THE STRUCTURE OF PRIOR KNOWLEDGE

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ABSTRACT

The phenomenon of prior knowledge is deep rooted in the rhetoric of education. There is much discourse within pedagogy about its value and pivotal role in the formulation of new learning. However teachers are not able to use prior knowledge effectively as they do not have a working sense of it, but are using it intuitively and colloquially. While researchers provide a multitude of definitions of prior knowledge, no one has examined its elemental structure in a way that provides a model for teachers to use and support learning. This deficit is surprising as prior knowledge is a universally accepted pedagogical notion. The aim of this thesis is to fill the deficit and establish a structure of prior knowledge.

The research was situated within Year 1 primary mathematics classrooms following eight teachers across five schools over one academic year. Using naturalistic research methodology, the data were gathered through audio recordings of the interactions between teachers and children during mathematics lessons. These recordings were analysed using grounded theory and content analysis.

The research explored and produced a partial model of prior knowledge emerging from the data which includes at least eight interconnected elements – abstraction, acculturation, cognition, context, individual motivation, metacognition, perception and social group. These can be seen as elements which can shape children's memory – the central feature of the prior knowledge that they bring to each mathematical task. Children may manifest different degrees of these elements, and possibly of others which did not appear in these data, in different proportions and balances.

Such a prior knowledge model, even though it remains partial, gives a deeper understanding to a common but widely misunderstood term. The implications of knowing and understanding more and in more depth about the structure of prior knowledge are potentially far-reaching for children, schools, teachers and curriculum development.

Keywords: prior knowledge; prior learning; primary schools; primary education; mathematics education; mathematics teachers; elementary school mathematics; primary school teachers

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Ithaca

When you set out on your journey to Ithaca,
pray that the road is long,
full of adventure, full of knowledge.
The Lestrygonians and the Cyclops,
the angry Poseidon -- do not fear them:
You will never find such as these on your path,
if your thoughts remain lofty, if a fine
emotion touches your spirit and your body.
The Lestrygonians and the Cyclops,
the fierce Poseidon you will never encounter,
if you do not carry them within your soul,
if your soul does not set them up before you.

Pray that the road is long.
That the summer mornings are many, when,
with such pleasure, with such joy
you will enter ports seen for the first time;
stop at Phoenician markets,
and purchase fine merchandise,
mother-of-pearl and coral, amber and ebony,
and sensual perfumes of all kinds,
as many sensual perfumes as you can;
visit many Egyptian cities,
to learn and learn from scholars.

Always keep Ithaca in your mind.
To arrive there is your ultimate goal.
But do not hurry the voyage at all.
It is better to let it last for many years;
and to anchor at the island when you are old,
rich with all you have gained on the way,
not expecting that Ithaca will offer you riches.

Ithaca has given you the beautiful voyage.
Without her you would have never set out on the road.
She has nothing more to give you.

And if you find her poor, Ithaca has not deceived you.
Wise as you have become, with so much experience,
you must already have understood what Ithacas mean.

Constantine P. Cavafy (1911)

For Papa

I miss you reminding me

To never limit my challenges

But to challenge my limits

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1 INTRODUCTION

1.1 Motivation

Prior knowledge plays a key role in children's learning (Alexander, Pate, Kulikowich, Farrell & Wright, 1989; Dochy, 1992; Alexander, Kulikowich & Jetton, 1994). Whether it is examined from the constructivist, cognitive, behavioural or any other perspective, it is widely accepted that prior knowledge is the starting point for new learning (e.g. Vygotsky's Zone of Proximal Development). There are many studies which have concluded that the variance observed in children's test scores can be explained by a child's prior or pre-existing knowledge (Bloom, 1976; Tobias, 1994). Walker (1987) and Weinert (1989) showed that intelligence cannot compensate for low prior knowledge, however prior knowledge can compensate for low intelligence. The British education system is based upon the knowledge and understanding that the teaching function will be a process of building new blocks of subject knowledge placed on prior subject knowledge, as can be seen in the hierarchical structure of the National Curriculum. With such importance and value placed upon prior knowledge, it is essential that concentrated effort is given to understanding prior knowledge.

As a primary classroom teacher, I have been interested in the ideas and methods that children use to develop their mathematical skills. I am baffled by and curious about the widespread cultural perception that not being good at mathematics is acceptable. I also want to understand what children bring to bear upon each classroom experience in mathematics that leads to a huge variation in their ability to carry out mathematical tasks. Therefore I have chosen the primary mathematics classroom as my research context.

1.2 Gaps in Understanding

One of the most interesting and perplexing observations that I have made is the great variation in children, who seemingly have similar lives, in their ability to carry out mathematical tasks. In order to understand this variation in children's abilities to inform my teaching, I started by exploring the concepts and ideas that authors such as Vygotsky, Dewey, Piaget, Hughes, Evans, Clemson and Ginsburg had to offer. These readings concluded that teaching and effective learning can only take place when teachers have developed an understanding of what children know and have learnt before. All learning theories rely on some form of prior understanding or experience to be built upon in order for future learning to take place. Therefore it is essential to understand individual prior knowledge so that future learning can be tailored to individual needs. As a classroom teacher, I am aware that there is a missing link between the theoretical requirement to use prior knowledge for effective teaching for learning, and the practical understanding of prior knowledge to facilitate effective teaching for learning. That is to say, we realise the theories state *start from where the child is and build on this*, but no understanding is offered as to what is meant by *where the child is* or how to gain this understanding for children.

There is limited literature looking at prior knowledge in any depth. There are many reasons for this shortcoming. The major reason is due to the lack of a clear agreed definition for prior knowledge. Furthermore, there is even a lack in agreed labelling of prior knowledge. There are many terms defined in various ways which lend themselves to being classified as prior knowledge (prior learning, prior education, experience, prior concept, experiential knowledge, experiential learning, background knowledge, prior understanding). With such a variety of possible labels and the confusion that ensues, it is vital to explicitly explore and gain an in-depth understanding of prior knowledge. Before I do this, I must clarify the type of knowledge that I am interested in. If it is subject-specific knowledge (i.e. mathematical content knowledge), then the focus becomes mathematical content and categorisation of this content to formulate a detailed understanding of prior mathematical knowledge. However my research is not concerned with prior subject knowledge, but the broader concept of prior knowledge in the primary mathematics classroom. Therefore I am making an upfront distinction between prior knowledge and what is commonly understood as prior knowledge i.e. prior subject knowledge, with my focus being the former. If one considers prior knowledge to be all that an individual has as knowledge, then it goes beyond subject-specific knowledge. Prior knowledge is affected by experiences within and beyond the classroom. It is influenced by all areas of life. However this aspect of prior knowledge has not been examined by researchers.

Therefore the aim of this thesis is to provide an understanding of the structure of prior knowledge of children in the context of the primary mathematics classroom developed through a combination of theoretical and empirical investigation.

1.3 Data Gathering

The underlying methodology used for structuring the research was naturalistic research. The data collection comprised a year-long observation of eight experienced Year One teachers across five primary schools. Each teacher was observed regularly and their conversations in the mathematics classroom were recorded through the use of a personal remote microphone during the course of one academic year. The recorded observations were transcribed. All data have been gathered and reported as per the ethical guidelines for educational research from the British Educational Research Association (2004). The specific ethical issues relevant to my research are discussed in Sections 4.4 and 5.6.

1.4 Data Analysis

The structure of prior knowledge was developed through analysis of the transcripts. I used grounded theory as the framework for the analysis and content analysis to understand the meaning of each transcript so that the resulting interpretations may be organised using the framework of grounded theory. This analysis formed the last stage of the method used to gain an understanding of prior knowledge. Each transcript was looked at in detail to identify events (incidents within lessons in which children are engaged in mathematics), concepts (groups of events which have similar properties) and categories (groups of concepts which function in a similar manner or may be shaped by a similar force), and used memoing to identify patterns within the data.

1.5 Research Findings

The key contribution made by this thesis is a partial model for the pre-existing or prior knowledge of children in the context of the primary mathematics classroom through empirical understanding gained from analysing the transcripts. The prior knowledge model I propose comprises eight interconnected elements – abstraction, acculturation, cognition, context, individual motivation, metacognition, perception and social group – shaping children's memory which is the central feature of the prior knowledge that they bring to each mathematical task. These elements or building blocks that make up prior knowledge are the same in each child, with the fundamental difference being the proportion and balance of these elements present in each child at any given time.

1.6 Chapter Outline

The structure of the thesis is conventional with the hope that this uses the reader's own prior knowledge to focus upon my research process. Though this thesis is sequential, and in some ways hierarchical in its structure, it should not restrict the reader to a linear process for reading it. The aim is to present a three-dimensional thesis which can be viewed from any angle, none being the beginning or the end. The justification for this tacit form is the very nature of the content. Not knowing the reader, your needs and your prior knowledge, it is hoped that giving the ability to view this as a sphere, one can approach it from any point which suits individual needs and extract from it any ideas which are useful.

Chapter 2 provides a review of the relevant literature which has influenced my thinking and research. Key focus areas are the research context, prior knowledge and teachers' understanding of it.

Chapter 3 explores various research paradigms and methodologies to identify a suitable methodological framework to conduct the research.

Chapter 4 presents the method used for the data collection. It includes information about the schools and teachers used for data collection, recording and transcribing lessons, and the overall data set and also discusses relevant ethical issues.

Chapter 5 focuses on the exploration, evaluation and explanation underpinning the selection of a methodology for analysing the qualitative data gathered for this thesis. It includes the criteria for selecting an analysis methodology, brief description of a number of relevant analysis methodologies, a description of the selected analysis methodology along with a worked example, and also discusses relevant ethical issues.

Chapter 6 explains the overall outcome from the research and analysis carried out for this thesis. It presents the structure of the partial prior knowledge model.

Chapter 7 examines the key findings, implications and value of this research on schools, teachers, children and curriculum, and possible next steps.

2 LITERATURE REVIEW

2.1 Introduction

This chapter provides a review of the relevant literature which has influenced my thinking and research. Through this review, I aim to establish a theoretical framework for prior knowledge which is firmly based upon the foundation of previous work by other researchers. This framework is relevant in aiding the understanding and placing of questions being asked through this thesis into a well-established context. Another by-product of analysing relevant literature will allow determining the boundaries and contextual parameters within the areas in which this research makes an original contribution. By the end of this chapter, I plan to establish the current state of research in understanding of prior knowledge, and identify any shortcomings within this understanding.

It is worth re-iterating my research objective, which is to provide an understanding of the structure of prior knowledge of children in the context of the primary mathematics classroom. The aim of the structure is to assist teachers to develop their understanding of how to support children's learning.

In order to be transparent, it is vital to explicitly identify and explain the research process which has evolved through the course of this study. These are processes for the location, identification and analysis of secondary sources of knowledge to give an anchor to my study. The progression of this chapter shows the evolutionary path which I have gone through to develop as a researcher, to establish the relevance of this research for future application, and to further my existing knowledge in the areas that I am considering. I have made extended efforts to knit together not only the many different sources of information, but also the vast plethora of ideas which have aided in understanding and clarifying what it is exactly that I am trying to establish.

The biggest struggle for me in carrying out the literature review was not the finding of relevant material, but the elimination of ideas which I concluded as not having any value to my thinking or my research objective. The process of thinking is crucial to the whole thesis as it gives it a structure and sets out the limitations from the onset.

In Section 2.2, I describe the methodology that I used to identify, critique and summarise the relevant literature reviewed in this chapter. I address the problematic issues of varied terminology linked to the relevant literature. Also stating the limits and parameters of the literature review will establish a true picture of what is pre-existing knowledge in this area and the limitations of this knowledge in informing this study.

In Sections 2.3 and 2.4, I consider the overall context for this research. In order to understand any socio-educational research, I must establish a picture of the reality within which this research is based, as it is not possible or desirable to conduct this research in a vacuum. I look at the historical, political, social and cultural backdrops of primary education and the primary mathematics classroom as they were at the time of data collection. I aim to provide research that will have future worth and is based within a practical and real context.

Though I am not looking at the effectiveness of classroom practice as my focus is on the prior knowledge of children, I acknowledge that this practice has an influence on the nature and characteristics of the data that I can gather. Due to the ever-changing nature of education and the political climate, there have been evolutionary steps in the pedagogical philosophy of the delivery of the curriculum which I have examined.

In Section 2.5, I examine prior knowledge by looking in turn at knowledge, prior and prior knowledge. This section presents the many difficulties which have come to light in relation to the different terminologies and definitions found in the literature. The main themes explored in the section are the complex issues linked to what I mean by prior knowledge and how I define it. This section culminates in my own working definition of prior knowledge. Academically I would like to establish an unambiguous definition of prior knowledge which can be applied to my empirical study. Through the thesis, I would like to develop something that teachers can use in order to enhance children's learning of mathematics.

I specifically look into prior knowledge in relation to mathematics to establish that I am contributing new knowledge. My main goal in this research is to develop an initial model for understanding and identifying the structure of prior knowledge in relation to primary school mathematics, therefore without analysis of this area it is not possible to establish an effective approach to the research.

Section 2.6 considers the value of looking at prior knowledge from the perspectives of learning and learning mathematics.

In Section 2.7, I examine teachers' understanding of prior knowledge in general and in the children they are teaching. It is vital that in order to build and establish any sense of value to the research, the role of the teacher and their understanding of prior knowledge is established.

In the final section, through the synthesis of all the sections, I establish the gaps which exist in understanding prior knowledge within the literature. Crucially this section achieves the main outcome of defining and establishing a shared understanding of the complexities of meeting my research objective.

2.2 Methodology for Literature Identification

2.2.1 Introduction

In order to cover all the possible lines of enquiry related to this research, the process of locating the relevant literature went through many phases. The initial temptation as a novice researcher was to look at the entire plethora of available literature databases, to consider all the possible related concepts, and to examine the multitudes of literature that was located as a result. Through the process of initially searching all the major databases, two things became apparent. Firstly, the vastness of the possible literature which could be considered and the huge impracticality of demands which came with wanting to look at all of it without any omissions. Secondly, the interlinking of the literature and how this added an extra layer of complexity, as it did not allow for straightforward identification of the relevant literature. This mixing of concepts forced me to consider ideas in ways in which I had not done before, and allowed me to further consider and combine ideas which were not intuitive.

The starting point was my research objectives:

1. To gain an understanding of prior knowledge of children in the context of the primary mathematics classroom.
2. To use the understanding to develop a structure of prior knowledge within the primary mathematics classroom which can be used by teachers to enhance children's mathematical learning.

To address the above, I took each objective and fragmented it into possible root notions (Table 2.1). Literature was located under the following parameters:

1. Only materials written in English or translated into English were considered.
2. The databases were searched only up to 1986. Through reading, material prior to 1986 which was identified was also considered.
3. Five of the major research literature databases were used – ERIC, BEI, IBSS, Zetoc and PsycINFO.
4. The searches were carried out with some keywords which were identified as a product of the background reading. I have considered the identification of pertinent vocabulary in detail in the following section.

Some of the above parameters were as a result of my own shortcomings. For example, I have only considered literature written in or translated into

English. Also I have made the choice to only go as far back as 1986. The logic behind this choice was the idea that through looking at a substantial body of past work, any other seminal work prior to that should be evident in the literature identified up to 1986.

The overwhelming fear at this stage was having gaps in my literature review. However I felt, as a result of my initial background reading, that there was a *ball of string effect* in place. That is to say, through the location of some of the initial relevant literature and following their references, I was able to locate further literature of relevance. Furthermore, previously identified relevant references would often keep reappearing. Thus, like a ball of string, there were many points at which the same literature appeared and crossed over. This ensured that key themes and seminal articles were located.

This drive to review all the possible areas of literature which may have even the vaguest influence on the concepts being investigated led to the identification of an enormous quantity of literature. This stage of the searching process seemed endless, and through a process of dual classification – the information that the material had to offer and the type of subject matter it was covering – I was able to hone in on the literature which would form the cornerstone of my research.

Table 2.1 Literature review concepts

Knowledge
Prior knowledge – gaps in understanding
Primary school education – overview of political, historical, cultural and social contexts

Nature of the primary classroom – what does teacher and pupil interaction show in mathematics
Teachers' understanding of prior knowledge in general and in mathematics
Mathematics education – overview of political, historical, cultural and social contexts
Mathematics and prior knowledge
Children's learning and the effects of prior knowledge on performance/ability and understanding

Having detailed the practical process and the obstacles faced in the path to identification and location of key literature, it is hoped that the limitations and extent of the scope of the study have been made transparent. Openness to the background from which the ideas presented in this thesis have been obtained allows the reader to gain a firm understanding about the possibilities that the results have to offer and increases the applicability of the outcomes established.

2.2.2 Determination of Vocabulary

The most problematic issue that I faced in this thesis was one of definition and identification of relevant vocabulary to explicitly explain the notions I wished to explore. From the onset, there were many methods which I used to try and verbalise what it was that I wished to consider and the notion of defining that which was not understood has been a great challenge. Here I feel it is of value to look at the different stages of thinking which have passed and how these have fed into the process of forming a personal lexicon which has formed the conceptual framework for this research.

Firstly, I wanted to understand the processes which take place in the classroom within each individual child which enable them to have an understanding of the mathematics they are involved in. Secondly, I wanted to reflect on the causes of the varying abilities of children which facilitate reactions and interactions while involved in mathematics. Therefore what are these processes or structures which determine the level of engagement and the success that each child has with the mathematics taking place in the classroom? Furthermore, the extended nature of this interaction manifests itself in the ability or aptitude which the individual shows towards mathematics. So how to define this abstract and almost random process?

I also wanted to understand what children bring to bear upon each classroom experience in mathematics. What is it about the processes which take place in each child that result in such huge variation in the outcome/understanding of the mathematics they are involved in? The initial reading of the literature which looks at children's understanding in mathematics (because the understanding or outcome that they show in carrying out mathematical tasks is a direct result of their processing and thinking) puts heavy emphasis upon the notion that "understanding seems to take two major forms: *perceiving* accurately and *making connections* among various areas of knowledge, including our intuition" (Ginsburg, 1989, p. 183).

Furthermore this concept of understanding focuses on the construction of "schemata to link what we know already with our new learning" (Clemson & Clemson, 1994, p. 18).

I wanted to explore this notion of what we already know being the lynchpin to any new understanding, as this was the constant and recurring theme in all the literature that I considered in order to understand why children are so different in their ability, interaction and success in mathematics. Literature alluded to knowledge, understanding, exposure, and experience prior to the learning experience that the children are engaged in as the factors that shape the children and create differences in each individual. Furthermore, in contrast to many theorists e.g. Piaget, this process of learning is not simply a biological progress (Blanck, 1996). Hence these factors, among others, need to be considered in order to understand and conceptualise the solutions for this thesis. Therefore the various terms which came from these initial readings were *prior experiential learning*, *prior knowledge* and *prior learning*.

To summarise, in order to understand the reasons for the differences in individual ability within mathematics, the literature read as a background to this thesis highlighted prior knowledge as a key factor which children bring to the classroom, prior knowledge which has not been influenced by their current situation but by their past experiences. Therefore the proposed lexicon of terms stated above formed the search path for the identification of the literature which will help to understand this small key concept and how it functions and enables children to carry out mathematical tasks in the classroom.

2.3 Primary Education

This section maps changes which have historically occurred in English primary education. Reviewing the legislative path of education allows me to consider the historical perspective as well as the political, social and cultural views influencing changes in the culture of schools. It is through understanding the engrained history that has evolved that we can consider how change can be implemented and ideas that are likely to succeed.

2.3.1 Historical Backdrop

The social and moral pressure to invest in children and their education has constantly been the subject of debate within society. This has resulted in numerous initiatives, reports and laws. A landmark publication to ignite the reformation of the current system was the Plowden Report (Plowden, 1967). This was the first comprehensive review of primary education since the Hadow Report of 1931 (Hadow, 1931). The Plowden Report emphasised the need to see children as individuals and also relied heavily on Piagetian theories which were the dominant influences of the time.

> The report's recurring themes are individual learning, flexibility in the curriculum, the centrality of play in children's learning, the use of the environment, learning by discovery and the importance of the evaluation of children's progress – teachers should 'not assume that only what is measurable is valuable.'

(Gillard, 2004)

This is in grave contrast to the introduction of the National Curriculum (NC) through the 1988 Education Reform Act (1988 c. 40). The focus on individual and free learning was now changed to the fixed "syllabus and content that every child should study until he or she leaves school" (Moon, 2001, p. 1).

In some senses, this has led to removal of the child (the individual) from the way we teach to be replaced by children (the masses). The NC removed any sense of children being different or having different ways of learning. The Rumbold Report (Rumbold, 1990) completes the cycle of primary education and the philosophical changes it has been through since the 1960s. The report recommends a rethink of how a system can develop and support the children in a new society. There is emphasis once again on quality and provisions being made for children as young as three and the ability for parents to have choice of many settings for the care of their children.

Since then, there have been many other reports and reviews into the way in which primary education is delivered or should be delivered in England, with the latest being the Cambridge Primary Review (Alexander, 2010) and the Rose Review (Rose, 2009). Educators continue to struggle with the balance between education of the masses and the individual. This brief overview illustrates the pendulum swinging between education for all and education for the individual.

Principles within education are influenced by changes in societal attitudes and demands of the individual through time. Knowing this allows us to see the change in the nature of schools and the views we have of children and their development within the system. Within the current educational landscape, there is great ambiguity and debate on the nature and shape of primary school education which has manifested itself in the position we find ourselves in at present, with lack of agreement on a new curriculum and suspension of all existing guidance.

2.3.2 Political Social and Cultural Backdrop

Having considered the path taken through history in primary education which has led to a set of underlying philosophies, the main aim of this section is to consider the influences which brought about these changes.

The introduction of the National Curriculum (NC) was very closely linked to the political situation of the 1980s. Moon (2001) argues that the reason for the creation of the NC was that it allowed for a reduction of differences between schools, and a reduction in the inequality of provision.

> The government believes that all people should follow a broad, balanced and suitably differentiated programme until age 16; that such a programme should contain a strong element which relates to the technological aspects of working life.
>
> (Department of Education and Science, 1985, para 46)

The NC aims to raise standards, improve communication, allows for provision to be made for progress and continuity, and necessitates measurement and tracking of individual attainment. At the time of introducing the NC, the social structure was demanding all of these and viewed these to be lacking in the education system. The 1980s growth of incomes, the growth of two-parent working families, and to some extent, a greater movement of individuals geographically, all led to the need for a national measurable structure for schools. Also the economic and political situation of the time focused on employment and the need for young people to be employable.

> By the 1980s the effects of the global economy were being realised. The 'Asian tiger' economies of Japan, South Korea and Taiwan were producing better industrial goods more cheaply and were sucking away customers from Britain. Their education systems appeared to benefit from teaching basic skills through traditional methods. Controlling the curriculum to make it more suited to industrial production was seen as one of the means of enabling Britain to compete.
>
> (Ward, 2004, p. 83)

The overall cultural, economic and social environment put pressure on educational change to be a major part of the political agenda. The enterprising materialistic 1980s demanded the same from schools. It can be argued that the Thatcher administration was responsible for some of the most radical changes in education in the UK to date. There were many political reasons behind such a radical change in the way the system was structured and functioning.

> On the one hand, the government had taken central control of the curriculum and national testing, but had de-centralised spending and management. In fact, the so-called devolution of funding was designed to reduce the power of the LEAs (Local Education Authorities). It was the Conservative government's political intention to limit the power of left-wing Labour-controlled local authorities, particularly the Inner London Education Authority (ILEA).
>
> (Ward, 2004, p. 84)

The need to gain control on a local level to ensure political longevity was another crucial reason behind this great change. There seemed to be little pedagogical motivation for introducing the NC, but one that did have an impact on the pedagogical dialogue of schools.

In the late 1990s, the Labour government did little to change the nature and ethos of education as they enjoyed this centralised structure and control over education. Therefore we were left in the UK to date with a system which, in many senses, was rigid and set in an inflexible structure. Furthermore, it was a structure which required great amount of maintenance and also demanded a lot of tasks which were not related to the job of teaching and learning.

The primary schools in England suffered from a severe case of split allegiances. Firstly, there was the rigour of the NC and the state control through the NC. With this came the whole mechanism of assessment levelling, teaching only written content, administrative duties which must be completed, and ranking and reporting to the *consumer* or *stakeholder*. All of these were in line with the capitalist market methodology for the functioning of schools. Secondly, there was the need of the individual child and the teachers' understanding of what their children needed. Thirdly, teachers needed to push children to measure up to the required standard for the results to be achieved for the school.

There was a pedagogical mismatch between the way in which the NC was implemented and the needs of children. This mismatch has been identified, and since September 2008 there have been some moves to allow teachers greater freedom in the ways in which they implement the curriculum, e.g. removal of the Qualifications and Curriculum Agency subject guidance from schools. Furthermore, the move to an open-ended curriculum structure has given greater opportunities for schools and teachers to teach in the way their children learn best. However, paradoxically there still looms over teachers this need to validate their choices in terms of fixed and constant measurements. This is most evident in the Foundation Stage. For example, though teachers have been given free rein to choose methods for teaching which they feel best allow their children to learn (through play and unstructured activities), there is still the need for them to measure this learning and produce comparative data. So in some senses, the changes in place have given freedom with one hand, but still tie the teacher to the NC and all its trappings on the other hand. Overall there continues to be a huge mismatch between political intentions and pedagogical needs which has an impact on the nature of the classroom and the relationship between knowledge and the individual.

It needs to be noted that, as was the case historically, some of the motivation for educating children has changed little. Furthermore, the expectation of the system from outside observers is that it will aid in the production of effective members of the working society. The question of knowledge being possessed for its own sake has not been addressed by the system.

Therefore to conclude, the system in place at present is

> an anticipatory mirror, a perfect introduction to industrial society. The most criticised features of education today – the regimentation, lack of

> individualisation, the rigid systems of seating, grouping, grading and marking, the authoritarian role of the teacher – are precisely those that made mass public education so effective an instrument of adaptation for its place and time.
>
> (Toffler, 1970, p. 355)

Though this observation may seem a little out of date and an overly dark view of what education is in England, it depicts the atmosphere in primary schools which prevails, to some extent, even today. As we approach a time of change, we are poignantly reminded to pay heed to our prior experiences.

> Wheels have been pointlessly reinvented. Initiatives have been introduced at such a pace that they have been superseded before being properly evaluated. The lessons of past attempts to reform have not been learnt. The lessons of past research and development have been treated as irrelevant not because they are genuinely inapplicable but merely because they are more than a few months old, or maybe because they challenge the preferred political agenda. Yet knowledge, understanding and progress, in policy as in the classroom, grow by cumulation – by understanding, respecting, learning from and building upon past experience – not by relentless quest for novelty.
>
> (Alexander, 2010, p. 38)

However overall the dominant force of central control means that what goes on in the classroom needs to be accountable, and therefore can be quite mechanical, with very little scope for overall variation from school to school and class to class. The school culture is one of rigid structure and depends on the state to dictate the ways in which teachers behave. This is slowly changing with new demands to personalise and individualise learning. My data were collected at the ebb of that changing tide. This thesis is perfectly placed to be part of this change and rethink about how we teach and manage children's knowledge.

2.4 Primary Mathematics Classroom

This section examines the nature of the primary mathematics classroom. I will only focus on Key Stage 1 (pupils aged five to seven) and not look any further as it is not within the parameters of my research.

To support this examination, I will consider the following areas:

- the mathematics curriculum and content, specifically the National Curriculum, the National Numeracy Strategy and the Primary Framework for Mathematics;
- the impact of the mathematical content i.e. the National Numeracy Strategy and the Primary Framework for Mathematics on teachers' pedagogical choices.

2.4.1 Mathematics Curriculum and Content

There are many external influences on the mathematics classroom today. As considered in previous sections, the centralisation of education has had the largest impact upon the way classrooms are shaped. Major influences upon mathematics in the classroom were the issuing of the Cockcroft Report in 1982 *Mathematics Counts* (Cockcroft, 1982), the primary report issued by the Numeracy Task Force in 1998 *Numeracy Matters* (Reynolds, 1998b), and more recently the Williams Review in 2008 *Independent Review of Mathematics Teaching in Early Years Settings and Primary*

Schools (Williams, 2008) and the House of Commons Public Accounts Committee report in 2009 *Mathematics Performance in Primary Schools: Getting the Best Results* (House of Commons Public Accounts Committee, 2009).

The Cockcroft Report considered not only the nature, content and level of mathematics being taught, but also the changes that were taking place in society and how these affected the mathematics needed. The main aim of the report was to give recommendations to enable building of better mathematics teaching. However a key point to note is that the report looked at teaching and learning of mathematics with the lens of further employability of individuals, and not the learning of mathematics for its own sake. The report made a slight shift in its focus from what was in place in the classroom at the time – mathematics that was more theoretical (declarative knowledge) in principle to a more practically applicable mathematics (procedural knowledge). The report made several recommendations which resulted in major changes that are still prevalent in classrooms today.

As noted in the previous section, one of the main goals of the government of the 1980s was to restrict the power of urban LEAs which led to the overall centralisation of the curriculum. This resulted in the establishment of the National Curriculum (NC) in 1988. However, due to the lack of clarity in the NC of what was required by teachers to teach, there was demand for a further detailed curriculum document for mathematics and English. As a result, the National Numeracy Strategy (NNS) started as a project in 1996 culminating in implementation in all primary schools from September 1999 (Department for Education and Employment, 1999).

> The Numeracy Strategy provides a highly structured model for the teaching of elementary mathematics … The strategy offers schools a very detailed year-by-year curriculum, and incorporates a requirement that each primary school class should devote 45-60 minutes each morning to mathematics.
>
> (Gardiner, 2000, p. 6/6)

These (the NC and the NNS) have been the most dominant documents to influence the primary mathematics classroom to date.

> National Curriculum for England and Wales in 1989 was undoubtedly the most significant statutory intervention in primary mathematics for over a hundred years. Nevertheless, the arrival of the National Numeracy Strategy into English primary schools in 1999 will almost certainly have had a greater impact.
>
> (Askew, Millett, Brown, Rhodes & Bibby, 2001, p. 5-6)

The nature of teaching, planning, use of mathematics and language, and also the content covered and content omitted was determined through the implementation of the NC and the NNS. These documents have shaped the nature of primary mathematics teachers as well as the training of new teachers. Gardiner offers an interesting logic for the enormity of the impact upon the system of one reform that has been supported.

> England has no tradition of pedagogy and didactics. There is therefore no accepted formal way of analysing the challenges which confront the mathematics teacher, or of communicating intended modifications to existing or intending teachers. The only vehicles are therefore pragmatic ones: from textbooks, syllabuses and

> examinations, to personal example and encouragement to "reflect on one's experience" (though without a theoretical framework).

(Gardiner, 2000, p. 7/7)

Before the advent of the NC, it can be argued that there was no single national pedagogical philosophy upon which teachers could base their teaching decisions. It was this lack of pedagogical framework which led in part to the rigidity with which the NC was adopted. Hence the NC, to some extent, filled a gap in our pedagogical framework and further, in our social views and discourse of education. The ripple effect of this fundamental change was felt in every aspect of school and knowledge dissemination.

The NNS has and continues to shape, due to the absence of any other guidance during the current process of rethinking, both the attitudes of teachers and the expectations of parents. One of the key visible changes in the primary classroom has been the introduction and emphasis on mental maths and the view that mathematics is only valuable if there is an application of it in *real life*.

> The National Curriculum (and associated assessment) encourages teachers: To see school mathematics as being motivated and justified by its uses ("We believe it should be a fundamental principle that no topic should be included unless it can be developed sufficiently for it to be applied in a way which pupils can understand" (Cockcroft, 1982, p. 133). "Pupils should be given opportunities to use and apply mathematics in practical tasks [and] in real-life problems" (Department for Education, 1995, p. 11)).

(Gardiner, 2000, p. 7/7)

The balance of values between mathematics for practical applications and mathematics for its own sake is currently under question with the current coalition government considering reduction in the curriculum constraints, and through changes in Ofsted's (Office for Standards in Education, Children's Services and Skills) emphasis towards assessing learning. The nature of the teacher-pupil interaction changed considerably as a result of the philosophical change in approaches to mathematics brought upon by the NNS. It is argued by many proponents of the NNS that there was greater clarity in what teachers were to teach and, to a great extent, the methods they were to apply. There was a balance to be achieved when we consider the limitations which existed in the NNS when the learning of such a diverse subject as mathematics was too *prescriptive*. Some of the studies carried out to look at the impact of the NNS noted

> the *de-professionalisation of teachers*. The pressures which have been exerted on schools in recent years to try to *change the culture* have undermined the sense of professional autonomy which is an essential ingredient in all good teaching: teachers feel that their every move is being monitored, often using inappropriate criteria.

(Gardiner, 2000, p. 15/15)

As a result of such criticism, in 2006 the Primary Framework for Mathematics (PFM) superseded the NNS (Department for Education and Skills, 2006). Overall these are some of the factors influencing the *culture* of the current primary classroom. Though there are wider issues, these factors have a role to play in how teachers plan and implement the teaching of mathematics. There is no unanimous agreement on the value or validity of the changes in place through the NC. However, I must accept that they inform the nature of the classroom and are a backdrop to my study. It is not the scope of my research to question this backdrop, merely to work with full knowledge of its strengths and flaws.

2.4.2 Impact of Mathematical Content on Teaching

In this section, I want to look at the mathematical content from the perspective of the impact it has had on the teachers and their pedagogical choices. Looking at these factors is important as the backdrop of my thesis is the National Numeracy Strategy (NNS) and the Primary Framework for Mathematics (PFM) (collectively called strategies in this section) as they play out in the classroom. All of my data are collected in the culture of classrooms using both the NNS and the PFM. Teachers have an assortment of complex and diverse approaches to the way in which these two very similar documents are used. Despite the PFM being the latest guidance, the teachers involved in my data collection preferred the NNS as it offered detailed guidance for planning and delivery of mathematics lessons while covering the same learning objectives as the PFM. Therefore understanding the very nature and purpose of the NNS remains vital as the classrooms in which I collected my data were still depending upon the NNS as a major influence in supporting teacher planning. Furthermore, taking time to examine how these documents have shaped teacher behaviour is crucial, as it will allow me to look at the data collected within context.

The structure of both the NNS and the PFM content is in school year groups. The outline of what children should be able to do is organised in strands. However the PFM makes no attempt to indicate how teachers should teach each learning objective. Hence teachers tend to rely on the NNS and the vast departmental online resources. Furthermore there is little indication given as to the methods for measuring the level of children's ability once they can achieve the objectives. There are overall assessment criteria, but they are not as clear as the content criteria. The planning structure emphasises continuous assessment through the use of Assessing Pupils' Progress (APP).

Critics of both documents argue that the extent to which *mathematics* was considered is limited and the emphasis is more on *numeracy*. There is very limited application of terms such as mathematics or mathematical. The language applied throughout the strategies is to aim, it would seem, to move away from traditional notions of mathematics and promote a new *rebranded* form of considering numbers. The strategies view numeracy as an aspect of mathematics.

> Numeracy relates to the broader area of mathematics. Numeracy is described below as a proficiency in various skills. The National Curriculum for mathematics at each level is in part focused directly upon such skills and in part upon laying the foundation for higher levels of mathematical study which, in turn, provide further skills valuable in adult life.
>
> (Reynolds, 1998a, p. 11)

The content for both strategies is developed under this definition of numeracy:

> Numeracy at Key Stages 1 and 2 is a proficiency that involves a confidence and competence with numbers and measures. It requires an

> understanding of the number system, a repertoire of computational skills and an inclination and ability to solve number problems in a variety of contexts.
>
> (Reynolds, 1998a, p. 11)

This definition of numeracy and overall philosophy of the strategies are, and continue to be, the rooting of values, practices and culture of the primary mathematics classroom.

One of the biggest weaknesses of the strategies is the inability of the curriculum content to guide teachers in terms of assessment. This lack of clarity in assessing children has, to some extent, reduced the ways in which the strategies have been applied with teachers initially rigidly applying the requirements and measuring children in terms of levels based on the NC documentation. However through the use of APP and Assessment for Learning (AfL) models, teachers are beginning to look at other methods for assessing children, though this is an area which needs further development.

Mathematical concepts are varied in their complexity and how children understand the concepts can also be varied. This has created an ambiguous precedent within the teaching of numeracy. For example, when we look at a Year One teaching program and consider one of the objectives from the Calculating strand, it states, “Relate addition to counting on; recognise that addition can be done in any order; use practical and formal written methods” (Department for Education and Skills, 2006, p. 72).

This objective can be demonstrated by children in many different ways. For example, a child could simply show that they are able to count on as a way of achieving addition, or can also demonstrate that they know that adding can be done in any order by using the larger number as a starting point, or also that tens can be added first and then units next, and so on. The difficulty is that the teacher is not given flexibility to make any different assessments. That is to say, all that can be noted is whether the child has met the objective or not. There is no scope to consider how the child met the objective as only the achievement of the objective is recorded. This target-led assessment means that knowledge is treated in a very linear manner and learners move along this linear continuum, and hence pedagogical choices are made to fit this mould. The result of this is that the progress of each child's knowledge can be placed on a limited trajectory with one target after another to be met and children moved on accordingly. Among others, this has been one of the key criticisms of the strategies.

