a concept that described physical action, i.e. doing something, which means that the teachers were making a physical alteration to the world around them and that in making this alteration they were being in some part guided by their negative, traumatic memory. This implies that the traumatic memories continued to have a kind of power over the teachers. Most importantly, the concept has the property of being reactive in that it is a physical action which is in reaction to the internal condition of having a traumatic memory.

I explored with teachers their reasons for doing it differently through using questions derived from the grounded theory flip-flop techniques such as 'what would happen if you didn't do it differently?'. Here the teachers I spoke to described how they would feel a sense of guilt and remorse and they would feel that they were damaging their pupils. Teachers were assuming that the pupils in their class would have the same reaction to the events in the classroom as the teachers did.

'I could never live with myself to know I was putting them through that' (Teacher E, page 12, line 31)

'I couldn't bear it. I would feel like a really bad person to be treating them like that. That's why I would always make sure they felt confident to let me know if they are wobbly on anything' (Teacher F, page 10, line 31)

These quotes illustrate how through their actions the teachers were trying to protect themselves from engaging in something that would make them into a 'bad person' and also protect their pupils from the actions of that 'bad person'.

This suggests using conscious choices to prevent the replication of a bad memory, which is an internal factor, with the aim of protection.

Teachers seemed to be most strongly guided by the desire to do it differently in two particular situations: this was firstly when the teacher was choosing how to respond to pupils' errors.

'I think for me I particularly remember how embarrassing it was to be called on to give the answer and then get it wrong and be told off, basically made to look stupid and so I am really careful to avoid anything that make a child feel shown up. I do things like always let them work out the answer in pairs or check their answer on a calculator.' (Teacher E, page 22, line 25)

'If they made a mistake I don't point it out, I say something like 'go and have a look at this again.' Or I just pick it up with the group later down the line. (Teacher E, page 28, line 19)

Here we see that when thinking about how pupils should give answers and also responding to children's errors Teacher E was thinking about how her own errors had been responded to when she was at school

It also seemed to influence making choices about children asking questions and other kinds of decisions, such as choices of activity at the planning stage. This adds to the

concept of 'do it differently' having a reactive property in that it was triggered more when making choices in the moment rather than before the lessons where there was a degree of separation from the situation itself.

It was also possible to explore what the consequences of doing it differently were for the participants by probing into what teachers noticed the effects of doing it differently were. Teachers described how it gave them a sense of satisfaction to know that their pupils felt secure, happy or able to answer questions. They enjoyed the idea of their pupils feeling like this and felt like they were able to use their own bad experiences to become a better teacher themselves.

'Yes. I would say it feels good to know that they are confident and feel they can approach me to ask questions. It gives me a good feeling to see this. Like you are putting the world to rights.' (Teacher G, page 32, line 28).

'I know that when I have planned a really fun lesson that they are going to enjoy it and they are not going to be sitting there bored out of their brains and thinking I am the worst teacher ever. I guess those bad experiences are good in a way because they tell you what not to do.' (Teacher I, page 24, line 45)

3.3.6.ii. Responding to errors

I explored with teachers the processes surrounding choices in terms of how to respond to pupils' mathematical errors. Teachers described how the choices they made in response to children's errors were pivotal in building the culture or climate for learning and risk-taking in their classrooms. However, they also reflected on the many problematic and seemingly paradoxical aspects to handling children's errors. On the one hand, errors can be an excellent learning opportunity for the whole class, while on the other hand, drawing attention to a person's error can give a message of judgement.

Responding to errors in a way that achieves the desired outcomes of a positive climate of peer learning, required controlled and thoughtful choices on the part of the teachers.

'I always try to keep kind of tally in my head about whose errors I have used as a talking point, so that I don't always single out the same children,' (Teacher E, page 10, line 14).

Teachers who had undertaken additional CPD in mathematics education talked about applying ideas, such as scaffolding (Bruner, 1976), to children's learning and getting alongside children to mediate their learning experience if they noticed they were having problems.

'So if I see that one of them has a misconception through their response, I will give them an activity and sit beside them and do the activity talking all the time to articulate my thinking,' said one teacher.

3.3.6.iii. Activity planning

Teachers in the sample revealed some harrowing memories from when they were the recipients of the transmission styles of mathematics teaching in school. It seems that the activities through which they were ostensibly meant to learn maths were a salient part of these memories. It seemed that in their planning, teachers made active choices about the activities through which children would experience mathematics and thereby lay down memories. For example, one teacher said:

'One of the objectives is to learn the months of the year and I teach it using paper chains where children write the month on each piece of paper in the chain. And then they remember it rather than if you just make them write it out like we would have had to do.' (Teacher E, page 4, line 22)

Many of the activity choices teachers described to me seemed to be activities they believed would be fun for children. However, while the teachers described how they always tried to make lessons fun, they were aware that they probably made these choices more often than not in regard to teaching maths. For example;

'Maths is often a subject that can be very boring and where children can get quite anxious, and so for that I make the lessons fun' (Teacher E, page 6, line 11)

Possibly there was the sense that dressing maths up and making it 'fun' inoculated children against the emotionally dangerous and traumatising aspects of the subject.

3.3.6.iv. When children get it or don't get it

Binary, black-and-white descriptions of maths and mathematical ability has been recurrent throughout the interviews. With regard to teaching choices, this concept was apparent once again and was relevant when a teacher had shown children how to do something in a maths lesson and some of them 'got it' while some of them 'didn't get it'. One teacher described how difficult she found it when children 'didn't get it'.

'When I started as a teacher. It was difficult as first. I would explain it and then say ok off you go and they would just sit there looking at me with blank faces. It was awful…I could see they just didn't get it and I didn't know what to do next" (Teacher A, page 22, line 120).

She recalled that when she started as a teacher she would explain things and just expect the children to understand. When they did not understand and looked at her with blank

faces she did not know what to do. I was interested in this Teacher A's experience of this phenomena as she had always been very good at maths and had excelled in the subject at school. On questioning her further, I discovered that when she had been at school she was good at maths, but felt she had never had the experience of having it explained to her.

'I don't know why I was good at maths. I just got it. I could just do it because it kind of made sense to me in its own way. I don't ever remember ever really listening to what the teachers said. I just went off and did it.' (Teacher A, page 10, 45)

She just knew it as though the maths was already part of her and as soon as she was presented with new mathematical activity she instantly understood what the numbers meant and what she had to do with them.

This was interesting for two reasons. Firstly, there was her experience of intuiting maths as though the understanding of how numbers operated was already inside her, possibly as a result of play experiences. Secondly, this intuitive ability seemed to be a disabling factor in her teaching of the subject because she had no internal working model enabling her to work out the choices available to her and the concrete steps she might take when children did not appear to understand an initial presentation.