The results of the 2007 assessment of Trends in International Mathematics and Science Study (TIMSS) showed that England did not fare well taking seventh place after countries such as Hong Kong, Japan, Singapore and Taiwan (Sturman et al., 2008). This, among other reasons, has prompted a rethink within the current government to consider other methodologies for further raising standards of mathematics. However as this has not been made public knowledge, one can only guess what shape these new strategies may take. This current rethinking and possible investment is a result of the realisation that the strategies have not had the long term effects it was hoped that they would in raising standards in mathematics.

> Since 2000, results at both Key Stages 1 (age seven) and Key Stage 2 (age 11) have levelled off. In 2008, 79% of pupils attained the expected standard or above in mathematics at Key Stage 2 in national tests. While this was the highest ever recorded result, and 2% higher than the previous year, it fell well short of the target of 85% that the Department set to achieve by 2006. 21% of pupils started secondary school without a secure foundation in mathematics. In 2008, 30,000 (5% of 11-year olds) left primary school with mathematical skills that were, at best, at the level of those expected of a seven year old.
>
> (House of Commons Public Accounts Committee, 2009, p. 7)

For teachers, the above findings imply that though the strategies were put into place to raise standards in mathematics, there are still shortfalls which they need to address (House of Commons Public Accounts Committee, 2009). This could be due to the lack of pedagogical choice offered through the constraints of these strategies and what needs to occur is allowing teachers to make choices for addressing the needs of the children they are teaching. Teachers feel under pressure to continuously improve in all areas. The NC has *entitlement* as its core root. That is to say:

> Entitlement to equality of access to an appropriate curriculum
>
> Entitlement to equality of teaching experienced
>
> Entitlement to equality of learning outcome
>
> (Askew et al., 2001, p. 6)

Askew et al. (2001) argue that it is unreasonable to expect this notion of entitlement to be the same for all children, and causes "tension between teaching to meet the needs of the individual and teaching to meet the needs of the collective" (p. 7).

It is this tension that is influencing the role of the teacher, the pedagogical choices that they make and the atmosphere of the classroom with mixed external messages, leaving teachers to make judgments and interpretations as individuals and as schools (Askew et al., 2001).

To conclude this section, the nature of mathematical content and the overall implementation of the strategies have caused some difficulties with teachers and offer limited ideas for individualised teaching. But overall, the fundamental issue in the classroom is the way in which teachers have been encouraged to consider equity and entitlement. This has led to teachers viewing children as groups rather than as individuals. The demand for improvement of outcomes and need for equity has put pressure upon teachers to provide the same educational provision for all children. This interrelated conflict is between the knowledge that individualised planning is the most supportive approach to extend children's learning and the dilemma of equity needs to be supported by the understanding of prior knowledge.

2.5 Prior Knowledge

There are so many points from which I could start to consider the following questions. How do I define prior knowledge? What do these words mean? Are there different meanings linked to different contexts? Are there different interpretations of these words in the literature?

In this section, I will address these and other questions in order to gain a picture of the current views in the literature of prior knowledge. I will establish a definition, according to the literature available, of prior knowledge which can then be the springboard for development and the basis of this thesis. At first I consider the literature available in all the contexts, and not just primary school mathematics, as this will enable me to derive a precise lexical definition of the term prior knowledge. The ultimate goal at the end of this thesis is to propose a structure of prior knowledge based on the outcome of this study which may be applied in practice.

The section is organised in the following way:

- considering the complex ideas linked to terminology and semantics of the words prior knowledge, i.e. prior and knowledge, and the many different definitions found in the literature for prior knowledge;
- looking at how prior knowledge can be defined using the literature already available as a point of reference;
- concluding with an unambiguous working definition of prior knowledge based on literature which will be developed throughout this thesis. Also a definition that can be understood by others and form a common vocabulary between the researcher and the reader.

2.5.1 Knowledge

Defining knowledge is pivotal to this thesis. In this section I will look at knowledge from the following perspectives:

- philosophical and theoretical (epistemological);
- cultural and societal;
- educational (school knowledge) views on children;
- mathematical;
- individual.

It is of value to look at each perspective individually and distil the key points which are applicable to my research objective. The definition formulated here will be the first step in defining prior knowledge.

2.5.1.1 Philosophical and Theoretical Perspective

Knowledge is an ambiguous term which means different things depending upon the context. Rand (1979) gives a sound starting point to the philosophical debate when she writes "Knowledge is … a mental grasp of a fact(s) of reality, reached either by perceptual observation or by a process of reason based on perceptual observation" (p. 45).

Therefore knowledge, it can be argued, is an abstract concept which allows us to contextualise and, to some extent, verbalise what we see, do, observe, and interact with as humans. Furthermore, knowledge is increased by what we gain from those interactions. Rand's definition is in no way an attempt to simplify the wider and more detailed definitions offered by epistemological theoreticians, but more of a way to focus upon the issues. Considering Rand's statement in detail allows me to focus upon what knowledge looks like, how it is acquired, and provides a starting point for the development of a working definition. Knowledge is the by-product of synthesising individuals' observations and interactions. David Hume (an *empiricist*) offers an overarching theory of knowledge which forms one end of the spectrum by which Rand's above statement is supported. Sense perceptions which are broken into two notions of *impressions* and *ideas* are the ways in which we expand our understanding and knowledge (Hume 2010). Therefore to follow Hume's argument – we cannot know anything which we have not had prior impression of in sensory experience. That is to say, our minds are void of knowledge and only interactions with our sense allows for our knowledge to grow.

However, Immanuel Kant's theory of knowledge opposes this view of the human mind being void of any knowledge prior to interaction with the world and forms the other end of the knowledge spectrum (Kant 2010). Kant proposes that the mind has twelve pure concepts (or categories) which enable us to organise our vast numbers of sense observations. These concepts are *unity, plurality, totality, affirmation, negation, limitation, substance-accidents, cause-effect, causal reciprocity, possibility, actuality* and *necessity*. One of the key arguments made by Kant is that "the mind is not passive, as Hume and other empiricists also claim" (Lavine, 1984, p. 194).

The mind is more active in the process of acquiring and sorting knowledge. Knowledge gained is given some structure and meaning through the twelve concepts and the process of sorting the incoming knowledge. Furthermore Kant states that the concepts remain the same and universally form the structure of any mind (Lavine, 1984, p. 194). Thus the concepts make sensory observation a more interactive process rather than passive as thought by the empiricist school of thought. Kant's twelve categories presuppose all experiences and remain unchanged through any experience. Lastly Kant proposes that these twelve concepts are a necessary tool for the mind as they enable the processing of experiences to take place without which there would be no knowledge which could be of further value.

There are further perspectives which believe that knowledge has its source in rational truth and knowledge is derived from the use of senses and critical analyses of those thoughts. Not just mere organisation into categories or filtered through the categories as Kant stated, but going one stage further, and using what has been before to assess and develop new knowledge. This type of knowledge requires a deeper sense of consciousness of all things and is built up over a series of interactions. Therefore knowledge is always changing and fluid.

Whichever definition is prescribed, be it Hume's which states knowledge is limited to the moment and does not interact with the mind to a great extent, or Kant's views which consider the brain as a filter of knowledge which is flexible, it is most striking that these perspectives of knowledge are not simply facts and figures which must be learnt. Hume's and Kant's definitions give scope to bring in all aspects of life as knowledge.

2.5.1.2 Cultural and Societal Perspective

The culture in which we exist and attain knowledge has a huge impact upon the nature of that knowledge. It is this relationship between the external (the culture) and internal (the knowledge that we are able to acquire) factors which shape our thinking. In this section, I want to focus not on what types of cultural knowledge there are, but more so on what the culture we are operating in has to offer in the way of understanding knowledge. Furthermore, I want to examine what knowledge is valued within our culture. It is essential that I consider this with society and culture being linked and influencing one another.

> Culture should be regarded as the set of distinctive spiritual, material, intellectual and emotional features of society or a social group, and that it encompasses, in addition to art and literature, lifestyles, ways of living together, value systems, traditions and beliefs.
>
> (UNESCO, 2002, p. 9)

This is a concise but vital description of culture as it allows me to examine the vastness of knowledge. In order to understand knowledge in this culture, there needs to be a brief examination of English culture, the place it gives to knowledge, and how it uses and expands knowledge. English culture is wide and varied and has been and continues to be influenced by many other cultures. Though a part of Europe, England is vastly different in its nature and responses to the development and value it places on knowledge. Schools are the pivotal way in which knowledge is disseminated to the nation, and thus affect national identity. Merttens and Head (2000), in Coulby's book's preface, ask the key question "To what extent is what we know we 'know' bound in with what we believe we are, in terms of our ethnic, national, religious and cultural identity?" (p. ix).

As teachers (one of the distributors of knowledge), if what we are and who we are as individuals is linked strongly to what we know, then it must be crucial to examine what is it that we define as key knowledge within our culture. Within England, the structure of knowledge and the selection of what is considered to be true knowledge is visible in the National Curriculum (NC) and other institutional structures such as colleges (and their courses) and universities (and their degree programmes).

> All curricular systems are a selection from the vastness of human knowledge. What humanity knows and what it thinks it knows has been amassed, revised and refined across many centuries.
>
> (Coulby, 2000, p. 12)

Therefore a reflection of accepted knowledge has been selected within our system. The NC for all state primary schools focuses on the following areas of knowledge – mathematics, science, English, art and design, geography, history, physical education, information and communication technology, religious education, music, design and technology, and personal social health and citizenship education.

England has been influenced in the selection of this path towards curriculum-based knowledge by societal attitudes towards the systems in place for the acquisition of knowledge. According to Apple (1979), institutions such as schools and colleges are there for *cultural reproduction*. He goes on to further argue that "The dominant fact of our current social order is the central role that capital, wealth, and economic power play in it" (p. 69).

Furthermore, knowledge is "cultural capital" (Apple, 1979, p. 2). By defining the knowledge that everyone is expected to have, schools confer special status on that knowledge which is important to dominate interests. This is the key point in defining cultural knowledge. Though there are vast areas in human knowledge and understanding within this culture, there are only some small aspects that are valued and therefore expanded. However the wider question of knowledge dissemination through the Web is one which needs to be considered as it has almost eliminated the societal selection of knowledge for dissemination, as it allows the freedom to any individual to share and gain any knowledge. Though this area is fascinating, it requires more investigation than the scope of this thesis.

A good barometer for the areas of knowledge valued within the UK are the statistics for applications into different university courses, as these indicate what is popular within the culture and will go some way to defining what we within the UK value as knowledge. In 2011, there were 122,787 applicants for a law course in contrast to the 13 applicants for Classical Greek studies (UCAS, 2011). Also there were 97,055 applicants for psychology and only 13 for Portuguese studies. From these figures and the shape of the current curriculum, it seems that, as a society, we place higher value on studying areas that have a practical application and lead to a well-defined career path. Society is choosing to acquire knowledge in areas in which the knowledge that it gains has practical and financial value. The number of applicants to non-applied courses is far lower (e.g.

physics – 24,046, zoology – 9,991). We seem not to value knowledge for knowledge's sake, but more for the output that can be achieved. This is supported by the UCAS (The Universities and Colleges Admissions Service) figures for 2011.

This notion of knowledge is in contradiction to the previous section (Section 2.5.1.1) which takes the theoretical view of knowledge being all aspects of human life and all its variations. The cultural response is to limit the knowledge which is explored and to place value on only a very limited area of human subject knowledge and not the wider view of knowledge.

In conclusion, English society and culture does put a high value on some aspects of knowledge, and this importance is perpetuated through institutions and other such structures. Therefore when considering knowledge from this perspective, we need to bear in mind the value placed on each area as these are what the culture regards as knowledge, which in the case of England is reflected in the content of the various curricula in place. So for this thesis, I will consider subject knowledge in terms of the NC as this is what affects the age range of my research group. This is in no way denying the vastness of knowledge and what I have left out, it is simply narrowing the parameters for the search in understanding prior knowledge.

2.5.1.3 Educational Perspective

The previous section (Section 2.5.1.2) illustrates that what has been chosen for teaching within school is a reflection of societal and cultural views of knowledge. Therefore I need to examine the curriculum and how knowledge is structured within the formal educational setting of a school.

The National Curriculum (NC) influences what knowledge is important and at what stage of a child's development should this knowledge be taught and assessed. Within our society, we deal with knowledge in a very fragmented and hierarchical manner, and this is no different within the structures of the NC. The NC views knowledge as being only subject-specific knowledge and not the wider view of knowledge. Hence any references to knowledge in the context of the NC refer only to subject knowledge. Furthermore, there is guidance on the progress children should be making and the levels they should have reached within the process of knowledge acquisition.

The curriculum is developed further up the school hierarchy with deeper content in the same areas. Irrespective of whether there is agreement within the educational institution on these areas of knowledge or even the structure with which it is implemented, it is a mandatory requirement of the state.

> In England and Wales, a centralised National Curriculum has been rigorously enforced, specifying in minute detail what is to be covered in primary and secondary schools.
>
> (Coulby, 2000, p. 17)

With the NC being key to the educational perspective, it would seem of little benefit to move away from it when considering the knowledge which is being assessed within children, irrespective of whether one agrees with the NC. Also though the debate of what other knowledge would be better covered in school is an interesting one, it serves no purpose for this thesis. However in the next section (Section 2.5.1.4) I am going to consider what is being covered within the current framework in mathematics as this has an impact upon prior knowledge in the classroom.

The final question remains – if the NC is a small aspect of all human knowledge, what else is there that is not considered? Furthermore, what implication does this have on our understanding of the individual and the knowledge that is present in these settings? Plato offers a possible method for looking at what knowledge is and how different types of knowledge are linked to each other (Lavine, 1984). In his divided line model (Figure 2.1), there is a distinction between the visible or sensory knowledge (object) and the invisible or theoretical knowledge (thought). Though there is no implication of linear progression between each area of understanding, there are a number of similarities between Plato's (Lavine, 1984) views about the structure of the world and Piaget's (Piaget, 1954) view of understanding and knowledge. For example, Plato believes that awareness of images is the lowest form of knowledge (Lavine, 1984); Piaget (1954), in his theory of cognitive development, indicates that the sensory motor stage, which is the first stage of an individual's development, constitutes sensing images and the physical environment as the start of knowledge development. Both Plato's (Lavine, 1984) and Piaget's (Piaget, 1954) views support the ability to abstract and analyse thought as being a higher level of knowledge.

	Thought	Object	
Knowledge	Reason Dialectic	Higher Forms	Intelligible World
	Understanding (Science, Mathematics)	Forms of Science and Mathematics	
Opinion	Belief (Perceptions)	Things, Objects	Visible World
	Conjecture (Imagining)	Shadows, Images, Reflections	

Figure 2.1 Plato's Divided Line Model (Lavine, 1984, p. 32)

This is paralleled in the way in which knowledge is ordered and structured within the NC. Overall the dominant theory within culture and society today is that knowledge in its nature has stages and is hierarchical. Also through the systems in place for acquiring knowledge, there is the overarching thought that the access to this knowledge can only take place in a predetermined order which, according to Piaget (1954), is linked with age and has no bearing on ability or experience. Therefore the change from the basic knowledge e.g. that 1+1 is indeed 2, to understanding the reasons why 1+1 is 2 has many stages which are influenced by many factors and must be passed through and, it seems, cannot be omitted.

To conclude, the educational view of knowledge is that knowledge is ordered in interconnected stages. Furthermore, as reflected in the NC, each facet of knowledge is linked and dependent on a previous aspect of knowledge, and this is built up over time in the structure which is set up by the curriculum. Knowledge has a defined path which can be measured and valued. There is a start and end to knowledge within education.

2.5.1.4 Mathematical Perspective

In this section, I have taken care not to use the title mathematical curriculum as I do not want to constrain the debate to the mathematics which exists within the current narrowly-defined curriculum. Furthermore, the debate needs to be much broader in order to allow the development of a structure for prior knowledge. There are many ways to approach the analysis of mathematical knowledge. The parameters are quite broad. However, in order to make the points relevant, I wish to consider mathematical knowledge within young children and look at what this means in terms of this thesis. The key question I want to address in this section is: what is meant by mathematics? What are the key ideas within mathematics which form the basis of mathematical knowledge? Clemson and Clemson (1994) propose the following areas: counting and ordering, reasoning and proof, the triangle, zero and place value, statistics, standard measure, and calculators and computers as being the key areas of mathematical knowledge that must be considered.

The Cockcroft Report looks at similar areas of knowledge which should be taught in schools. It proposes that measurement, shape and space, graphical work, logical thinking, number and computation (e.g. place value) are all key areas of mathematical knowledge which should be prominent in the primary classroom (Cockcroft, 1982). These are reflected in the current curriculum.

However, there is more to mathematical knowledge in these areas than what is being taught in schools. Asimov (1991), in the foreword to *A History of Mathematics*, writes, "Mathematics is a unique aspect of human thought" (p. vii). Therefore, what is mathematical knowledge?

> Virtually every philosopher who has discussed mathematics has claimed that our knowledge of mathematical truths is different in kind from our knowledge of the propositions of the natural sciences. This almost unanimous judgment reflects two obvious features of mathematics. For the ordinary person, as for the philosopher, mathematics is a shining example of human knowledge, a subject which can be used as a standard against which claims to knowledge in other areas can be measured.
>
> (Kitcher, 1984, p. 3)

The common understanding that mathematical knowledge is a priori – "mathematical apriorism" (Kitcher, 1984, p. 3) – is linked to the theories which are debated in Section 2.5.1.1. However, the epistemological view is debated by many and the influence upon mathematics in the past two decades has changed the nature of the current view of mathematical knowledge.

> A growing number of scholars question the universality, absoluteness and perfectibility of mathematics and mathematical knowledge.
>
> (Ernest, 1999, p. 67-68)

> Although mathematical apriorism has been – and continues to be – an extremely popular doctrine, it has not gone completely unquestioned.
>
> (Kitcher, 1984, p. 4)

The debate, it seems, lies between the historical philosophical concept of mathematical knowledge and the more recent context-influenced mathematical knowledge “mathematical apriorism — mathematical empiricism” (Kitcher, 1984, p. 4). Is it possible to have mathematical knowledge which exists without expression and evaluation of this knowledge? Kitcher (1984) rejects the view that mathematical knowledge is tacit, and questions the traditional view that time does not change the nature of mathematical knowledge which is consistent through time. It would seem therefore that there is only one perspective – that mathematical knowledge is an evolving process which is influenced by historical events and also by the current context. This is in contrast to most philosophers of mathematics.

> They have supposed that, independently of the historical process through which mathematics has been elaborated, the individual mathematician of the present day can reconstruct the body of knowledge bequeathed to us by our predecessors, achieving systematic knowledge which does not reflect the patterns of inference instantiated in the painful historical process.
>
> (Kitcher, 1984, p. 5)

Mathematical knowledge is changing due to the influence of “social context and professional communities of mathematicians” (Ernest, 1999, p. 68).

> Their social organisation and structure is central to the mechanisms of mathematical knowledge generation and justification, and they are the repositories and sites of application and transmission of tacit and implicit knowledge.
>
> (Ernest, 1999, p. 68)

So it can be concluded that mathematical knowledge is not simply a set of truths, but a combination of truths and the interaction that humans have with these truths which create new understanding.

> The argument for including tacit 'know how' as well as propositional knowledge as part of mathematical knowledge is that it takes human understanding, activity and experience to make or justify mathematics.
>
> (Ernest, 1999, p. 69)

Therefore mathematical knowledge is, in terms of this, not only the philosophical perspective of tacit knowledge, but also the ability to apply techniques to give solutions.

2.5.1.5 Individual Perspective

This section serves two aims – one, of summarising or concluding all the previous sections; and the other, of looking at what all these theories and deliberations mean in terms of individual knowledge.

So far I have considered knowledge from various key perspectives, all of which have reached the core conclusion that knowledge is not merely present and stable, but evolving in its nature. Furthermore, the evolution is influenced by many factors such as:

- individual experiences through one's senses of the environment;
- individual ability to make connections and filter the experience received through the senses;
- communal influences upon knowledge construction and interpretation through the cultural and societal context;

- the expectations of cultural communities such as schools and the demands and values that they place upon knowledge;
- the natural process of historical change. Time has an impact on the way knowledge is interpreted, used and applied, therefore changing philosophical views of knowledge.

What of the individual? Knowledge is not stable, and therefore an individual's perception of knowledge is also not stable. This section has argued that knowledge and understanding of it has little to do with ability, but more so to do with the nature of that knowledge and the relevance of that knowledge in context. Furthermore, it has been argued that it is through experience that we gain in knowledge and make sense of the world. One could say that knowledge is a process of development for individuals and society. It is a way by which we mark how far we have come from our starting point. We must, however, not attempt to categorise a path which needs to be taken and leave each individual to create their own knowledge path to "mental grasp of the fact(s) of reality" (Rand, 1979, p. 45). With this understanding, I am in a position to conclude and move the discussion onto the main aspect of this thesis – prior knowledge. The foundation has been set, and a clear and distinct definition of knowledge established. Therefore in the next section, I will look at the concept of prior and how this then leads to the establishment of an understanding of prior knowledge.

2.5.2 Prior

Having considered in detail areas and issues concerning knowledge and its definition in Section 2.5.1, I am now at the stage where I can focus on defining *prior* and then how prior and knowledge meld together and develop the ideas for prior knowledge. Common definitions of the word prior allude to events in the past. Therefore any definition I consider must allow for this passing of time and the effects it has on the knowledge being gained. Furthermore something that is prior has already taken place and is part of the individual's reality as a consequence of their experience of it. Though it is not yet clear if this is conscious or subconscious, it is an act which is already completed or an experience which an individual has already passed through.

2.5.3 Prior Knowledge Research

Having defined prior (Section 2.5.2) and knowledge (Section 2.5.1), the ideas in those sections lead me to begin defining prior knowledge. Prior knowledge is a vast term with many interpretations. The literature search I carried out for this thesis revealed some interesting outcomes. When searching through the various academic literature databases, I used the terms *prior knowledge* or *prior experiential learning* or *prior learning* as a way of getting a broad base (as established in Section 2.2.2). Looking at the type of publications that they appear in, 4173 sources were located which consider these terms as part of their research. Very few of these sources give any definition or structure to what they mean by prior knowledge in terms of their research. The literature fell into ten broad categories of studies that use prior knowledge as their central tenet:

1. Accrediting applicants / students in higher education for their prior learning / knowledge, be this formal or informal learning, and various methods to be able to carry out this process formally (around 5% of the literature located).
2. Subject-specific research and what causes variation in individuals' ability to understand the subject matter with prior subject knowledge being one of the many variables considered (around 10% of the literature located).
3. Expert versus novice debate, factors which influence the process of becoming an expert, and differences between experts and novices based on many factors including prior knowledge (around 5% of the literature located).
4. Effects of prior knowledge on learning and performance, with some of them linking what students know about one area to what is being taught (around 33% of the literature located).
5. How prior knowledge is used in learning and the learning experiences it forms (around 20% of the literature located).
6. Pre-service teachers and the effect prior knowledge has on their choice of methods to teach (around 7% of the literature located).
7. Prior knowledge as a general factor in learning (around 1% of the literature located).
8. Prior knowledge as a specific part of the learning process (around 14% of the literature located).

9. Evaluation of prior knowledge as an entity on its own (around 4% of the literature located).
10. Defining prior knowledge (around 1% of the literature located).

This very simple survey illustrates that though there is wide acceptance of the key role that prior knowledge plays in learning and knowledge acquisition, there is little understanding or agreed vocabulary which defines prior knowledge in any given context. This raises many questions about the understanding we have of prior knowledge.

Using some of these areas of research as a starting point, I am going to tease out what they offer my understanding of prior knowledge. Though these areas are not directly related to the area of my research in terms of their context, they will aid in informing the understanding of my work, and hopefully they will start to shed some light on many alternative views to the understanding and the questions I am asking.

In the remainder of this section, I examine in detail only the first three categories of studies from the list above as they had allowed me to consider how prior knowledge is understood. The next five categories are related to the effect of prior knowledge on learning and therefore do not consider what is prior knowledge. The last two categories have ideas to offer which run throughout my literature review, and therefore are integrated into the examination of the first three categories.

2.5.3.1 Accreditation of Prior Learning

An area of research which has prior knowledge as a key concept for their studies considers the complex issues which need resolving when trying to accredit students for their prior knowledge or prior learning in higher education. There are many researchers who have looked at the process of accrediting students in higher education for the knowledge, skills and understanding they bring to their studies. It is interesting to consider how the assessments may take place as it will offer me a process by which I can view what their criteria are and understand what may constitute prior knowledge. Approximately 200 sources were identified, and many common themes emerge from them. Having analysed many of the sources, the similarities are striking. Therefore it is of little value to review all of the literature. It is much more valuable to assess a small key sample from the overall pool and pull out from them some fundamental principles which can then guide our understanding and develop thought. Researchers such as Dochy, Segers & Buehl (1999); Taber (2001); Ajello & Belardi (2002); O'Donnell, Dansereau & Hall (2002); Starr-Glass (2002) and Spencer (2005) are all concerned with developing tools to assess the knowledge gained by individuals outside the formal contexts of an educational setting in a variety of subject areas by asking key questions such as "how to make learning, which takes place outside the context of formal education and training institutions, more 'visible'" (Ajello & Belardi, 2002).

Interestingly all the sources in this area talk about prior learning and not prior knowledge, hence giving me my first semantic stumbling block. Prior learning is the skill and knowledge acquired from previous experience – formal or informal. There is much ambiguity in the research about what is meant by prior learning. However learning implies change, and knowledge as established in Section 2.5.1 is the process by which experiences and understanding of the world are ordered. Therefore the relationship between knowledge and learning is crucial to the understanding of prior learning. Learning is the process by which we gain knowledge, with old learning being prior knowledge. According to Harris (2000), Kolb defines learning as "Experience + reflection = learning".

Therefore the gaining of knowledge is based on experience and reflection. This simple notion helps widen the definition of prior knowledge. Surely for an individual to have any knowledge, there must be some prior learning and if learning in relation to Kolb's definition is situated in experience which has taken place in context, then all learning will eventually be prior knowledge. Therefore this, to some extent, gives me an understanding about the nature of gaining prior knowledge. The learning process is an active one, and it is this that aids in the use of prior knowledge and also helps develop our prior knowledge. Sotto (1994) explains this link between prior learning and prior knowledge; when he discusses perception and learning, he asks "But how is it possible for a drawing to be recognizable as two so very different things?" (p. 68).

It is this interplay between perception, reflection and inference that allows the development of prior knowledge, that is to say, learning which changes into knowledge (the structure upon which new learning will be based). The above groups of researchers have established that prior learning and factors which affect it are key to prior knowledge. Therefore prior learning and prior knowledge can be considered to be synonymous.

Another theme which has occurred throughout this group of researchers is the notion of what knowledge is worth. The ability to measure learning in terms of use value of certain knowledge is complex and arbitrary (Briton, Gereluk & Spencer, 1998). Briton et al. (1998) argue that it is the exchange value of knowledge that is important. That is to say, when considering prior knowledge as a factor in the ability to achieve success in any given area, one of the key features of prior knowledge has to be the ability to transfer understanding from one situation or context (in which the gaining of knowledge/learning has taken place) and apply it to another. Though I am not concerned with giving formal values for prior knowledge in my study, it is vital to know that only transferable knowledge is valuable in the context of impacting upon a child's ability to perform, and for any knowledge to grow and develop, it must be able to evolve through transfer.

Evans (2002) argues that knowledge, and more so knowledge individuals bring to new situations (prior knowledge), in its widest sense has both tacit and explicit elements. Tacit knowledge, in terms of prior knowledge, is knowledge which is classified as intuitive knowledge, but in its infancy, it was knowledge which was explicit and susceptible to change with variation in context.

It is this notion of tacit prior learning and the assessment of it that covers complex issues for the purpose of our understanding. It is not so vital to understand how to weigh or quantify prior knowledge, but how to recognise its existence within children in the context of doing mathematics and the shape it has taken.

The final theme that Spencer (2005); Evans (2002); Harris (2000) and many others have identified is the key area for understanding prior knowledge acquisition as reflected experiences in context. The constructivist school of learning considers experience as a key feature of prior knowledge.

> Learning does not originate “in the head” nor is it a product of individual meaning-making. The learner acts within the environment rather than on it.
>
> (Harris, 2000)

Therefore I argue that prior knowledge is knowledge which has been acquired through interaction with many different settings and is contextually situated. To summarise, the following have been the key concepts so far:

The relationship between learning and knowledge is intertwined in such a way that it is difficult to differentiate what is learning and when this has turned into knowledge. Furthermore debating the difference between prior learning and prior knowledge is semantic as both have the same characteristics. If an individual has learnt something, it is a fair assumption that they have knowledge of the said something.

The value of any particular type of knowledge has also become established. It has been established that all prior knowledge has equal value. However usefulness in or transferability to any given context is key to prior knowledge. Therefore when concerned with prior knowledge in mathematics, it is crucial that all prior knowledge is considered as useful as long as it is transferable and useful to children in carrying out mathematical tasks.

The final outcome is the essential factor of context. All knowledge is gained in a context and is shaped by the context in which it was first acquired. Therefore when considering prior knowledge, what will be visible is the whole knowledge base of an individual in a given context, and what will determine its impact on individual's learning is the ability for each facet of knowledge, no matter where it was gained, to be transferred into new situations and aid in further knowledge acquisition. That is to say, an individual will bring to bear all their prior knowledge in any given situation and only the facets that are useful will be used to understand and gain new knowledge.

2.5.3.2 Subject-specific Research

Another area of research into prior knowledge is subject-specific research i.e. research which considers what causes variations in student's ability to understand particular subject matter, with many studies focusing on prior knowledge as one of the factors contributing to this variation. Hazel, Prosser & Trigwell (2002) consider methods by which meaningful learning can occur. Furthermore they consider work by Ausubel and Novak and give me the starting point for considering this group of research.

> In addition to *what* students know and learn, *how* they learn has proved crucial in contributing to our understanding of the pathway to high quality learning outcomes. ... Prior knowledge had both a direct and an indirect impact on post knowledge and at this level there were differences across contexts. The limitations of this research were that it included learning strategies but not learning intentions which are considered to be a part of a learning approach, and that propositional but not experiential knowledge was tapped.
>
> (Hazel et al., 2002, p. 738-739)

The question which needs to be considered is – why does prior knowledge have such a powerful influence upon students' understanding of any subject? What does prior knowledge provide to the process of developing new knowledge? These are some of the questions addressed by this area of research. I examine how this area of research approaches the concept of prior knowledge. What do they mean by prior knowledge? Before considering these key questions, I took a step back and looked at two main researchers in this area – Ausubel and Novak – as they seemed to offer the seeds from which much thinking in this area has developed. It must be noted that much of the debate is subject-specific to science and the learning of abstract concepts within science. Ausubel and Novak express views which oppose the dominant Piagetian perspective on learning.

> The past decade has witnessed a controversy between the Ausubelian and Piagetian science educators regarding the relative importance of prior knowledge and formal reasoning ability in students' understanding of abstract concepts and hence for their achievement of these concepts. Joseph Novak, one of the strongest advocates of Ausubel's postulates, claims that children who lack formal thought may acquire

> some abstract concepts so long as they possess the relevant background knowledge.
>
> (Zeitoun, 1989, p. 227)

The central tenet of Ausubel's theory is that knowledge is organised hierarchically. New knowledge is linked, anchored, attached to existing knowledge and is meaningful. Ausubel's views do not agree with rote or repetitive learning, or even discovery learning (Ausubel, Novak & Hanesian, 1978). The relationship between prior knowledge and learning in Ausubel's view is that "prior knowledge influences the process whereby this learning occurs" (West & Fensham, 1974, p. 62).

And by this learning, it implies further learning. As with many other researchers, Ausubel's view of prior knowledge is that it plays an essential role in any *meaningful* learning. The other factor to take from his research is this view of meaningful learning. Ausubel defines different types of learning.

> Ausubel distinguishes between 'rote' and 'meaningful' learning and postulates that meaningful learning occurs when the learner's appropriate existing knowledge interacts with the new learning. Rote learning of the new knowledge occurs when no such interaction takes place. The distinction is not simply a dichotomy. Rote learning is the lower end of the meaningful learning continuum. Depending on the nature of the learner's existing knowledge and how it interacts with the new knowledge so there will be varying degrees of meaningful learning. Ausubel calls those aspects of existing knowledge that can provide these interactions of meaningful learning, 'subsumers'.
>
> (West & Fensham, 1974, p. 63)

This notion of subsumers is key to the development of learning, and is an element of an individual's cognitive structure. The difference between a competent student and a poor student in terms of Ausubel's theory is the degree and depth of prior knowledge.

> Meaningfulness is best judged by the number of associations possible in a given piece of information – the richer the associations, the quicker the learning and the slower the forgetting.
>
> (Brightman, 1982, p. 217)

Therefore it would seem that the thoughts offered by Ausubel are crucial to the development of this idea of prior knowledge being a pre-requisite for the development of new learning.

> A subsumer is any concept, principle or generalising idea that the learner already knows.
>
> (West & Fensham, 1974, p. 63)

Therefore Ausubel offers to the definition of prior knowledge that it is any knowledge "that can provide association or anchorage for various components of new knowledge" (West & Fensham, 1974, p. 63).

This in many ways links back to the Piagetian idea of construction of knowledge. Both Ausubel and Piaget view prior knowledge and its use as an active process in learning. For Ausubel, prior knowledge not only has a role to play in learning but can be changed in its behaviour, and the view that prior knowledge acts as *subsumer* is key to new learning.

Novak further explores this notion of the role of prior knowledge as subsumers in the efficiency of learning. He takes ideas presented by

Ausubel and, still in the area of science education, investigates further this idea of how prior knowledge is constructed and influences the process of new learning. Novak developed the ideas of concept mapping which linked directly to Ausubel's ideas of all knowledge needing a *hook* upon which to hang new concepts. When looking at Novak's work, this idea of meaningful learning occurs in his thinking as well and links to the need to have prior knowledge which is *relevant* to what is being learnt.

> Concept maps are graphical tools for organising and representing relationships between concepts indicated by a connecting line linking two concepts.
>
> (Novak & Canas, 2007, p. 29)

The notion of concept maps links with the Ausubel theory of *cognitive structures*. It is this framework of complex links which enables individuals to learn further. Both Ausubel and Novak have looked at how new knowledge is developed and have added the value of prior knowledge in this process, but only Novak has, to some extent, proposed a plan of prior knowledge and how this is structured in any individual. However he still falls short of a definition of prior knowledge. Though he touches on how this prior knowledge is formed through the theories of child development, he has not looked at the factors which influence the structure of this map which in essence is a map of prior knowledge. In his paper with Canas (2007), there is some inspection of the psychological basis of concept maps which gives me some idea of how they are formulated and some clue about the factors which cause the variations in individuals. These are: the concepts acquired between birth and three; the discovery learning process; and the use of language after three to create new concepts and understanding.

The chain reaction between these factors is clear e.g. if a child has not gained a breadth of experience in the discovery learning process stage, then it will limit the child's ability to use language to ask questions to aid discovery of new more complex concepts. There again Ausubel's notion of meaningful learning is key as it is this present learning which will open the paths for future learning, and this requires three conditions:

> 1. The material to be learned must be conceptually clear and presented with language and examples relatable to the learner's prior knowledge
>
> 2. The learner must possess relevant prior knowledge
>
> 3. The *learner must choose* to learn meaningfully
>
> (Novak & Canas, 2007, p. 30)

So how does this inform my definition of prior knowledge? It presents me with the start of a structure for prior knowledge based on these studies and the key characteristics of prior knowledge. Ausubel and Novak, through their studies in science education, have started to offer a structure for prior knowledge and the causes for variation in this structure within individuals. This helps me to understand that prior knowledge will not be formulated or look the same across individuals. One thing I must contend with in my research is for the vast variety in the structure of prior knowledge. Also that present knowledge is future prior knowledge and this can be influenced in the ways it is acquired. This leaves education with the potential for great achievements and changes in future development of understanding.

2.5.3.3 Novice vs. Expert

There are many researchers who have looked at the area of novices versus experts (Chi, Glaser & Farr, 1988; Schmidt et al., 1989; Schneider, Körkel & Weinert, 1989; Shrager & Mayer, 1989; Haenggi & Perfetti, 1992; Kaplan & Murphy, 2000). This links to my initial reason and curiosity for considering this research – understanding individual differences. They have all used various contexts to assess what makes an expert and a novice, and examined why an expert is more competent than a novice. This understanding and the ideas it explores has input to offer to my research. What does the development process of an expert do to prior knowledge and how is it influenced by prior knowledge? The deviation from the norm that experts display raises the question of how and what are the factors which have influenced their development into experts. More importantly, what is the role of prior knowledge? Chi et al. (1988), in their review of experts and their characteristics, give me a historical perspective about the development in understanding of experts and novices.

They point to research carried out in the area of artificial intelligence and how this has enhanced understanding of what constitutes as an expert, and the factors that contribute to the creation of an expert. The outcome of all this research is a move away from *power-based* strategy which performs vast searches in order to achieve tasks efficiently to knowledge-based systems which are concentrated on the knowledge that underlies human expertise (Chi et al., 1988).

Knowledge-based systems are developed in domain-specific areas based on emulation of the knowledge which the expert possesses. The need to fill the gaps in knowledge in order to build systems has led to a vast amount of research into what develops expertise and the nature of experts. Chi et al. (1988) give six characteristics of an expert:

- experts excel mainly in their own domains;
- experts perceive large meaningful patterns in their domain (have a greater number of connections in their knowledge);
- experts are fast, they are faster than novices at performing the skills of their domain, and they quickly solve problems with little error;
- experts have superior short-term and long-term memory;
- experts see and represent a problem in their domain at deeper (more principled) level than novices; novices tend to represent a problem at a superficial level;
- experts spend a great deal of time analysing a problem qualitatively.