It appeared that subject knowledge about mathematics was something that teachers drew on when making decisions about how to respond to children who don't get it. One teacher who had undertaken extensive CPD in maths explained to me:

'There are only a few simple principles at the heart of all maths and once you see it like that you realise that it's just about giving children lots of open-ended experience with number and quantity and being alongside them, getting them to articulate what they are doing, what they are thinking and supporting them by reinforcing what they are telling you and rephrasing it. I guess it's really about getting them to play with maths and that's the best way for them to learn.' (Batul to add teacher's identification?)

Here, the teacher had used the ideas learned in his CPD to reconstruct his beliefs about maths and possibly to transform his own experiences of learning the subject himself. This new construction of the subject served as a rationale from which decisions and choices could be made about the teaching and learning experiences provided for children in his class. This teacher appeared to conceptualise his classroom as an environment into which children entered to have mathematical play experience. Through choosing to set up his teaching in this way, the teacher obviates the dilemma of 'what to do if they don't get it' because each child will have his/her own unique learning experience.

3.4. Grounded theory

In the findings section above, I have presented factors that teachers raised as influencing their choices in the mathematics classroom, such as curriculum aims and objectives, CPD, beliefs about maths and learning maths and teachers' past experiences and explored the many dimensions of these. These phenomena exist within

the social strata, in that they exist within human relationships, and have causal powers in relation to the social processes of teaching mathematics by teachers in primary school classes. The properties that these phenomena possess have the power to bring about events or states (Dupré & Cartwright, 1988). Identifying causal relationships requires the researcher to provide an account of these causal powers and how they operate. The grounded theory is presented in the figure 3 below.

Mathematical biography
-memories, some traumatic,
-rituals
-teachers
-activities

Teacher

Re-enactment of

Interaction
Do it differently

Child

Intervening conditions
-CPD
-Curriculum/Programme of Study
-School-specific rules about maths teaching
-Classroom resources
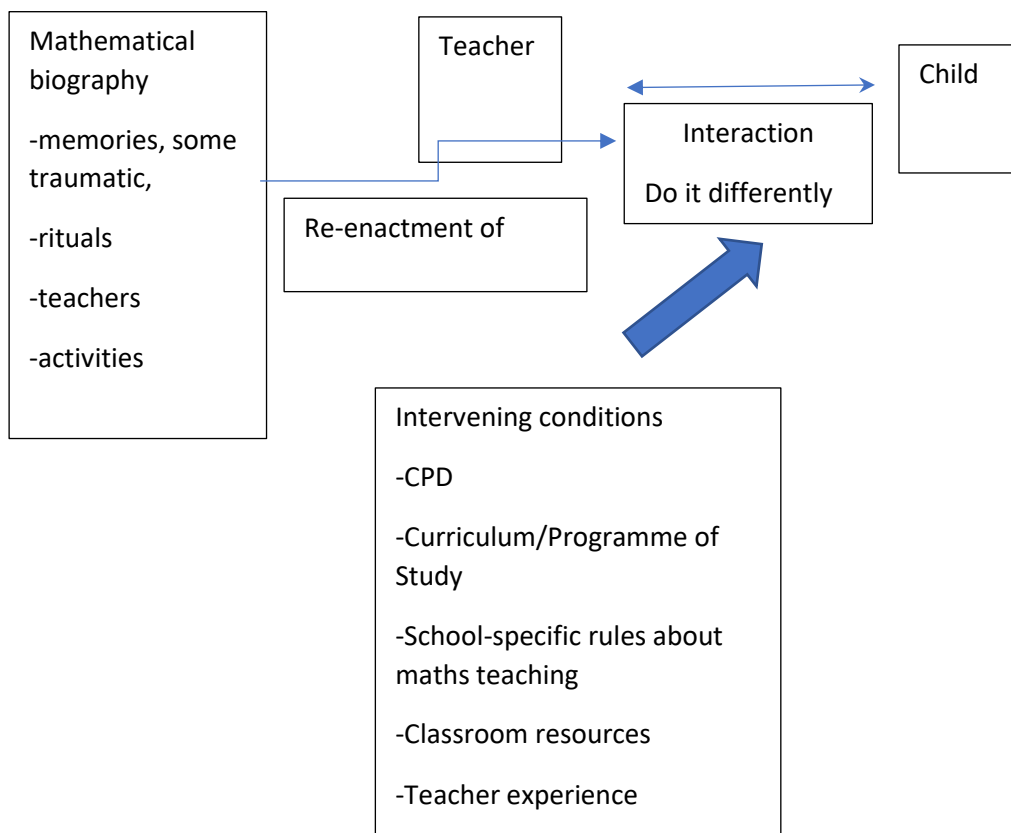-Teacher experience

Figure 3: Diagram of grounded theory

As the different phenomena were identified and analysed through constant comparison and memos and explored further through theoretical sampling, a core concept that appeared to be woven through many of the interviews emerged. This was the idea of 'do it differently' which was the participant teachers' desire to react to their own traumatic experiences of learning maths by making opposite choices in certain interactions with children in the classroom. As will be explained further in the next chapter, the concept of 'do it differently' can be understood as a way of indirectly re-enacting one's own experience.

4. ANALYSIS

4.1 Introduction to the fourth chapter

The main research question that this study set out to address is 'what influences come to bear on primary school teachers when teaching mathematics to children in their class?'. Through a process of interviewing, coding and making memos a core category emerged which was the idea that when teachers have themselves had upsetting or traumatic experiences of learning maths there is a desire to 'do it differently', which affects the teachers' choices when teaching maths to their pupils.

Upon further exploration, the concept of 'do it differently' appeared to mean making choices that produced a set of conditions in their classroom that was diametrically opposite to the conditions they had experienced themselves as learners. For example, if they had never been allowed to ask questions, they encouraged their own pupils to ask questions or if they had been made to feel very anxious about making mistakes, they made action choices which they believed would engender a state of calm within their pupils. The intention of this action strategy seemed protective in that the teachers wanted to protect both their pupils and themselves by doing the opposite of what they felt had been done to them as learners with emotionally damaging consequences. In this chapter, the grounded theory is developed into a possible causal mechanism by linking core components of the emergent grounded theory back into the main frame of theory and published research. The linking process was essentially a complex thinking process shaped by the researcher's own theoretical sensitivity, discussions during supervision and with critical friends and, most importantly, literature searches.

After describing the literature review method, the theoretical discussion begins. First, I describe theories about traumatic memories and the process of , whereby previous experiences are acted out or repeated in the present. Distinctions and parallels are drawn between these and the current scenario. As I was not able to identify any research specifically explaining the ways in which teachers' own experiences as learners are re-enacted in their teaching, I look at what is known about the process of re-enactment within other areas of social activity that are related to teaching: in this case, the project of parenting and the discipline of psychotherapy where the Jungian concept of the 'wounded healer' will be considered. I will then make a case proposing that re-enacting a traumatic memory by choosing to act in the opposite way is a more general social mechanism, which is operational within different social domains. Second, I present theoretical accounts for the mediating effect of the curriculum and CPD on the teachers' espoused beliefs about maths as a subject, the teaching of maths, themselves as mathematicians and, subsequently, their choices when teaching maths to their own pupils. I will also put forward alternative theoretical explanations for the role that a teacher's biography may play in the teaching of mathematics.

4.2 Identifying relevant literature

As the grounded theory began to take shape, I returned to the literature and attempted to find out whether the theory, or conceptual components of the theory, bore any resemblance to what is already known. However, as these concepts had emerged from the study, their descriptions were couched in the local language of the study from which they had arisen. And, in the case of *in vivo* codes, the concepts were wrapped in the participants' own words. This led to unanticipated problems as I found that many of the code labels from the study had multiple and different meanings within the different fields

of academic research. For example, the word 'traumatic' was used in the study to describe teachers' memories of events that had been psychologically distressing to them. However, the word traumatic, or trauma, has a more specific definition within psychology and psychiatry, denoting extreme experience that involved being exposed to 'one or more event(s) that involved death or threatened death, actual or threatened serious injury, or threatened sexual violation' (APA, 2013). This made the literature search a long, convoluted, tangential process.

A full description of the process that I went through to locate literature is beyond the scope of this thesis, however, a flavour of this is given in the following description. I brainstormed a range of words and terms – 'act out', 'psychological distress', 'memory', 'teaching', 'teachers', 'cope' and 'repeat' – which could be used as Boolean phrases. Multiple searches were conducted using the databases on Ebsco Host between 2 July 2016 and 1 September 2016. Although a large number of articles were returned, none of these were relevant to this study. This necessitated a return to the word 'trauma' in conjunction with the words 'repeat' and 'cope'. This was more fruitful, so I made the decision to work with the word 'trauma' and, subsequently, the word '[Batul to add missing word]'. As the majority of my searches proved fruitless, rather than giving a blow-by-blow account of the literature search instead the Boolean terms are used as the headings for each sub section for section 4.3.1.

4.3 Theoretical understandings of band re-enactment

4.3.1 Psychological trauma re-enactment

Psychological trauma was recognised as a phenomenon in men after they had been involved in wars (Lerner, 2003). The concept was adopted and the definition widened by the women's movement in the 1960s to encompass physical and sexual abuse in women and children. Since then, the definition has been successively broadened to take account of discoveries in neuroscience made in the nineties. Finally, a formal definition was developed by Carlson (1997), which suggested that for events to be considered traumatic, three necessary conditions must be present. First, the event must be perceived by the individual as resulting in physical pain, physical injury, emotional pain or death. Second, the traumatic event must have a sudden onset and must be perceived by the individual as an immediate threat. That is to say, the perception of immediate threat does not allow time for the individual to cognitively or affectively employ coping strategies that would facilitate adaptation to the traumatic event. Third, the event must be perceived by the individual as being out of his or her immediate control. This last point is based on the considerable amount of research that suggests individuals experience significant distress when they perceive a lack of control over their immediate environment, especially when the environment includes potentially painful experiences (Mineka and Kihlstrom,1978; Ozer, Best, Lipsey, & Weiss, 2003).

In the study some of the participants recalled events in maths lessons and described these as upsetting or stressful. The events described by the teachers were not major catastrophes and therefore not traumatic events. However, just as sadness can very broadly be said to fall into a similar semantic category to depression, I would also like to draw a tenuous connection between an upsetting experience and a traumatic experience and in doing so conceive of trauma on a continuum. This is to allow for the fact that, although upsetting experiences and traumatic experiences are altogether

different, the teachers' descriptions of the upsetting experiences can be said to fit the three conditions, mentioned above, albeit in a extremely diluted form.

Further links can then be drawn between models of trauma and the way that the certain teachers appeared to attempt to resolve the upsetting experiences. Individuals with memories of trauma are known to manage the symptoms by recreating and repetitively reliving trauma in the present – this is known as re-enactment (Green & Owens, 2017). Some conceive of re-enactments as spontaneous behavioural repetitions of past events that have often never been verbalised and cannot even be remembered (Bryant & Harvey, 1995). Within this conceptualisation, internal states are expressed through physical actions rather than words. Other explanations suggest that elements of past trauma are re-enacted as a way of resolving and mastering it. In this conceptualisation, the re-enactment may take place in a more complex and indirect manner. For example, an individual who is beaten as a child becoming a detective and mastering his early experiences of victim through a drive to fight violent crime.

Where the aim of re-enactment is to master and cope with a traumatic experience, a further distinction is made between re-enactment as an adaptive process compared to a maladaptive process. Adaptive processes enable successful resolution of trauma by working through earlier trauma in an effort to master it. Maladaptive re-enactment attempts to resolve the trauma but results in continued distress and difficulties for the individual (Paley & Alpert 2003). Bamber & McMahon (2008) tested the hypothesis that individuals with maladaptive early schemas (those with histories of dysfunction and abuse) are more likely to choose occupations where they re-experience the same type of toxic dynamics, they themselves were exposed to with the, usually unconscious, aim of coping with and therefore resolving the internal schemas. They found evidence of

higher than usual incidents of maladaptive early schemas in health care workers and that those with the most rigid schema were more likely to suffer from burn-out and occupational stress.

Adaptations are characterized by the individual adopting a flexible coping style, whereby he/she is motivated more by the present and future than by the past, and where secondary-thinking processes are operationalised rather than immediate emotional responses. In addition, where an adaptive strategy is in motion, the individual's emotions stemming from the past are less overwhelming and destabilising, and over-generalised negative schemas about oneself and others have been altered. These adaptive changes enable the person to respond to the present free of the categories laid down by past experiences (Pine, 2007). Interventions, such as play therapy and hypnotherapy, are premised on the notion of adaptive re-enactment (Landreth, 2012). In these scenarios, the child's or adult's re-enactment mechanism is triggered within the safe environment of a therapeutic space and the client is facilitated through the process of re-enactment with the help of a containing other who will assist in processing the difficult experience.

In the case of this study, it is proposed that the teacher's desire to 'do it differently' signals the triggering of re-enactment of an upsetting or unpleasant experience that the teacher remembers from his or her own school days as an adaptive process with the aim of giving his or her pupils are (delete?) better learning experience than he or she had himself/herself/themselves. An example of this would be that a teacher who was humiliated as a child for asking questions in a maths lesson, encourages the pupils in his or her class to ask questions whenever they like and reiterates frequently that it is good to ask questions.