It is the *domain knowledge* that allows the expert to be so. From the perspective of prior knowledge, the process of developing expertise allows for crossover of knowledge and interlinking of information. To summarise therefore, an expert has not only spent a vast amount of time building knowledge in a particular area, s/he also has the ability to apply that knowledge in a wide variety of ways. Furthermore, an expert is able to access the knowledge in many unrelated ways in order to solve different problems in a given area. It is this crossover that Chi et al.'s (1988) research emphasises in knowledge that creates an expert. That is to say, the greater the interaction of experience in a given area, the greater the chances of being an expert. Anderson (1995) offers three stages for the acquisition of skills – *cognitive*, *associative* and *autonomous* stages.

Chi et al. (1988) and Anderson (1995) offer key elements in understanding the role and effect of prior knowledge in experts and what makes an expert. An expert has ordered knowledge in many different ways to allow for not only quick retrieval, but also to make many links between different relationships. Anderson (1995) goes on to consider the effects of practice on experts' movement from one stage to the next. Practice allows the formulation of connections and aids the learner to move from the cognitive to the associative stage. This is the stage where prior knowledge has its main effect and change.

> The connections among the various elements required for successful performance are strengthened.
>
> (Anderson, 1995, p. 274)

This is the case in mathematics. The ability to connect with great speed differs with areas of understanding. Bugelski (1962) states that time spent studying content, sometimes referred to as total time on task by classroom researchers, is a good predictor of learning.

The question is why – what is it about repetition and practice that develops a novice into an expert? The key difference, it would seem, between the novice and the expert is the wide variety of experiences that an individual has been exposed to in a related area. It is this constant and varied interaction that individuals have between what they have experienced and what they have learnt. Effective practice is the key to expertise development. Practice influences prior knowledge in many ways. Hayes (1985) found that no one reaches genius levels of performance without at least ten years of practice.

When looking at the transition from one area of skill to the next, the key role that practice plays in shaping prior knowledge is highlighted. Practice or rehearsal is the key to moving from one stage to the next.

To summarise therefore, the major differences between a novice's and an expert's prior knowledge are:

- novice's structure of knowledge is not ordered for quick retrieval;
- expert's structure of knowledge is not only ordered for quick retrieval, but also has many overlaps and interconnections;
- the practice carried out by an expert allows this structuring of knowledge and fine tuning of how to approach a problem based on experience and to find the shortest worked-out route to a solution;
- experts are more flexible in their use of knowledge and can find usefulness in many contexts as they are using their knowledge in a given area in many ways;
- the ability to abstract is greater in an expert due to practice.

Overall, an expert's prior knowledge is shaped differently in relation to a given domain.

2.5.4 Summary

This leaves me with the difficult task of conceptualising what I mean by *prior knowledge*, especially as this has not been defined in its entirety in any literature. From the literature that I have just reviewed, I can establish a fragmented framework for prior knowledge. Knowledge, and to some extent prior knowledge, is the whole of a person's actual knowledge that is:

- available before a certain learning task (Hume, 2010);
- transferable (Briton, Gereluk & Spencer, 1998);
- structured in schemata (Clemson & Clemson, 1994);
- declarative and procedural (Anderson, 1995);
- partly explicit and partly tacit i.e. internalised and intuitive (Ernest, 1999; Evans, 2002);
- dynamic in nature i.e. it is not a quantity but an ever-changing pattern of connections made through different experiences (Kant, 2010);
- stored in their knowledge base (Ajello & Belardi, 2002);
- contextually situated (Harris, 2000);
- subject-knowledge forming a subset of prior knowledge (Zeitoun, 1989).

The above understanding is synthesised from the reviewed literature and highlights the gap within this body of literature, that of a clear and definitive definition of prior knowledge. If I take the key points discussed so far in order to assist with developing my own definition, I come up with the following:

> *Prior knowledge is the experiential framework which has brought an individual to the level of knowledge at which they are at present.*

Exploring this definition, it is what has gone by and where the individual is at in their knowledge and understanding as a consequence of their life journey to date. It is, in effect, a roadmap for each individual which shows the cause and effect relationship which an individual has with their knowledge.

2.6 Why Look at Prior Knowledge?

At this juncture in the research, I feel that it is important to question the value of prior knowledge. Why consider prior knowledge as an area that requires any investigation? Does it have anything to offer to education? In order to do this, an examination of the effects that prior knowledge has on learning and learning mathematics will offer me a valuable insight into why it is an area worth researching. Therefore this section will consider the following questions:

- What is the effect of prior knowledge on children's learning?
- What is the effect of prior knowledge on children's learning of mathematics?

The information gathered from reviewing literature to address the questions above should allow me to give justification to the value of considering prior knowledge in the process of educating children.

2.6.1 Effects of Prior Knowledge on Learning

Within education, prior knowledge is recognised as a key element in the process of new learning.

> The most important single factor influencing learning is what the learner already knows.
>
> (Ausubel et al., 1978, p. iv)

Bartlett's (1932) proposal of schema theory recognised the contribution of prior knowledge in the construction of new learning. Dochy et al.'s (1999, p. 145) review highlights many researchers who have considered the value of prior knowledge and its effects on learning (Alexander et al., 1994; Bjorklund, 1985; Chi & Ceci, 1987; Chi et al., 1988; Dochy, 1992; Glaser, 1984; Glaser, Lesgold & Lajoie, 1987; Pressley & McCormick, 1995; Schneider & Pressley, 1989). Indeed much of the research I found concluded that prior knowledge has an effect on learning and performance. This illustrates the importance that the education process puts upon prior knowledge.

> A well-organised and coherent knowledge base initiates inference, conceptualization and the acquisition of principled understanding.
>
> (Glaser & De Corte, 1992, p. 1)

Many researchers look at the impact of prior knowledge on performance. Dochy summarises Lodewijks' work as:

> This involves a tripartite assumption i.e.
>
> prior knowledge is a very important variable in educational psychology;
>
> the degree (content and degree of organization) of prior knowledge of a student must be familiar or measurable for the achievement of optimal learning;
>
> a learning situation is optimal to the degree to which it is in accord to the level of prior knowledge.
>
> (Dochy, 1992, p. 23)

While researchers and teachers are unanimous in agreeing that prior knowledge has an effect on learning, what type of effect does prior knowledge have on this process? In the remainder of this section, I examine whether the effects are positive or negative. Though there is data available on the different effects of prior knowledge on the learning process, for my thesis it is of greater value to consider whether these effects are positive or negative. I am not going to consider *how does prior knowledge affect learning and performance* as this adds little to establishing my goal in this thesis of understanding the structure of prior knowledge.

Several studies demonstrate that prior knowledge is potentially an important variable contributing to the explanation of post-test variance (Bloom, 1976; Dochy, 1992; Tobias, 1994). Bloom (1976) offers quantitative data which claims correlation of 0.50 to 0.90 between pre-test and post-test results. Dochy (1992) found that up to 42% of test variance can be attributed to prior knowledge. There are several different figures available on the variations of performance due to prior knowledge as a variable in the testing process e.g. Tobias (1994) 30-60%. When considering these results, Dochy (1992) points out that one must consider other factors such as the environment within which the data are collected. However even with a reduction in percentage of variation due to other factors, he argues

> The results of these investigations reveal that prior knowledge generally explains a considerable amount of the variance in performance.
>
> (Dochy et al., 1999, p. 155)

Resnick (1981) reviews various papers in her research in order to understand how to instruct better, looking at areas of reading, mathematics, science and problem solving. She notes that variation within reading from many researchers such as Voss "have shown that individuals with high prior knowledge of a topic remember more propositions from a text on that topic" (p. 669).

The quantitative data concur with some of the anecdotal data that prior knowledge explains the variability in learning and performance outcome. Other studies consider variables such as motivation, quantity and quality of instruction (Parkerson, Lomax, Schiller & Walberg, 1984). Along with other factors such as peer groups which influence achievement, Parkerson et al. (1984) found that prior knowledge still influences achievement by 0.72 which is the greatest impact on achievement from all the factors. Therefore, based on the above review, it is a fair conclusion that prior knowledge has an overall positive effect on learning and performance.

On the other hand, Dochy et al. (1999) have located eleven studies which have found a negative effect or no effect of prior knowledge. However they conclude that due to methodology, these are fundamentally flawed in their results and therefore should have little value placed upon them. Also the simple fact that there are so few studies even reporting negative effects on learning due to prior knowledge limits the weight we put on this. The key question which was also addressed in this paper, which does need to be noted, is that if flawed methodology can produce negative results, can the same be the case for positive results?

> Overall, we conclude that only four studies used weak assessment methods. ... There is a strong relationship between prior knowledge and performance.
>
> (Dochy et al., 1999, p. 168)

2.6.2 Effects of Prior Knowledge on Learning of Mathematics

In order to understand the effects of prior knowledge on learning of mathematics, I am going to consider the body of research which focuses on studying the impact of prior knowledge in the mathematics classroom setting. This research is organised into different areas, many of which are subject-specific. For example, Thompson (1995) looks at pre-number activities and the early number curriculum, and Marshall (1993) considers understanding of rational numbers through a schema-based approach. However, though these are interesting, they give me little understanding of the direct effect of prior knowledge on children’s mathematics and also add little to the scope of my thesis. I am interested in looking at what children bring to the learning experience and how this affects their ability to perform mathematical tasks, not just prior subject knowledge, but the wider idea of prior knowledge. Considering research that focuses on children's informal mathematics in the early years will allow me to explore the prior knowledge which children have before they come to the classroom that affects children's learning of mathematics.

There is a great deal of research carried out on the informal mathematics that children bring to the classroom (Atkinson, 1992; Ausubel et al., 1978; Baldwin & Stecher, 1925; Baroody, 1987; Dickson, Brown & Gibson, 1984; Donaldson, 1989; Gelman, 1980; Groen & Resnick, 1977; Haylock & Cockburn, 1989; Hughes, 1986; Lave, Murtaugh & de la Rocha, 1984; Resnick & Ford, 1981; Skemp, 1987; Starkey & Gelman, 1982; Tizard & Hughes, 1984). It is worth considering a few of the themes that this area of research has considered. The research falls into the following eight characteristics.

i. The developmental theories which consider what young children know about mathematical concepts.
ii. Research which looks at the process/facts surrounding *bridging the gap between school formal and home informal*.
iii. Research which explores the learning which takes place in the informal setting and its effects on school learning.
iv. Research which considers using informal settings in the classroom to encourage mathematics.
v. How children learn mathematics.

vi. Looking at the mathematics curriculum and what it offers to the learning process.

vii. Assessment of informal knowledge in mathematics.

viii. Looking at the informal understanding of written symbols in mathematics.

The wide body of research considers small aspects of what children bring in terms of subject knowledge to the formal learning experiences, but does not look at the wider prior knowledge framework that children bring to bear upon the learning of mathematics. Though it is agreed and recognised that prior knowledge has an effect, there is no understanding of *how or what this effect is*. I argue that this is due to lack of comprehensive understanding of what is meant by prior knowledge and a clear definition for it. It is also interesting that this lack of clarity is linked to the plethora of ideas about how children learn.

> There is no single comprehensive theory that explains how children develop intellectually or how they learn.
>
> (Clemson & Clemson, 1994, p. 4)

> Prior knowledge also forces a theoretical shift to viewing learning as "conceptual change". ... it is impossible to learn without prior knowledge ... there is widespread agreement that prior knowledge influences learning, and that learners construct concepts from prior knowledge.
>
> (Roschelle, 1995)

I would contest that we cannot begin to use prior knowledge effectively if we do not know what it is and therefore need to define it, and therein lies the gap. However this still leaves unanswered the effects of prior knowledge on mathematics.

Wakeley (2002) investigates the relationship between low birth weight and mathematical development. She concludes that the achievement of lower scores in mathematical tasks is related to support from home. This is because support from home for early mathematics development overrides factors such as birth weight and health.

This leads me back to considering the informal mathematics that children learn and carry out as being the lynchpin to new understanding. There is focus on informal mathematics that children engage in and how this leads to learning formal mathematics.

> Before entrance to school, children possess important concepts and skills concerning mathematics.
>
> (Ginsburg, 1989, p. 20)

This understanding of numbers is based on experiences the children have had. It is this idea of informal mathematics and its acquisition which forms the prior knowledge for future mathematics learning. What do I mean by informal mathematics and what impact does it have on learning mathematics? Ginsburg (1989) explores many mathematical concepts and how they are expanded initially before being formalised. He argues that informal knowledge is gained from different experiences of different aspects of life. Furthermore the initial informal experience with mathematics forms the filter for new understanding.

From a very young age, children build on intuitive understanding of mathematics which is based on their environment (Ginsburg, 1989). Through self-directed practice and errors, children are able to develop many ideas in mathematics. It is this constructivist school of thought that dominates the theory of mathematical learning. As stated already, it is the powerful filter that prior knowledge forms which influences the development of mathematical understanding.

It is interesting and worth questioning what Roschelle (1995) labelled as the "paradox of continuity". So far, I have made the assumption that all prior knowledge is valid and contributes positively to new learning. However if I use the filter analogy, it is possible that individuals have knowledge structures that are erroneous. How then can learning progress?

> Constructivism depends on continuity, because new knowledge is constructed from old. But how can students construct knowledge from their existing concepts if their existing concepts are flawed?
>
> (Roschelle, 1995)

In order to understand how learning can still take place within the possibility of incomplete or inaccurate prior knowledge, I need to consider learning theory. However as there is a common understanding of Piaget, Vygotsky and Dewey, rather than looking at the principles of each of these, I want to consider how they aid in allowing this incongruence in prior knowledge and new learning to be resolved. Within each of their theories, there is the ability for the learner to develop or change through time.

To summarise therefore, how do we go from informal to formal understanding in mathematics? Also what is the role of prior knowledge? In this section, I have noted that prior knowledge in the form of informal knowledge has an impact on new learning, but need to resolve how erroneous prior knowledge can still aid new learning and the answer lies in the major theories linked to learning, those of varied experiences and practising the skills that are acquired. It is the application of ideas in many different contexts that will allow the development of new knowledge.

> Piaget suggests that learners overcome the paradox of continuity with the help of slow, maturational processes that operate when doing a task provokes conflict between accommodation and assimilation, and support for equilibration between these ... Dewey overcomes the paradox of continuity by focusing on the nature of experience under the right conditions, a learner engaged with a problematic experience can effect a transformation of prior knowledge ... Vygotsky can overcome the paradox of continuity by suggesting that learning coordinates spontaneous and specialized concepts in a gradual transformative process.

(Roschelle, 1995)

Therefore, based on this, prior knowledge affects mathematics learning, and it does so through maturity, social interaction, experiences, resolving problems, and addressing contradictions. Therefore I conclude that the building blocks of prior knowledge based on this line of enquiry are:

- Experiences an individual has engaged in;
- Maturity – the time that has passed; and
- Social interaction an individual has engaged in.

These have an enormous effect upon the development of mathematical knowledge and skills.

If prior knowledge is the informal mathematics that children bring to the school study, then there is a labyrinth of knowledge that children have acquired in an informal method. Ginsburg (1989) outlines what babies already know and use to make crude judgements. He argues that this knowledge is universal, is full of both weaknesses and strengths, and has a complex effect on performances.

Prior knowledge has several effects on the understanding and progress of early mathematics. Every mathematical development is dependent upon what children bring into the learning situation. Many authors have classified this as informal mathematics. Its effects on learning mathematics are to:

- allow children to hook new learning to old knowledge;
- allow for experiential learning;
- allow children to choose many different strategies to be tried out and learned.

2.7 Teachers' Understanding of Prior Knowledge

In this section, I am going to consider teachers' understanding of prior knowledge as fundamentally it is this notion that needs clarifying in order for teachers to be able to use prior knowledge to support children's learning. Also I will consider what teachers' understand of children's prior knowledge, as this is the motivation for this research.

Throughout history, Piaget has had a great impact on how we view children and their learning, especially in mathematics.

> For some time now, Jean Piaget has been regarded as one of the leading authorities on the question of how children learn mathematics.
>
> (Hughes, 1986, p. 12)

The way in which English curriculum and schools are structured is greatly influenced by Piaget. The notion of Piaget's age-related developmental stages has influenced teachers' understanding of children and their knowledge. Teachers, to some extent, do not expect the knowledge structure to be any different in children of similar age. The difficulty which has been created is the lack of assessment methodology to enable teachers to establish accurately what children's actual prior knowledge is in mathematics. The firm belief that each child will pass through each stage (as suggested by Piaget) means that there is no need to understand what children's prior knowledge state is. In terms of prior subject knowledge, many methods have been implemented to assess where children are such as Assessing Pupils' Progress (APP) and Assessment for Learning (AfL). However this only offers limited scope for teachers evaluating prior knowledge. The heavy dependency on structuring learning through ages and stages has not allowed teachers to build a picture of what individual children know and to have the ability to assess them with accuracy.

> Given prior knowledge's central role in learning, there is a surprising lack of research that explores how teachers – pre-service and in-service – understand the concept of prior knowledge and make instructional decisions based upon their understanding
>
> (Meyer, 2004, p. 971)

The role of teachers is the facilitation of learning and, as established in the previous sections, one of the most influential factors in the process of learning is prior knowledge. Therefore understanding, evaluating and effective planning for prior knowledge are essential in order to be an effective teacher. The connection between teaching and learning is intertwined.

> Theories of teaching must be based on theories of learning and also must have a more applied focus.
>
> (Ausubel et al., 1978, p. 16-17)

Furthermore, Ausubel et al. (1978) have emphasised the importance of checking prior knowledge and using it in teaching. The inability to do this or inaccuracy in doing this leads to lack of progress.

> It is impossible for teaching to succeed if it does not address the current forms of students' understanding of a subject.
>
> (Laurillard, 1993, p. 187)

> Prior knowledge can have positive and/or negative effects on learning.
>
> (Jones, Todorova & Vargo, 2000, p. 206)

I must therefore question how much do teachers really understand prior knowledge, and how do they use it in their teaching? Meyer (2004) looks at this question in greater detail when he considers how novice and expert teachers use prior knowledge.

> In summary, for the novice teachers prior knowledge tended to be the result of prior teaching and could be defined by what students formally knew about a concept. They saw it having an important role in learning since a teacher would want to be sure that the proper information foundation was in place before new learning could take place. If students had misconceptions, then the teacher could replace the faulty information brick with a new one before going on in their teaching. On the other hand, the expert teachers emphasized the role of students' ideas and explanations as central to prior knowledge. Therefore, prior knowledge was important in learning because it revealed how students put their ideas together. If the students had misconceptions then you have to get them to think a new way about the concept.

(Meyer, 2004, p. 977)

So for each group of teachers, i.e. novices and experts, their understanding of prior knowledge takes very different shapes. Meyer (2004) goes on to look at how teachers make use of prior knowledge and again finds a huge distinction between novice and expert teachers. Furthermore an interesting point to be noted here is "the novice teachers' lack of strategies for finding out their students' prior knowledge" (Meyer, 2004, p. 977).

This could be extended to teachers who are novice not to teaching, but to the subject matter they are being asked to teach as is often the case in mathematics.

The understanding that teachers have of prior knowledge and their ability to use it as a central element of teaching and planning is very much dependent on their own prior knowledge of the subject, children, teaching, school and other environmental factors. The novice teacher has a very "superficial conception of knowledge and prior knowledge" (Meyer, 2004, p. 980). Slightly more experienced teachers were similar to complete novices in many ways, but "were limited in their focus and because their own knowledge was poorly organized they interpreted the events in their classrooms in a limited fashion" (Meyer, 2004, p. 981).

It was the expert teachers who were able to use their experience and knowledge to focus on their students (Meyer, 2004). This notion of using experience-based intuition allows expert teachers to be better at the process of teaching and ensuring that their students engage in effective learning. This review demonstrates that prior knowledge and teachers' understanding of prior knowledge is very ad hoc and based on individual level of experiences.

Studies have shown that the process of planning and how it is carried out is a key indicator of teachers' level of understanding of prior knowledge and the constructivist learning process. Though these studies' results are not earth shattering, it does enable me to question the nature of this gap between novice and expert teachers in their understanding and use of prior knowledge. One of the key ways I can look more closely at this gap is by looking at the teachers' planning process. It is while planning that teachers should and do introspect about what the teaching process for any given lesson should constitute. The use of the planning cycle also inculcates this process further. Yinger (1978) states that planning is part of the preactive phase of teaching.

> Preactive teaching takes place before and after school, during recess, and at other times when the teacher is alone in the classroom.
>
> (Yinger, 1978, p. 1)

He further argues that it is in this phase that teachers are most reflective. I would also argue that it is here that teachers can take prior knowledge into account. So in order to understand and answer my initial question of what do teachers understand of prior knowledge, I must examine what goes into their planning. What factors are considered in this process as this will inform me of the extent to which prior knowledge is understood and, more importantly, used.

Borko and Livingston (1989) look at how mathematics planning is carried out by expert and novice teachers. For novice teachers, as also noted by Yinger, the planning process constitutes the following facets (Borko & Livingston, 1989):

- Strategies for the presentation of content;
- No strategy for unpredictable events;
- No addressing of students' comments and questions that may occur during teaching;
- Rigidity leading to less scope for improvisation.

Yinger summarises the results of a study by Peterson, Marx and Clark (1978) which showed the following behaviour of teachers while planning:

> i. Teachers spent the largest portion of their planning time on content (subject matter) to be taught.
>
> ii. After subject matter, teachers concentrated their planning on instructional processes (strategies and activities).
>
> iii. The smallest portion of planning time was spent on objectives.
>
> (Yinger, 1980, p. 109-110)

Considering the three steps in planning above, it must be noted that teachers spend most of their planning time in considering the content of the lesson, irrespective of the children they are teaching.

Teachers engage in many levels of planning, some of which takes place outside the ebb and flow of the classroom and some in situ. Yinger (1978) identified five different types of plans – yearly, term, unit, weekly and daily (p. 18). From the point of view of my research, these are five different opportunities to account for prior knowledge in the teacher's teaching process. The key outcome of Yinger's (1980) study, which is pertinent to my discussion here, is that though teachers plan in a very systematic way, their formal (written) plans did not contain *pupils' characteristics* though they were reflected upon during the planning.

> Attention to pupils' background characteristics was evident in this teacher's planning-not in the plans themselves, but in the planning process.
>
> (Yinger, 1980, p. 124)

To conclude, teachers' understanding of prior knowledge and its use in the planning process is heavily dependent on their level of experience, and their own prior knowledge of students, subject and possible outcomes.

Furthermore there are external pressures upon teachers which also influence how they plan and use prior knowledge within the classroom. However the overall outcome of this section is the random manner in which prior knowledge is used by teachers at all levels in planning. The major way in which teachers use prior knowledge and their understanding of it is to overcome and implement as closely as possibly the complexity and unpredictability and the immediacy of the classroom (Yinger, 1978). That is, they use prior knowledge as a management technique and not as a way to develop knowledge. Despite establishing that prior knowledge plays a key role in learning, it is definitely not a key focus in planning for learning with no formal written consideration for it in majority of teachers' plans.

> The most profound challenges for teachers are not associated merely with acquiring new skills but with making personal sense of constructivism as a basis for instruction.
>
> (Windschitl, 2002, p. 131)

> Teaching then requires teachers who understand students' existing conceptions and can create learning experiences that will allow students to either accommodate or restructure their knowledge frameworks for new learning.
>
> (Meyer, 2004, p. 971-972)

This does not occur, and I must question why. The answer may lie in the lack of a definition or structure of prior knowledge as identified in Section 2.5, or the lack of clarity in understanding of prior knowledge. Overall prior knowledge is based on intuition by teachers as it is by researchers due to the vagueness of its structure, and must be investigated.

2.8 Conclusion

This literature review has considered all aspects of knowledge linked with the examination of prior knowledge. The structure of my enquiry was determined by my research objective, which is to provide an understanding of the structure of prior knowledge of children in the context of the primary mathematics classroom. Firstly I have been able to establish an explanation of how I gathered all my information. I feel that this was essential to allow transparency. The second thing I have been able to carry out is to give my research a context having looked at the political, social, cultural and historical background within primary mathematics education. This has enabled me to frame where my findings can be placed. For other researchers, this allows an understanding of the limitations of the findings and the context within which they have been derived. I have also looked at the primary mathematics classroom in order to allow a detailed picture to be framed for this key context.

I then went on in this chapter to examine knowledge in order to tease out the many theoretical arguments and perspectives to establish what my view was and the view that will inform the outcome of the data collection. There are many complex possibilities as to what I mean by knowledge. I conclude that knowledge is not stable, but it is ever changing, and furthermore has little to do with ability, but more to do with the relevance of knowledge to context. From this, I examined what is prior knowledge and there the literature review falls short of providing an answer to my research objective. By synthesising the literature, I was able to come up with a fragmented framework for prior knowledge in Section 2.5.4, which will need to be validated and extended through my empirical research. All the literature unanimously agreed on the pivotal nature of prior knowledge in the process of learning – there was little disagreement on this point. Also there was overwhelmingly wide recognition of the notion of prior knowledge and its positive effects on learning. This points to a huge gap in literature. There is no clear definition as to what is meant by prior knowledge in primary mathematics and teaching. This outcome is of great surprise as prior knowledge is one of the universally accepted pedagogical notions. Why is it that thus far there have been no attempts to define it? I feel through the literature that this is due to the intuitive nature of prior knowledge. It seems that this is a concept that has seeped so deep into our intuition that though we all have our own understanding of it, we are unable to define it. I have been able to glean some features of it through the literature as stated in the conclusion of Section 2.5.4. This is by no means a definitive outcome, and I will need to examine this through field research.

I felt it was important to examine the reasons for looking at prior knowledge and whether it really does have the value I have placed on it. So I have done this through the point of view of learning mathematics and teaching, and it seems that the outcome of this reflects the outcome I established for the definition of prior knowledge. It was agreed that prior knowledge overall has a huge effect on learning, but teachers were not able to use it effectively as they did not have an understanding of it, but were using it intuitively and randomly.

Therefore my next step is to investigate and define the real nature of prior knowledge in the primary mathematics classroom. The following chapters will look at the process for doing this.

3 IDENTIFYING RESEARCH METHODOLOGY

3.1 Introduction

In the previous chapter, I have provided background information on areas touched by this research. In this chapter, I explore various research paradigms and methodologies to identify a suitable methodological framework for the collection of data. The methodologies for analysing the data are explored in Chapter 5.

In addition to an introduction and conclusion, this chapter has four main sections. In Section 3.2, I reiterate the research question – understanding children's prior knowledge within the classroom – to provide the context for the sections which follow.

In Section 3.3, I explore the nature of research, and describe why I have positioned my research within the qualitative research paradigm. This positioning and exploration of the philosophical assumptions are crucial to the identification of a suitable research methodology. The following key issues are considered:

- an exploration of positivist and anti-positivist research paradigms;
- a debate on what constitutes good research;
- an examination of objectivity and subjectivity and their significance to my research.

In Section 3.4, I describe the chosen methodological framework – naturalistic research – for understanding children's prior knowledge within the classroom. The following key issues are considered:

- an exploration of a variety of available research methodologies;
- a description of naturalistic research methodology;
- the overall implication of the selection of the research methodology on understanding the data gathering process and the subsequent analysis.

In Section 3.5, I examine the generalisability and validity of the results. These are required to ensure that naturalistic research can stand up to scrutiny.

3.2 Research Question

Before proceeding any further, it is useful to reiterate (as stated in Chapter 1) the initial motivation for this research – my own experience within the classroom. I find teaching in a primary school to be not only rewarding but also personally challenging. The most challenging factor, and the one which affects all areas of teaching mathematics, is the difference evident in children's ability to perform any given mathematical tasks. This observed difference in children started a process of self-questioning. Initially, there were vague questions:

> *Why should there be a difference in children's ability? What makes us each different? What is it about the difference that affects mathematical ability?*

Underlying all of them was a recurring question:

> *What is it about who children are at any given moment in time that makes them so different in their ability to perform mathematical tasks?*

I felt that I did not have an understanding of the process involved in creating the differences that manifested themselves in the children. Furthermore, as my thinking and self-questioning progressed, there were yet more questions. Through talking to other teachers, I concluded that this was a question for which many of them felt that they did not have a clear answer. Additionally (as considered in Chapter 2) wider research evidence and investigation of the thoughts of other researchers revealed that there are no definitions, descriptions, structures or processes which address the specific question of what accounts for the individual differences in children's ability within mathematics. However, these sources did point to prior knowledge as a possible cause for the differences. This puzzle and my desire as a teacher to somehow bring into the realms of understanding these abstract and complex everyday notions of prior knowledge have been pivotal to my research, and to the identification of a suitable research methodology.

3.3 Nature of Research

Throughout this chapter, my focus is on establishing the methodology for performing the research. A secondary objective is to present systematically the steps that I took in arriving at this methodological framework. This was in two phases. The first phase, discussed in this section, focuses on the nature of research and the positioning of my research among various research paradigms. This results in the second phase, discussed in Section 3.4, which focuses on formulating the research methodology appropriate for the selected research paradigm.

Ontologists have classified research into various paradigms. Each research paradigm is associated with its own appropriate methodologies which lead to their own working methods and resulting outcomes.

> Research is concerned with understanding the world and that this is informed by how we view our world(s), what we take understanding to be, and what we see as the purposes of understanding.
>
> (Cohen, Manion & Morrison, 2001, p. 3)

Focusing on this perspective, I must give consideration not only to providing my definition of the nature of research but also to the position that I (as the researcher) take in the process of understanding and establishing a suitable methodology for this research. Cohen et al.'s (2001) statement implies that it is unrealistic to be objective in research, that is, it is not possible for researchers to provide an objective view of the world being considered, to be detached from the research that they are carrying out, and to report their findings without any interpretations. This lack of detachment is further reinforced by Smith and Hodkinson (2002):

> We all make judgements and prefer some things to other things and will continue to do so for as far as anyone can foresee. It is, in fact, impossible to imagine any serious concept of personhood in the absence of judgement and preference.
>
> (Smith & Hodkinson, 2002, p. 293)

This statement implies that my views and opinions have an important role to play in the process and nature of my research. Thus I need to state them openly as these views and opinions not only are crucial to understanding the methodological framework chosen, but also contribute to its development, implementation and final outcome. Furthermore, Edwards (2002) contends that the nature of who we are is rooted in our cultural context, and "as learners, we try to act on a world that is not of our own making and do so using the conceptual tools available in our cultures" (p. 161).

Having established the importance of my views, opinions and cultural context, I now explore various research paradigms with my voice as the backdrop. Where essential, my views and opinions are stated clearly to avoid any ambiguity.

Initially my exploration focuses on the positivist and the anti-positivist paradigms, widely regarded as two dimensions for looking at human nature. Where does my research fit?

Hitchcock and Hughes (1995, p. 21) propose that ontological assumptions give rise to epistemological assumptions, which in turn give rise to methodological considerations, and these in turn give rise to issues of instrumentation and data collection. The ontological assumptions that I make about the world around me are rooted within my personal opinions. These opinions have been formed through various epistemological experiences. Thus the questions asked by my research are fixed in the nature of who I am. This, as argued in earlier chapters, is influenced by the culture in which I am situated. Therefore the nature of research and the researcher cannot be separated.

As described by Comte (Cohen et al., 2001; Turner, Beeghley & Powers, 2012), the positivist/scientific school of thought depends on, and is structured around, the doctrine that all genuine knowledge is based on sense experience and can only be advanced by means of observation and experiment. This view has many implications. Firstly, it implies that knowledge is in some way hermetically pre-packaged, just waiting to be discovered through objective experimental research. I think that Comte offers a limited view of the nature of knowledge as his view does not allow for knowledge gained through the vicarious experiences of others. Secondly, Comte's view implies that knowledge can only be defined through a process of observation and experimentation, leaving no opportunity for gaining knowledge through introspection or analysis of the experiences of others based outside their personal senses. Thirdly, Comte's view implies that all knowledge can be classified and has predetermined properties. Lastly, his view implies that the reactions towards others and towards situations that are based on an individual's knowledge will be the same for each individual placed in similar situations with similar knowledge. The process of gaining knowledge in the positivist paradigm assumes that knowledge is like the elements on the periodic table, all having a fixed place with predictable characteristics to any intervention to which they are subjected. It further assumes that knowledge is structured in this preset order and is the same for all individuals. Comte's point of view does not allow for individual differences and opinions based on their understanding and conceptualisation of reality, nor does it consider past experiences or the level of understanding of those experiences.

The positivist perspective views the real world to be "out there independent of our interest in, or knowledge of, it. This is a reality that can be known, at least in principle, as it really is." (Smith & Hodkinson, 2002, p. 292). This implies that reality is fixed and predetermined and external to the knower.

Though the above is an oversimplification of the beliefs and values of the positivist paradigm, it gives some indication about the necessity for considering and clarifying my position. However the belief that all actions, reactions and interactions are a direct result of external influences and would be the same for all individuals is an oversimplification of the complex nature of humans. There is a wide variation in the interpretations we all make from what we see and experience. Standing on the same point, each individual will observe, feel and interpret the same view in very different ways due to the context he/she is placed in and the contexts available to him/her due to his/her past experiences and knowledge. There is a sheer, though perhaps minute, distinction between whether we view human behaviour as behaviour in response to external influences and stimuli or whether we view it as actions in relation to what we assess, think, and feel in conjunction with past experience and past gained knowledge. This distinction will determine the approach and nature of the methodology that can be implemented.

3.3.1 What is Good Research?

A significant hurdle in determining the methodology is to explore the notion of what I believe is *good research*. The positivist research paradigm considered so far relies on studies with a large number of subjects divided into control and intervention groups. For most people, including myself, the initial response when thinking about research is to focus on the positivist paradigm. Though this is my initial belief, I am struggling to overcome this initial positivist reaction as my sense of right and wrong in performing any research stems not only from my internal values, but also from the values placed upon me by my social and cultural background (being Indian). My cultural identity places a higher value on quantitative deductive research (positivist paradigm) as opposed to qualitative interpretive research (anti-positivist paradigm). This cultural identity shapes my values and makes me feel less qualified or less productive in society if I have, in any sense, a leaning towards an interpretive outlook on research. This strong cultural benchmark and the desire to fit this mould as a means of self-validation helps in explaining my initial positivist reaction. This tendency to *fit in* to reflect the cultural expectations of my peers and society is also observed by Edwards (2002), who states that "as researchers, we also interpret and respond in ways that are permitted in our own research cultures" (p. 163).

The cultural expectation and my initial inclination to consider the positivist research paradigm (and its accompanying research methodologies) to be indicative of good research must be questioned in relation to the impact it has on my research question. This amounts to a psychological tug of war between what is expected culturally, and what my research question needs. My internal values compel me to focus on the research question, taking into account the skills and resources needed to address it rather than dwelling on the culturally acceptable trends in methodological approaches. In order to resolve this tug of war, I need to explore the principles underlying the positivist and anti-positivist paradigms, namely objectivity and subjectivity respectively.

Though the dissection of my values and the cultural influences on it seems to be a huge indulgence for scant benefit, these experiences have shaped and structured my prior knowledge and thoughts throughout the progression of this research. Thus they form a key part of the exploration of my research methodology and the derivation of its eventual structure.

This gives rise to the following questions. Is the best way to gain new knowledge through the use of experimental methods and mathematical deduction of the result using objective methods, or is there benefit to observing and inductive reasoning using subjective methods? Furthermore are the results being gained through detailed observations of interactions within the classroom (naturalistic approach) of any less value than a syllogistic approach?

3.3.2 Objectivity and Subjectivity

In order to evaluate and understand the values of the various research paradigms and resolve the questions proposed at the end of the previous section, I now consider the underlying principles of objectivity and subjectivity, and their significance to my research. Clarifying my position on these two notions will help to place my research within a suitable methodological paradigm. The choice must be based on how the chosen methodological framework will aid in understanding prior knowledge.

> Objectivity is both a metaphysical and an epistemological concept. It pertains to the relationship of consciousness to existence. Metaphysically, it is the recognition of the fact that reality exists independent of any perceiver's consciousness. Epistemologically, it is the recognition of the fact that a perceiver's (man's) consciousness must acquire knowledge of reality by certain means (reason) in accordance with certain rules (logic).
>
> (Rand, 1965, p. 7)

Rand's definition of objectivity implies that reality is fixed and the same for all within any given context. The tradition of quantitative research is based on the principle of objectivity, and aims to discover the fixed reality which answers the research question (Winter, 2000). Since the reality is independent of any observer, it puts a limit on the role of individual researchers engaged in quantitative research.

Using Rand's definition of objectivity, a structure for prior knowledge within the Year One classroom can be derived through observation and deduction. If I assume that my research is located in the quantitative research methodology, then the methodological approaches available to achieve this are deductive and require a hypothesis to be proved, which is not the case in my research. Also by definition, any quantitative research is replicable and the observations performed should give the same outcome even with a different researcher. Most quantitative scientific research, notably randomised controlled trials, fall within this methodology.

Having considered objectivity and its implication on my research question, I now turn my attention to subjectivity.