4.3.1.i. Re-enactment and parenting

Humans' propensity to play out and repeat earlier experiences is well recognised, particularly in regard to parenting where parents' own attachment style has been shown to be an indirect predictor of parenting style (Bifulco, Moran, Jacobs, & Bunn, 2009). Re-enactment of psychological distress, where one person projects his or her internal affected states into another to recreate aspects of early experiences in the present, has been explored in relation to parenting. Generally, negative experiences in childhood are found to increase parental stress (Bai & Han, 2016).

Parenting and teaching bear some similarities in that they both involve the provision of care and being responsible for others who are more vulnerable than oneself. Through drawing this parallel, we can conceptualise the teachers' descriptions of feeling impotent and unable to think when they were confronted with children who did not understand the explanation given as being the re-enactment of past feelings of helplessness experienced as a child when learning maths.

4.3.1.ii Re-enactment and psychotherapy

The current study looked initially at how elements of a teacher's biography may influence her actions and choices in the classroom. Through the research process, this was narrowed down to looking at the consequences of certain types of autobiographical experiences. Little is written about the emotional lives of teachers and the relationship between this and their work (Bower & Carroll, 2017). However, it is the subject of interest in other 'helping professions', in particular psychotherapy where the emotional life of the

therapist is seen as fundamental to achieving the main aim of psychotherapy which, put broadly, is improving the emotional life of the client.

A large body of research focuses on the early years of the therapist's personal life (Barnett, 2007) and it has even been suggested that early family life may access the propensity for choosing a career as a therapist (Martin, 2010; Kottler, 2017); a construct known as the 'wounded healer', which was introduced by Jung (1963). Here, the wounds of the therapist are seen as playing a dual role; they give the ability to empathize and relate to the pain of the client, which is known as a curative element (Lilliengren & Werbart 2005). However, if the wounds are not understood, they may have negative repercussions for the client with the therapist's 'blind spots' being transferred to the client (Sedgewick, 1994). The requirement for psychotherapists and counsellors to undertake their own analysis, therapy or supervision is premised on the construct of the wounded healer with the idea that the therapists' understanding of the process through which they have gone to resolve their own difficulties can be used to inform the therapists/them of a similar process with the clients (BACP, 2016).

The role that the therapist's emotional life and past experiences plays in the therapeutic process is conceived of in a variety of ways. Freud described how patterns of our relationships, which are formed through our early relationships, are being transferred to our current relationships and, therefore, through studying the emerging relationship, as it emerges within a tightly controlled set of parameters, the patient and analyst can gain access to the patient's possibly unconscious experiences of early care-giving relationships (Gelso, & Hayes 2012). These 'transfer' experiences that go from the client to the therapist are at the heart of most psycho-dynamic psychotherapies. Through

examining the analyst's countertransference responses and the emerging relationship between the client and therapist, a deeper understanding of the client's history and problems is gathered (Rowan and Jacobs, 2002). The therapeutic relationship is also considered to be a vehicle for change within person-centered therapies (Rogers, 2000) and cognitive behavioural therapies (Gilbert and Leahy, 2007). Within these paradigms, past experiences and self-knowledge, rather than being a tool for data gathering, are seen to shape the therapist's ability to communicate a sense of safety and respect, as well as his/her capacity for empathy and ability to understand his/her clients when interacting within this relational environment. As the therapist's emotional state is either the tool and/or the platform or environment within which effective therapy takes place, the therapist's capacity to understand him/herself and what affects him/her emotionally and to seek help for him/herself is paramount.

The 'wounded healer' is a personality archetype that is most commonly applied to the profession of psychotherapist. It is used as a framework for understanding countertransference and from it various Jungian countertransferential techniques have been developed and used in clinical supervision (Sedgwick, 2016). However, it can be drawn on more broadly within the helping professions to look at the complex ways in which our autobiographies play out in our chosen occupations. By virtue of the fact that they are minors, children are disempowered members of society and, as a result, are vulnerable to maltreatment and subjugation by others. For example, it would be very difficult for a child to complain about the way he/she was being taught or even to recognize that the way he/she was being taught was ineffective or damaging. Within a helping profession, we have the opportunity to encounter scenarios that we have ourselves been party to as children and have suffered detrimental effects as a result of

the actions of others, but this time from a position of power and agency. This means that there is the possibility of subverting the outcomes.

4.3.1..iii Models of reflective practice for teachers

Within other helping professions, such as educational psychology and teaching, there is no requirement for personal development, however, reflective practice, which shares similar aims to therapy, is generally encouraged (HCPC, 2015). The term reflective practice was first coined by Schon (1983) in his work, *The Reflective Practitioner* (Stedmon & Dallos, 2009). Schon explicitly described the reflective processes in which practitioners engage and argued that, in their decision-making, practitioners inform themselves by their own practice experience, rather than by external professional guidelines. He suggests that this leads to a more valuable and empathetic way of working because each situation is recognised as unique and requiring conceptualization. Two crucial processes in reflective practice were identified by Schon: reflection in action, which is the awareness of the practitioner's physical and emotional response in the moment; and reflection on action, which is a retrospective process in which the practitioner reviews his emotions and behaviour. These processes require practitioners to use both their intuition and professional knowledge, and to understand the interaction between the two.

Reflective approaches have been on the increase in health and social care education in the UK and internationally, as well as becoming a requirement in standards of education and training by regulatory bodies, such as the General Medical Council and the Health and Care Professions Council. It is widely recognised among practitioners from many professions as a means to develop self-awareness as well as to improve practice.

Different models of reflective practice with diverse aims have been developed within various disciplines. For example, within the discipline of psychotherapy, reflective practice formally takes place within the forum of supervision and is seen as essential in preventing the unconscious harming of the client by replaying the therapist's unhealthy relationship patterns of the past (Leitch & Day, 2000). While in teaching, reflective practice was traditionally a cornerstone of initial teacher training and took place within the forum of mentoring arrangements with the aim of sustaining the teacher in his/her role and developing the novice into a more effective practitioner (Sellars, 2017). However, increasingly there is exploration into different methods of reflection, such as mindfulness, learner feedback and critical reflection (Russell & Martin, 2017)

Building on Schon's model, Brookfield (1995) suggests a model for teachers that explicitly recognises the influence of previous experiences as a learner upon a teacher's practice. Brookfield states that to be reflective, teachers need to employ four critical lenses through which to view and reflect upon practice. These are: our own view, which Brookfield refers to as the lens of autobiography; the lens of our students; the lens of our fellow professionals; and the theoretical lens. Although he concedes that "all experience is inherently idiosyncratic", Brookfield asserts that our autobiographies are "one of the most important sources of insight into teaching to which we have access" (Brookfield, 1995, p31) and that studying our own experiences as learners and teachers helps us "to uncover our most deeply embedded allegiances and motivations as teachers" (Brookfield, 1995, p32).

4.3.1.iv. Reformulation of the grounded theory

In the previous sections, the original language terms used to describe the grounded theory, which were local to the interview of this study, were compared and contrasted to concepts within the extant literature. This resulted in a reformulation of the theory itself, which can now be restated as: teachers may re-enact their own traumatic experiences with learning maths via a conscious mechanism espoused as a desire to 'do something different', which involves acting diametrically. It is tentatively proposed that this process is an attempt at an adaptive re-enactment in that the teacher is consciously aware of his/her traumatic experience and through acting diametrically, the teacher is attempting to resolve that experience. However, it may be that the outcomes are not necessarily adaptive as the actions may not be in line with the learners' needs.

4.3.1.v. Continuing professional development and transitional space (search terms)

We now turn to some factors that seem to influence the re-enactment of traumatic learner experience in maths teaching. Continuing professional development appeared to have brought about transformation in terms of the way that teachers understood the processes through which children learn maths, their needs in regard to this and the teacher's role in regard to this. Continuing professional development experiences had enabled teachers to encounter maths in a new way and from this, develop ideas about how to present maths to children in a manner that is more congruent with their needs as learners. In the case of the teachers I spoke to, this involved making maths fun, being flexible and allowing children to take control. The CPD transformed the teachers' notions of maths as a practical activity rather than the absolutist notion of maths as a static set of facts. It also brought about a shift in views about the development of mathematical intelligence. There appears to be a widely held perception that mathematical ability is

fixed and enduring (Ruthven, 1987), however, through having a different experience of maths via CPD, the perception of the teachers in the current study shifted to a more socially developmental view of maths. Within this view, maths ability is seen as being fluid and a coefficient of social development, which means that teaching is about giving mathematical experiences to pupils that are culturally and socially relevant to them and, through, this increasing their engagement in mathematics.

The paediatrician and psychoanalyst Donald Winnicott developed a theory of emotional development that described how a person's personality and character evolves through their lifetime. In the introductory chapter of this thesis I described the way in which mathematics education researcher, Dr Tamara Bibby, applied Winnicott's ideas of the maternal holding environment and the maternal functions of feeding to the role of the teacher (Bibby, 2010). A further concept developed by Winnicott is that of transitional space. Transitional space is a psychic space characterised by thinking processes, which connect inner reality and external reality and bridge subjective experience and objective reality (Winnicott, 1971). This is a critical phase of an infant's development as it marks where the distinction between inner and outer reality begin to become apparent. It is through thinking activity in the transitional space that the individual person gradually, over the course of his or her lifetime, transforms from being an infant in a state of solipsism, where the individual is omnipotent and merged with the objects around it, into an independent thinker who has the capacity to relate to an objectively perceived object. The type of mental activities associated with the transitional space are imagining, dreaming and thinking creatively (Creme, 2008). Winnicott relates transitional space to the capacity to play and be playful – both as a child and an adult.

Transitional objects, such as dolls and teddy bears, act to facilitate the infant's creative impulse because they function as a bridge to and from external reality and allow the

transitional space to be opened up. Good enough environmental provision also plays a key role in facilitating difficult transitions an individual may face. Winnicott related these ideas to education and the importance of making connections between the inner and outer world within education. He proposes that there are two stages in learning: the first, where the learner accepts what he or she is taught in a rote fashion, for example, knowing what is in the national curriculum; and the second, where the student begins to think about what this learning means for him/her personally – in doing so he/she is making connection between the inner and the outer world. In the case of higher education, this is done through playing creatively with ideas and subjecting the ideas to critical interrogation (Ellsworth, 2005).

When we look at the types of remarks that teachers made in the interviews about the effects of CPD, parallels can be drawn with Winnicott's notion of transitional space. For example:

'It made me see maths as a practical subject, something that you could do.' (Teacher I, page 4, line 21)

'It showed me how I could use maths and what was useful about it.' Teacher (Teacher E, page 13, line 2)

'I saw how maths could be fun. (Teacher B, page 12, line 34)

Pulling together the idea of transitional space with the idea of re-enactment and "doing it differently", my theoretical hypothesis is that within the transitional space offered through CPD, teachers are able to play creatively with mathematics, enabling them to process their own psychologically distressing experiences with learning maths in the past in a way that is similar to the psychodynamic process of containment. One critical feature of containment is its relationship to learning: Youell & Canham (2006) note that

'being able to learn has its roots in a meeting of minds between mother and baby (p15). By experiencing containment, the infant learns to make sense of his or her own experiences of the world. In the context of a project that aims to support new ways of thinking about children's needs, the value of restoring the capacity for thinking (and, therefore, learning) through the function of containment cannot be overstated. The containment from operating within the transitional space reduces the need for the re-enactment of trauma in the classroom, so when teaching their pupils mathematics, teachers are freed from this and are able to draw on ideas about maths that have been created within the containing, holding environment of re-enactment, such as a training day or on a course.

4.3.2 Which other theoretical concepts can help to make sense of 'doing it differently'?

It is fully accepted that this grounded theory is a partial product of the researcher's theoretical sensitivities and background, and that other explanations are possible. To illustrate this, another hypothesis considered in regard to the construct of 'doing it differently' was that it related to social-modelling theory. Here, I imagined how I would go about doing something I had no training in. Supposing I was asked to herd cattle: as I have no knowledge of how to do this, the first thing that I would do is try to remember any experiences I have had where I have seen somebody herding cattle or carrying out a similar activity. I might then use these memories to identify what people did to herd cattle, but also think about how the experience went and whether there were any problems. I would use this critical analysis to determine what my actions might be. If we were to model 'doing it differently' in this way, it would suggest that when caught in the moment during teaching and feeling unsure of how to respond to a pupil, the teacher

draws on his/her own autobiographical experience and thinks back to how he/she has seen this kind of scenario played out before. The teacher who recalls an action that had a detrimental effect upon him/her, determines that he/she will not repeat this action. In the absence of knowing other possibilities, the teacher does the opposite. This is a simple strategy which, logically, should ensure there are different results.

5. CONCLUSION

5.1 Introduction to the fifth chapter

In this concluding chapter, there will first be a reaffirmation of the study's purpose. The findings are then mapped onto the critical realist ontology which underpins them. Following this, the limitations of the study are considered and finally, the contribution that I believe my research has made to the field is defined.