> Subjectivism is the belief that reality is not a firm absolute, but a fluid, plastic, indeterminate realm which can be altered, in whole or in parts, by the consciousness of the perceiver.
>
> (Rand, 1965, p. 7)

This definition of subjectivity allows for the fact that the world exists, but different people construe it in very different ways. This definition precludes certain properties inherent in objectivity such as the notion of a single shared reality or common understanding of variations of reality and the concepts that constitute this variation.

> As soon as subjectivity is represented in any way, linguistically or through mental imagery, it becomes intersubjective. One gets an idea of what another person intends or feels by implicitly taking the position of that other person; in other words, by implicitly sensing what one would feel or intend oneself when talking in a similar manner.
>
> (Carspecken, 1996, p. 167)

This implies that there are a multitude of truths. This arises from the fact that subjectivity is based on personal interpretations, and the truth experienced by one person cannot be ever experienced by another person in the same manner.

The above discussion demonstrates that objectivity and subjectivity are opposite extremes. The objectivist outlook allows for only one truth (the same truth for all). The subjectivist outlook allows for many truths and personal interpretations and recognises the importance of an individual's experiences in life. However, as observed by Rand (1965), objective knowledge, in its purest form, cannot exist.

> Knowledge, man merely observes that which is. When it comes to applying his knowledge, man decides what he chooses to do, according to what he has learned.
>
> (Rand, 1965, p. 7)

The notion that man makes choices based on his observations means that he interprets his knowledge. So if I am concerned with how individuals respond or choose to respond to the existing reality, then the subjectivist outlook provides some pathway forward.

As stated earlier, my research is focussed on exploring what is meant by prior knowledge, and on investigating how prior knowledge is structured within the classroom. The discussions in Section 3.2 helped me to identify some of the key requirements to address my research question. These key requirements include the ability to reflect and self monitor, and the ability to consider meanings for complex interactions between teacher and pupils in the context of the mathematics classroom. The methodological approaches offered by taking a subjectivist outlook allow these requirements to be taken into account.

The mechanisms required for understanding the structure of prior knowledge require not only some sense of logic in their explanation, but also a sense of setting. Jaworski (1994) proposes that, in order to provide some validity to research using the naturalistic approach, "a researcher needs to embed the research in its total situated context, and that this includes his or her own experiences and thinking” (p. xiv).

From the perspective of my research, it is vital for me to observe how the teacher and pupils interact with each other, and change, create and control their reality and their understanding of reality based on the cognitive tools that they have. The only way for me to gain this understanding is by sharing the same frame of reference as the teacher and pupils. This can only be achieved by embedding myself in their frame of reference, i.e. the research context which in this case is the classroom. Carspecken (1996) proposes the way forward for creating a common understanding of thought.

> One must believe that sense objects exist in such a way as to be open to multiple observers who will agree on their existence if they share certain features of a language and a culture.
>
> (Carspecken, 1996, p. 64)

Though Carspecken is referring to a physical reality, the argument extends to understanding behaviour. Without a common language and a shared frame of reference (with teachers and children), it is difficult to assess the observations made in the classroom in relation to the research question. The central common issue in creating complete detailed understanding of prior knowledge is the issue of a shared cultural reference point.

> To point out that elucidation of the formal categories of subjectivity and objectivity does not depend upon taking a position on the ultimate nature of objective and subjective phenomena is not simply to skirt a difficult issue

> … all validity claims involving objectivity and subjectivity can be doubted in some way.
>
> (Carspecken, 1996, p. 72-73)

Thus far, I have analysed the root notions of objectivity and subjectivity, and their implication for my research question. The key conclusion is that the research methodology needs to provide the ability to gain understanding within a context that is shared by the researcher and the researched, and supports interpretation.

3.3.3 Positioning the Research

So the question remains – now that a theoretical backdrop has been established, where does my research situate itself? Through the debate in the previous sections, the positivist quantitative paradigm has limited value in gaining understanding of the complexity of the myriad of interpretations made in a classroom and defining prior knowledge in the classroom. There is no methodological or analytical framework within the positivist paradigm which allows for understanding to be based on individual interpretations made about reality as it is experienced by the researcher. Furthermore the positivist paradigm does not account for the ontological assumptions made so far that a multitude of realities exist due to varying human experiences, and that the knowledge and views created as a result of these experiences need to be understood through different mechanisms such as observation of human behaviour.

On the other hand, the anti-positivist interpretive paradigm provides methodological and analytical frameworks which allow for understanding to be based on embedding myself within the research context. This paradigm supports the epistemological understanding that events can be understood through many processes of analysis and interpretation which are rooted in context, and lead to the development of new knowledge. This paradigm also allows me to take into account the complex interactions between the teacher and the pupils in the context of the mathematics classroom. Taking all of these into account, I need to situate my research within the anti-positivist interpretive paradigm.

3.4 Choosing a Research Methodology

The debate in Section 3.3 and its subsections concluded that my research needs to be situated within the interpretive paradigm. The methodological framework that I have chosen is based on the key interpretive methodology known as *naturalistic research*. The subsections that follow examine its appropriateness for my research question, and highlight its key benefits.

3.4.1 Naturalistic Research

My research question requires an approach which allows for the ontological assumptions that all individuals have various realities with a shared common understanding of these realities. To facilitate this shared common understanding, the research methodology needs to provide modes of communication and descriptions which are familiar to the groups under observation (i.e. teachers and pupils) and common to groups with whom the observations are shared (i.e. other researchers). The shared common understanding of various individual realities by different observers is known as "multiple access" (Carspecken, 1996, p. 65).

The naturalistic research paradigm contains various tools and techniques that provide a wide range of options for exploring my research question. It allows for constant shifting of the reality of an individual caused by gaining new knowledge. It allows for the notion that individuals are constantly trying to gain understanding of their reality. The individual has, as stated in previous sections, the ability to evaluate themselves in light of new knowledge which is in a constant state of change. There are three broad schools of thought within the naturalistic research paradigm – phenomenology, ethnomethodology and symbolic interactionism. I now consider each of these to offer some ideas for identifying the methodological tools that will aid in the research process.

Phenomenology holds the belief that all understanding and interpretations about others and their actions is in the subjective consciousness. Carspecken (1996) believes that understanding is synthesised within experience, with reflection forming a great part of this approach. By reflecting we are able to reshape understanding in relation to what we already know.

Ethnomethodology focuses on the world of everyday life, and how people make sense of their everyday world. It also allows for focus on what creates each interaction and what perpetuates these interactions from the viewpoint of the individual. Erickson and Schultz (1981) extend this notion of everyday life and make sense of the everyday by being explicit about the meanings we attach to the occurrences under observation stating that, "all events are mutually shared and ratified definitions, and the actions are taken on the basis of those definitions" (p. 147).

This wide focus on all situations from the viewpoint of the individual allows for many perspectives to be taken and to some extent, proved a vast challenge for me.

Symbolic interactionism allows each individual to act towards things based on the meanings they have for them (Woods, 1979). This implies that meaning is being constructed continuously due to the constant change in the experience and reality of individuals.

My research question demands tools that provide a vehicle to explain, conceptualise and contextualise the notion of prior knowledge. The debate so far has described some of the key facets offered by the naturalistic research approach such as an understanding of the ever-changing nature of each interaction, and a need for the researcher to be open and part of the research process. Key features of the naturalistic research approach include description rather than prediction, induction rather than deduction, generation rather than verification of theory, construction rather than enumeration, and subjective rather than objective knowledge (LeCompte & Preissle, 1993, p. 39-44). The inductive nature of the naturalistic research approach and these features have proved to be appropriate and valuable to my research question.

The classroom is a dynamic environment, with interactions occurring rapidly. Each of these interactions has the potential to change the course of the pedagogic encounter. Thus, in order to explore the role played by the prior knowledge of pupils in this complexity, I need to observe with an open mind to the meaning inherent in each interaction and to the sets of consequences of the sum of interactions. Actions are determined by the individual's interpretations of the meaning of others' actions. This places me in a potential paradox. To understand, I need to explore, to question and to delve. However, in the process of exploration, I impact on the interactions by altering the prior knowledge available. This is the dilemma of whether I should be a participant or non-participant observer. As a participant, I may have greater access to essential data, yet I cannot be certain of how much I will have influenced the very thing being observed. The challenge for me is to "examine situations through the eyes of the participants … to grasp the viewpoint of the native, his view of the world and relation to his life" (Cohen et al., 2001, p. 137).

I am assuming that all readers have been in a classroom before, and have some notion and conceptual idea of what constitutes a classroom setting. My particular interest is in the interaction between the knowledge bearer (teacher) and receiver (pupil). As stated earlier, the nature of this interaction depends significantly on each pupil's prior knowledge. Since my interest is to consider what this prior knowledge looks like and how teachers elicit it in their interactions with pupils, I need to observe not only the teacher but also the pupils.

The key features of naturalistic research (LeCompte & Preissle, 1993; Thomas, 1923) are perfectly suited to the ever-changing face of prior knowledge. The interpretive nature of naturalistic research allows me to build a structure of prior knowledge. Unlike quantitative research, there is no hypothesis to be tested and no intervention to be applied. The outcome of my research is simply a detailed and full description of prior knowledge and how it is structured.

The tools offered by the naturalistic research paradigm give me great flexibility and provide me with the possibility to be present *in situ* and make observations and experience the cultural interchange which occurs. The researcher's role should be to elicit sociocultural knowledge from participants, rendering social behaviour comprehensible (Spindler & Spindler, 1992). This dovetails perfectly with the outcome for which I am striving – to comprehend what prior knowledge is and formulate its structure.

3.4.2 Summary

To arrive at a satisfactory outcome for my research question, I need to use the principles and procedures set out by naturalistic research. This approach allows consideration of prior knowledge in the classroom with clear boundaries and guidelines to allow for choices to be made at difficult junctures during the research. The ability to observe others and use those results in order to reflect and formulate a description of prior knowledge allows for depth and richness in the resulting prior knowledge description and framework.

Naturalistic research feeds the notion of reflexive internal thinking and equips me with the ability to use its protocols to structure naturalistic observations.

So far I have deliberated on the following aspects of the methodological debate enveloping this study:

1. The different methodological options available and the needs of the research question.

2. The underlying principles of objectivity and subjectivity and how they have informed the formulation of my research methodology.
3. The methodological framework of naturalistic research, to provide a common understanding of the research process.
4. Reconciling theory and the practical needs of the research question.

The methodological choices made through this debate shape not only the nature of the research process but also the outcome achieved. Having debated and resolved the theoretical and structural issues involved in the selection of the most appropriate methodology, it is essential for me to consider the validity of the methodology. Also it is important to look at the ability of the methodological framework to stand up to scrutiny. The process selected for answering the research question must itself be examined and questioned in terms of the validity of the results it provides. Section 3.5 focuses on examining the methodology in order to address the vital issues of generalisation and validity.

3.5 Generalisation and Validity

For my research, I use naturalistic research to discover a description of prior knowledge and to derive a partial model for it through induction. This raises the key question of the value or the generalisability of the research. In the previous sections, I have clarified my views on this research. These views impact my position on the issues of generalisation and validity. In the process of selecting my research methodology, I gave consideration to the issues of internal validity, reliability and external validity. These are further considered in turn in the sections below.

3.5.1 Internal Validity and Reliability

My research has focused on using a traditional research methodology which is practised and understood by other researchers. This has enabled me to establish a high degree of openness to my research process.

> The goal is not to produce a standardised set of results that any other careful researcher in the same situation or studying the same issues would have produced. Rather it is to produce a coherent and illuminating description of and perspective on a situation that is based on and consistent with detailed study of that situation.
>
> (Schofield, 1993, p. 202)

This implies that one of the goals of this research must be to be transparent in order to achieve the objective of deeper understanding and shared common generalisation of meaning. Further, as stated by Merriam (1995), "notions of validity and reliability must be addressed from the perspective of the paradigm out of which the study has been conducted" (p. 52).

Hammersley and Atkinson (2007) argue that validity refers not to the data but to the inferences drawn. This is a process that Merriam terms:

> Member checks – taking data collected from study participants, and the tentative interpretations of these data, back to the people from whom they were derived and asking if the interpretations are plausible, if they 'ring true'.
>
> (Merriam, 1995, p. 54)

The traditional quantitative process by which reliability is established (replication of outcomes through repeated implementation of the study) is not suitable for establishing the validity of this methodology. Lincoln and Guba (1985b) propose that qualitative research should strive for *dependability* or *consistency*. That is, question whether the results of the study are consistent with the data collected. In order to achieve this within my research, presentation of both the study and data must be transparent and detailed. These then provide the reader with the full breadth and depth of the contextual setting so that reliability can be established.

3.5.2 External Validity

A key shortfall of naturalistic research is that the results are not easy to generalise. Campbell and Stanley (1963) refer to generalisability as an element of "external validity" (p. 175), combining generalisability and validity as parts of external validation. Their definition applies to the results of naturalistic research, as well as to the implications of those results which cannot be replicated or applied to other settings. Therefore the key question is whether it is crucial for good research to be generalisable. I question whether there is any value in diluting the results gained so that they can be generalised, for example, procedures for effective teaching (Kincheloe, 2003). Or is there greater benefit in providing results which are "sufficiently rich data for the readers and users of research to determine whether transferability is possible" (Cohen et al., 2001, p. 109).

> The idea of sampling from a population of sites in order to generalise to the larger population is simply and obviously unworkable in all but the rarest situations.
>
> (Schofield, 1993, p. 205)

I have no expectation that my research and the resulting data can be applied across the entire population in the state in which they are presented. The processes that I observed are context-specific and individualised not only to the teachers, children, school and settings, but also to the relationship that I built with the teachers. As a result, the specific outcomes generated from my research are highly contextualised. However, the overall outcome of interest is the set of elements that I describe as the building blocks of the partial prior knowledge model (I have used the terms categories and elements interchangeably throughout this thesis to describe the components of my prior knowledge model). These elements are present in varying degrees in the prior knowledge of every individual. This aspect of the outcome can indeed by applied to others and is generalisable.

> People can learn much that is general from single cases. They do that partly because they are familiar with other cases and they add this one in, thus making a slightly new group from which to generalise, a new opportunity to modify old generalisations.
>
> (Stake, 1995, p. 85)

This implies that the generalisation of meaning is possible if the partial model proposed has enabled me to gather a clearer picture of the complex situations and individuals during the course of the research. LeCompte and Preissle (1993) argue that studies based on naturalistic research gain their potential for being applied to other situations by providing what they call comparability and translatability.

Thus generalisability and validity are achieved through the knowledge and findings of this study in understanding other similar situations, a process Stake (1995) terms as "naturalistic generalisations" (p. 85). My research aims that the partial model formed through this work becomes a flexible template for understanding prior knowledge. Though there are many variables, the research provides a vehicle for understanding the structure of prior knowledge in a classroom through the generation of a partial theoretical model established from a range of contributory elements.

Becker (1990) claims that generalisation in qualitative research is achieved through building a theory which makes sense of individualised contexts, situations and persons studied, and further describes how similar processes could result in different outcomes in different situations.

The aim, therefore, is to achieve generalisability through a partial model that is formed from a range of contributory elements, concepts and conclusions of the study. With the presentation of an initial prior knowledge model, it is possible for others to draw from this and apply or add to their array of familiar cases and create a "new group from which to generalise" (Stake, 1995, p. 85). This aids the process of naturalistic generalisations. Also the naturalistic research methodology implemented will aid in gaining results which will add to the knowledge base of the classroom as a whole thus maximising opportunities for generalisations.

3.6 Conclusion

In this chapter, I have considered the theory behind the proposed methodological framework – naturalistic research. I have considered the value of using this construct to understand and create a fuller picture of the structure of prior knowledge. As part of the process, I have considered theoretical options available to aid in the research process, as well as the issues of validity and generalisability. There has been some reference to the methods and options available to implement analysis which are explored in detail in Chapter 5. Overall this chapter has provided the foundations and structure for more detailed and accurate collection of data to allow for greater and clearer understanding of prior knowledge. Now that the research methodology has been identified from a theoretical perspective as being naturalistic research, the next chapter focuses on its practical implementation.

4 DATA COLLECTION METHOD

4.1 Introduction

In this chapter, I present the method I used for the data collection. I give consideration to the motivation behind the choices I made with regards to the research context, i.e. the schools used, and the whole design process for the data collection. I also examine the logistical issues which are resolved in order to dovetail theory and practice as part of the design process.

There are three main sections in this chapter, following this introduction. In Section 4.2, I take the theoretical framework from Chapter 3 and lay out the following:

- the design process which I undertook for the data collection, concentrating on establishing the choices made;
- how I implemented the data collection including the logistical decisions made and how these appear in the data collection process. I reflect on how the practical steps taken relate to the theoretical framework of naturalistic research.

In Section 4.3, I look briefly at the data focusing on the nature of the data collected. However, there is no analysis of the data in this chapter, as I feel that it is vital to consider first the data collected in their entirety in order to gain a high level understanding and a *feel for* the picture that is developing. This will allow me to develop methods for detailed analysis in subsequent chapters.

In Section 4.4, I consider the ethical implications arising out of my proposed data collection method.

4.2 Design of the Data Collection

There are five main points examined in this section. The first is the research environment – the schools. I present the schools I have used for the data collection and the reasons for choosing these schools. The second point is the teachers that I observed within the chosen schools. The third point examined is the method of observing the lessons. The fourth point is the means of recording the lessons and transcribing these recordings. The fifth point is concerned with other sources of data which need to be retained.

4.2.1 The Schools

It was important to identify a number of schools in order to be able to meet the criteria of a multi-sited design (Glaser & Strauss, 1967). The use of several schools, cases, and situations, especially with some variation, will allow the results to be applied to a greater range of other similar situations. In the process of selecting the schools, I looked for variations in a number of factors – school location (the social context), school type, class size, number of Year One classes, mixed year group, availability of teaching assistant (TA) linked with the class, and the values, philosophy and beliefs of the schools as stated by the schools themselves.

I identified the schools through two means:

- I reviewed the Ofsted reports for the schools in Worcestershire LEA, and called the heads of the schools that I felt would fit the needs of my research question;
- I placed a request in the weekly Worcestershire County Council teaching vacancy newsletter asking for schools that might be interested in the study.

After the schools had responded, I selected five schools based on the criteria listed above. Table 4.1 contains the list of schools that I selected and relevant information about them relating to the criteria above.

Table 4.1 Schools used for data collection

School	School Type	# Y1 classes	Class size	Mixed year group	Location	Class-linked TA
Hatton	Church of England First School	1	15	No	Rural small village	No
St Paul	Church of England First School Voluntary Aided	3	30	No	Small town	Yes
Argyle Common	First School	1	30	Yes (Y1/Y2)	Small town	No
Draycott	Church of England First School	1	30	Yes (R/Y1)	Rural small village	Yes
Greenville Park	Community Primary School	2	30	No	Inner city	No

In order to assess the values, philosophy and beliefs of the schools, I looked at their Parents' Prospectuses and Ofsted reports. I reproduce below relevant portions from the Parents' Prospectus for each of the five schools. A summary of the Ofsted reports for these schools can be seen in Appendix A.

Hatton First School

> We are proud of our close links with Hatton Church and the local village community. We have regular visits by the Rector and the school celebrates with parents many of the religious festivals at the church. We encourage your children to develop their talents to the full within a caring, Christian environment. It is hoped that they will acquire skills, knowledge, healthy attitudes, insights and appreciation within the orderly structure of the school. Enjoyment of the school is an important factor so that your child's appetite for learning and pace of work is stimulated.

St Paul First School

> We endeavour at St Paul's to give every child the opportunity to achieve their maximum potential in all areas of school life by learning through confidence within a Christian setting. Children will be treated as individuals while being encouraged to be part of the school family. Our school strives to be a stable, secure environment, where all children are seen to be treated fairly and equally and where high standards of behaviour are expected.

Argyle Common First School

> The school aims to provide a caring, friendly environment where children can develop their full potential, both social and academic. Great emphasis is placed on each child's individuality and the contribution that the child can make to the whole life of the school. Respect for others, both fellow pupils and adults, is strongly encouraged along with a caring attitude towards the environment. All are made welcome at the school, particularly parents who are encouraged to become part of the school life.

Draycott First School

> The aim of Draycott First School is to provide a broad balanced and relevant curriculum, within the framework of the National Curriculum, and an excellent all round education. We view each child as an individual whose needs are met through continuous assessment, careful planning, varied lessons and continuous review. We view the parental involvement as an essential part of our pupils' schooling, and are always pleased to have new ideas of ways that parents can become more actively involved.

Greenville Park Community School

> The main aim of the school is to educate our children to the best of their ability. In order to do this, we provide a place where children

> know how to behave and to think before they act. The classrooms and corridors provide lively and stimulating surroundings that encourage children to explore and think as they learn. Each child is treated according to their individual need and we draw on their experiences and skills in developing our teaching plans to make sure that we are equipping all children with the skills necessary to move onto high school.

These five schools formed the basis for my data collection. As can be seen from the Parents' Prospectuses above, the five schools are all very different in their characteristics. However there are some common themes such as the desire to provide breadth in the curriculum, their moral values, and inclusion of parents in the learning process. There are also differences between church schools and community schools, and the range of demographics within the schools. The next step of the design process was to consider the teachers from these schools who will take part in the data collection, and what I was going to tell them about my research.

4.2.2 The Teachers

In the five schools that I selected for my data collection, there were nine Year One teachers with one of the Year One classes at St Paul First School having a job share. Due to logistical reasons, I could only work with one of the two teachers in the job share. I requested each of the eight teachers for a short overview giving me information about themselves. These overviews (reproduced below) were the only things I knew about the teachers at the start of my data collection.

Mrs Sally Crane, Hatton First School

> I have been teaching for about thirty years with just a few years off to have my family. I taught Reception for most of those years – first at an inner city school, and then at a large first school. I then

did supply, worked for the special needs service, taught in a private nursery, and taught art at O level.

I returned to work full time at a middle-sized first school with a class of 7/8 year olds and finally to Hatton where I have been for fourteen years (teaching Reception, Year 1 & 2, Reception and Year 1, Year 1, Year 3 & 4, and Year 1)!

I am the Science, Environmental Studies and Health Education co-ordinator, and responsible for the school in absence of the Head. My main subjects at college were Art and Science.

Miss Lora Hunter, St Paul First School

I trained and qualified in July 1995. My specialities were Early Years (3 to 8 years old) and Religious Education. I taught Year 1 for six years in a village school in Norfolk and two years in a market town also in Norfolk. I have been at St Paul's since 1998 teaching Year 3 for one year, supply across whole range, and then Year Two for two years, and then Year One ever since.

Mrs Rebecca Rice, St Paul First School

I have been teaching for about nineteen years. I have been part time for the past two years in Year 1. I have taught Reception, Year 1, Year 2 and Year 5. During my career, I had post of responsibility for Computers, Art, Maths, and PSHE. At a previous school, I was part of senior management team. My philosophy: children learn from hands-on experience and the curriculum needs to be geared more for practical experience rather than paper work!

Mrs Jill Thomas, St Paul First School

I trained at a college on a three-year course and was awarded a Cert. Ed. in 1976. From 1976 to 1981, I taught at a first school in a town. From 1982 to 1988, I did supply teaching (mainly in this area). I have been at St Paul First School since 1988. I have done the following additional courses: in 1996, English in the primary school (Open University); in 1997, designated maths course on primary maths active learning; in 1998, BA (Ed) Hons.

Mrs Jane Marshall, Argyle Common First School

I have been teaching for twelve years. Four years at a 3-11 year old 600-pupil school in the next town where I taught Year 2. Eight years at Argyle Common where I've mostly taught Year 1 & 2, but taught Year 4 for two years. As a child I hated Maths – I couldn't do it. I had extra tuition to get me through GCSE – poor teaching at high school. Therefore I always try to make Maths fun and not seem hard – I feel the children learn more this way.

In 1994, I did a designated maths course. In 2000, I did a four-day National Numeracy strategy course. This was brilliant and I was made Maths co-ordinator in September 2000. I am pleased as Maths SAT results have improved dramatically since then.

The National Numeracy strategy has changed my way of teaching – particularly mental maths – with more emphasis on finding methods of working out, listening to children's ideas. I do feel that it does not give me time to dwell on concepts as I need to get everything done. In some ways I prefer topic maths, where more seemed to be done in more depth – link to Art, English, etc. I am trying to develop more maths in real life where it is back to topic linking maths skills to other areas to practice and consolidate skills. We were awarded a grant of £300 to develop a maths trail around our local area by the Chamber of Commerce. This is almost finalised and will tie in with maths in real life. I do try to link what they know with what they are going to do and will begin to use again system of flow diagrams to see what they know and retry after a topic to see if ideas have changed.

I think (hope) that most of my children enjoy Maths and that I use a wide range of teaching styles to get over points of view depending on the children, i.e. some may need more practice, some enjoy challenge of mental work, some just plod on! I do worry that the National Numeracy strategy leaves the slow children behind as when they are working independently, and I am with a focused group, nothing gets done – whereas before, I could wander around and check more!

Mrs Jennie Brooks, Draycott First School

I started teaching many years ago in 1968. My first job was at an infant school in Birmingham where I taught Year 1. Usually the Easter intakes, therefore they had only had one term in school. In 1970, I got married and we moved to Warwick where I taught at another infant school. This was very different to the school in Birmingham and had a very high immigrant population.

In 1973, my first child was born and I gave up teaching. I spent twelve very happy years at home looking after my four sons. As the boys were growing up, I did not want a full-time job, so I taught adults to read on a one-to-one basis in the evenings. When my youngest son started school, I decided to do supply teaching, and spent most of my time at local schools. I came to Draycott in about 1992 as a supply teacher, and have been here ever since. At Draycott, I have always taught Reception/Year 1.

Mrs Helen Fellows, Greenville Park Community School

I did a PGCE and qualified in 1989. I taught Reception in a 240-pupil school from 1989 to December 1990, and had responsibility for English. I moved to Greenville Park Community School in January 1991 and have taught Reception, Year 1 and Year 2. I am responsible for Information and Computer Technology (ICT), Design

> Technology (DT), and am Key Stage 1 Co-ordinator. I have done some team teaching in Year 3/4 and 5/6. Also I support the NQT.

Mrs Jo Fishily, Greenville Park Community School

> In 1988, I completed my A levels. From 1988 to 1989, I was a full-time nanny for a one-year-old and a six-year-old (both girls). From 1989 to 1990, I spent short periods of time as a mothers help, dental nurse and catering assistant. From 1990 to 1992, I did an HND in Public Administration. From 1992 to 1995, I did an English and Drama degree. From 1995 to 1996, I did a PGCE in Early Years.
>
> From 1996 to 1998, I spent one-and-a-half terms as a supply teacher, one-and-a-half terms teaching Year 2 in an infant school, and two terms teaching Year 4. Since 1998, I have been a full-time teacher at Greenville Park including one term teaching reception, and then as Year 1 teacher. I have subject responsibility for RE. I am very happy in Key Stage 1 and love the younger children. I would be happy to teach Reception again.
>
> I am not a very ambitious teacher in terms of gaining more responsibility, my only ambition is to become a better teacher, continually improve and hopefully receive the recognition of being a good teacher. I also aim to keep stress levels to a minimum and have developed much better strategies of coping with the job and having proper leisure time!

The teachers had a diverse set of experiences and values. They all had a range of prior knowledge which impacts upon their pedagogical choices and the experiences they provide in the classroom. I arranged to meet with the teachers at their schools near the end of the summer term. We discussed the details of my research and the process of observation. The teachers had common concerns such as who would have access to the information that I collected, what was I expecting the teachers to do, and how often would I come in. After talking over their concerns, I established with the teachers that they were happy to participate in my research and agreed a timetable for the observations.

4.2.3 Lesson Observation

As established in the discussions in Chapter 3, this research is based within the naturalistic paradigm which provokes the exploration of understanding the reality as it occurs. One of the ways to achieve this understanding is through observation of lessons. My experiences as a classroom teacher has given me insights into the complex nature of observations, such as how each observation revealed greater detail about the increasing complexity in the nature of the classroom interactions and the structure of the classroom.

A key issue to address was whether I would be a participant or non-participant observer during the data collection process. Taking the role of a non-participant observer would enable me to step back and observe the classroom without interacting with the children or the teacher, thus gaining understanding of prior knowledge in a natural state. However, my experience as a classroom teacher has indicated to me that I could not remain detached from the classroom as my presence would mean that I was involved and no longer a non-participant. The problem of wanting to be detached and observing without influence on the classroom is summarised as "the theoretical notions of what constitutes a reality to be observed, and the disturbance of that reality by activities of the observer" (Edwards & Westgate, 1994, p. 74).

For me, the terms participant and non-participant did not offer any guidance to structure my observations. I did not want to participate in the classroom interactions because it could change the very thing that I wanted to understand. Being a non-participant observer meant that I would have to be completely detached and have no contact with the context being observed. I needed to be in the classroom to observe the interactions and understand the changing context within which I was observing prior knowledge. Gold (1958) offered some guidance in classifying the roles that a researcher can take in observation, stating that, "These range from the complete participant at one extreme to the complete observer at the other. Between these, but nearer the former, is the participant-as-an-observer; nearer the latter is the observer-as-a-participant." (p. 217).

Defining my position as an observer related not only to the methods used to carry out the observation, but also to the way in which the context is framed for the observation. It allowed me to structure my role in the classroom, i.e. I was part of the classroom but was not there to work within the classroom. Before starting the data collection, both the teachers and their classes would be made aware of my role and intention. Further, as my presence in the classroom would be explained to the children, it would make me a participant in the classroom but an outsider to the process of teaching.

Despite discussions with the teachers and their classes, I was aware from my experience as a classroom teacher that there was a possibility that the teachers and the children were going to take time to get adjusted to the process of being observed and this could affect some of the early observations. I addressed this by performing observations over an entire school year, which led to acclimatisation, observing each teacher at least once a month where possible.

I recorded my observations as field notes in an unstructured and evolving document, a running report of the events within the classroom while I was *in situ*. I included the time of each major event in the classroom such as moving from one setting to another (e.g. carpet work to group work on the tables), length of each event, additional adults and their roles within the lesson, brief notes on the mood of the children, any special events which were going on in the school that day, and any deviations from the daily routine. In the margin, I included annotations with notes of thoughts prompted by the observation.

4.2.4 Recording and Transcribing

The aim of the observations, lesson recordings and informal interviews was to be able to reconstruct each lesson for retrospective analysis. I recorded each teacher by using a small remote microphone as they taught the lesson I was observing. Recording meant that I could remain in one place in the classroom and still have a record of all the interactions and conversations of the teacher. The nature of the recording meant that I could focus on the visual aspects of the classroom interactions, such as movements of the teacher and children, and the equipment children chose to aid them in their tasks.

As I transcribed the recordings, I did some mental analysis of the recordings. However I did not make any omissions or do any coding as Edwards & Westgate (1994) state that:

> Interaction is constructed both through the participants' interpretation of many factors not easily accessible to an outsider, and in ways which are influenced by the structure of the discourse itself. Those participants draw on background knowledge of which the observer may be unaware, they respond to the constraints of particular types of discourse at various stages in the lesson, and they regularly reinterpret the meaning of what was said in light of what was then said after it, or make provisional interpretations while waiting for further 'evidence'. All these subtleties are seen as defying instant coding. Instead, they are judged to require patient scanning of a transcript, and also (because any transcript is itself selective) a willingness to return to the original recording to check or amplify details.
>
> (Edwards & Westgate, 1994, p. 61)

The layout that I established for the transcripts is shown in the extract below. There are many features associated with traditional transcription methods which I did not include in my transcripts as the purpose of my transcripts was to be able to read the words which were said and to understand prior knowledge through the interactions. To enable ease of reading, I did not use a specific code to depict any features such as multiple children speaking. To balance the complex conversations and the need for simplified representation, I transcribed in a linear fashion.

> The most sympathetic transcribing – that is, the most attentive to details of intonation, pitch and so on – is unlikely to make informal spoken language look coherent because speech and writing are not different ways of doing the same thing.
>
> (Edwards & Westgate, 1994, p. 63)

They advise, therefore, to include in the transcript whatever features are necessary for the research purpose. As my purpose was to be able to consider the lesson and understand prior knowledge from it, complex transcription methods looking at linguistic features were not needed. I asked each teacher to verify the accuracy of some of their lessons by reviewing the transcript to ensure that they had been informed, and that my transcripts were as accurate as possible, and 'rang true' (as stated by Merriam in Section 3.5.1). Given below is an extract from a transcript.

Extract from transcript of seventh lesson by Mrs Sally Crane at Hatton First School

Teacher: Sixteen good boy well done … I was looking to see who I could tell was counting in their heads and that was very good indeed well done … and Olivia I noticed you suddenly stopped and you realised that you've got to carry on and you did really well there good girl that was excellent … let's have one more go

Few children: Oh

Teacher: Right what number is this?

Few children: Twelve

Teacher: Twelve all right … now this is quite a hard one to stop at so let's see if you're being really clever this morning … are we ready then

(Children clap)

Teacher: No … no … no … it will be no good if we don't all start together ready … and

(Teacher and most children clap twelve times ... some children clap thirteen)

Teacher: Ah I told you number twelve is a difficult one I don't know why we get going to ten

Child: I know it's cause

4.2.5 Other Data

Spradley (1979) and Kirk and Miller (1986) recommend keeping four sets of observation data:

1. Notes made *in situ*.

2. Expanded notes that are made as soon as possible after the initial observations. (This was in the form of tape recordings which were transcribed in their entirety without omissions.)
3. Journal notes to record issues, ideas, and difficulties which arise during the field work. (This was done in the margin of my field notes in order to keep the context of the thoughts.)
4. A developing, tentative, running record of ongoing analysis and interpretations. (In the case of this research, this was done throughout the classroom observations and the transcribing process by formulating a pictorial representation of the emerging model.)

In order to rebuild the classroom interaction at a later date with some degree of accuracy, I also collected lesson plans and notes that the teachers had made about children involved in the lesson being observed. Where possible, I talked with the teachers after the lesson to understand their view of the lesson (this too was recorded and transcribed). I carried out unstructured interviews with the teachers to establish the accuracy of my transcriptions, and to understand from them how they viewed their teaching and their knowledge of the children.

4.3 The Data

The data set consists of sixty lesson observations, fifteen informal interviews, notes on informal conversations with the teachers, lesson plans for each lesson, and notes on various children that teachers had made for the purpose of sharing with me during the academic year. The observations were done over the course of a school year (from September to the following July). Each lesson was approximately forty-five minutes long. All the lessons and informal interviews were recorded and transcribed. Additionally, I also had observation notes from the lessons.

During the process of transcription, I was beginning to analyse the data and look for some indication of understanding prior knowledge. The different forms of the data, namely the audio recording and the notes, provided different angles of perspective for each observed interaction. When the lesson transcripts are augmented with my written notes, lesson plans and notes on the children, they enable me to reconstruct the interactions in the classroom.

Therefore to analyse and understand the interactions involves the reconstruction of the classroom using all the different viewpoints and making sure that they all tessellate together. This multi-pronged approach forms the basis of my analysis which is considered in greater detail in the next chapter.

4.4 Ethical Considerations

A multitude of ethical considerations were taken into account in the theoretical and practical design of the data collection, as per the ethical guidelines for educational research from the British Educational Research Association (2004). They are detailed in Table 4.2 below.

Table 4.2 Discussion on ethical issues in data collection

Ethical issue	Discussion
Selection of schools	As stated in Section 4.2.1, schools were identified from among those who responded to a request for

Ethical issue	Discussion
	participation. Good research practice dictated that I should get the widest variation in the schools that I chose to ensure generalisability of the results. There was a risk that all schools that may want to take part would be similar e.g. over 40% of the primary schools in Worcestershire were church schools. To avoid this, I selected from the responding schools by looking at their Ofsted reports to ensure there were a range of schools which fit the factors stated in Section 4.2.1. I achieved this by selecting five of the eight schools who responded to the request. The three schools which were not selected were very similar to the schools that were selected. As the schools chose to reply to a call for participation, this was a random self-selecting group and avoided any sampling issues. Though all the schools were local to me, I had no prior involvement with any of the schools in either a professional or a personal capacity.
Selection of teachers	In order to ensure that teachers were fully informed about what it meant to take part in the study before taking agreeing to do so, the following were carried out: • I met with each of them individually to talk over the research project, the data collection process and how the data would be used subsequently; • all the teachers were able to ask questions about the research throughout my involvement with them, as this openness did not hinder my data collection; • the teachers were made aware that they could withdraw at any point without any consequence to themselves or their school; • the teachers understood that they had open access to all my data at any point in the research process (and indeed, they helped out by reviewing the transcripts for accuracy, privacy and anonymity); • we talked about the nature of the study and considered some of the concerns that teachers had such as how many others were involved in the study. After considering all the concerns and issues, the teachers were given time from the summer term till autumn to consider taking part in the research. Throughout this time, they were able to ask questions in order to support their choices. As reported in Section 4.2.2, all nine

Ethical issue	Discussion
	teachers chose to participate in the study, though I had to turn one of them down due to logistical considerations. I am aware that there was no gender variation in the teachers. Nationally 87% of the teachers in primary schools are female (Department for Education, 2008) – which means that I would have at most had one male teacher in any case. However none of the schools that I chose had male Year One teachers, making it impossible for me to ensure that the teachers I chose reflected the national gender distribution. Though all the teachers were local to me, I had no prior involvement with any of them in either a professional or a personal capacity.
Consent / participation	The head at each school provided voluntary informed consent on behalf of the school. The teachers' consent was implied by the fact that they chose to be part of the research after understanding all the information mentioned above. The parents of the children were informed of the process and purpose of my research through the systems that each school had in place. As part of this, they were given the option to ask further questions of myself or to withdraw their child at any point, though none of them chose to do so. Before starting the data collection, I ensured that I had adhered to all the guidelines for voluntary informed consent laid out by the British Educational Research Association (2004).
Incentives	There were no incentives offered to any of the participants (schools, teachers, children or parents).
Privacy	Privacy was upheld throughout the process by ensuring the following: • schools were not aware of which other schools were taking part; • teachers were not aware which other teachers outside of their school were taking part; • as part of the initial discussion with the teachers, they were informed that any personal information that they revealed would not form part of the study without their consent; • names of schools, teachers and children were anonymised throughout to ensure that no data could be linked back to an institution or an

Ethical issue	Discussion
	individual; • teachers reviewed all the raw data to ensure that the children's and their privacy was maintained; • the data in its raw form (i.e. the transcripts) were only stored on my home computer which no one else could access.
Impact of participation	As the dominant tool for data collection was the recording of lessons by the teacher wearing a small recording device, it did not impede on their ability to teach or carry out any other classroom activities. Since I was interested in the entire class rather than any particular group of children within the class, there was no impact on the children in terms of any bias towards any particular group.
Disclosure	I established from the outset that information collected in the classroom would not be shared with anyone else not connected to that class (including other teachers from the same school irrespective of whether they were participating in my research or not), unless something occurred that needed to be addressed in relation to issues of child protection or any other criminal reasons. It was agreed in discussion that I would only use the data for the purposes of my research.
Observation	My role as a participant or non-participant is addressed in detail in Section 4.2.3.
Transcribing	Transcriptions were made as accurately as possible. This was enhanced by getting the teachers to review the transcripts for accuracy.
Other data	All of this data were similarly anonymised, and were shared with the teachers in discussions.