5.1.1 The purpose of the study

Mathematics skills are of foremost importance to our society and economy and by default so too is an understanding of the factors which lead to effective teaching of mathematics skills to children in UK schools. Most, if not all, teachers have also been formal learners of mathematics themselves, mainly at school but possibly also at other various points in their lives. This study set out to understand more about how the experiences gained as learners of maths, both as child learners and as adult learners, intertwine with teaching practice. The impetus for this came from a combination of my own professional and intellectual interests as an EP and from salient experiences of being a learner of mathematics myself, both at school and at university. The purpose of the study was to explore individual teachers' conscious thoughts and feelings in relation to teaching mathematics within broader social and local contexts and systems and to trace within these thoughts and feelings, which connect to the same teachers' biographies of learning mathematics and to envisage this process within a critical realist ontology. As it is a realist study, it went beyond a thick description of these thoughts and feelings and attempted to understand mechanisms which may be generating aspects of

these. Ultimately, the aim is to disseminate these findings in a way that leads to more effective teaching of mathematics, however, the findings are highly speculative and are only a starting point for further empirical enquiry.

5.1.2 Key findings of the study in critical realist terms

The study found that a mechanism of conscious, re-enactment was a process by which aspects of a teachers' autobiography affected their teaching of maths. However, there were also many other mechanisms and factors involved. In the previous chapter, the emergent grounded theory was gradually worked through so as to bring it in line with concepts which already exist within the extant literature. The findings were stated as: teachers may re-enact their own traumatic experiences with learning maths via a conscious mechanism espoused as a desire to 'do something different' which involves acting diametrically. It was suggested that this was an example of adaptive reenactment whereby the teacher was driven consciously by his/her memory to act diametrically, possibly in an attempt to resolve the experience.

From a critical realist ontological perspective, the process of the literature review resulted in the 'do it differently' mechanism which was discovered through a grounded theory analysis, being subsumed into the more general causal mechanism of 're-enactment'. A critical realist ontology does not assume that there are universal laws, instead there are 'real' causal mechanisms some of which have the possibility of being discovered through empirical exploration of either the natural or the social world. These mechanisms are triggered by a certain set of conditions which may exist in a variety of 'real life' contexts. In the case of the social world where we are looking at the psychology of individuals, once the causal mechanism is triggered it will produce certain effects or

'symptoms' in the individual which will be behaviours such as thoughts (both conscious and unconscious), feelings or actions (Cruikshank, 2012). The aim of the researcher is, through working in the 'empirical' domain, to capture and describe some of these symptoms by gathering data from the subjects. The way the causal mechanism operates and the symptoms produced may vary according to the specific ingredients in any particular social context.

In the case of this study, the experimental subjects are primary school teachers most of whom have a conscious memory of traumatic experiences when they learned maths themselves. The study has found that when these teachers are teaching maths to their pupils, within a certain set of conditions which include broad conditions such as the curriculum, the current socio-political climate and local conditions such as their particular class and factors in their own lives, these teachers reflected upon these traumatic experiences and then reverse re-enacted them by doing what they thought was the opposite. The teachers assumed that their pupils would have the same traumatic experiences as they did if they repeated the actions of their teachers and they wanted to avoid this, so they did the opposite.

In the literature review presented in chapter 4, I looked at how the mechanism of reenactment is described within the context of psychotherapy and how a therapist's own therapy and supervision is a prophylactic for the potentially damaging effects of therapist 'reenactment' within the therapeutic relationship. I also looked at how reenactment may operate within the context of parenting by looking at parents who have been the victims of abuse as children and describing how, possibly as a result of the mechanism of reenactment, this experience is correlated with defects in parenting such as inhibiting

the ability of the parent to put appropriate boundaries for sexualized behaviour in place thereby increasing the likelihood that the children may display sexually inappropriate behaviour or, in a portion of other cases, becoming an abuser as a parent. The ontological proposal of the findings is that the causal mechanism, of 'reenactment' can also take place in the context of teaching and specifically that when teachers have traumatic memories of learning maths themselves, the re-enactment has a particular form which is consciously choosing to act in the opposite way.

Here, I am stating that conscious re-enactment is a causal mechanism which can be triggered in a range of different contexts. To illustrate what is meant by this point, I will use the conscious, process of 'goal setting' analogously. Goal setting is a mechanism which motivates individuals to engage in 'change' behaviour towards a new and more desired future which is different from the present. Goal setting is a process that is made use of within many different contexts such as in a diet and exercise programme for weight loss, psycho-therapy, coaching, business planning or accomplishing a research project. The effect of 'goal setting' and the way goals are recorded (i.e. visual, written, oral) will depend on and be triggered by the context in which this activity takes place. In the same way, the mechanism of reenactment can take place in many different contexts; the context may alter the form that the reenactment takes but the aims remain similar. This concretizes Brookfield's model of critical reflective practice, which recognizes the power of autobiographical experience, by mapping out, very specifically, the process by which one aspect of autobiography might actually shape teaching. Were we to look at another aspect of autobiography such as for example, the influence of home-based mathematical experiences, we should assume that there are other additional

mechanisms involved and the process of exploration would need to broaden to consider these too.

5.2 Strengths and limitations of the study

The strengths and limitations of specific dimensions of the study will be considered in this section. However, first it is important to begin with a general statement about the tentative status of the view presented in this thesis. Although every effort was made to ensure that the emergent theory remained as close to the participants' words and intended meaning, inevitably just one of many different possible accounts of the data is given. Furthermore, as to some extent the data gathered, which was the voices of participants, is cocreated and influenced by all manner of context-specific factors, different data would have been generated had another researcher interviewed the same participants, possibly leading to a very different theory. Hence, overall the study is just one possible story of the research, viewed through one theoretical lens.

5.2.1 Strengths and limitations of grounded theory as the research approach

Grounded theory offers a practical and flexible approach to interpret complex social phenomena. It was developed as a reaction to the passive acceptance that all great theories have already been discovered and the main task of the research is to test these theories by using quantitative scientific procedures. It is a way of thinking about data with the intent to conceptualise it. The research questions of the current study required conceptualisation and a detailed exploratory account of how primary school teachers' autobiography influence their choices in the classroom. The starting point was the teacher's accounts of how they perceived of and managed their teaching rather than a

preformed explanation. Grounded theory involves gathering data broadly which enables the researcher to collect rich data representing multiple views of the participants which made it a legitimate method of enquiry in the current study.

As a research paradigm, I found grounded theory to be straight forward and flexible. On a personal level, it was motivating and engaging to be able to get going straight away with the process of interpretation and sense making through the constant comparison method which, through my training and work as an applied psychologist who must constantly make sense of client data, has become my modus operandum. One of the principle strengths of the approach is that by working inductively, close to the ground, and studying the lived experience of the participants, the findings are linked into the real world and therefore highly relevant. I found that when the concept of 'do it differently', which was discovered through the coding process, was described during supervision to teachers during informal discussions of the thesis and during research presentations, it appeared to have traction with the experience of others and was quickly appreciated and recognised.