5 ANALYSIS METHODOLOGY

5.1 Introduction

The focus of this chapter is the exploration, evaluation and explanation underpinning the selection of a methodology for analysing the qualitative data gathered for this thesis. In the previous chapter, I have described how these data were gathered and recorded. The debate now revolves around how to make sense of the vast quantity of qualitative data generated in order to address my research question. The initial prompt for my research question was my own experience in the classroom and the desire to understand why there were such variations in children's ability to perform a range of mathematical tasks. What accounts for the wide variety of differences when, at first sight, children have so much in common which should lead to a smaller degree of variation in their mathematical abilities, especially in the current homogeneous nature of schools and the curriculum that they deliver? The overall aim of this chapter is to select a methodology by which my data can be analysed. The steps taken to select the methodology must be described explicitly so that they can be scrutinised and the outcome is transparent. Vitally, the selected methodology must filter through pertinent information without losing any context of the classroom where children are working in their natural environment.

The methodology used for analysis should assist in developing a comprehensive understanding of prior knowledge. It is crucial to the shape, strength and value of this thesis that any methodology used for analysing the data is rigorous enough to give an accurate picture and understanding of all the nuances that may exist in prior knowledge. This is analogous to doing a chemical analysis of DNA – I want to define not only the key components of prior knowledge, but also the structures of these components and how they work together in a learning situation.

As considered in Chapter 4, the data were gathered through recording teachers while working with a class. The recordings formed naturalistic transcripts of what was picked up by the teacher while in a mathematics lesson. The transcripts are what the teachers would have also heard from their interaction with the children. It is important to understand that this data gathering method does not give a complete picture of any one child, nor does it offer a before-and-after idea of the ability of the children. The decision to not follow such a scientific process in a controlled environment is an intentional omission. I want to be able to develop a model of prior knowledge within a realistic environment and from the teacher's perspective. It is not the concern of this thesis to consider the effect that prior knowledge has on mathematical ability – just to define it. It is the situated nature of the data which will make it most relevant to defining prior knowledge and being able to apply it within the classroom context. Using what the teacher can hear in children's conversations not only gives the teacher's perspective, but also allows us to notice what the children choose to share and bring to their learning of mathematics. Thus using the scientific research paradigm would not have allowed for any understanding of how prior knowledge manifests itself in the classroom environment. This firmly places my research within the qualitative research paradigm. Qualitative research is "somewhat difficult to define, as specific practice that covers a variety of studies" (Wiersma & Jurs, 2005, p. 13).

There is overall agreement within the education community that qualitative data takes a whole range of shapes. Essentially it comprises information that is not numerical information in its raw form. Therefore it is any data generated as a result of interviews, observations or written text. It is noteworthy that each of these data gathering methods can also produce quantitative data. However they are predominantly used to understand everyday phenomena as a result of human behaviour, and to address not just what is happening, but more crucially how. These approaches all offer a deeper understanding of a microcosm of human behaviour. The key need that qualitative data address is the need to understand human behaviour in minute detail and to formulate theories or models to address the observations gathered. The complexity which the data generated bring makes it essential to consider how best to analyse and understand what the data are trying to express. It does not measure but merely describes, and once analysed, attempts to define the nature of human behaviour, in this case prior knowledge.

The ethnomethodology implemented for data gathering, while being well-suited to understanding the everyday behaviour of children in the contextual sense, leads to "massive volumes of data typical of qualitative research" (Dey, 1993, p. 86).

It is essential to note that such complex, interlinked and varied data in their raw state "won't speak for themselves if left in the form in which you collect them … these raw data do not constitute the findings of the research” (Ryan, 2006, p. 92).

Therefore it is essential to analyse the data to deal with the enormity of the information presented in its raw form. In order to understand how best to do the analysis, this chapter will consider what methodologies are available for analysing the data. The selected methodology will allow me to see what emerges from the mass of information. There must be a substantial process of scrutiny and assessment of the methodologies available.

Therefore this chapter will contain:

1. Criteria for selecting the analysis methodology
2. Exploration and evaluation of possible analysis methodologies
3. Selection of analysis methodology
4. A worked example of the analysis process

5.2 Criteria for Selecting the Analysis Methodology

> The purpose of data analysis is to translate the evidence into a form which allows the researcher to make clear and concise statements of description and/or association.
>
> (Anderson & Burns, 1989, p. 200)

The selected analysis methodology must:

- be suitable for the type of data gathered;

- provide the framework for understanding the data in relation to the questions asked;
- also establish a solid evidence base linking the understanding to the source data;
- address what counts as evidence;
- supporting following for the raw data;.

> organizing them, breaking them into manageable units, coding them, synthesizing them, and searching for patterns
>
> (Bogdan & Biklen, 2007, p. 159)

- support all three generic stages of the data analysis and model generation process;

> data reduction, data display, and conclusion drawing and verification
>
> (Miles & Huberman, 1994, p. 10-11)

- allow for the exploration of ideas for categorising the data allowing for the emergence of any relationships between categories;
- enable key themes to emerge from these categories in a transparent manner without changing the true nature and meaning of the data collected;
- be robust enough for reanalysis and refinement of categories and themes;
- allow for understanding of the interpretations and assumptions made of the raw data;
- allow for choices to be made about what data can be omitted and why;

- allow a refined narrative of how and why the analysis was performed and further allow understanding of the resultant model or theory;
- allow consideration to be given to the ethics of the data analysis process.

There is much demand on this process for finding an answer from the information gathered. Therefore the methodology "requires that the data be organised, scrutinised, selected, described, theorised, interpreted, discussed and presented to a readership" (Ryan, 2006, p. 95) and understanding that the information needs to provide coherence, consensus and validity to the raw data collected. Thus the analysis methodology must be selected with care, and the outcomes of the analysis must be explained in detail with a transparent trail back to the raw data which can then offer a simple narrative to support the outcomes.

The criteria above make the choice of methodology easier in many ways. From the start of the research process, the nature of the question and the subsequent data gathering methods involved place this study firmly in the naturalistic / ethnomethodological realms of research. Therefore statistical methods, which are valuable for quantitative data, offer little benefit and will not be considered.

> The special task of the social scientist in each generation is to pin down the contemporary facts. Beyond that, he shares with the humanistic scholar and the artist in the effort to gain insight into contemporary relationships
>
> (Cronbach, 1975, p. 126)

> Where quantitative researchers seek causal determination, prediction, and generalization of findings, qualitative researchers seek instead illumination, understanding, and extrapolation to similar situations. Qualitative analysis results in a different type of knowledge than does quantitative inquiry.
>
> (Hoepfl, 1997, p. 48)

The nature of the data gathered and the subsequent process of analysis will result in this *different type of knowledge* being gained, filling the gaps identified in the literature in Chapter 2 and leading to an understanding of prior knowledge.

5.3 Exploration and Evaluation of Possible Analysis Methodologies

There are many methodologies for the analysis of qualitative data such as hermeneutical analysis, domain analysis, typological analysis, analytic induction, content analysis, phenomenological / heuristic analysis, metaphoric analysis, and grounded theory. These methodologies have a lot to offer to the process of understanding the everyday behaviour of individuals. I will be considering some of these methodologies with the criteria presented in Section 5.2. There are no quantitative data to consider.

> Qualitative research: research that describes phenomena in words instead of numbers or measures.
>
> (Krathwohl, 1993, p. 740)

In my case, it is based in a naturalistic paradigm. Therefore analysis requires a lot of consistent interpretation of the evidence presented. It is worth looking at how the various qualitative methodologies work, and considering if they meet the criteria outlined earlier.

5.3.1 Hermeneutical Analysis

Hermeneutical analysis is the art of interpretation, more so interpretation of text and language.

> It seeks to understand situations through the eye of participants … Hermeneutical analysis involves recapturing the meanings of interacting others, recovering and reconstructing the intentions of the other actors in a situation.
>
> (Cohen et al., 2001, p. 29)

That is to say, looking at language to explicitly express what the meaning behind the text really is "rather than the phenomena" (Cohen et al., 2001, p. 29).

Although hermeneutical analysis developed from the analysis of ancient scriptures and other historical legal documentation, it has been developed by Dilthey, Gadamer and others (Cohen et al., 2001) into a general theory of human understanding through the use of literary text.

The process of analysing texts takes into account the context not only of the author, but also of the text itself considering historical, cultural and philosophical contexts to allow interpretation of meanings, meanings that allow fundamental understanding to be developed about human nature. This process of analysis does not aim to generalise but, in some sense, merely report literally what is written and its intent as a way of understanding human nature.

This method places restrictions upon how my data can be understood.

> A social science that restricted itself to hermeneutic interpretation would be radically incomplete. It would exclude from the scope of social science research the whole range of causal relationships and structural influences on action.
>
> (Little, 2008)

Therefore this methodology would not allow for the identification of any patterns, and hence the formulation of categories from analysing data. Consequently there would be no understanding of the interrelationships between categories, if any. As a result, this methodology does not meet the selection criteria outlined earlier.

However this methodology has something to offer in the way of understanding my data. The transcriptions I have, which are written text, are not truly literary but are mere written representation of the spoken word. They do allow the slowing down of speech and the ability to consider and reconsider how what was said explains the variation in mathematical ability. The methodology raises awareness of the continuous attention that must be given to the layers that make up the analysis of the text in order to extrapolate meaning and intent. The layers – social, historical, cultural, time and place of writing – are important to consider when analysing other data which are not in the form of text. Furthermore consideration needs to be given to the context not only of the text, but also of the author and the reader. Understanding the interplay between these three elements is vital when using this form of analysis. While considering my transcription data, similar issues and layers must be understood. The elements – children, teacher, classroom and researcher – each have their own context which will influence the outcome.

5.3.2 Domain Analysis

As stated earlier, essentially all methods for analysing qualitative data are concerned with organising and sorting the vast volume of information generated by observations and interviews into an understandable and applicable format. Domain analysis is one such approach. Spradley (1979), the prominent author of *The Ethnographic Interview*, looks at how to understand the linguistic ideas expressed by individuals and put them into manageable chunks which allow researchers to describe social situations and cultural patterns that may be within these ideas. This understanding, as Spradley (1979) sees it, can be gained through categorising the data through the lens of predefined semantic relationships which allow me to sort the ideas into categories, and then further sort these categories into domains. Spradley (1979) states, "A domain is any symbolic category that includes other categories" (p. 100).

In some ways, it is similar to the process that botanists may use to sort the wide variety of plants. There is an overall predetermined domain e.g. evergreens. Within this domain, there are several smaller groups of plants which are grouped into categories for their common features and other similar properties. This form of sorting allows several key things to happen. Firstly, it makes the comprehension of the data gathered easier, as it allows for critically understanding the nature of the data. Secondly, it allows for consideration to be given to the relationship, if any, between each individual category. Lastly, it allows descriptions to be developed in relation to the domain. For this method to work, it relies on the researcher's ability to sort the data using the nine predetermined semantic relationships defined by Spradley (1979).

> The basic idea behind creating domains is to find categories by reading the data with specific semantic relationships in mind.
>
> (Hatch, 2002, p. 166)

Spradley (1979) offers steps to help with the process of creating domains. However domain analysis is limited in supporting understanding of my data as they can only be sorted by the use of semantic relationships which in themselves are linear. This in itself is not an issue in understanding any data, however in the case of my research, it does not provide a way of sorting the data without considering any relationship. It presupposes that there will be some relationship between domains which follows a set pattern, thus making no provision for simply sorting the data and allowing relationships to emerge. Furthermore this approach assumes that once a relationship has been established within the domains, these relationships cannot be changed and are constant. E.g. a fir tree is a type of evergreen, and through the use of domain analysis, it cannot be categorised as any other. There is much to be learnt from the nine relationships that Spradley (1979) defines as a starting point to considering the data gathered. However it does not allow for the complex ever-changing nature of human behaviour to be understood and presumes that reality exists in nature waiting to be discovered (Hatch, 2002). Hence domain analysis alone will not provide the answer to my question. There needs to be further support from other processes which will allow the clarity needed from the complex data set. It is not enough to use the process of sorting and categorising, there needs to be greater understanding of the interplay between domains and further steps may need to be taken to establish that.

5.3.3 Typological Analysis

This method requires the processing and classifying of data. LeCompte and Preissle (1993) defined the process as "dividing everything observed into groups or categories on the basis of some canon for disaggregating the whole phenomenon under study" (p. 257).

The approach towards the data is quite different when carrying out typological analysis. The data set is split into broad predetermined exhaustive categories, in contrast to domain analysis which is more inductive in nature. Typological analysis already presumes a theory / research objective / an idea of what the data may show. In order to use this method of analysis, the first step is the identification of a typology.

> If typological analysis is the appropriate data analysis strategy for a study, the selection of typologies should be fairly obvious as well.
>
> (Hatch, 2002, p. 152)

In relation to my data, on first consideration, there are no obvious typologies which can be identified. Therefore it makes the use of this method difficult. Also having looked at the data, it is of little help to set out with preconceived ideas of what the patterns are, as that is the essence of the questions being asked. There is little to be gained by using this process as the thesis, in some ways, is asking for a typology of prior knowledge to be developed. Therefore the use of this deductive approach is not a natural fit to the demands of my data.

> Typological analysis only has utility when initial groupings of data and beginning categories for analysis are easy to identify and justify.
>
> (Hatch, 2002, p. 152)

This is not the case in my research. However it is important to consider if this approach has anything to offer. The deductive nature of the methodology expects there to be stronger understanding not only of the data, but also of the behaviour being studied and the formulation of generalised rules which will allow me to understand the data collected. It is these overall predetermined exhaustive categories which allow the mass of data to be processed and some sense to be made of what the information gathered is trying to tell us.

For this research, the process is reversed and is, in part, inductive in that it is hoped that through looking at the data, some categories should start to emerge and then the rest of the data can be put through the filters of the emergent categories to allow testing for validity. Mouly (1978) suggests that there is a relationship between inductive and deductive which is interdependent. It is this

> back-and-forth movement in which the investigator first operates inductively from observations to hypotheses, and then deductively from the hypotheses to their implications in order to check their validity from

> the standpoint of compatibility with accepted knowledge.
>
> (Mouly, 1978, p. 5)

Though in its purest form typological analysis will draw a dead end in understanding my data, it does prompt the need to categorise which will allow all the data to be sorted into more manageable chunks and tested for robustness against the whole of my data.

> The primary strength of typological analysis is its efficiency. Starting with predetermined typologies takes much less time than "discovering" categories inductively. The potential weakness is that applying predetermined categories will blind the researcher to other important dimensions of the data.
>
> (Hatch, 2002, p. 161)

5.3.4 Analytic Induction

The key proponents of this methodology – Znaniceki, Howard, and Katz – offer steps in understanding the data, and also using the data analysis process systematically to formulate a theoretical basis for the phenomena being examined.

In order to carry out analytic induction, it is necessary to consider some of the other approaches available to organise and review the vast quantity of qualitative data. The process of analytic induction allows me to test the strength of the partial model developed. LeCompte and Preissle (1993) suggest that data must be filtered to create manageable categories, and the categories must be examined to see how they relate to each other. Many of the methods discussed in this chapter e.g. domain analysis, can be used to get to this point. Essentially it is this sorting, categorising and grouping which holds the key to understanding the data and what they have to tell us. Denzin (1989) goes further to recommend that it is not merely enough to categorise and filter the data to get to a model, but the researcher also needs to examine what does not quite fit with the overall model. Any data that do not follow a particular pattern must force the reformulation of the categories. The process of analytic induction encourages deliberate seeking of disconfirming cases (Bogdan & Biklen, 2007). It is this search for disconfirming cases and consequent re-examination of the data that will ensure robust applicability and accuracy of the model which is generated.

Therefore analytic induction is not a mechanism for categorising or organising data, but is the next step in ensuring that the data are presented and evaluated thoroughly. The process focuses on using disconfirming data to enhance the robustness of the model which makes this a good second step in the process of analysing my data. However, as an overall method for analysis, it does not support one of my criteria for selecting the analysis methodology.

- supporting following for the raw data;.

> organizing them, breaking them into manageable units, coding them, synthesizing them, and searching for patterns
>
> (Bogdan & Biklen, 2007, p. 159)

The question still remains – what is the best tool for organising the complex data collected? So far only domain analysis and typological analysis have offered some methodological support to categorise the data. However they have not fulfilled the criteria set out for choosing an analysis methodology.

5.3.5 Content Analysis

The process of content analysis is predominantly concerned with looking at the content of written text or people's speech in various media.

> Research using qualitative content analysis focuses on the characteristics of language as communication with attention to the content or contextual meaning of the text.
>
> (Hsieh & Shannon, 2005, p. 1278)

The main idea in this type of analysis is to define and measure carefully the content in order to allow categories to be determined. In the case of my research, the text is in the form of transcripts and observation notes which allow slowing of speech down in order to examine it in more detail.

> Content analysis itself has been defined as a multipurpose research method developed specifically for investigating a broad spectrum of problems in which the content of communication serves as a basis of inference.
>
> (Cohen et al., 2001, p. 164)

Rosengren (1981) gives a broader definition, "Content analysis describes a family of analytic approaches ranging from impressionistic, intuitive, interpretive analyses to systematic, strict textual analyses" (Hsieh & Shannon, 2005, p. 1277).

It is this ability to explore a broad spectrum of problems which makes this method suitable for dealing with qualitative data. There is much to be gained by the flexibility this approach has to offer. Hsieh and Shannon (2005) have identified "three distinct approaches: conventional, directed, or summative" (p. 1277).

Conventional approach starts from observations; direct approach starts with a pre-formulated theory; and summative approach starts with predetermined keywords for categorising the data. Weber (1990) states that, "Investigators must judge what methods are appropriate for their substantive problems" (p. 69).

The conventional approach is most suitable for my research, as it starts by considering the observations, and then coding and defining these observations through the analysis process. However Hsieh and Shannon (2005) have identified that "the conventional approach to content analysis is limited in both theory development and description of the lived experience, because both sampling and analysis procedures make the theoretical relationship between concepts difficult to infer from findings" (p. 1281).

Content analysis does have something to offer in terms of understanding the phenomenon of prior knowledge. However its lack of ability to support formulations of links between concepts is a major shortfall. When considering the data through the lens of conventional content analysis, it allows for understanding the data in a literal form, but provides no ability for formulating a deeper understanding of how the data may be connected. However, as an overall method for analysis, it does not support one of my criteria for selecting the method of analysis.

- allow for the exploration of ideas for categorising the data allowing for the emergence of any relationships between categories;

which is crucial to understanding any phenomena being observed.

5.3.6 Phenomenological Analysis

> Phenomenology asks, "What is this kind of experience like?", "What does the experience mean", "How does the lived world present itself to me (or to my participant)?"
>
> (Finlay, 2008)

The study of how we experience our world, phenomenological analysis stresses "the careful description of phenomena from the perspective of those who experience the phenomena" (Wiersma & Jurs, 2005, p. 243).

There is an intense need to understand how/why everyday actions/behaviour occur. Burrell and Morgan (1979) wanted to question "the 'taken for granted' assumptions of everyday life" (p. 193). Phenomenological analysis approach offers a methodology for understanding the deep-rooted meanings which individuals place on the world around them. The difficulties for the researcher in understanding the real world is how to extract understanding from observations, interviews and other methods used to gather information on the world that surrounds us. There are multiple layers of complex actions and reactions within different contexts, with the added variable of the researcher's own experiences and context make this simple need to understand the everyday one of the most complex processes. It is not the place of this section to consider the methods for the collection of data using the phenomenological methodology as this has been covered in Chapter 4. Here I need to consider how to understand from this data what is going on in this everyday experience being examined. How to go from capture of information through various methods to understanding the phenomena? The process of analysis is dependent on the key premise that "phenomena should be studied without preconceived notions" (Hatch, 2002, p. 29).

Husserl termed this practice as bracketing which "means holding a phenomenon up for inspection while suspending presuppositions and avoiding interpretations" (Hatch, 2002, p. 86).

> Bracketing requires that we become aware of our own assumptions, feelings, and preconceptions, and then, that we strive to put them aside – to bracket them – in order to be open and receptive to what we attempting to understand.
>
> (Ely et al., 1991, p. 50)

The key idea being that the phenomena is able "to present itself to us instead of us imposing preconceived ideas on it. This openness needs to be maintained throughout the entire research process, not just at the start." (Finlay, 2008).

Therefore the process of analysis is based on an inductive school of thought, looking at what the data relay about each individual and their experience while being observed. The process of understanding this type of data involves some level of interpretation on behalf of the researcher, and also the need to understand how to organise the mass of data collected. In order to gain understanding of the data, it is possible to use both inductive/deductive methodology to establish understanding. The methods for organising the data can also vary depending on the nature of the question being asked. However it must be noted that any analysis, organising and reporting of the data is carried out with the key principle of detachment from the situation.

This form of analysis creates a difficult paradox for the researcher, one where there is the need for interpretation, but in order to interpret there is some degree of personal experience involved in the process. It is worth considering the nature, method and process of interpretation which will be made in order to carry out this analysis. Clearly interpretation is making sense of the observation data collected. In order to carry out any interpretation, there will need to be some explanation for what is going on within the situation being observed (Hatch, 2002). The researcher is central to this process of understanding and explaining what is being observed. Therein lies the contradiction – the phenomenological analysis process requires that the data are allowed to reveal themselves, but this cannot take place without interpretation from the researcher. The way to meet the complex need for complete detachment is to clarify, as part of the process of analysis, what the individual researcher's context is in order to allow the data to then be understood with this in mind. The researcher must play this balancing act between being objective and acting as a mere lens for the data to be understood through and the need to make sense of what is being seen. The approach for this analysis therefore must again start with a clear question which is being asked of the data and consider all possible outcomes using a systematic methodology for going through the observations.

In relation to my research this approach goes some way to allow understanding and analysis of data. There needs to be greater structure and this is not provided by this approach.

5.3.7 Metaphor Analysis

Metaphor analysis offers a creative dimension to understanding and filling the possible shortfall identified by some of the analysis methodologies, that of understanding the complex relationships between categories. As a researcher, a key outcome is to form some clarity in understanding of the phenomenon being observed, and also formulate some conceptual understanding that can be simplified and shared by others. The use of metaphors within language offers the mechanism for this simplification and conceptualisation to occur seamlessly.

Cameron (2003), in her research, identifies the value of searching for metaphors as the core approach for understanding how people think – the metaphors that people use can reveal something of their ideas. This key notion drives metaphor analysis and offers a possible process for understanding prior knowledge. The steps in metaphor analysis are similar to that of many of the others considered so far – locating the data, identifying key ideas (in this case, identification of metaphors as a unit of data), organising metaphors into categories, and finding patterns. The identification of these metaphors are directly from the qualitative data generated.

On the face of it, this seems to be a valuable tool for gaining insight into the thinking of individuals, and therefore perfect for in-depth understanding of prior knowledge of individuals. The underlying assumption of this approach is that all individuals use metaphors in their dialogue and speech. This in itself is a problematic assumption as it is not always the case. Furthermore if the process of analysis only looks for metaphors as a way of understanding any of these phenomena, then there is a significant possibility that some pivotal ideas may be missed.

The other more pertinent issue for my research is dependent on the pure nature of a metaphor. Metaphors are complex linguistic tools which are developed by individuals through experiences of the world linked to sophisticated development of language and vocabulary. E.g. to use / understand what is meant by the metaphor "life is a journey" (a metaphor examined by Lakoff and Johnson (2003) in their work on metaphor analysis), there are many layers of complexities which are only understood through experiences which most children, due to their age, do not have. Figure 5.1 depicts some of the conceptual notions which must be grasped before one can understand this metaphor and gain its true meaning and appropriate application. There needs to be a vast amount of other knowledge and experience which will not be present in children. Therefore to expect them to speak in such a complex manner is misguided. Thus this approach has little to offer in terms of a tool for analysis of my data.

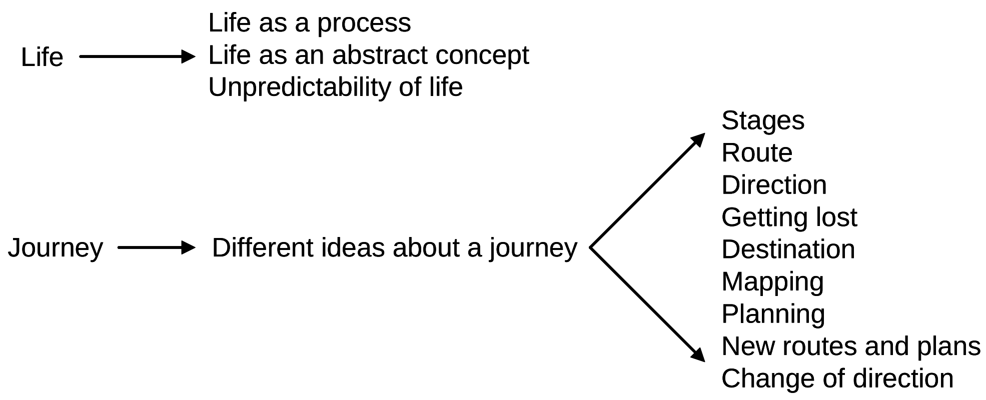

Figure 5.1 Breakdown of *life is a journey* metaphor

However I do feel that it is by the use of metaphors that we can explain the ideas found in the data. Also it allows some strong images to be formed by readers which tap into their experiences in order to allow true individual understanding of my research to be formed. LeCompte and Preissle (1993) argue strongly for the value of metaphor, simile and analysis as a vehicle for exploring and explaining ideas presented in the data.

Though the tool of metaphor analysis is not one which provides me any value, the debate has allowed the emergence of a tool to aid the description of the prior knowledge model.

5.3.8 Grounded Theory

Grounded theory is the most well known methodology for collection and analysis of qualitative data. Its mass use in understanding qualitative data provides me with many benefits, one of these being that there is much support in literature for its implementation. On the other hand, this popularity means that there are many interpretations of the same theory.

These interpretations and variations make it very difficult to ensure that the process being used is essentially as intended by the core ideas provided by the initial theory.

Glaser and Strauss' (1967) seminal work defines grounded theory as "the discovery of theory from data systematically obtained from social research" (p. 2).

The aim of grounded theory is to consider the observations made and to use them to explain or answer the questions posed by the researcher which firmly places this methodology in the inductive paradigm for understanding the world around us. The methodology aims to develop a theory which meets four pivotal criteria – fit, understanding, generality and control (Strauss & Corbin, 1990). The essence of grounded theory is to try and make sense of the world in a systematic manner. In order to gain a complete understanding of the meaning of grounded theory, I must consider the meaning of theory.

> Theory in sociology is a strategy for handling data in research, providing modes of conceptualization for describing and explaining.
>
> (Glaser & Strauss, 1967, p. 3)

Theory is a comprehensive explanation of the phenomenon being observed. This, in terms of grounded theory, is derived from the data itself. In grounded theory, the role of the researcher is quite different compared to the other analysis methodologies. The use of grounded theory demands that the researcher is open minded with no preconceived ideas, but has skills in the area being studied. Glaser and Strauss (1967) define this characteristic as being "theoretically sensitive" (p. 46). It is through this ability to be theoretically sensitive that discoveries or understanding can not only emerge but also be recognised and developed. Central to grounded theory is the maxim that the data shines a path to the answer and understanding of the phenomena.

There are many stages to carrying out grounded theory. At this point the methodology parts into different directions. The original process proposed by Glaser and Strauss (1967) was modified further by Strauss and Corbin (1990) resulting in two different approaches to grounded theory. There are some key philosophical differences, summarised in Table 5.1.

Table 5.1 Key differences in grounded theory approaches (Onions, 2006, p. 8-9)

Glaserian	**Straussian**
Beginning with general wonderment (an empty mind)	Having a general idea of where to begin
Emerging theory, with neutral questions	Forcing the theory, with structured questions
Development of a conceptual theory	Conceptual description (description of situations)
Theoretical sensitivity (the ability to perceive variables and relationships) comes from immersion in the data	Theoretical sensitivity comes from methods and tools
The theory is grounded in the data	The theory is interpreted by an observer
The credibility of the theory, or verification, is derived from its grounding in the data	The credibility of the theory comes from the rigour of the method
A basic social process should be identified	Basic social processes need not be identified
The researcher is passive,	The researcher is active

Glaserian	**Straussian**
exhibiting disciplined restraint	
Data reveal the theory	Data are structured to reveal the theory
Coding is less rigorous, a constant comparison of incident to incident, with neutral questions and categories and properties evolving. Take care not to 'over-conceptualise', identify key points	Coding is more rigorous and defined by technique. The nature of making comparisons varies with the coding technique. Labels are carefully crafted at the time. Codes are derived from 'micro-analysis which consists of analysis data word-by-word'
Two coding phases or types, simple (fracture the data then conceptually group it) and substantive (open or selective, to produce categories and properties)	Three types of coding, open (identifying, naming, categorising and describing phenomena), axial (the process of relating codes to each other) and selective (choosing a core category and relating other categories to that)
Regarded by some as the only 'true' grounded theory method	Regarded by some as a form of qualitative data analysis

Considering the synthesis presented in the table above, the Straussian approach does not meet my criteria as it does not allow, due to the coding paradigm it prescribes, the pure emergence of categories. There is presupposition of what the data are going to show. The researcher is already charged with some clear idea of what the coding structure will entail. This does not allow for creativity in the discoveries made.

The best way to understand the minute but key difference between the two approaches is to consider the role creativity plays in allowing the emergence of theory. Looking at Karl Duncker's (1945) candle problem helps to distinguish the differences. You are presented with a candle, a box of matches and a box of drawing pins, and are asked to place the candle on the wall. At first, you may use the drawing pins to try and fix the candle to the wall, or melt the candle via the matches, and eventually you may come up with a better solution which is to empty the box of drawing pins, fix the box to the wall and place the candle in the box. In the Glaserian approach, there is no clear starting point and many possibilities are explored until a solution is found. In the Straussian approach, the problem is presented with the drawing pins already outside the box, and with you already having some idea that the box may hold the solution to the problem, thus reducing the need to try many possibilities as an answer is obvious. This reduces creativity as it focuses the researcher on one way of thinking which may prevent the true discovery of theory. Also it depends on the researcher already having formulated some ideas about the end outcome, maybe through reviewing the literature.

In the Straussian approach, there is less freedom to be creative and to really allow the data to say *their own narrative*. On the other hand, the Glaserian approach is less structured and allows the researcher to be led by the narrative from the data. It assumes that the researcher has some knowledge or skills to consider and understand the content, but no idea of how to formulate a theory which will explain the question being asked. The researcher will discover the answer by using the constant comparison method, unrestricted by what has been learnt before and being only led by the data.

> The main intellectual tool is comparison. The method of comparing and contrasting is used for practically all intellectual tasks during analysis: forming categories, establishing the boundaries of the categories, assigning the segments to categories, summarizing the content of each

> category, finding negative evidence, etc. The goal is to discern conceptual similarities, to refine the discriminative power of categories, and to discover patterns.
>
> (Tesch, 1990, p. 96)

5.4 Selection of Analysis Methodology

So far, I have considered eight methodologies which fall into deductive or inductive processes for understanding any phenomena. It is worth noting that I have not considered all possible qualitative analysis methodologies e.g. matrix analysis, event analysis, discourse analysis, semiotic analysis, narrative analysis, and many others. It is of little value to consider these methodologies as they are not extending the tools already on offer, but are merely providing a different starting point for analysis, a different way to consider the same data or are not applicable to my data.

The eight methodologies reveal the complexity of understanding qualitative data. The common theme throughout all these analysis methodologies is a set of generic stages for analysis. All the methodologies advocate some form of collection, sorting, categorising, making links between categories, leading to the outcome. However not all methodologies provide adequate tools for all these stages.

> The collection of qualitative data in evaluation is common. However, knowledge about strategies for efficient and defendable procedures for analyzing qualitative data is less common.
>
> (Thomas, 2006, p. 237)

Hence no single methodology will enable me to answer my research question. This leads me to conclude that I need to use a blended approach in the selection of analysis methodologies. If I accept the generic stages for analysis together with the criteria for selecting the analysis methodology (Section 5.2), then the eight methodologies are sufficient for selecting and defining the blended approach.

Therefore I have selected Glaserian Grounded Theory together with content analysis as the way to sort and categorise my data, identify links between categories and answer my research question. These two methodologies together meet the criteria set for selecting the analysis methodology. Grounded theory supports the generic stages for analysis, and content analysis supports the coding process by enabling the constant comparison of data in order to fulfil the grounded theory approach.

5.5 Worked Examples of the Analysis Process

In this section I am going to illustrate, through extracts from my transcripts, how I have used the blended approach of content analysis and grounded theory to analyse my data to answer my research question. I have used grounded theory as the framework for the analysis and content analysis to understand the meaning of each transcript so that the resulting interpretations may be organised using the framework of grounded theory. I have made no attempt to give the final outcome as it is the focus of the next chapter.

This section is very procedural and descriptive. Alongside the process, I have explained some of the choices I have made in interpreting my data.

In line with Glaserian grounded theory, choices have been led by the data and the direction that these choices have taken. The detailed description of the analysis process ensures that it is completely transparent and clear in how the outcome is established, as being transparent will set the context for the model being proposed. Furthermore this enables reproducibility and applicability in a wider variety of contexts, or in grounded theory terms – generality. Most importantly, going through the steps taken and using actual data helps to tell the all-important narrative of the research process.

The central premise of Glaserian grounded theory is that there is no theory to verify, but for the researcher to be "generating grounded theory is a way of arriving at a theory suited to its supposed uses" (Glaser & Strauss, 1967, p. 3).

The starting point is not from any *a priori* assumptions. The blended approach forces me to take a step back and look at prior knowledge *de novo* and not be influenced by any meaning of prior knowledge pre-established due to the common use of this term.

Figure 5.2 is a diagrammatic representation of my analysis process and how it fits in with the data collection.

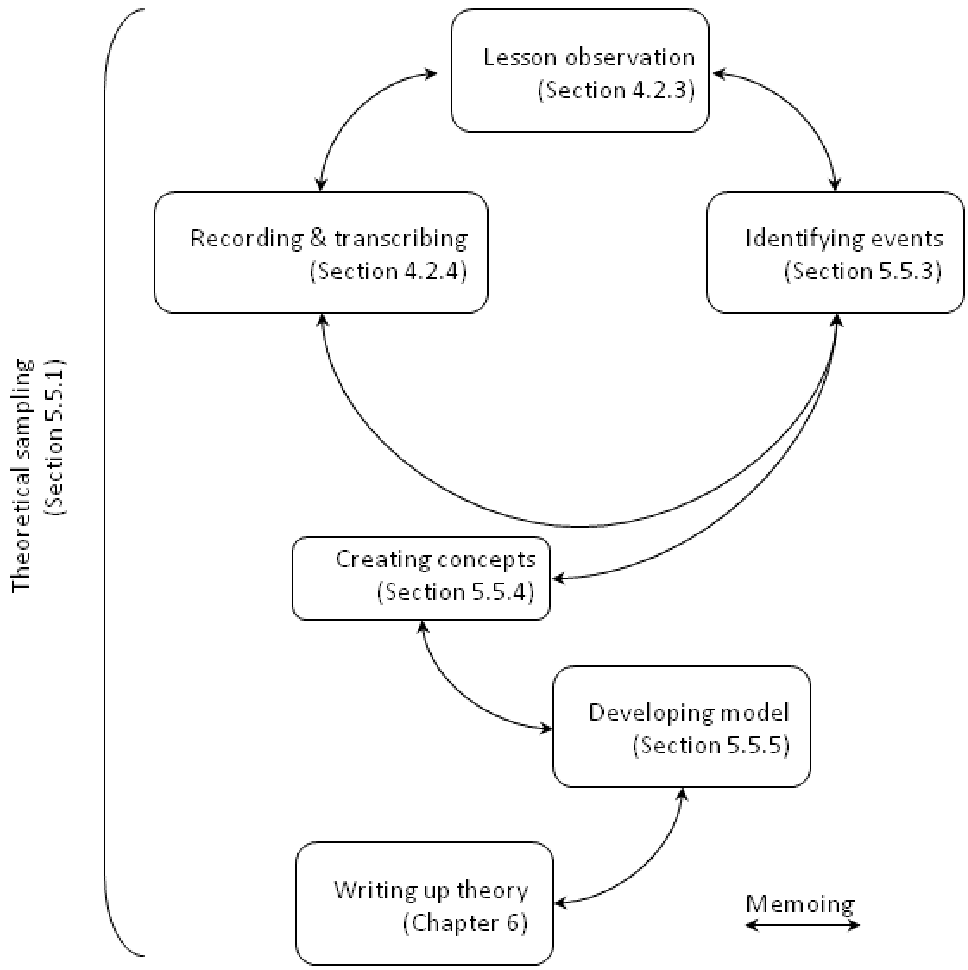

Figure 5.2 Data collection and analysis process

5.5.1 Theoretical Sampling

As discussed, grounded theory is an open-ended analysis process and can be implemented in many different ways. Grounded theory states that analysis starts from data collection, as the data being gathered are continuously interpreted by the researcher and shape the choices made for further data collection and analysis. Glaser and Strauss (1967) term this process as theoretical sampling.