This is in contrast to working within a top-down, hypothetico-deductive paradigm which is driven by the starting point of a grand theory and involves making predictions about participants' experience based on this. The research design is then constructed in a way that enables the testing of the hypothesis and through the results either verification or modification of some aspect of the grand theory. The researcher progresses through the study with a hypothesis about how he or she expects the data to come out, if the theory were true. In grounded theory, the researcher avoids having a preconceived idea about the outcome of the research and this forces the researcher to be focused on the data

itself. These features of grounded theory made it an appropriate choice for the current study where there is currently little known and where there is no major pre-existing theory that has been applied to explain what is happening within the area of interest.

My undergraduate training as a psychologist-researcher involved learning the hypothetico-deductive scientific method and designing the type of experiments described above to develop, amongst others, theories of hearing and psycho-perception (Darwin, Hukin, & Al-Khatib,1995). Grounded theory was an entirely new paradigm for formal research although, as I have previous described, I recognise that the constant comparative method bears a strong resemblance to the internal thought processes which I engage in as a psychologist working in the field where, as stated by Glaser (p145, 2001), 'all is data'.

Although it is not necessarily a limitation of the grounded theory paradigm per se, as a novice trying to both learn about grounded theory whilst at the same time actually carrying it out, I found the controversy and competing accounts frustrating and limiting. There is seemingly an immense amount of contradictory advice and guidance that exists. It is also true to say that the authors of grounded theory are not always explicit about their ontological and epistemological stance and emphasise a practical approach. This meant that despite reading a great deal about grounded theory, I had to commence my study and make decisions without feeling fully clear about what grounded theory was and the options available to me, which resulted in what some may consider to be methodological errors.

For example, there is contradictory advice around the place of literature reviews within grounded theory with many of the key players advising that researchers should limit their prior reading before exploration of the grounded theory (Glaser and Strauss, 1967 Corbin and Strass, 2008) whereas others state that a literature review is important in helping the researcher recognise subtleties and connotations in the data and therefore guards against potential biases (Schreiber, 2001). A further conflict arose as a result of the institutional requirement for a literature review in order to construct a research protocol for the purposes of obtaining ethical approval, justifying your research and constructing research questions.

I had not resolved this dilemma for myself prior to starting the project despite many conversations in research supervision and with colleagues on my doctoral course. I feel that there were both advantages and disadvantages to the reading that I had done prior to data collection. The initial research questions laid out in my proposal were drawn from this reading. This was limiting as it presupposed what teachers were going to talk about in relation to teaching maths. It was for this reason that I had to change my research design and use the initial interviews as a pilot, the aim of which was to orientate me away from any pre-formulated ideas and onto the data itself. From that point on, I found the combined techniques of constant comparison and memo writing made it possible to generate concepts with ease. If I were to use grounded theory again, I would approach the data collection without specific research questions and instead I would talk generally with the participants about the area of interest and from there I would formulate my research questions.

Returning more broadly to the debate surrounding the place of the literature review which is still ongoing between different proponents (Bryant and Charmaz, 2007); in my view, this is anachronistic and a moot point. It is generally accepted that there can be no theory neutral observation. As humans, whatever we do is always unavoidably embedded in a theory or interpretation. All data that is gathered will inevitably be biased by the researcher's perspective whether or not this perspective is shaped by prior reading or some other form of information gathering pre-dating the formal research data gathering process. What is of greater importance is the steps the researcher takes to understand her own biases and make these explicit to the readers of his/her research. It is also important to be flexible and accept the idea that the initial literature review may bear no relation to what is discovered. In the case of the current study, one of the key papers in the initial literature review was Bibby (2002) where she identifies primary school teachers having a sense of shame when doing maths and discusses how the teachers defend themselves from this shame through the processes of distancing, shutting off and self-denigration. Although shame was certainly a concept that was identified, the research became focused on a different set of processes, those of re-enactment rather than defence.

Although the conflicting accounts provided from the 'parents' of grounded theory was limiting at some points in the process, ultimately it brought clarity as the thesis criteria demands that one addresses the contradictions and thinks critically about these splits to understand them. In my case, I used the psychology of group dynamics and relationships to see beyond the intellectual arguments and understand them within the frame of human competition and collusive avoidance through conflict. Clearly emotions run high within the different grounded theory camps and I came to wonder whether the

desire of each to make their own approach distinct skews the explanations given and closes down constructive debates through which the epistemological and ontological differences could be identified, explored, learned from and ultimately resolved into a robust, unified critical realist account which is what, to my mind, seems to account very well for the approach.

Ultimately, the contradictions demand that the users of grounded theory be pragmatic and determine for themselves which aspects of each approach are most useful rather than follow a recipe blindly. For example, the reflexive strategy of the research diary, drawn from a constructivist approach, was essential in supporting my understanding of how the contextual setting and my own reactivity impacted on the original interviews. I used this understanding to make adjustments to the research design. However, I do not hold with the constructivist ontological position that the researcher co-creates the ideas with the participants. Rather, as a critical realist, I subscribe to the view that mechanisms which are described by the grounded theory are inherent within the data and exist independently from me and my descriptions of them. This is also the view of Glaser (2002) who, as an adjunct to this, suggests that reflexivity is not required in a grounded theory methodology. In my view, reflexive strategies are a useful tool enabling the researcher to bring into view and see more clearly her own assumptions and preformed concepts and in doing so possibly reduce the effect of these on the data gathering so that it is the experience of the participants which is at the fore of the 'empirical domain' (Bhaskar, 1989).

5.2.2. Strengths and limitations of the research design

The grounded theory research design involved selective sampling of participants, interviewing, transcribing and coding of data. There were a number of aspects of the research design which would have affected the findings and introduced bias.

Although steps were taken to reduce the impact of the EP role on the power dynamics with teachers, it was most probably still a factor which may have shaped the data that the teachers provided, causing them to either emphasise or minimise aspects of their experience while reconstructing the stories (Smith 1994). For example, teachers may have felt less able to be open about practical constraints on their teaching and sharing their vulnerabilities. A possible measure that could have been taken here was to ask a different person, not an EP, to carry out a further interview using a previous agenda and compared the transcript generated.

Further weaknesses of the current study are the limited sources of data which were drawn upon and the small number of participants which means it is not clear to what extent the findings describe a more common experience amongst teachers. The small sample size means that the effect of sampling bias is magnified. The participant group comprised eight women and two men. Seven women were White British, one woman was mixed White/Asian, one man was mixed White/Asian and the other man was White other (Australian). Although the gender mix reflects UK Government data about the relative proportion of women to men in nursery and primary school teaching, the ethnicity composition of the group was skewed.

According to the ethnicity data collected about the UK workforce, 88.9% of nursery and primary school teachers were White British, 0.3% were mixed White/Asian and 2.9% were White other (DfBEIS, 2018). This means that the study's participant group had a far higher proportion of mixed White/Asian participants and White other than would be found in the general population. Although the nature or size of any bias in a very small sample cannot be specified (Bornstein, Jager & Putnick, 2013) there is the potential for it to have had a sizeable impact on the findings and mean that the emergent grounded theory bears no relation to the concerns and lived experience of the wider group of primary teachers in the UK. This is especially true in the regard to the White other participant who represented 10% of the sample size but was not educated in the UK. This means that the influences on his teaching from his own school-based educational experiences stemmed from a different education system.

The opportunistic-sampling strategy meant that although I did not have a relationship with any of the participants prior to or after the study, they were individuals with whom I had an indirect connection through the person who introduced us. For example, one participant was the sister of an educational psychologist colleague who worked in the same team as me. It is appreciated that even this kind of second degree connection could have potentially biased what the participants said in the interview and their willingness to be involved in the study. Primary school teachers have a large work load and it might have been that without this personal connection, I would have struggled to recruit teachers and the interviews may have been shorter.

The study used only interviews and no formal steps were taken to corroborate the findings using other methods such as participant validation. It is therefore fully

acknowledged that the research design means it can only be argued that the emergent grounded theory is relevant to the participant group itself. The findings are limited to the status of a tentative hypothesis which would need to be developed through the replication of the current study in different contexts, with different participants, by different researchers and explored through studies with different research methodologies.

5.2.3 Strengths and limitations in trustworthiness

5.2.3.i Credibility and Dependability

The dual role of researcher and EP was both a strength and a limitation to the data collection and to the credibility and dependability of the analysis and emerging theory. My role as EP facilitated my access to suitable participants. As I work within schools continuously, it also meant that I had many informal opportunities to discuss the research process and the ideas as they emerged with primary school teachers which was a kind of informal theoretical sampling process which did influence the theory generation. However, my professional interest in the subject matter and the use of unstructured interviews meant that I was involved in data generation and meant that my interest was inextricably woven into this. It is not possible for me to say at this stage to what extent the findings arise from my participants or from myself.

I made use of grounded theory strategies which aim to either reduce, or if this is not possible, at least recognize personal bias such as a research diary, in which I captured my thoughts and responses to the data. The diary gave me a mechanism for examining my partiality and challenging my thinking. An example of this is a diary entry (03/04/14)

where, after discussing continual professional development, I express concern that following CPD the teachers seemed to see their role as a provider of mathematical experiences rather than a corrector, which is similar to my own experience when I specialised in maths during my initial teacher training. I needed to be careful that I did not project my own experience onto theirs, so I asked for additional support in this area when working with the inter-rater. This enabled me to look differently at the effect of the CPD as acting as a bridge between the teacher and the needs of her pupils so the choices could relate more directly to them. However, I have no way of knowing what the impact of the research diary was and whether, if I had used a different strategy or no strategy at all, whether the grounded theory would have been different. Therefore, although my research may be judged credible in that I have supplied an audit trail, the dependability is not possible to judge without replication.

5.2.3.ii. Transferability and Confirmability

The focus of the current study was on identifying mechanisms active for primary school teachers in the context of teaching mathematics in the classroom. The findings come from a small number of individuals and no claim is made in regard to transferring these to other situations or populations at this stage. However, it would be very feasible for the study findings to be triangulated by other researchers, who would be able to confirm/disconfirm the findings through other methods within the analytic categories of this study using different methods such as questionnaire or observation.

5.3 Contributions of the study

5.3.1 What knowledge has your study contributed to the research field?

Due to the limitations of the study discussed above, the grounded theory that has emerged from the study has the status of tentative hypothesis rather than knowledge. With this caveat in mind, the study has contributed to the current understanding of the processes that take place in primary school classrooms during the teaching of mathematics. The study discovered a tendency of teachers to talk about wanting to 'do it differently' in light of their own traumatic experiences of learning mathematics at school. By this, they were referring to teaching maths in a different way from how they themselves were taught and commonly what was meant by different was in the opposite way. This suggests that when teachers are teaching a subject with which they have a problematic relationship (in the case of this study,2 mathematics), they may attempt to resolve their own psychologically distressing experiences through re-enacting the same scenarios but this time with a different ending.

The findings of this study and the subsequent discussion of these in the second literature review have highlighted two important points. Firstly, it has called to attention the lack of research into the specific effects of teachers' autobiography on their teaching and the processes through which this takes place. Secondly, it highlighted the potential role of teacher training and CPD in remediating problematic relationships with mathematical subject matter and suggests a mechanism by which this may happen which is the idea of transitional space.

This study was extremely narrow and mapped out only the mechanism of conscious traumatic autobiographical experience in that it was the teachers themselves who identified that they wanted to 'do it differently'. However, there may be a whole network

of interdependent conscious and unconscious re-enactment mechanisms taking place within teaching which is yet to be unearthed. In the introductory chapter of this thesis the important role that teachers play in securing the country's financial future was spelled-out. It seems that the mapping out of these processes could be of value to our education system as it would provide a strong rationale for reflective practice and enable teacher educators and teachers to fine-tune practice using their experience in the moment.

It may also be of use to fellow EPs when working directly with teachers and as consultants to education systems by giving them further insight and avenues of enquiry when faced with making sense of educational problems and underachievement.

5.3.2 Future research directions

The current study was exploratory in nature and intended to provide some initial starting points that may be of interest to other researchers. It has brought into relief how a teacher's childhood experiences can become triggered during teaching and then become an active part of that teaching, thereby shaping the experiences of the pupils in his/her class. Although the traumatic memories require the host of the teacher's psyche within which to exist, they are described in this study as having common properties and causal powers enabling them to influence reality in the here and now.

The literature review illuminated a lack of research into the specific mechanisms that take place in teaching and the extent to which they may be similar to the mechanisms that take place within other relational processes such as parenting, counselling or psychotherapy. If the findings of this small-scale study were to be substantiated then

this could be used to develop very specific strategies within CPD such as exploratory, play like experiences with the subject itself, which in turn could enhance teachers' ability to teach.

From the study comes further questions about firstly, whether there is further broader evidence confirming real substance to the theory of re-enactment mechanisms within subject teaching and secondly, to what extent these are subject specific i.e. is there evidence for similar process in the teaching of art or science, if not why not, if so, what are the specific mechanisms.

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