> Theoretical sampling is the process of data collection for generating theory whereby the analyst jointly collects, codes, and analyzes his data and decides what data to collect next and

> where to find them, in order to develop his theory as it emerges.
>
> (Glaser & Strauss, 1967, p. 45)

Theoretical sampling allows the researcher to be creative and question the data as they are gathered to arrive at a comprehensive understanding. Therefore theoretical sampling can be seen as a method for formulating live instructions for data collection; a guide for the direction to be taken to ensure that the most suitable data is collected. This method of constant analysis is in tune with how I develop my thinking. As a researcher, it is impossible to gather data and not to start letting them influence my views and understanding which in turn affects my data collection. The analysis revealed the need for immediacy in shaping the data collection. Without the responsive nature of theoretical sampling, I would be left with a static understanding of a constantly changing phenomenon.

Theoretical sampling is a very organic and evolutionary process which enhances and allows for magnification and analysis of data. The actual data collection mechanism has been described elsewhere (Chapter 4) and will not be described here again. Instead, I will focus on the key stages of identifying events, concept development and categorising before the ultimate stage of theory production, and how these stages influence and nurture the overall data collection and theory development. When using theoretical sampling, the overall data collection is determined as the process is carried out. Therefore there is no indication from the outset as to what the data set will look like and how much data will be needed. Only the analysis will determine what is gained from the data and whether more data are needed.

5.5.2 Analysis

Before seeing worked examples of my analysis, it is essential to define the key terms used during the analysis process.

Events	These are all incidents within lessons in which children are engaging in mathematics. They are not labelled or defined. They are just the identification of possible areas of interest in terms of helping develop an understanding of prior knowledge.
Concepts	These are groups of events which have similar properties and are similar in their function. Therefore any number of events can be grouped to form concepts.
Categories	This is further classification of ideas in order to start to develop an understanding of how the ideas being considered function. Number of concepts may function in a similar manner or may be shaped by a similar force, and therefore form a category. Developing categories may allow me to understand not only how prior knowledge may be structured, but also how it may function and formulate a model of prior knowledge.
Memoing	The annotations made throughout the data collection and analysis to record my thoughts and ideas related to what I was observing or analysing. These formed prompts when later considering events, concepts and formulation of categories.

5.5.3 Identifying Events

In order to analyse the data gathered, the constant comparison methodology with the procedural mechanism of content analysis was used. This allowed each recorded lesson observation to become part of a larger trail of ideas. I started with each lesson observation and transcribed it so that it would become easier to identify events, evaluate and understand what is taking place when children are engaging in mathematics. For me, the process of transcription was the first step in analysis as I was listening to each part of the lesson in great detail. So I tended to use this opportunity to consider the following general questions:

- What is going on in these lessons?
- What are the different situations that present themselves in these lessons?
- What are the children engaged in?
- How are the children managing the mathematics they are being asked to engage in?
- What are the children bringing to each mathematical task to support their understanding?

These questions led to other questions, which in terms of analysis are crucial:

- What are the key events that can help my understanding of prior knowledge?
- Are there any groups or characteristics suggested by the talk taking place within the lesson being considered?

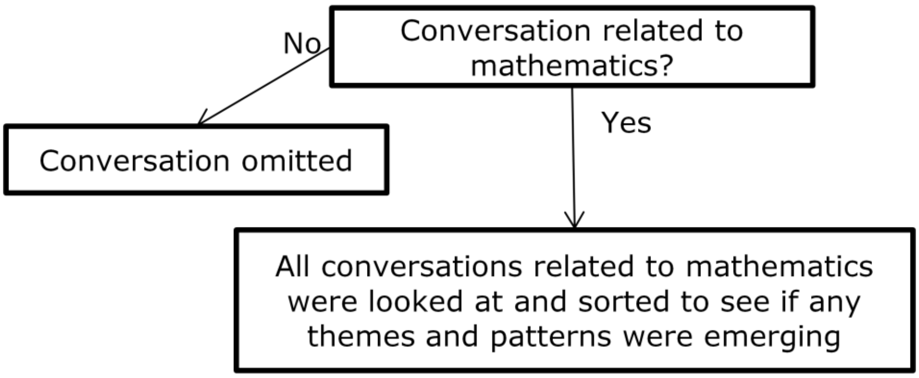

Figure 5.3 Identifying relevant events

The answers to these questions were dependent not only on what was on the audio, but also on me being physically present in the classroom at the time of recording and my notes (memos). The notes prompted and added important context and depth to the analysis. When looking at the data at this stage, I initially sorted the data and started to group them conceptually. The transcripts of the lesson observations allowed me to identify all events that may be relevant to my original question. Figure 5.3 shows the broad grouping at this very early stage of analysis.

I considered in the first instance all events that were related to mathematics which occurred in a lesson. At this early stage there was a mass of data all having some possible connections. The transcript extract below shows the broad nature of the coding at this first stage. I simply highlighted all conversations that had any mathematical content.

Extract from transcript of fifth lesson by Mrs Helen Fellows at Greenville Park Community School

Teacher: Estimate is a good guess … too many, too few, about, less than, more than, roughly, those are the sort of words we might use ok … two games to play today about estimation … ok here is the first one … I have a number in my head it's between five and eleven … ok and to help me remember the words we are going to use I am going to keep the key vocabulary here

Child: I know what it is

Teacher: Put your hand up if you can estimate or have a good guess which number I have got in my head … thinking caps on

Child: Between five and eleven?

Teacher: Correct … ok team Demi?

Child: Umm eight

Teacher: Ohhh less than eight … Wesley?

Child: Seven

Teacher: Spot on … thumbs up to Wesley … ok I am going to close my eyes I've thought of another number … ok it is between five and eleven … and I am going to use this vocabulary to help you work out the number … would you put a teddy in the teddy jar Wesley … that was spot on … ok Angel?

Child: Umm is it five

Teacher: More than … Richard?

Child: Is it six

Teacher: That's too few

Child: I know I know four

Teacher: It's between five and eleven so … too few … Amber ?

Child: Ten

Teacher: Ohhh thumbs to Amber she's earned a teddy in the teddy jar … well done … going to close my eyes ready to do it once more cause you've got this one sussed very good … I am thinking of a number umm right … I've got a number I am a number I am between five

Child: Eleven

Teacher: Five and eleven … that was a very good estimate working it out … ok can you give me a number please … Jenna?

Child: Sixteen

Teacher: Ohhh that's too many cause the top number I've got in my head at the moment is eleven

Child: You can't get bigger

Teacher: Ok this is how we are going to play the game … I'll say too big too small sometimes yes

Child: Is it nine?

Teacher: Toooo many … Dominic?

Child: Eight

Teacher: Umm too many … Melissa good girl for having your hand up

Child: Is it one

Teacher: Too few remember we were stating the lowest number we could have is five and the highest number we could have is eleven … let's choose someone else with their hand up Kya?

Child: Twelve

Teacher: Too many remember the highest number we are talking about at the moment is eleven … Bethany?

Child: Six

Teacher: Spot on good girl put a teddy in the teddy jar … ok

Child: I was going to say that

Child: No you were not

Child: Can we count them

Teacher: We'll count them in a minute … Bethany could you estimate how many teddies we've got in that teddy jar?

Child: Umm twenty

Teacher: You think twenty we'll see at the end of the session thank you very much indeed … right the next game we're going to play is called pick a card

Child: Pick a card

Teacher: Pick a card and I am going to ask Mr Collins to choose someone who is sat beautifully on their bottom and didn't shout out … to come and pick five cards from here

Teaching Assistant: Azaad

Teacher: Well done Azaad … I want five cards ok … come and pick five cards

Child: You're not allowed to look

Teacher: All right ok thank you … pick a card … thank you

Child: You are not allowed to look

Teacher: Shhh no peaking … I'll huff and I'll puff

Child: I can see em

Teacher: There we go ok shhh shhh … (*long pause*) … that one ok … and we need one more … all right that's lovely go and sit down then … we're going to play with only those cards and I'll just show you what is on the other cards … right just to show you we've got spots on the other cards … I'll show you and you are going to guess … estimate how many spots there are … ready … ok how many

Child: Five

Teacher: Oh that means that's too slow I am showing you then … that's dead easy … right again

Child: Ten

Teacher: Ok right … now I am going to show you one of these cards really quickly … and I mean just like (*click*)

Child: That

Teacher: And I want I would like you to estimate how many spots Charlie

Child: It has got

Teacher: It has got … and I am going to write your estimations down on the whiteboard … (*whispers*) … if you have a go at estimating what you do need to do Kya? … (*child puts hand up*) … thumbs up to Kya please … (*stops whispering*) … right … are you ready

Child: I know what it is

Teacher: Haven't shown you yet … right on your bottoms time to

Few children: Look listen and concentrate

Teacher: I think Jenna and Leanne need a bit more help come over here Leanne come and sit by Wesley and Jenna come and sit by Kya cause they are looking and listening brilliantly … quick … right ok you have to look really quickly … and it goes like … that

Child: Four

Teacher: Put your hands up don't shout out … estimate Wesley

Child: Four

Teacher: Ok … ok … Dominic

Child: Four

Teacher: You think four Angel?

Child: Four

Teacher: Four ok

Child: It is four

Child: It is four I saw it

Teacher:	Let's have a look then … oh well done ready … let's do another one … I was going to try and catch you out here be a bit mean
Child:	He sawer it
Child:	It is four I told you … I knew it
Teacher:	Now it was quite easy to do that one … because it was in an easy pattern
Child:	Do a tricky pattern
Teacher:	I might at the end do a tricky pattern … who is sitting beautifully Angel … thank you let's have a look … put your hands up please Richard
Child:	Seven
Teacher:	Ok let's put that there our estimation Angel
Child:	Nine
Teacher:	Nine
Child:	I know
Teacher:	Another estimation Gemma … (*long pause*) … not sure Thomas?
Child:	Eleven
Teacher:	Eleven
Child:	She thought that
Teacher:	Another estimation Bethany?
Child:	Umm six
Teacher:	Six
Child:	I know one
Teacher:	Another estimation Umar?
Child:	Ten

The next step was to consider what was important to leave out of the analysis and why. Using the constant comparison loop revealed that there were incidents appearing in the transcripts which did not support any understanding of the way in which children were engaging in mathematics, and hence the development of a theory. These incidents comprised conversations linked to classroom routine or logistical procedures such as instructions in relation to how children should move about the classroom between areas of learning. Also any conversations in relation to behaviour management were not included for analysis. The transcript extract below shows what was omitted from the data set, with the omissions highlighted.

Extract from transcript of sixth lesson by Mrs Jill Thomas at St Paul First School

Teacher: Right can you move just a little way please … *(long pause)* … there we are … come on Kaitlin and Jonathan B!!! … I want someone to hold … have you nearly finished Evie? ok can you hurry up and put your milk carton in the bin … come and join us … thank you Evie umm I'll have Jordan

Some children: He's done it before

Teacher: You've done it before!!

Child: Yes

Teacher: All right we'll get someone else then … come on Jessie

Child: She's done it too

Child: No I haven't

Teacher: Let me see … no she hasn't … right now remember I am going to say one number you have got to give me the number that together with it makes … ten … *(more children come in)* come in quickly

Child: Where

Teacher: There we haven't started yet … right not yet not yet … we've got to beat seventeen … in one minute … ok … right quickly sit down Evie

Child: I think we can do a hundred

Teacher: I don't think you'll be able to do that many not with this … because it's only one minute … right … shh shh … ready steady … shh … go seven

(Children shout the answer when asked)

Child: Two

Teacher: No … seven

Child: Three

Teacher: Yes nine

Child: Five

Teacher: No … nine

Child: One

Teacher: Yes five

Child: Five

Teacher: Yes ten

Child: None

Child: Oh I was going to say that

Teacher: Yes three

Child: Six … no eight … no seven

Teacher: Yes two … Jack?

Child: Eight

Teacher: Yes four … *(long pause)*

Child: Oh six

Teacher: Yes three Chris

Child: Seven

Teacher: Four … four

Child: Six

Teacher: Six yes six six

Child: Four

Teacher: Yes two

Child: Eight

Teacher: Yes four … *(long pause)*

Child: Oh six

Teacher: Good girl yes … three … Reece?

Child: Seven

Teacher: Yes seven … seven … Jack

Child: Three

Teacher: Yes five … five

Child: Five

Teacher: Yes ten … ten

Child: Zero

Teacher: Yes zero

Child: Ten

Teacher: Yes four

Child: Six

Teacher: Yes five

Child: Five

Teacher: Yes two … two … *(long pause)*

Child: We've run out

Teacher: Oh right stop … how many … five ten fifteen sixteen seventeen

Teacher and some children: Eighteen nineteen

Teacher: Wow give yourselves a clap … very good and I think … I think that we could improve on that score because at the beginning … there were one or two children who were a bit unsure so I think we can try and beat nineteen next time … thank you Jessie

Child: I think we could get loads

Teacher: Thank you Kaitlin

Child: If every single one of us played then we

Child: Then we could get loads

Teacher: Yes but remember we've only got one minute … *(long pause)* … you've only got one minute

Child: We could go faster … and quicker

Child: Can we practice now

Teacher: We'll try it again later

Child: How much is a minute … this one's got three we could use that

Teacher: Well that one is three minutes but a minute is long enough for what we want to do … all right then … *(long pause)* … now we're going to see … Brian what are you doing?

Child: Going there … he is shoving me

At this stage, I amassed a large set of events which were increasing through the continuing data collection. There was no structure or pattern to the events that I could discern at this stage. It was through the collection and repetition of the analysis process of many more lessons that a pattern began to emerge which allowed grouping of different parts of the transcripts which were similar.

5.5.4 Creating Concepts

The complexity at this stage was figuring out how to be completely true to the grounded theory approach which calls for the removal of oneself in an attempt to be led purely by the data. However, as Charmaz (2007) suggests, suspending one's knowledge and experience is impossible and often undesirable, especially as the researcher is investigating something she is drawn to out of interest or experience. Therefore I have used my experience of being in the classroom to support the analysis.

> No effort should be made to put aside ideas or assumptions about the situation being studied, on the contrary, the researcher should draw on previous knowledge and experience to understand better the process under investigation.
>
> (Baker, Wuest, & Stern, 1992)

In addition, the analysis process was also given some direction and orientation by the initial literature review supported by the recognition by Glaser in relation to the use of literature where he stated that "all is data" (2001, p. 145). Despite this availability of literature as an analytical aid, I kept the key grounded theory principles of open-mindedness and objectivity at the forefront. Hence the focus of my analysis was to consider what the transcripts illuminated in terms of what children were bringing to bear upon tasks. Furthermore I looked for the nuances and tried to understand the subtlety of what was being expressed through the transcripts, and was led by what the data were showing in terms of understanding prior knowledge.

Alongside the event identification process described in Section 5.5.3, the mass of events needed to be ordered into manageable groups which would allow me to examine in detail what children really brought to bear upon each mathematical task. In this section, I will consider stage by stage how concepts emerged through the constant reviewing and comparison of all events.

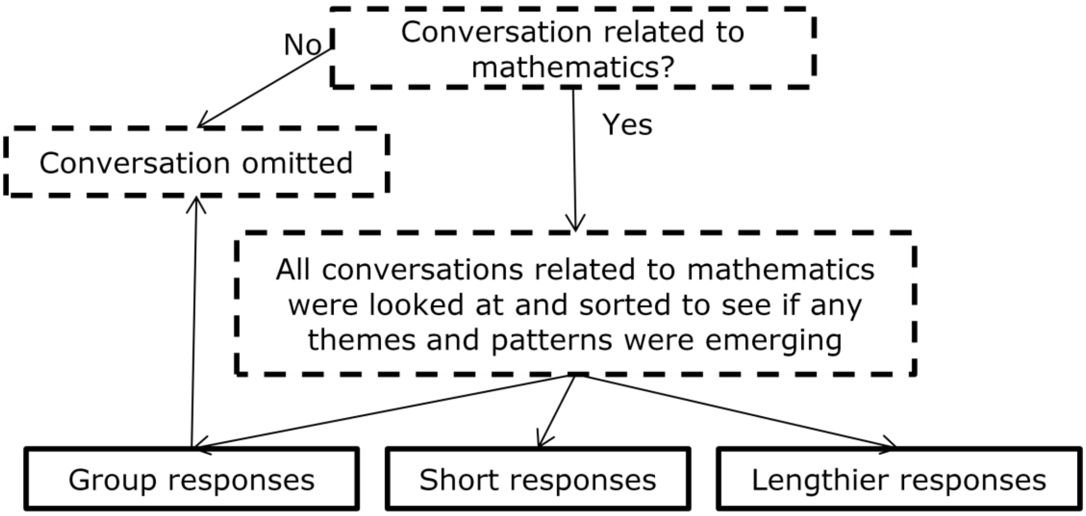

Figure 5.4 Initial sorting of mathematical events

Figure 5.4 shows the next stage in analysing the data. The dashed boxes are from Figure 5.3, and support the identification of all possible relevant events. Examining the transcripts closely revealed the different types of responses and conversations that the children were having while engaging in mathematics. These could be grouped into smaller manageable concepts – group responses, short responses or lengthier responses. At this stage, all the relevant events were put into these three concepts and no event was left unsorted. It is important to note that as more data were being generated, there was constant refinement through the constant comparison process of which events were in each of these three concepts.

The data revealed events comprising responses given by children while working as a whole class, mostly in the mental/oral starter section of the lesson. I labelled these as *group responses*. The transcript extract below is one such example from my data. Through closer examination and trying to identify what children were saying individually, I made the decision at that stage to omit all group responses from my data set as it was not possible to clearly attribute responses to individual children. Furthermore group responses tended to be responses which had been rehearsed (e.g. the transcript extract below includes counting from different starting numbers and counting odd numbers), and gave no hint in order to understand the nature of prior knowledge of individual children.

Extract from transcript of sixth lesson by Mrs Rebecca Rice at St Paul First School

Teacher: Can you shut this please … right … *(long pause as the class settles in)* … shh shhh move up move there thanks … right … let's see if you can count for me from umm let me see ten to eighteen please …

Most children: Ten eleven twelve thirteen fourteen fifteen sixteen seventeen eighteen …

Few children: Nineteen …

Teacher: Oh you are not listening eighteen … can you count from umm let me see … seventeen up to twenty-four

Most children: Seventeen eighteen nineteen twenty twenty-one twenty-two twenty-three twenty-four … twenty-five …

Teacher: Uhh you've got to listen twenty-four … can you count from nine toooo twenty-five

Most children and teacher: Nine ten eleven twelve thirteen fourteen fifteen sixteen seventeen

Most children: Eighteen nineteen twenty twenty-one twenty-two twenty-three twenty-four twenty-five … twenty-six twenty-seven …

Teacher: *(clicking all children)* … right odd numbers from three up to eleven …

Most children and teacher: Three five seven nine eleven …

Teacher: Jolly good odd numbers from one up to thirteen

Most children: One three five seven nine eleven thirteen

Another group of events were responses (correct or incorrect) where no elaboration or explanation was offered by children as to how the child derived the answer. I labelled these as *short responses*. The transcript extract below is one such example from my data. All events labelled as short responses could potentially offer some understanding of the child's thinking process, though at this early stage of the analysis it was not clear what this understanding might be.

Extract from transcript of sixth lesson by Mrs Jo Fishily at Greenville Park Community School

Teacher: Yes solid … yes … right now … what I want you to do first is can you tell me what all these shapes are called? we'll start with the easier one what's this one called?

Child: Rectangle

Teacher: What's this one?

Child: Square

Teacher: Brilliant now it gets a little bit harder … so concentrate …

Child: Cube …

Teacher: Cube very good …

Child: Cone

Teacher: Excellent

Child: Cill

Teacher: Cylinder cuuub

Child and teacher: Cuboid

Teacher: And …

Child: Circle

The remaining set of events comprised responses where children gave more detailed explanations and conversations to support their thinking. I labelled these as *lengthier responses*. The transcript extract below is one such example from my data (the highlighted sections are lengthy responses of two different children – Damian and Rhian). This concept formed the basis of majority of the focus for my analysis, and is considered in more detail through the rest of this section.

Extract from transcript of second lesson by Mrs Jane Marshall at Argyle Common First School

Teacher:	It costs two pence … If I wanted to buy three plants and they cost two pence each how much would it cost? One flower cost two pence how much would it cost to buy three
Child:	Umm three … oh
Teacher:	Jay?
Child:	Three pence
Teacher:	If they are two pence each I wanted to buy three …
Child:	One pence
Teacher:	Sharna can you help him out?
Child:	Six pence
Teacher:	Why would it be six?
Child:	Umm umm well it's … *(long pause)*
Teacher:	Why six … Damian?
Child:	Cause you know you've got three flowers if you've got two lots … it is double three … you add another three pence on if there was 1p it would be three pence on if there were 2p it would be six pence because you are adding another three on … cause if you had six plants all at one three would be at two be same as three plants all at 1p
Teacher:	Right so you have halved this number oh that is a bit of tricky thinking … Rhian is there another was of working it out?
Child:	Well yes cause 2p is one more than 1p you can just figure it out by counting in two up
Teacher:	Right I could just count in two's … ok I want three plants so it would be two four six … so if one plant … is 2p all right … that's my one plant … there it is ok and I want to buy three I am going to need another plant and another plant ok so I've got
Child:	2p and 2p and 2p

The next step in the analysis process was to look at all the lengthier responses. Through constant comparison of each of these responses and looking at new relevant events being identified, I looked for patterns and similarities which could be used to sort the large volume of lengthier responses into meaningful similar groups to support further detailed analysis and theory formulation. The data slowly revealed that among the lengthier responses, there were different ways in which children were responding to the tasks they were tackling. At this stage, I put these responses into different concepts based on their similarities, as can be seen in Figure 5.5.

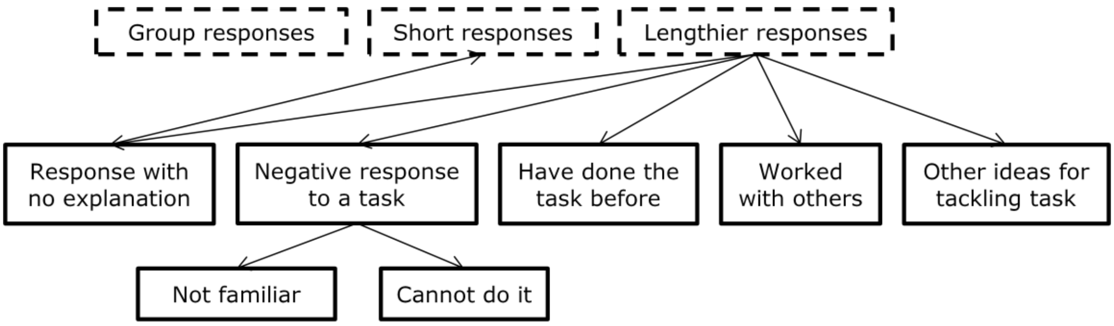

Figure 5.5 Different subsets of lengthier responses

Figure 5.5 also shows how these concepts link with the previous step in the analysis (represented using dashed boxes). Below are brief descriptions and examples from transcripts to exemplify each of the concepts within lengthier responses.

Responses with no explanations were related and similar to short responses, in that children did give an answer, and when probed were not able to give further explanation of how they were able to address the question. Therefore these were considered and grouped together with the short responses. The transcript extract below shows one such example from my data.

Extract from transcript of fifth lesson by Mrs Jane Marshall at Argyle Common First School

Teacher: Sorry three and what makes ten … three and what makes ten … right let's see … three there and four five six seven eight nine ten … Elliott count both hands fingers on both hands … show me … what am I going to add to three to get to ten …

Child: Seven

Teacher: Well done you've got it … right shhh shhh ready … ten

Child: Ten that's no …

Teacher: Shhh … shhh … *(long pause)* … show me … *(long pause)* … right you should have nothing cause you can't add you've got to ten already … right next one I am getting quicker … five

Child: Five and …

Teacher: Five and what makes ten? … *(long pause)* …

Child: That's easy five …

Teacher: Yes five and five make ten … five and … show me how…

Child: Five and five make ten …

In the transcript above, the child did not give any further detail as to how he arrived at the answer. When probed, he again only responded with the answer. There is nothing in this interchange that would inform me further about the child's way of thinking. So I deemed this similar to a short response, and grouped it as such.

Continuing the examination of the events revealed that there were a group where children's responses were *negative to the task*. In this case, children either stated they could not do the task even with support, or were not familiar with what was being asked. The transcript extract below is an example from my data where the child stated that he could not do the task.

Extract from transcript of fifth lesson by Mrs Jo Fishily at Greenville Park Community School

Teacher: I'll be there in a second … ok ready … right … now show them Aiden … ok everyone write down their guess … under my guess … let me see … you think seven and Martha says …

Child: I can't do it …

Teacher: Have a go …

Child: I can't do this …

Teacher: Have a guess …

Child: Six

Teacher: OK … right shall we count them now

Few children in group: One two three four five six seven …

Teacher: Seven … so in that box you write … seven … well done spot on … Martha was

Child: Too less …

Teacher: One too few … and Aiden you were a bit too high … and you did it …

In the transcript extract above, there is some understanding on the child's part that they are not able to do the task. But in this example, no reason is given as to why – just that they were not able to do the task. All such events were grouped together.

The other type of negative response which was noted in a few of the events were children who expressed no familiarity or understanding of what the task was and thus could not do it. The transcript extract below is an example from my data where the child was not at all familiar with the task involving quarter, half and whole turns, and needed much support. Even after this, she found the task difficult.

Extract from transcript of sixth lesson by Mrs Rebecca Rice at St Paul First School

Child: I don't know what this is

Teacher: What don't you understand?

Child: This one here …

Teacher: Right let's have a look a minute … umm right can we all stop a minute … we need to think about what strategies … what ideas we can use to help us to find out what we … what ball is going to go in the gap … ok so what is Anna doing to find out where her piece … what was she doing with her jigsaw … can that help …

Child: She was turning them

Teacher: She was turning them around wasn't she Megan … so can that help us figure out what we need to do … so let's have a look at this first one here … we want to know which one will go here … so what you can do is if you get one of them and put it on top exactly the same as the ball as the pattern if you then … can you just watch for a second then you can try it … if you then look at the next one and then turn yours round to look at the next one … you can see if you have done a whole turn … that is much easier now isn't it?

Child: Umm

Teacher: Right so have I done a whole turn … a quarter turn or a half turn

Child: A half turn … a whole turn

Teacher: A whole turn!! a whole turn would be this … look it would go weeee … like this … weee … weee that's a whole turn … ok so let's see half a turn … a half turn would do that … is that right? is that about right?

Child: Ummm

Teacher: Is that matching … is that right … is that matching that?

Child: No

Teacher: No it's not no that's right … so start again ready all watch again Robbie … turn it round like that a quarter turn … is that matching now?

Child: Yes

Teacher: Yes that's right so this first line is a quarter turn … so you've only got to turn it a quarter turn … so I'll put that on there Robbie you can do a quarter turn for me … do a quarter turn for me … go ahead I am watching … (*long pause*)

Child: What do I do?

Teacher: Well you need to make a quarter turn … so that is going to go there … all right? … if we do another quarter turn … what will it look like?

Analysing further events showed more patterns, one such being that in order to carry out the task, children were recalling something from the past. I labelled these as *have done the task before*. This recollection spanned various timescales from the immediate based on what had just been carried out to ideas from further back. Upon further examination, it emerged that the nature of what the children were recalling varied in its forms. Though children were recalling ideas, concepts or procedures, the nature of what they recalled was very different. At this stage, any events which had any recollection were grouped together. In the transcript extract below, we can see an example of ideas that children are using from previous maths lessons.

Extract from transcript of fifth lesson by Mrs Rebecca Rice at St Paul First School

Teacher: Right well done ok … *(long pause)* … now I am going to add something … what am I going to do? ok I've come down in my spaceship and I've landed from the planet Zorb … and I don't know what to do … someone's told me I've got to do that sum and I don't know how to do it … someone's said that I've got to put these two numbers together

Child: Easy … you told us before

Teacher: *(long pause for writing on the board)* and I don't know how to do it … who can put up their hand and help me … I don't want the answer yet … I've got to find out how to do it first before I can find the answer … Isaac what have I got to do?

Child: Umm add it up

Teacher: I don't know what add it up means … what do I have to get the numbers and do this?

Child: No

Teacher: How do I add it up … it is a very funny word add

Child: I know

Teacher: Joshua?

Child: Put it together

Teacher: Put it together … ok umm it won't go … *(trying to push the number on the board)* … Georgina?

Child: Count your fingers … like we always do

Teacher: Count my fingers … one two three four five six seven eight nine ten … *(long pause children laughing)* … Maisie

Child: Put three on one hand and two on the other one

Within the lengthier responses, there were also responses which were intertwined with work that children had done as a small group or in pairs, and this had supported the child's understanding of the task and the consequent response. I labelled these as *worked with others*. The transcript extract below gives an example where Daniel explains to Harvey why he is wrong and how he should perform the task. These conversations were very different in nature to group responses which I have discussed earlier and argued for omission. The key difference is that these events were not whole class and clearly gave a greater level of detail in how the interaction between children supported their understanding. On the other hand, group responses were short responses by generally the whole class to rehearsed ideas and therefore shed no light on individual thinking or understanding.

Extract from transcript of seventh lesson by Mrs Rebecca Rice at St Paul First School

Teacher:	You are right you have got the same … umm *(shouts)* everybody do this … everybody do this *(clicking)* shh everybody do this *(tapping her head)* oh Hannah, Isaac, Edward, *(long pause stops shouting)* I know you're all working extremely hard and I can see that green group are enjoying their game … and I see blue and red group working hard but we are far too noisy … *(long pause)* … we are going to carry on working for five more minutes and this time I don't want to have to stop for the noise … I can't hear the children I am working with on the floor and they are right next to me … whisper … right … *(long pause)* … Joshua you say you've got six pence Charlotte's got six pence you've got the same amount of money haven't you … what about you umm Alex what do you think? have you got the same amount as everybody else or have you got more money than everybody else?
Child:	The same
Teacher:	The same as Joshua … has Joshua got the same amount as everybody else then or are you richer than everybody else?
Child:	We're both richer …
Teacher:	You're both richer … why do you think you're both richer?
Child:	We've got more coins … look one two three
Teacher:	You've got more money? Harvey's got six pence … Harvey's got six pence Daniel's got six pence … how much have you got?

Child: No I have 3 [Harvey counts the number of coins he has – 2p 2p 2p – making 3 coins] and Daniel has 2 [Harvey counts 1p and 5p coins as 2 coins]

Child: No look 1 … 2 3 4 5 6 that's 6p [Daniel adds value of 1p and 5p to make 6p]

Child: But I have 3 … 1 2 3 [Harvey again counting the coins]

Child: No the numbers on it are 2 2 2 so 6 [Daniel asking Harvey to use the value of each coin]

Child: Oh six pence

Teacher: Six pence … is that more or less or the same as everybody else?

Child: Same

Teacher: The same … does that make you richer?

Child: Same

Teacher: What have Alex and Josh got more than everybody on the floor?

Child: Coins

The last concept identified within the lengthier responses related to other ideas that children brought to bear upon the task to support their understanding. I labelled these as *other ideas for tackling task.* There were a large number of events which showed that children were not just recalling or giving responses, but were using some other experiential ideas to support the understanding and eventual solution to the question. The transcript extracts below are three such examples from my data where children used the idea of cakes at their fête, a number track in the playground, and a hundred square to support how they addressed the question being asked.

Extract from transcript of seventh lesson by Mrs Jill Thomas at St Paul First School

Teacher: Umm now we're going to see how good you are at listening and how you can try and work out the answers to these number stories … you could use adding … or taking away so let's try … ready ok? … Ok let's think I had ten cakes and I ate three of them … how many cakes did I have left … Lucy?

Child: From the cake sale yesterday … but you were helping at the table miss.

Teacher: Yes at the cake sale … I had ten cakes and I ate three of them … how many cakes did I have left …

Child: Seven

Teacher: Seven good girl … I have five pencils … if I put five more in my tin … five pencils in my tin I put five more in my tin how many altogether Molly

Child: That's my job to sort the pencils..

Teacher: Ok can we just work out the answer to the number stories … I have five pencils … if I put five more in my tin

Child: It is ten that is how many you have in there now …

Teacher: How did you work out that the answer was ten?

Child: I can see them from here … hehe … we had to tidy up yesterday … remember?

Teacher: You had five and you counted five more good girl … right I had nine bananas if I gave three of them to my brother how many bananas were left? … *(long pause)*

Child: My brother does not like bananas…

Teacher: Ok

Child: Six

In the transcript extract below, Jo has used the understanding she has of moving on a snake in the playground to understand the question and work out the answer.

Extract from transcript of sixth lesson by Miss Lora Hunter at St Paul First School

Teacher: Let's ask Jo to see if we can work out how to do this … Jo

Child: I got seven on the number line then hopped on three more like I do on the playground snake on ten

In the transcript below, Peter points to the poster of the hundred square in the classroom to extend his understanding of counting.

Extract from transcript of second lesson by Mrs Jane Marshall at Argyle Common First School

Teacher: Then this afternoon we are going to some umm maths again like we did last week … all right a bit of a maths day today … right start off let's do some counting … let's start at three and we are going to count in tens ok so we all need to be looking and sitting where we can see the board … ok are we ready off we go

Teacher and most children: Three

Most children: Thirteen twenty-three thirty-three forty-three fifty-three sixty-three seventy- three eighty-three ninety-three a hundred and three

Child: We've run out

Teacher: What would come next? After a hundred and three … Devon

Child: Two hundred and three

Teacher: No that's counting in hundreds counting is tens … look at the clues three thirteen twenty-three a hundred and three … Emily

Child: Two hundred and three

Teacher: No that's counting in hundred Liam?

Child: A hundred and thirteen

Teacher: A hundred and thirteen … what would come next after a hundred and thirteen? Jay?

Child: A hundred and twenty-three

Teacher: Thank you a hundred and twenty-three … what would come after a hundred and twenty-three?

Child: Hundred and

Teacher: James hundred and thirty-three

Child: A hundred and thirty-three

Teacher: Brilliant next … Peter

Child: Hundred and forty-three … you can see it is the same [child points to the number square on the wall]

Teacher: Excellent … ok

Child: I know what's next hundred and fifty-three

Teacher: Just cos it's not there doesn't mean you can't do it you've got to use the clues all right … it's our know one thing and get another thing for nothing … ok six in tens off you go

So far the events have been analysed in the following manner:

- firstly into all the relevant events (maths and not maths);

- then into three broad concepts (group responses, short responses and lengthier responses);
- finally events labelled as lengthier responses above were analysed again individually and further sorted into concepts depending on the nature of the responses into – responses with no explanations which were regrouped with short responses; negative responses to a task (which revealed that they could be grouped as tasks that children expressed no familiarity with or stated could not do at all); responses in which children expressed that they had done the task before; responses in which children worked with others; and lastly responses which used other ideas to tackle the task. The last three concepts were complex with no cohesive understanding emerging, and hence needed further analysis.

One unavoidable feature of the process is the messy cumbersome moving of events from one pot to another. This stage of analysis has a lot of critical theorising and testing of ideas in terms of how these concepts are formed. The ideas and structure offered by theoretical sampling allowed me to continue to collect additional data and use content analysis to exemplify and further understand what was going on in terms of children's engagement with mathematics.

> Comparison between the explanatory adequacy of the theoretical constructs and these additional empirical indicators go on continuously.
>
> (Draucker, Martsolf, Ross & Rusk, 2007, p. 1137)

As a result of this constant reviewing of data already gathered in conjunction with sorting new data, the concepts developed in even greater detail and it this that I will consider in the next step of analysis.

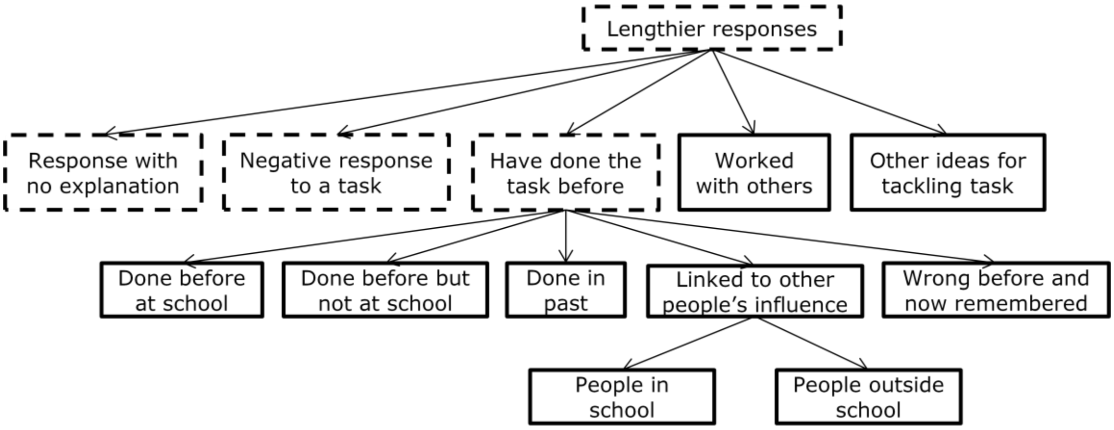

Figure 5.6 Granular concepts for *have done the task before*

Within the lengthier responses (as seen in Figure 5.5), there were many events in which children were referring to how they understood the tasks in relation to what they had already experienced of similar tasks (which I labelled as *have done the task before*). Within these events, deeper analysis further revealed that there were different aspects of past experience that children were using to understand and respond to the tasks they were being set, as can be seen in Figure 5.6. Below are brief descriptions of each of these granular concepts illustrated with relevant extracts from transcripts.

The first granular concept in Figure 5.6 (*done before at school*) relates to all of the events which reveal that children are attempting tasks using their past experience within work that they have carried out in school. The transcript extract below shows that the way in which Jack was able to tackle the question being asked was by remembering an exercise that he carried out before in the classroom which supported his understanding of 2D and 3D shapes.

Extract from transcript of third lesson by Mrs Jo Fishily at Greenville Park Community School

Teacher: Brilliant well done is that what you were going to say Hannah … Everybody together …

Most children and teacher: Learning about 2D and 3D shapes …

Teacher: Right do that …

Child: We got this before when we did on those things [child waves hands in a circle] before here on the carpet.

Teacher: Yes yes it was … put your hand up if you can tell me a 2D shape … put your hand up if you can tell me a 2D shape … uhh Jack a 2D shape

Child: It's got to be flat

The next granular concept in Figure 5.6 (*done before but not at school*) relates to all of the events which reveal that children are able to attempt tasks based on their past experience outside school. In the transcript extract below, the way in which Martha is able to understand and explain the concept of addition is linked to putting sweets in a cup. This is not an experience in school, but has supported her understanding of addition.

Extract from transcript of fourth lesson by Mrs Jo Fishily at Greenville Park Community School

Teacher: That's ok really don't fuss … right you are fine … right sitting up straight right Kealee … Megan what do we mean by adding what do we do if we are adding?

Child: Adding on

Teacher: Say that once more please …

Child: Adding on

Teacher: What happens if you were adding what are you doing?

Child: Taking away a number

Teacher: Shhh Megan this time …

Child: Taking away …

Teacher: Let's ask someone else … umm Martha do we do if we are adding … you had your hands up nicely well done …

Child: We put two numbers together to make them bigger

Teacher: You know what Martha said we put two numbers together to make them bigger … that is true Martha but you can add more than two numbers we can add two or three or four …

Child: You know on a Friday me and Tom got sweets and put them all in a cup and there are lots but only on some Friday and that is lots

Teacher: Ok Martha can add more than two number

Child: Or ten

The next granular concept in Figure 5.6 (*done in past*) relates to all of the events in which children are able to attempt tasks based on their past experience, but are unable to recollect where the experience took place. In the transcript extract below, the child has not given any more detail in their answer as to how they know and interpret ideas being explored other than that they have done lots of these before.

Extract from transcript of sixth lesson by Mrs Sally Crane at Hatton First School

Child: A hundred a hundred and ten a hundred and twenty a hundred and thirty a hundred and forty a hundred and fifty a hundred and sixty a hundred and seventy a hundred and eighty a hundred and ninety two hundred …

Teacher: I think we better give him a clap for that don't you *(class clap)*

Child: That's good

Teacher: I think so yes … how did you know how to do it? how did you know because the number aren't there … for you to read

Child: Umm well umm

Teacher: Shhh

Child: Umm because umm it is just well it is a hundred and the rest are down there so you go just go like a hundred and nine and ten I have done this lots already so it is easy

Teacher: So the numbers are exactly the same aren't they over a hundred … it doesn't matter whether they are over hundred two hundred or three hundred it's still ten twenty thirty forty fifty sixty seventy eighty ninety a hundred …

The next granular concept in Figure 5.6 (*linked to other people's influence*) emerging as a result of further analysis of the transcripts was the influence of interaction with other people that children expressed as a trigger for remembering ideas which supported understanding of tasks. Upon closer inspection of the events, there were two key groups of people who influenced children's understanding leading to this concept being split into two further concepts – *people in school* and *people outside school*. I could have left the concept at the stage of remembering as a result of other people's influence. However this would not have accurately reflected the distinct difference between the influences that the children referred to and were revealed in the data.

In the first transcript extract below, the child has used their experience with someone from school i.e. the teaching assistant Mrs MacDonald, to support her ability to add. In the second transcript extract below, Victoria recalls having skipped with her child minder Charlotte as a way of remembering odd numbers.

Extract from transcript of fifth lesson by Mrs Jennie Brooks at Draycott First School

Teacher: Or ten you can do that but we are just going to do two … Yes so Martha said you put two numbers together to make them bigger … that's adding … adding up numbers … right listen right … write down on your board … ready Harry three … write a number three … come along … write it three add two add four … who can work it out for me?

Child: Mrs MacDonald told me before that it is nine

Extract from transcript of seventh lesson by Mrs Sally Crane at Hatton First School

Teacher:	Now I just want to spend two minutes seeing if we can work out and remember what we did yesterday with the odd and the even numbers … can anybody tell me what the odd numbers were that we looked at when we first looked at them between zero and up to ten … which are the odd numbers? Victoria?
Child:	One three five seven nine
Teacher:	Good girl that's very good well remembered … yes let's say them together …
Child:	I know all of them I skip with Charlotte and we count [Charlotte is her child minder]

The final granular concept in Figure 5.6 (*wrong before and now remembered*) relates to events which show self-correction from what the children recalled and the mistakes they had made. In the case of the transcript extract below, Megan self-corrects in relation to the units she is referring to and also clearly understands that she has difficulty recalling and using correct units.

Extract from transcript of sixth lesson by Mrs Rebecca Rice at St Paul First School

Teacher:	Oh we're doing doubles Megan … so you've got seven in one hand you are going to have …
Child:	Seven
Teacher:	Because a double is exactly the same number isn't it? yeah? so if I've got … oh it's really really heavy … five hundred in this hand … what am I going to have in this hand?
Child:	Five … no no I know I keep forgetting the other bit … hundred

In summary, all the granular concepts in Figure 5.6 are recollections of having done something similar before, but are very different in nature leading to the granular concepts that I have just described and illustrated. However this did not account for all the events within the lengthier responses.

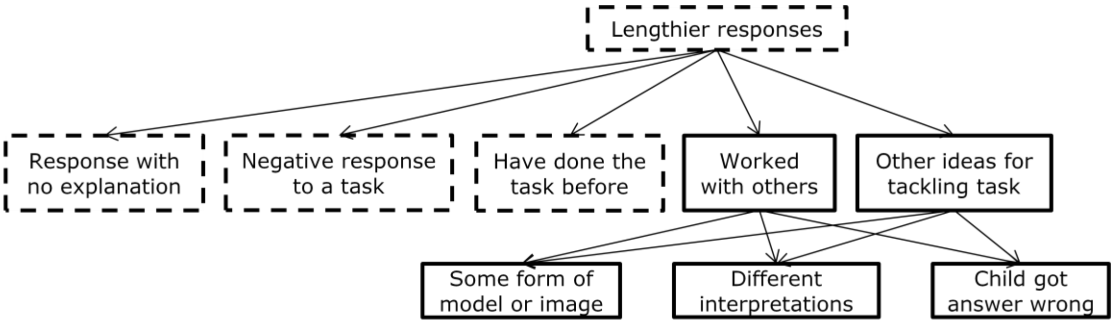

Figure 5.7 Granular concepts for *worked with others* and *other ideas for tackling task*

The last two concepts under lengthier responses labelled *worked with others* and *other ideas for tackling task* have been introduced earlier in this section with some sample transcript extracts. However as the process of analysis continued and events were being reviewed, it emerged that these needed further filtering and separating into greater detail as there were aspects within each of these concepts which gave further insight into what children brought to bear upon the tasks they were performing. I will now consider each of the three resulting granular concepts – *some form of model or image*, *different interpretations* and *child got wrong answer* – separately (Figure 5.7).

There were a group of events which highlighted that when children carried out a task, they were using some form of model or image to support their understanding. These were often complex and linked to how children had understood the ideas originally. As there were many different types of models or images that children were using, I was able to sort them initially into crude groups such as in school and out of school, then consider further what each of these were telling me about how children approached the task. This content analysis resulted in the concepts shown in Figure 5.8 below.

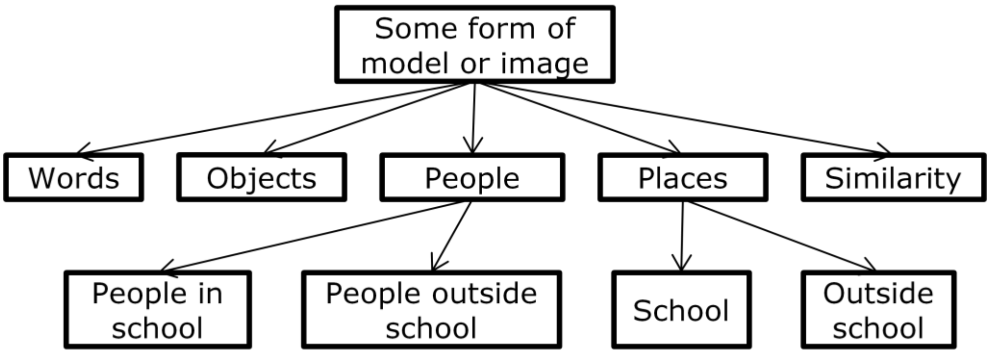

Figure 5.8 Granular concepts of *some form of model or image*

There were events where children used *words* to support the meaning that they derived about the task at hand. As can be seen in the transcript extract below, the child has linked to the word *lose*, in this case by motioning to put pens in the bin, to understand subtraction.

Extract from transcript of sixth lesson by Mrs Jill Thomas at St Paul First School

Teacher: You added three more … all right I think if we knew we had ten to begin with … no I'll leave that bit … I'll leave that … let's think … I have got six …

Child: Six what …

Teacher: Six felt pens … if I lose three of them Jonathan how many will I have left?

Child: Umm … *(long pause)* … can you say it again …

Teacher: I'll say it again I had six felt pens if I lose three of them how many will I have left?

Child: Put them in the bin [child makes a motion of throwing something away] ok lost them … so they have gone away … three

There were instances in the events which highlighted the use of *objects* to support children's understanding of the questions being asked. They also supported the explanations that children gave to rationalise the answer.

In the transcript extract below, the understanding of counting in 5's is linked to the child's image of a *clock*.

Extract from transcript of seventh lesson by Mrs Jennie Brooks at Draycott First School

Teacher: No right what did you notice about the numbers you counted and the numbers they counted

Child: *(shouts out)* I know they had the clock number and we had the tens …

Teacher: Well done you mean they had the fives …

Continuing to look at a range of events, there were a cluster of events appearing where children had used the images of *people* in various ways to support tackling the task. However this was very different to the previously identified influence of people (Figure 5.6). In that case, people were a direct reminder of what they had done before. In this concept, the events highlighted that people formed an image or model to support understanding. The model being used in this set of events relies on people within school and is referenced to school. In contrast, there were events where children had linked their understanding of the task and how they would answer it to people outside of school. In the first transcript extract below, Mitchell is using the class and the daily routine of working out how many dinners to understand counting on. In the second transcript below, Josh is using the image of his father (a person outside school) to determine the bigger number.

Extract from transcript of fifth lesson by Mrs Jane Marshall at Argyle Common First School

Teacher: … eighteen and what makes twenty? you need to put eighteen into our heads and count on until we get to twenty … … (*long pause*) … I can see some people really wanting to join in Mitchell what do you think … ?

Child: Two

Teacher: Can you show me how you did it?

Child: Umm twenty dinners [child points around the room] and sometimes Jade and Poppy have sandwiches so I counted back

Teacher: Counted back from where?

Child: Twenty dinners

Teacher: Right so can you do it so it's …

Child: Two …

Teacher: Hang on Mitchell cause twenty's got to go in your head … so …

Teacher and child: Twenty … nineteen eighteen [child points to two children as he counts] …

Extract from transcript of seventh lesson by Mrs Jill Thomas at St Paul First School

Teacher: Let's look at which number is bigger can you hold up with your number fans the number which is bigger … 31 or 27… (long pause) good Josh why do you have 31

Child: My daddy is 31 and he is big

As the events were being filtered through the different stages of sorting, there were a range of events which showed that children use physical *places* to support their understanding. Furthermore, the data led me to subdivide these events into school and outside school. In the first transcript extract below, Emily uses the classroom routine to help with counting. In the second transcript extract below, the child uses the racing game in his room to describe a shape with no straight lines as the answer.

Extract from transcript of fifth lesson by Mrs Jane Marshall at Argyle Common First School

Teacher and few children: Nineteen eighteen seventeen sixteen fifteen …

Teacher: Emily

Child: Fifteen

Teacher: Well done … roll the dice … right Emily … two … what number am I going to put in my head to start with?

Child: Eighteen

Teacher: Why?

Child: We do that when we register and count the class

Teacher: Umm what number am I going to put in my head to start with? Jay

Extract from transcript of sixth lesson by Mrs Jo Fishily at Greenville Park Community School

Teacher: Corner wasn't it? you said some of them have got corners and some of them have got one smooth side … so which ones got the smooth side? you tell me

Child: Rectangles

Teacher: What's got one smooth curved side … no points no corners … no what are these called?

Teacher: No stttraight sides … straight lines has a circle got any straight lines?

Child: No …

Teacher: Right if you've so that shape has got no straight sides

Child: It's got curvy line like this [child makes a swerving pattern] I have that in a racing game in my room …

The last concept – *similarity* – refers to what has been seen in the task as a very similar image for the child to one they have already developed. In the transcript extract below, the teacher starts by developing an image of a grid with the children to support their understanding of division. The child towards the end of the transcript extract has linked this grid to his understanding and the similarity between arrays and multiplication to arrive at the answer for the division sum.

Extract from transcript of ninth lesson by Mrs Jane Marshall at Argyle Common First School

[The class were doing division using a grid]

Teacher: What am I going to do now that I have drawn the grid … to find the first number in my sum?

Child: Count the squares

Teacher: Good come on then …

Child: One two three four five six seven eight nine ten eleven twelve thirteen fourteen fifteen sixteen seventeen eighteen

Teacher: Brilliant eighteen put an eighteen here Shannon one number per square …

Child: They are like Mr Marshall's eight

Teacher: Much better than Mr Marshall's eight (laughs) he does two circles that's naughty … so what am I going to do next … Henry what do you think?

Child: You need to put the divided sign

Teacher: Brilliant so it's eighteen shared by … divided by … shared between ok so what's the next thing I am going to do …? Nathan?

Child: Count down … umm (laughs)

Teacher: Count down ok

Child: Six

Child: You know this it's the one on to that's three and then you go down there and there's three on the top and then on the bottom it will be six

Teacher: Ok what am I going to put next …

Child: Six

Teacher: Ok well done and what am I going to do find the answer

Child: Count the number across

Teacher: Ok

Child: Three

Teacher: Now excellent so now I've got eighteen squares altogether … I counted how many down?

Child: Six

Teacher: And how many across?

Child: Three

Teacher: And that's my divide sign my share between sign … but look do you remember when you did it with grids to make it times I counted down

Child: Yep

Child: I knew that sum all along … it was because I did a times making eighteen … six times three equals eighteen …

As I continued with the constant comparison approach, there was another pattern appearing in the data which was quite different to the concepts discussed so far – *have done the task before* and *some form of model or image*. In this case, it was the way in which children had interpreted the tasks in that they were not using something they recalled or an image or model, but in some sense translating what they were being asked to do. I was able to sort these into granular concepts, as seen in Figure 5.9. Using examples from the transcripts, I will now illustrate the nature of each of these concepts.

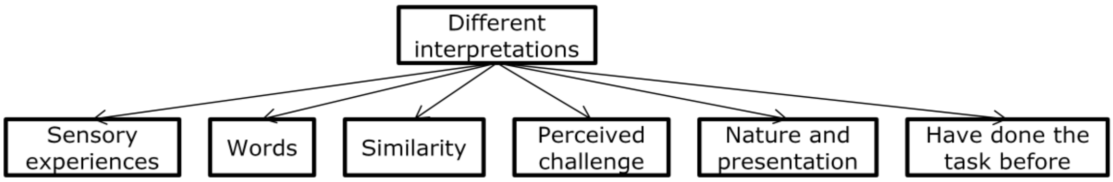

Figure 5.9 Granular concepts of *different interpretations*

Sensory experiences were events in which children used their physical experiences such as things they had done or seen or heard or felt to make sense of their mathematics. In the transcript extract below, the child has interpreted addition in terms of a physical act which is linked to his experience of playing football. Removing the zero and adding a five is not used as a model or an image in this case, but as a physical sensory process which has helped him to address the need of the task.

Extract from transcript of eighth lesson by Mrs Rebecca Rice at St Paul First School

Teacher:	You know we did this before you do ten add ten and then take away three it's …
Child:	Seventeen
Teacher:	Ok so what is ten add five
Child:	Kick the zero off like a football and put the five there … [child brushes his hand and draws a 1 then moves the 5 in the air next to the 1 he has drawn in the air] … fifteen
Teacher:	Interesting … what were you doing
Child:	Adding

Words were events where children were making their interpretations based on the way in which they understood the words in different tasks. In the transcript extract below, there is a literal interpretation of the word *up* as the child has moved up the hundred square, and thus not been able to complete the task. The hundred square does present a particular problem in its layout as is illustrated here. The numbers go up in value as you move down the hundred square, leading to the confusion experienced by the child in the words used by the teacher to set the task. There is a clear misinterpretation of the word *up* based on the child's understanding in terms of physical movement and how it is different to the movement on a hundred square.

Extract from transcript of seventh lesson by Mrs Sally Crane at Hatton First School

Teacher:	Yes I know … now then let's just you two turn round Jake and Owain and look at the hundred square for a minute … Ellie … now on here we've got all the numbers that we've just been umm counting and we've got a pattern … if you remember when we did a pattern of tens … last term we noticed it was just one line didn't it … now what we are going to do is we are going to work out our pattern of fives and see whether we can see something happening on our hundred square … Ellie am I going to have to have you sitting by me
Child:	But there is a spider on there
Teacher:	All right ok we'll put him outside now then let's count first of all let's count in fives using the number square …
Child:	Five ten fifteen …
Teacher:	Right we've got to number fifteen I am going to put a circle round number fifteen let's count up another five ok
Child:	I am off the hundred square.
Teacher:	What do you mean?
Child:	Look [child starts counting going up the hundred square from fifteen to five as one count] … see no more space
Teacher:	What number do we get to?
Child:	Ten
Teacher:	To ten ok …

Child: There is a spider there

Teacher: Never mind … now let's see if we can count on … Oliver another five … for me one

Few children: … two three

Teacher: Excuse me I said Oliver … come on Oli

Child: One two three four five …

Teacher: And what number do I get to?

Similarities were ideas and interpretations that children had already made about other notions of mathematics and were applying them to new tasks. Similarities refer to the ability to use related and unrelated known facts and interpret them to support the task. In the transcript extract below, understanding the similarity between 4 + ? = 10 and 14 + ? = 20 has been used by this child to address the task. He has interpreted the two possible ways of looking at the task as being similar in supporting the outcome.

Extract from transcript of fifth lesson by Mrs Jane Marshall at Argyle Common First School

Teacher: You were right weren't you … seven … *(long pause)* … let's try this one? … *(long pause)* … fourteen add what makes twenty? so you put fourteen in your head shhh … put it down you can't have number fans in your hands cause you need them for counting … fourteen in your heads and count on till you get to twenty … *(long pause)* …

Child: Mrs Marshall it is easy it's …

Teacher: I'll come to you in a moment I know what you're going to say … Liam?

Child: Umm six

Teacher: You are well on the ball now … you've got it haven't you Emily? … it is six Devon what are you going say?

Child: It's changing the fourteen over to a four and then it's easy …

The set of further events to fall into the concept of *perceived challenge* are events where children have made their own interpretations as to the nature and level of difficulty of a given task. In the transcript extract below, the level of difficulty perceived by Emma has been done by observing that the number ten contains two digits. Emma does not want to attempt to consider possible answers as she has interpreted the task to be of a higher level and difficult. This has stopped her from engaging in the task.

Extract from transcript of seventh lesson by Mrs Rebecca Rice at St Paul First School

Teacher: Good boy that is called reversing it isn't it? changing it around … *(long pause)* … so is that it? one two three four five six seven eight nine … well done shall we do number ten the last one … ok very very quickly then … tens Emily oh sorry Emma …

Child: Umm … *(long pause)* … ten … that has two numbers so … it is not the same … that is harder …

Teacher: Someone else have a try number bonds for ten

Child: Ten add nothing … *(long pause)* … ok James … ?

Child: Five and five

Teacher: Good boy!! that's the double isn't it … five add five fantastic … Robbie?

Child: Zero and ten

Teacher: Zero and ten right that's that one reversed …

Child: Six and four

Teacher: Six and four brilliant … *(long pause)* … Ella?

Child: Umm … *(long pause)* … four and six …

Teacher: Four and six that's that one reversed well done …

Child: Six and eight

Teacher: Six and eight make fourteen … it's a bit too big … *(long pause)* … Joe?

Child: Three and seven

Teacher: Three and seven … Philip can you reverse that one for me change that round

Child: *(long pause)* … seven and three

Nature and presentation refers to events where the way in which the task has been set has influenced directly the way in which the child has interpreted the task. In the transcript extract below, the initial presentation of the task has forced the child concerned to make very interesting interpretations in relation to the question being asked about the value of money. The child brings to bear upon the task the idea that ten pence have ten pennies squeezed into them, and this has caused complications for further questions asked as the nature with which the idea was presented instigated a particular interpretation of what value means in terms of coins.

Extract from transcript of seventh lesson by Mrs Rebecca Rice at St Paul First School

Teacher: *(working with a small group on the carpet)* … shh shh shh shh shh shh you've worked really fast … with your number bonds and we do a quick introduction on money then we get to our tables and do our work ok … all right I am going to hold up some coins and I want you to tell me what coin I'm holding up if you can whisper so we don't bother everyone … *(whispers)* … ok let's start off with that one …

Child: *(whispers)* One 'p'

Teacher: A one 'p' that's right a one penny piece … *(whispers)* … what about …

Child: *(whispers)* Ten

Teacher: A ten penny piece … Philip thought it might have been a two … why isn't it a two?

Child: *(whispers)* Cause it's silver

Child: *(whispers)* Cause it's round

Teacher: Cause it's silver Ellis? what colour would a two 'p' piece be Ellis

Child: Umm brown and that's a ten 'p'

Teacher: How do you know it's a ten 'p'

Child: Cause the number

Teacher: Oh what number can you see Ellis?

Child: Ten …

Teacher: Oh very good does that mean ten bananas?

Child: No

Teacher: What does that mean … ten what?

Child: Ten 'p'

Teacher: Ten 'p' so inside this … well not really but we could pretend inside this ten pence someone in the shh factory has got ten little pennies and gone uhhhgggg and squeezed them right into that ten pence piece …

Child: Do they really do that … so how come it is silver?

Teacher: Well it is just pretend … it just means that this is the same as having ten little pennies ok … shh right … let's find that two pence piece then here we are … here's a two pence piece … so how many little pennies are squashed into a two pence Isaac?

Child: *(long pause)* … ten …

Teacher: Ten pennies?...

Child: It is big and you can squash ten pennies

Teacher: Try again Ellis

Child: Two

Teacher: That's right two pennies have been squashed … right here is a very very tiny coin which always get caught in the corner of my purse … so I can never find them … what is this …

Child: A five

Teacher: A five pence piece … that's right … this is a five pence piece … Isaac how many pennies is a five pence piece worth … ? right if I said to you I'll give you pennies we'll do a swap how many pennies would I give you to give this to me?

Child: Five

Teacher: Good boy … five … what about this funny shaped coin?

Child: Twenty

Teacher: Well done Charlotte … it's a twenty pence piece … you're quite right … a twenty pence piece and how many pennies are squashed into this Isaac?

Child: It is very small so I think … five pennies

Within the concept *have done the task before* (Figure 5.9), there are a number of events which were attributed to having done a similar task before and therefore needed further unravelling as there was already a detailed mechanism for considering in depth what such events revealed.

They were considered through the *have done the task before* pathway discussed earlier in conjunction with Figure 5.6.

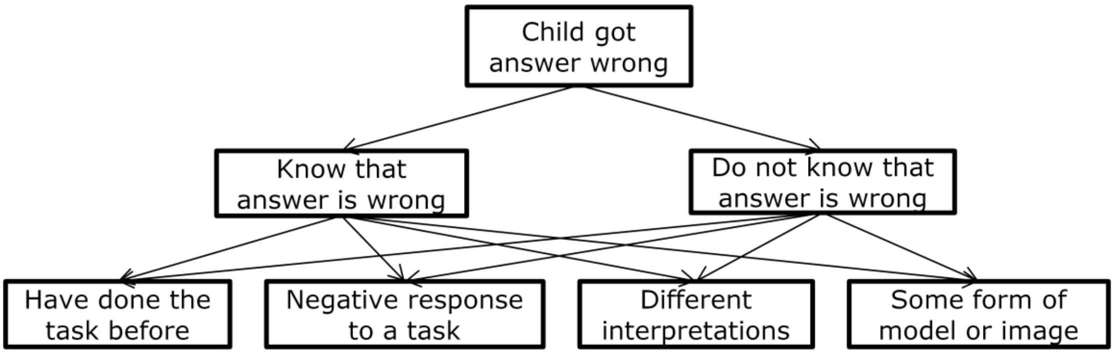

Figure 5.10 Granular concepts of *child got answer wrong*

The last cluster of events were events where children got the answer incorrect (Figure 5.10). In the process of analysis, I left all such responses initially to one side as it was not clear what they would have to offer. But as the analysis process continued and I examined these events closely, it was evident that there were a number of events where children were confident in what they were saying and did not know that they were incorrect. These could be further explored depending on the nature of the explanation through the different pathways already mentioned. There was another group of emerging events in which children had a clear idea of the error they had made and what this error may have been. These events could also be filtered through the same pathway as any of the other events had been for the lengthier responses. It was not important to the understanding of prior knowledge whether children got the answer right or wrong, but more important was to understand the journey that the child had made to gain their own understanding. Using the transcripts to *listen* to children and how they established their understanding was key to making sense of the data.

As with any research, an important question was when to stop the analysis process for my research. This is a very simple problem to solve. I stopped analysing data when no more new concepts were being formed. As I progressed through the analysis, each new transcript contained many new events but these fell into the same established concepts. Therefore the only purpose being served through greater analysis was an increasing volume of events, but no new understanding. After analysing 46 transcripts, there was no new information being gained through the data and therefore *theoretical saturation* had been reached.

> Additional analysis no longer contributes to anything new about a concept. In this way, the resulting theory is considered conceptually dense and grounded in the data
>
> (Schwandt, 2001, p. 111)

In order to pull all of these threads of analysis together, it is important at this stage to look at where we are. The constant comparison method, which encourages reflective and analytical thinking, supported the sorting, analysing and rationalisation of the data into concepts. Many different events ended up at the same point, thus forming concepts and ideas of how and what children were using to support their understanding and tackling of mathematical tasks. The process was refined many times and the paths presented here are a result of these stages of refinement. It should be possible, using these paths, to take any new event from the classroom and define the path it takes to reach the endpoint of a particular concept. At this stage of the analysis, I was able to sort all of the transcripts ensuring that each event has been placed into a concept which could not be refined any further, and all the events in any endpoint concept have the same features. Now we need to understand the role that these endpoint concepts play in defining prior knowledge.

Table 5.2 List of endpoint concepts

Response with no explanation	Not familiar	Cannot do it
Done it before in school	Done it before but not in school	Done it in the past
People in school	People outside school	Was wrong before and have now remembered
Words	Objects	School
Outside school	Sensory experiences	Similarity
Perceived challenge	Nature and presentation	

Thus far, the process of analysing the transcripts has been done using content analysis to dictate where they should be grouped. I have relied on my experience in the classroom to interpret and to some extent identify these concepts. This is consistent with the discussion at the start of this section that within grounded theory, the researcher can use her knowledge to guide the analysis process. I next considered each of the events within a concept and across concepts to determine if these concepts could be grouped and labelled to attain a best fit description of what my data were suggesting in order to understand prior knowledge and how it may function within an individual.

5.5.5 Developing the Model

This section will consider all the endpoint concepts (Table 5.2) and how they support the emergence of categories for the structural and functional understanding of prior knowledge. To understand what each of the endpoint concepts was revealing about how children were dealing with the tasks presented, it was essential to consider the commonalities, differences and characteristics through constant comparison to allow the nature of prior knowledge to emerge. This was achieved by looking at each group of concepts and assessing them based on the following criteria:

- What are the common properties, if any, in each of these concepts?
- Should these concepts be combined?
- Do the data show that there is interdependency between concepts?
- Do the data show any interaction between concepts?

Having many disparate concepts did not allow understanding to be gained in a comprehensive manner as to what was taking place when children were attempting tasks. So far, from careful listening to children, it has emerged that children bring many factors in order to address how they approach a task. Also different children did not bring the same methods to support their understanding, but a variety of mechanisms as can be seen by the concepts developed. At this stage, it was important to see if there is any pattern in these concepts to try and establish a working framework of what constitutes prior knowledge. There is a need to begin to describe what is taking place in each of these concepts, since at present they are just a collection of common events. Analysing the function of each concept, and giving a label to concepts which have commonalities will support description and allow further exploration of ideas in terms of understanding prior knowledge.

When looking at all the data, the dominant commonality which ran through each event, and thus all concepts, was the notion of recollection. Children were recollecting from memory what they needed to address each of the tasks. This can be seen in the transcripts in the previous section. E.g. in the transcript on page 178, the child is able to respond to the question without any support, thus recollecting from memory; in the transcript on page 179, the child is working out using various stages and is supported by what he is recalling to complete the task set. There is dependency upon memory in each event identified in the analysis process. Through the data, it has emerged that there is a difference in the nature of what is being recalled with each task and therefore it is important to describe each of these concepts through the use of a shared common language. Being led by the data, the formation of the emerging prior knowledge model has two key steps:

i. To look for common patterns between concepts through use of the criteria posed earlier and to formulate categories (groups of related concepts) to allow understanding of prior knowledge to emerge.
ii. After establishing the categories, to describe and explore them in a way that supports understanding of prior knowledge.

Using the process of comparing the characteristics of each concept, I was able to group concepts and to start describing what was taking place. The evidence from listening to children as to how they were understanding and developing methods to deal with tasks was being revealed. In order to see how categories emerged through comparison of concepts, I am going to consider in detail how one category was established.

First, I considered all the events within the concept *cannot do it*, two of which can be seen in the transcript extracts below.

Extract from transcript of fifth lesson by Mrs Jo Fishily at Greenville Park Community School

Teacher: I'll be there in a second … ok ready … right … now show them Aiden … ok everyone write down their guess … under my guess … let me see … you think seven and Martha says …

Child: I can't do it …

Teacher: Have a go …

Child: I can't do this …

Teacher: Have a guess …

Child: Six

Teacher: OK … right shall we count them now

Few children in group: One two three four five six seven …

Teacher: Seven … so in that box you write … seven … well done spot on … Martha was

Child: Too less …

Teacher: One too few … and Aiden you were a bit too high … and you did it …

Extract from transcript of sixth lesson by Mrs Jo Fishily at Greenville Park Community School

Teacher: Cylinder … right can you put your hand up if you notice anything about what is left on my white board this morning … Jack … what do you notice about what is left on my white board [the question put on the board was 9+3 =11 children were asked to consider the question] this morning cause you're talking … *(long pause)* … what do you notice Jack?

Child: Umm I don't know…it's too hard… I don't know…

Teacher: Make a guess

Child: I don't know

Teacher: Right anyone help … Jack right Hannah what do you notice

In these two transcript extracts (the first transcript extract was also seen earlier on page 181), the children have decided that the task is too difficult or beyond their ability, and as a result have made none or limited effort to address the task. They are unable to recollect any approach that may support them in addressing the task. The perceived level of difficulty is based on their inability to recall ideas to help address the task or to decipher the question. This on its own does not give any further understanding of prior knowledge other than the obvious conclusion that there are tasks which children find incomprehensible and therefore make a limited attempt to solve.

Secondly, when carrying out comparison between the characteristics of this concept and the remaining concepts, commonalities emerged between *cannot do it* and *perceived challenge*. The two transcript extracts below comprise some of the events analysed as the latter.

Extract from transcript of first lesson by Mrs Jo Fishily at Greenville Park Community School

[Children are using a 100 square playing various games]

Teacher: Right who could roll the dice for me? … then we're gonna move the button … that many times ok … we're going forwards … counting … Josh would you like to roll? just stay where you are, stay where you are and see if you can roll it onto the floor … oh what's it landed on?

Some children: *(shout)* Six

Teacher: Right, who can put their hand up and guess where I'm going to have to move button to? … uh let me ask somebody with their hand up … Louise

Child: Six

Teacher: Yeah, shall we see if you are right? Can you count with me?

Some children: One two three four five six

Teacher: Good girl Louise, right … *(whispers)* who can roll the dice this time? … *(normal)* shh … let's have Kealee can you roll it onto the dice onto the snake, ready? … ok … oops pass it to Kealee … ok don't worry, you're gonna have your own dice in a minute if you don't get a turn now … ooh … what's that landed on?

Some children: *(shout)* Four

Child: Easy … are we going to get to play this today?

Teacher: Yes four *(child makes a fist and punches the air with a smile)* … right put your hand up if you can work out already where my blue bead's going to be? … let me ask somebody with their hand up … let me ask Aiden

Child: Worked it out already its ten …

Extract from transcript of seventh lesson by Mrs Rebecca Rice at St Paul First School

Teacher: Good boy that is called reversing it isn't it? changing it around … *(long pause)* … so is that it? one two three four five six seven eight nine … well done shall we do number ten the last one … ok very very quickly then … tens Emily oh sorry Emma …

Child: Umm … *(long pause)* … ten … that has two numbers so … it is not the same … that is harder …

Teacher: Someone else have a try number bonds for ten

In the first extract, we see that the way in which Aiden approaches the task is dependent upon the level of ease that he perceives the question to have, which in this case is positive and easy. In the second extract (part of this extract was also seen earlier on page 204), Emma has approached the task with a preconceived notion based on her experience that a two-digit number will make the question too difficult for her to attempt.

Though these two concepts are very different – *cannot do it* is a clear statement from children without any explanation or detailed understanding of what they cannot do or why; *perceived challenge* is an indication of the level of ease or difficulty with which the child perceives a task which then calibrates the attempt that children make – they both have a common dimension in the approaches that children are using to determine the outcome in terms of the level of effort they put into a task. In order to describe what is going on, there are two key factors – first the individual, and second the level of motivation that is derived by the individual when interpreting the task at hand. These two factors are apparent in both concepts and common to both concepts. Therefore, I have grouped them into the category *individual motivation*. This label best describes the characteristics of the two concepts in that the dominant factor in how and what is being recalled is linked to the level of motivation that the individual feels as a result of looking at the task.

Within these two concepts, there were many other events which were similar to the examples quoted above. All the events are related to how the children were motivated by their view of the task. It could be argued that these events are about how children are perceiving the task, and these concepts should be grouped with other concepts which show different interpretations of the tasks made by children based on perception, e.g. *words, objects*, or *similarity*. However when comparing the events within the concepts where children's perception of the task is also considered, as can be seen in the transcript extract below (which was analysed as belonging to the concept *objects*), the clear difference identified is that in this example the child's thoughts are not structured by their perception of individual ability, but by how they relate the task to the object ribbons. Therefore events within the concepts of *cannot do it* and *perceived challenge* are very different in nature to events within the concepts *words*, *objects* and *similarity*, as they are reliant upon the motivation derived from considering the task itself.

Extract from transcript of first lesson by Mrs Helen Fellows at Greenville Park Community School

Teacher: It is the shortest piece … but why don't you think it is the shortest? … why have you got a different idea Katie?

Child: Because it is longer than that piece

Teacher: It's longer than which piece Katie?

Child: This

Teacher: Good girl … even though it's a short piece it is longer than others so this one must be the shortest … Mr Collins and Pam could you be the stands for the washing line for a minute? … John … does it matter that the washing line has moved?

Child: Yes

Teacher: Have ribbons gone any different sizes?

Child: Yes … look that one looks shorter now….

Teacher: Have we cut any off?

Child: No

Teacher: No have we put any in the bin?

Child: Its washing it got small in the wash… so now it is smaller.

Teacher: So let's check a minute who's sitting really beautifully … Kurt can you tell me which is the shortest? … can you pick someone to find which is the shortest? … we can measure it in… in … what

Child: Ruler

Teacher: Not quite what do we call this measure?

Child: Meter

In order to allow for common understanding of all these concepts, I have applied a best-fit label for groups of concepts which have similar properties. The collection of concepts were analysed by using this constant comparison method for all of my concepts. I identified similarities and common properties across them and derived eight categories which described what children were bringing at the point of tackling tasks. The categories are ***abstraction***, ***acculturation***, ***cognition***, ***context***, ***individual motivation***, ***metacognition***, ***perception*** and ***social group***. The mapping from concepts to categories can be seen in Table 5.3 below.

Table 5.3 Mapping from concepts to categories

Concepts	Categories
Nature and presentation Sensory experiences	Abstraction
Done before at school People in school School	Acculturation
Response with no explanation Not familiar Done in the past	Cognition
Done before but not at school	Context
Cannot do it Perceived challenge	Individual motivation
Was wrong before and have now remembered	Metacognition
Words Objects Similarity	Perception
People outside school Outside school	Social group

Having considered all the concepts using the method described above, and assessing them for commonalities and differences, I have organised them into the eight categories listed earlier. The eight categories are interlinked, and are all linked to the central category of memory. This concludes the description of the analysis process, and the next section examines the ethical considerations arising from the analysis process.

5.6 Ethical Considerations

A multitude of ethical considerations were taken into account in the analysis of the data, as per the ethical guidelines for educational research from the British Educational Research Association (2004). The process of using grounded theory and content analysis to analyse my data raises some key ethical issues, which have also been identified by Lincoln and Guba (1985a) in relation to qualitative data analysis – credibility, transferability, dependability, and confirmability of the data. Described below is how I have addressed each of these in my analysis process.

Credibility of the data was established by spending prolonged time (i.e. regular visits over one whole academic year) in each classroom. This allowed me to become oriented to and appreciate the nature and culture of each of the classrooms. A further benefit was that it allowed me to blend into the classroom and ensure that teachers and the children felt comfortable with my presence. This consistent presence meant that, as debated in Section 4.2.3, I was an "observer-as-a-participant" (Gold, 1958, p. 217) and the frequency of my visits to the classroom ensured that I blended into the culture of the setting and allowed me to gather data in its truest form. Also by asking teachers to review the transcripts, it allowed them to establish that I was interested in portraying the truth and establishing accuracy.

Transferability is important in ensuring that the data gathered has scope in wider understanding. I have achieved this by using what Lincoln and Guba (1985a) call "thick description" (p. 125). Thick description entails giving a detailed picture of the data and context that allows any reader to be able to completely place themselves and understand the positioning of the research. The ideal way in which this could be achieved is to report all data as recorded with as many points of reference which allow us to build an accurate picture of the context in which the data were gathered without any alterations to the data presented. However this directly contradicts the need for anonymity of the participants and settings. I settled this dilemma in my research by choosing carefully how I anonymised my data. E.g. the revised names for the teachers were chosen to be culturally identical to their actual names in order not to change the nature of the possible picture that may be established by the reader. The school details presented in Section 4.2.1 and Appendix A were altered to ensure that they could not be identified while keeping intact the actual nature of the schools. Furthermore the data to be presented as findings were done so with the focus on providing a clear and full picture of the points being considered and in no way to identify the school, individual teachers or children. I aimed to provide the data in as full a form as possible so that readers could come to their own understanding of what the data are showing and how, so that they may, if needed, use the outcomes in their own practice.

Dependability during the process of analysis is achieved by revisiting ideas and concepts constantly. As shown in Figure 5.2, there was a constant process of checking and comparison to ensure that interpretations made against new data were consistent and could be repeated. The process of theory generation requires repetition of the sorting and concept forming process. The data in my research were analysed, sorted and compared many times in order to ensure that the interpretations made of the data were in line with all the data collected. Grounded theory procedures force me to ensure, through the constant comparison mechanism, that there is dependability in the outcome.

Confirmability requires me to be as neutral as possible and ensure that there is no bias in the process of analysis and complete traceability in the use of data. Though clearly I am interested in looking to gain an understanding of prior knowledge in the mathematics classroom, this in itself leads to a bias in terms of which aspects of the data I will be considering as not all data collected would be of use. However in the process of collecting the data, I was clear to my participants that I was looking at only the interactions relating to mathematics within the lesson and also ensured that they were constantly aware of the developing theory. Furthermore, through the initial meetings with the participants, I shared my research perspective, beliefs, values and position in relation to the research I was carrying out. Also I shared with them some of my ontological and epistemological assumptions, and how these have led to the methodology selected for the research. In terms of my analysis process, I have maintained complete traceability from my raw data (i.e. transcripts) to events to concepts to categories.

5.7 Summary

There were two great challenges in this chapter. The first was to select an appropriate methodology from a range of qualitative data analysis methodologies to support the understanding and development of prior knowledge. The selected methodology had to meet a set of criteria which were established from the outset. The second challenge was to explain how the data were analysed through the methodology selected and any ethical considerations arising out of the analysis. I explored different ideas provided by dominant paradigms for analysing my data and found a blended approach which suited the criteria – an approach which used content analysis to understand what was being said and grounded theory to order, structure and support formulation of a theory.

This chapter has been procedural in merely giving the instructions for developing the partial model, and not the model itself. These instructions are not prescriptive, but are descriptive to help understand the broad range of data being considered, how sense is made of these data through theoretical sampling, and use of constant comparison as it is consistent with the principles of grounded theory. Through the use of examples from transcripts, I have illustrated the process of how I carried out the actual analysis which has resulted in the partial model established from a range of contributory elements presented in the next chapter.

6 PRIOR KNOWLEDGE MODEL

6.1 Introduction

This chapter explains the overall outcome from the research and analysis carried out for this thesis. I am going to define this entity that I am calling prior knowledge, and present the structure of my partial prior knowledge model which has emerged from my data, looking at its form, function and key features.

I will look at my model from its core to its periphery, looking first at the individual categories (or elements) that have emerged through the analysis of events and concepts, then considering how all of these categories link together and function, finally exploring a possible structure for prior knowledge. The individual categories are not considered in any particular sequence as they do not have any order or hierarchy within the partial model. I will define my model starting with the central category of memory and then the three categories –acculturation, context and metacognition – which emerged strongly in my data. For each of these categories, I will first examine its theoretical underpinning by presenting a thumbnail of the extensive work carried out by generations of researchers in that area. For each category, I am fitting the understanding of the category into existing theoretical frameworks in order to give an overarching picture of the links between my category and theory. This theoretical perspective is followed by my own definition of the category illustrated empirically using numerous extracts from the transcripts.

Furthermore, I will look at five other categories which are also emerging through the data – abstraction, cognition, individual motivation, perception and social group. These will be discussed in a similar structure as the first three categories, but in far less depth.

It is important to note that the proposed eight categories cannot be claimed to be a definitive list of features of prior knowledge, but can only be a partial model which has been established through the range of contributory elements in the context of my data. Though the description of my partial prior knowledge model is linear due to the limitations of the presentation medium (this paper-based thesis), the actual prior knowledge model itself is complex and multi-dimensional.

6.2 Memory

6.2.1 Theoretical Perspective

Research into memory and how it functions is extensive and broad. As far back as Plato and Aristotle, thought has been given to how we were able to learn, build our understanding and make links with what we experience. There are a number of disciplines and views on what memory is and how it functions – biological, psychological, social and cultural. Though there is much complexity in the form and function of memory and many subtle definitions, overall memory is about the retention, reactivation and reconstruction of experiences. Memory contains two components – the behavioural or conscious level, and the underpinning physical neural changes – which impact on what is recalled, or in very simplistic terms, encoding, storage and retrieval (Dudai, 2007).

> The word “memory” is misleading. Being a single word, it creates the impression that it refers to a single entity. ... Memory is not unitary. There are many dimensions along which different types of memory can be classified.

(Yuret, 1995, p. 1)

On a simplistic level, all types of memory are influenced and built upon through experiences and the construction of ideas through these experiences.

> ‘Memory’ labels a diverse set of cognitive capacities by which we retain information and reconstruct past experiences, usually for present purposes.

(Sutton, 2010)

Of greater interest, how is the information organised and developed in the brain or how is memory modified? My data suggest that there is no consistent method or logical process to the organisation of ideas.

> A picture of interlocked systems have started to emerge that support human memory function.

(Yuret, 1995, p. 9)

6.2.2 Definition

For the purposes of my prior knowledge model, the function of memory in its elemental form, defined earlier as a mechanism for retention, reactivation and reconstruction of experiences, is adequate.

Emerging from my data, the first noticeable link between all events identified through the analysis was that children were recalling information from their memory to support them in their mathematical tasks. Every event relied on some form of recollection from memory. Therefore the central category for my prior knowledge model is *memory*.

The question to consider next is – what are the factors that are shaping memory – as whatever is modifying memory shapes what children bring to bear on each task, and I am calling this prior knowledge. The data show that there are many different ways in which children solve similar mathematical tasks. They do not consistently use one method to manage the tasks they are being set. That is to say, data did not reveal a consistent element or process which children are recalling to tackle similar tasks. This leads to the conclusion that not only is memory modified and constructed with each task, but also that there are some forces influencing this reshaping as can be seen in Figure 6.1.

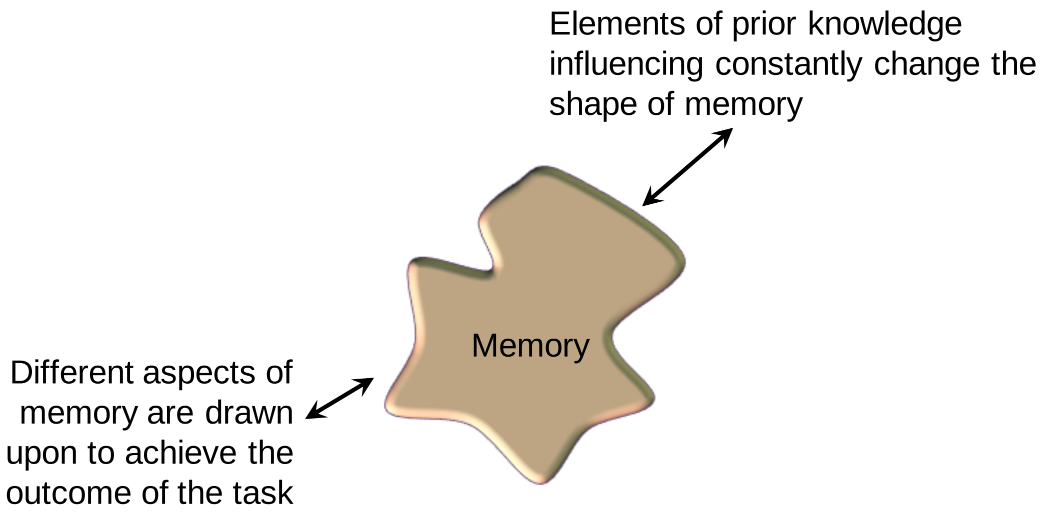

Figure 6.1 Forces influencing memory

6.2.3 Empirical Evidence

Below are some examples from my data which show a range of events and how they all depend on what children are able to recall.

Extract from transcript of fifth lesson by Mrs Jane Marshall at Argyle Common First School

[Children working with number fans]

Teacher: Show me … good right let's just have a think how did we work it out six and what makes ten … how can I work it out Henry?

Child: Umm I am not sure … if you know five and five makes ten then one less one is six

Teacher: Right right … I see … um Emily ?

Child: I worked it out

Teacher: How?

Child: Umm get six and go like this … [child uses her fingers] … you can put six in the air and count on four

Extract from transcript of fifth lesson by Mrs Jane Marshall at Argyle Common First School

Teacher: Right close up your fans Mitchell come on … what can you tell me about five and five Emily?

Child: It's a double

Teacher: What about this one … *(long pause)* … eighteen add what makes twenty?

Child: Oh I know

Teacher: I don't want to know the answer but who can tell me a way of working it out … can you put it on the floor please … a way of working it out … Devon

Child: What you can do is take the one off the end and umm take the two and put it in the box … and then you've got the answer

Teacher: Where did you get the two from sweetheart?

Child: The twenty?

Child: Yes

Extract from transcript of third lesson by Mrs Jill Thomas at St Paul First School

Teacher and few children: Let's start by counting in one's … one two three four five six seven eight nine ten eleven twelve thirteen fourteen fifteen sixteen seventeen eighteen nineteen twenty twenty-one twenty-two twenty-three twenty-four twenty-five twenty-six twenty-seven twenty-eight twenty-nine thirty … I think some of you are asleep this morning … there were some children who were not joining in there were some children not sitting properly so let's sit up straight … right just look at the person who is sitting next to you just and just check they are awake you don't need to say anything to them … just look and check that they are awake and let's count up to thirty once more everyone joining in ready

Teacher and most children: One two three four five six seven

Teacher: Stop being silly

Teacher and most children: Eight nine ten eleven twelve thirteen fourteen fifteen sixteen seventeen eighteen nineteen twenty twenty-one twenty-two twenty-three twenty-four

Most children: Twenty-five twenty-six twenty-seven twenty-eight twenty-nine thirty

Teacher: Well done right we are going to count in two's from four to sixteen … ready

Teacher and most children: Four six eight ten twelve fourteen sixteen

Extract from transcript of sixth lesson by Mrs Rebecca Rice at St Paul First School

Teacher: Now get your fingers show me ten fingers and take away two … *(long pause child counts)*

Child: *(whispers)* one two three four five six eight nine

Teacher: No count them again you're nearly right … ten put your fingers up for me like this … shh shh take two away … and how many are standing up nice and tall? count your fingers

Child: One two three four five six seven eight

Teacher: Good boy well done … eight … double four makes?

Child: Eight

Teacher: Double three makes

Child: Six

Teacher: Double two makes

Child: Four

Teacher: One and one makes

Child: Eleven…..oh no… silly me it's two

The small sample above is representative of the whole data set and shows that children's memory is a key feature of the prior knowledge that they bring to each mathematical task. The transcripts also show that children had very different recollections while engaged in mathematical tasks. Also children changed what they were using to address each task, with such changes, at times, occurring during the task.

The data showed no consistent pattern in what was being recalled or used by children on similar tasks. This lack of consistency suggests that children are drawing on different aspects of their own individual unique memory to support each task.

The fourth transcript above reveals that children's memory is changing shape and is different to how it was at the start of the task. This discovery in itself is not ground breaking, as constructivists would argue that we build our understanding of the world and our knowledge by constructing, changing and modifying the memory store we have. However it is ground breaking that my data reveal eight elements that shape memory. The rest of this chapter will focus on each of these elements in turn.

6.3 Context

6.3.1 Theoretical Perspective

As the data were analysed, a significant number of events emerged in which children were relying on some models or images to understand the task. Within these, there were events which relied upon experiences which specifically took place outside of school and formed a framework to help interpret the task. These all had some commonalities such as physical spaces and objects that allowed children to comprehend the task.

In order to understand how these (physical spaces and objects) contexts support children with their mathematical tasks, I must consider research around the concept of *context* in mathematics and develop a definition which helps to understand the data. As events were sorted, the commonalities which were present were the use of physical spaces and objects outside of the school. These spaces and objects, or contexts, outside of school supported children to understand and unravel the demands of their mathematical tasks. By using the context, children were able to contextualise the problem which they were attempting. The contexts which were expressed by children were part of their individual reality and experiences, were present prior to the task being attempted, and were drawn upon to understand the demands of the task, thus forming part of their prior knowledge. The role of context as a conduit to making meaning was a strong element of the data collected. It is important that some reflection on context is carried out. There needs to be a thorough examination of the role that context plays and why it forms part of prior knowledge.

Examining the research during the process of analysis allowed me to evaluate and focus on events which demonstrated a clear presence of context. Research considers and defines the role of context within primary mathematics in two ways – one view being the framing of mathematical questions in a real-life context to aid understanding; the other view being the environment in which learning takes place. Both these perspectives need to be examined in order to evaluate the understanding they brought to the events in my data.

It is only by considering our present understanding of existing research that we can layer new understanding as revealed by the data. Evaluating the data will allow for a definition to be determined and develop an understanding of context as a facet of prior knowledge and its forms and functions within prior knowledge. Therefore looking wider than my data set initially allows me to consider what the concept of context means in common understanding of the mathematics classroom within current literature.

One understanding researchers have is to consider context within mathematics as an enabler for the development of understanding.

> We define "context" as the situation in which the problem is embedded. The main role of the context seems to be that of providing the problem solver with the information that may enable the solution of the problem.
>
> (Borasi, 1986)

This perspective considers context as a way to pose mathematical problems to children, where the development of the context is in the control of the teacher. This is seen within the primary classroom as a way to frame questions within a narrative.

> The practice of embedding school mathematics into some "real" context supports learning.
>
> (Sullivan, Zevenbergen & Mousley, 2003, p. 109)

This embedding of a context within mathematics when asking questions is often an attempt by the teacher to link with the children's prior knowledge to support rationalisation of the questions being posed. Teachers sometimes lead the formulation of context and make assumptions about children's prior knowledge. If the context implied by the teacher is also part of the child's prior knowledge, then it supports easy understanding of the task. On the other hand, if the child is not familiar with the context being implied by the teacher, then the child will try and interpret the context based on their own prior knowledge, thus hindering understanding of the task. Therefore contexts used and reflected by the children are an insight into the world of the child and where they are placed in their understanding of mathematics.

In the transcript extract below, this is a mismatch between the teacher's expectation of what children's prior knowledge is in relation to the word *pattern* and their actual experience. For Chris, a pattern is a pictorial representation of a repeated pattern on paper with some understanding of numbers that appear while counting in 2's. On the other hand, the teacher expects the children to be able to relate the word pattern to numerical sequences.

Extract from transcript of ninth lesson by Mrs Jill Thomas at St Paul First School

Teacher: Well done when we are counting in two's … who can tell me something about the pattern for counting in two's … what is the pattern for counting in two's … Chris?

Child: Pattern? … like a wavy line … I was doing that at home … you know I had 4 colours and made four lines at the same time … you get to 4 when you count in 2's

Teacher: Not a wavy line … try again … what is the pattern when we count in two's?

Child:	Ummm … it's like this … [child puts dots in the air]
Teacher:	No I would like you to think what is the number pattern when we count in two's
Child:	Two four six eight ten …
Teacher:	That is right … we do say two four six eight ten … what do we call these numbers … Jo?
Child:	They are all even … they're all even numbers
Teacher:	That's it … the pattern when we count in two's is that they are all even numbers

Furthermore Cooper and Dunne (1998), through their research into how social class affects children's approach to mathematical tasks, also argue that this contextualising of mathematics may create a layer of complexity for students in that the experiences that children bring to school may not be reflected in the contexts used by teachers to frame tasks. At this juncture, it is vital to consider why this may be the case and question the use and deployment of contextualisation which causes this difficulty. Also what can be done to aid children when mathematical tasks are set in a real-world context to support understanding. The paradox is that teachers use a set of contexts in asking questions while they are not aware of the individual's prior knowledge and therefore cannot predict how the context will be interpreted. Therefore the use of context to support children in the mathematics they are engaging in often seems an arbitrary tool which does little to develop understanding. Furthermore my data support this in that they show children's efforts to use the context in which the mathematics is framed requires them to realign their understanding. They first link the embedded context to their existing contextual experience. They then process the questions by reframing them for themselves as there is not always a perfect match between the external context used and the internal contextual lexicon or the children's individual prior knowledge. This can be seen in the transcript extract earlier in this section.

Children have their own internal contexts that have been developed through their experiences which form a part of their prior knowledge. They use these contexts to understand and make meaning of the mathematics they are engaged in. Their individual contexts form a sort of translator for what is being presented to them within the classroom, that of context being an internal narrative which supports understanding of external structures that are used to frame mathematics. Thus context within my model as revealed by the data is this internal tool which allows children to make sense of the external processes of mathematics.

I would further argue that this layer of complexity is there due to the teachers' lack of awareness of children's own personal contexts and experiences, thus requiring children to decode not only the mathematics, but also the contextual information provided by the teacher. Therefore children's engagement with the mathematics is hindered through the use of teacher-led contextualisation. Considering this area of research has proved useful in two ways – one which clarifies the way in which the term context is currently used; the other which offers a path to linking this understanding to what the data are revealing, that of children using teacher-led contextual framing in a variety of ways. This is due to a mismatch as discussed earlier in understanding children's experiential base.

The other understanding of context has been developed by the work of Lave (1988) and Walkerdine (1990) when they consider the effects of the environmental context upon the ability of individuals to perform mathematical tasks. By this they mean the physical spaces in which mathematics is situated. This body of research suggests that there is a connection between the procedures and skills used by individuals to perform a mathematical task and the individual's situated context while carrying out these tasks. One of the ways in which individuals approach mathematical tasks is influenced by where they are physically situated. The studies further go on to show that there is a difference in the way in which children approach mathematical tasks in different environmental contexts and physical spaces. This implies that, in some form, the physical space influences the way in which children interact with the mathematics. The interesting question is why or what is it about the space that influences the relationship between the mathematics they are given and the way in which they approach it. The data from my study show that children layer their interpretation of what is being asked upon the narrative that they have formulated from past contexts.

In the transcript extract below, Nathan is using his experience of clearing a table as a way to understand repeated subtraction to support the calculation being asked. For Nathan, the concept of division is linked with the idea of the table and counting in pairs while removing objects.

Extract from transcript of fifth lesson by Mrs Jane Marshall at Argyle Common First School

Teacher:	Brilliant so it's eighteen shared by … divided by … shared between two … ok so what's the next thing I am going to do? Nathan?
Child:	Count down … umm (laughs)
Teacher:	Count down ok?

Child:	Eighteen, sixteen, fourteen … [child does the action of removing things from the table]
Teacher:	Why are you counting down?
Child:	Clearing the table … you take two things away at a time …
Teacher:	Can you explain?
Child:	Take two away each time to know how many you can share

Each child has an evolving relationship between the different contexts in which they have experienced mathematics and their interpretation of these experiences which are shaped by different factors such as setting. Lave's "Adult Math Project" (1988) illustrated this interrelation between individuals and settings, concluding that the physical context instigated choice in the mathematical process used. Therefore it is reasonable to conclude that in part it is the spaces that individuals have interacted with that influence the way in which they attempt a given task. Also that context is not just the physicality of the experience, but also the way in which experiences have shaped understanding. Data revealed that children approach tasks with their own sense of context, having engaged with something they see as familiar, and therefore constructing their own meaning of the mathematics they are given based on the nature of their personal contextual lexicon. Also as it is present before the task and used to rationalise the task presented, we see that different personal, social and physical environments have a different effect upon the way in which children carry out mathematical tasks.

In the transcript extract below, the child has seen the clock face in a similar position and related it to her sleeping time (based on seeing the moon on the clock) and thus can read it again with ease. However when asked how she worked out that it was seven o'clock, she was not able to explain in any detail where the hands of the clock should be to represent on the hour. So her ability to solve this task was dependent upon and fixed within her memory of the clock she has at home.

Extract from transcript of tenth lesson by Mrs Jennie Brooks at Draycott First School

Teacher: What time does the clock say now?

Child: Ooh ooh I know that is easy … it's the time I go to bed … 7 o'clock

Teacher: How do you know it says seven o'clock … can you tell the rest of the class how you worked that out?

Child: I have a clock in my room and there is a moon on the number 7 and it means bedtime … so I know it is seven o'clock

My data not only support both perspectives described above, but also allow us to understand the reasons why children demonstrate different approaches to similar tasks. There is an interlinking of the contextual experiences that children bring to a task and the way in which these direct their thinking, making context a crucial element of how children are able to carry out mathematical tasks. Children formulate their own unique understanding of the task by using their own experiential contexts. It is these contextual experiences which are an amalgamation of both the physical contexts, thus in line with Lave's findings, and the links between number and the experiences children have which creates an individual set of contexts for every situation that each child faces. Therefore within prior knowledge the notion of context is neither the physical nor the conceptual, but more the remoulding of the two to provide a unique lens through which tasks are interpreted.

6.3.2 Definition

In my prior knowledge model, my data show the importance of the meaning that children are bringing to their mathematical tasks using in part their experiences of and in physical spaces (e.g. parks, roads, playing in the garden, eating dinner in the kitchen, etc.) and how these have an influence upon the conceptualisation and comprehension of mathematical tasks. This element of prior knowledge is what I call context.

Children use their seemingly unconnected contextual links to help answer questions. The way in which children use and manipulate the external context is influenced by their internal contextual map. Within the data, there is a complex weaving of how prior knowledge is made up and one of the crossovers is that of contextual experience within school and outside of school. Having teased out the relationship between children's experiences of context and how this may influence what they are able to bring to bear upon mathematical tasks, data show that there is distinction between the way in which context within school and context outside of school influences children in their approach to mathematical tasks. Emerging through the data are two aspects of children's contextual experiences – one of these being the formal experiences of school (acculturation which will be considered in Section 6.4); the other being informal experiences outside of school. Therefore context, in terms of prior knowledge, is a distinctive feature which is not shaped by experiences linked to formal educational settings. From this, context is a key part of prior knowledge and is defined as the amalgam of all contextualised experiences children have had outside of school which they draw upon to support the understanding of mathematics by allowing them to view tasks through the lens of previous contextual ideas which have been rationalised.

Therefore my definition of context, as I define it here, does not include school, playground or any other areas connected with formal educational settings such as forest school areas or nurseries as these comprise the prior knowledge element of acculturation (see Section 6.4). When analysing the data, it emerged that children referred to and used context in very different ways to understand the questions being asked, thus leading to context forming a distinctive part of prior knowledge.

6.3.3 Further Empirical Evidence

When I consider the transcripts below, the data show that in order to understand a task, children search for ways to make meaning. One mechanism that they rely upon is to search for similar situations that they have been in before physically.

In the first transcript, Rowena has used the idea of playing snakes and ladders to achieve the mathematical task. It seems that for her, somehow memory of how to take away five from eight is inextricably linked to her past experience of playing a game. Part of the structure of her prior knowledge is influenced by the sensory and emotional experiences that she has had in the context of playing snakes and ladders.

The data show that it is not a simple connection between spaces and mathematics, but a wide variety of ways in which the contextual experiences children have shapes their memory and therefore forms an element of prior knowledge that they bring to support their tasks. Looking further into this extract, we notice that in order to be able to perform the calculation, Rowena relies upon understanding gained from the playing of snakes and ladders and has an image from the physicality of moving up and down the board which has formed part of her prior knowledge.

Extract from transcript of first lesson by Mrs Sally Crane at Hatton First School

Child:	Eight take away five leaves us with
Teacher:	Hang on … eight … I can only write that fast … so you think it's eight take away
Child:	Five
Teacher:	Eight take away five right
Child:	Gives us
Teacher:	Shh shh let Rowena finish the whole sum if she can eight take away five equals
Child:	Three
Teacher:	Three that's brilliant … why … did you how did you know that? … how did you see that … why did you think that? … you're right
Child:	Because you know I play this game snakes and ladders at home and in that you go up and down

The images formed in Rowena's mind of the snakes and ladders board has been drawn upon while looking at a task in school. Thus for Rowena, the context of snakes and ladders has supported her in addressing the mathematical challenge. Therefore Rowena is drawing on the context developed within her prior knowledge.

In the following transcript, the child's experience of physically standing in circles has allowed them to develop their understanding of the nature of shapes. This understanding is further enhanced by the ideas of how a point on a triangle may feel. Children's understanding of shapes and their properties depend on the many different contexts in which they have already seen these shapes. This knowledge is not built up by simply showing children pictures of the shapes, but the many different experiences that children will have had up to this point which supports their development of a set of personal definitions about shapes. In order to fully form prior knowledge for this child, the physical context has been merged to form a new context through which some understanding of shape has been developed. This is one of the mechanisms used by some children to develop personal definitions of each area of mathematics.

Extract from transcript of second lesson by Mrs Rebecca Rice at St Paul First School

Teacher: Ah but there is one shape that has less corners than the triangle … which one is that?

Child: You can't stand in any corners in a round… it just goes round and round like in the park … [child makes a circle in the air]

Teacher: Circle … because how many corners has that got?

Child: None

Teacher: None … so you are quite right the triangle has less corners than the square and the rectangle but it's got more corners than the circle … another difference

Child: If the circle balloon falls on the pointy bit it will pop

Teacher: That's quite right if the circle balloon fell on top of the triangle it might pop … shh … shh the balloon would pop … what other differences can you see? … what about this shape here? I can see some differences between this shape and this shape … Isaac

Child: The rectangle has got more … longer … it's a bit squashed … a bit longer that way a bit ummm … like the TV

Teacher: So the rectangle's got longer sides top and bottom than what … the square … yes if you look at the square top and bottom they've got short sides top and bottom … whereas the rectangles got long sides … what about the ends of the rectangle … Megan?

The child needed to refer to the TV as a way to allow the explanation of a rectangle to make sense. We can extrapolate from this that their prior knowledge of shapes (rectangular) is of a TV and the child draws upon this context to develop further understanding.

In the third transcript, Aiden has used the context of home to solve the question asked. He is able to use the idea of having done this at home to support his understanding of what is being asked.

Extract from transcript of first lesson by Mrs Jo Fishily at Greenville Park Community School

	[Children are playing a game of snakes and ladders as a whole class the counter is on 6 and the dice is rolled again]
Teacher:	Yes four *(child makes a fist and punches the air with a smile)* … right put your hand up if you can work out already where my blue bead's going to be? … let me ask somebody with their hand up … let me ask Aiden
Child:	Worked it out already its ten …
Teacher:	Ooh how did you work that out Aiden, how did you know?
Child:	Cause um I always works out my number at home
Teacher:	What did you think in your head though so that you knew that answer?
Child:	Um cause um I knew it was um cause I know the number

Though not able to explain in detail how the understanding is formed, there is some rudimentary recognition of the fact that Aiden is drawing upon experiences that have been informed by the context of home – again the contextualisation is forming part of prior knowledge.

In the next transcript, Paul has used his experience of various road signs to understand and answer his question. There is reliance on physical contexts of how children are forming understanding, and this understanding is then being referred to when engaged in mathematical tasks.

Extract from transcript of second lesson by Mrs Rebecca Rice at St Paul First School

Teacher: You are super stars aren't you … right over the next three days we're going to be looking at shapes … now you've already looked at fat shapes haven't you? shapes that we call 3D … and this time we are going to be looking at flat shapes … shapes that we call 2D … the sort of shapes that we draw on pieces of paper like those ones ok … Paul … shh … shh … James … Paul could you tell me what that shape is called?

Child: It's the same as the sign outside on the road where the man is digging

Teacher: Good what is the name of that shape?

Child: Umm … triangle

In the final transcript, where the children are asked to find a missing number, Hannah relates it to her experience of playing hide-and-seek in the garden to understand how to find missing numbers on a number line. This prior exposure to other ideas has an impact upon the methods that children can draw on to approach their tasks. These transcripts show that children are drawing upon these past experiences in different contexts to enhance their understanding of the present situation.

Extract from transcript of second lesson by Mrs Jennie Brooks at Draycott First School

Teacher: Nooo … Holly now what's the matter? … can you move she can't see? … Holly what's the matter with my line now? … shall we count it?

Child: One

Teacher: Nooo … zero

Child: Zero one two three four five six seven eight

Teacher: What

Child: Eight is hiding

Teacher: Is that eight? … Holly where's eight? … can you see it?

Child: It's gone

Teacher: Oh Hugh … has it gone? … Hannah where's eight?

Child: I like playing hide and seek yesterday in the garden we played that and then I found Jo … *(child scans through to look for number eight)* there is eight. I am good at that.

I argue through the data that context and its influence in modifying children's memory form a key facet of the overall prior knowledge that children use to develop their understanding of mathematical concepts. The use of context to support understanding is limited by what the children are familiar with and exposed to in terms of context. When considering individual prior knowledge, we must include the context that forms this prior knowledge and furthermore understand that context within prior knowledge is made up of many different external experiences which have been reshaped by the individual to formulate an evolving model or image to support new understanding. Without context, prior knowledge would not be complete as the physical experiences that individuals have shape the tools they bring to understanding the mathematical tasks presented.

6.4 Acculturation

6.4.1 Theoretical Perspective

Throughout the data analysis, another recurring theme was the noticeable reference by children to having done the task or aspect of the task before in a formal educational setting. Also there were some interpretations given to tasks which could be linked directly to having engaged with it in a specific manner before with formal instruction. These events were distinctively different to context, encompassed within which were external non-school contexts which children were using to rationalise the task. A category to emerge is one where all events are related to individual understanding of mathematics linked to formal education settings. It is this that I have labelled as acculturation.

Much of the research on acculturation is based within the context of multicultural integration and how individuals cope with the cultural, social and psychological impact. Cabassa (2003) defines acculturation as "the social and psychological exchanges that take place when there is continuous contact and interaction between individuals from different cultures" (p. 127). Berry (2005) states that "acculturation is the dual process of cultural and psychological change that takes place as a result of contact between two or more cultural groups and their individual members" (p. 698). The definitions above can be used to explain events that emerge where children bring their influences based on their prior formal educational experiences and are now becoming accustomed to the culture of the current setting.

> Every child in every society has to learn from adults the meanings given to life by his society; but every society possesses with a greater or lesser degree of difference, meanings to be learned. In short, every society has a culture to be learned though cultures are different.
>
> (Levitas, 1974, p. 3)

We could argue that all schools and teachers have a way of thinking which varies and is dependent upon the cultural values and demands of the school and challenge the notion that all teaching of mathematics is carried out in the same way. As Nickson (1994) states, the culture of the mathematics classroom is "the invisible and apparently shared meanings that teachers and pupils bring to the mathematics classroom and that govern their interaction in it" (p. 8).

These definitions have some bearing upon my research in that they emphasise that within primary schools, each classroom has its own culture, with different classrooms in the same school having different cultures by the virtue of being constructed by individuals who are different.

> First, we argue that teachers and students together create a classroom mathematics tradition or microculture and this profoundly influences students' mathematical activity and learning.
>
> (Cobb, Perlwitz & Underwood-Gregg, 1998, p. 63)

When considering classroom traditions and learning about mathematics in the classroom and in wider society, fundamental questions are raised about how children acculturate. I use the term acculturation and not enculturation as they are distinctly different. My data show that there are clear efforts made by both the teacher and the child to assimilate and change to come to a common cultural position which is defined as acculturation, that is the working of two cultures to adjust together. On the other hand, enculturation implies that teachers support and shape the way in which the children fit within the classroom culture which is not influenced by the children (so it is a one-way process from teachers to children). The data show that both children and teachers have made efforts to understand the influences of prior knowledge, and in this case the aspects of prior school experience, to support understanding of mathematical tasks, hence to acculturate. However, in my analysis, I have focused on the acculturation process of children.

In the transcript extract below, we see that Caitlin is using a previously established routine for calculating a difference that she has used previously in mathematics to support how she attempts the current task.

Extract from transcript of seventh lesson by Miss Lora Hunter at St Paul First School

Teacher:	What is ten and one more … when you've found the answer get your number fan at the ready … when you show me ten the one comes first and then the zero … Caitlin's got nine what did you do Caitlin?
Child:	I used my fingers and … like with Mrs Jones [Mrs Jones is the class teaching assistant]
Teacher:	You counted on your fingers … can you show me how you did it?
Child:	I had this many [holds up 10] and then I closed one…
Teacher:	You had ten … then why did you close one
Child:	That's how we worked yesterday in numeracy … made the first number then closed the other number … like this

The events show that in order to understand tasks, children refer to how they learnt within school and how this supports them to develop methods to approach similar tasks.

Data also show the ideas that children use to carry out mathematical tasks and how are these shaped by their past experiences in other formal educational settings. Furthermore children are required to adapt their thinking or, in Piagetian terms, assimilate their cognitive process to fit within the existing structure. Children bring their own social psychological culture and there is a process of negotiation between teacher and child to assimilate into classroom norms.

In the transcript extract below, we see that the child's understanding of the vocabulary to describe shapes has been shaped by their experience in previous lessons and the rules they gathered in terms of the use of prefixes. The teacher accepted the logic applied by the child to support the development of understanding in sorting out shapes into different properties.

Extract from transcript of fifth lesson by Mrs Jane Marshall at Argyle Common First School

Teacher: Everyone I looked at managed to sort out their shapes perfectly … so well done … I was just sad that one table couldn't share glue … so blue table are going to lose a star … (*long pause*) … right let's see red not thick red … instead of using the words not thick what other word could I have used?

Child: Unfat …

Teacher: Could do … is that a word?...

Child: Last time … un is the same as not… like in literacy when we did the opposite quiz

Teacher: Is that always the case? … unfat is not a word but ok we can use unfat here … so now look at this shape … where will I put it? … [teacher holds up a green thin shape]

Child: Over there [pointing to a Venn diagram on the floor made out of hoops with the label Not red]

As Cobb et al. (1998) noted, classroom norms are full of microcultures and routines which shape children's way of approaching the tasks presented. When children are in classrooms, they have to reacclimatise to the rules and order of that classroom and the data show that within prior knowledge, children's understanding of mathematics is formed in part by the cultural influences of previous formal educational settings. Therefore children need to begin to understand the social and psychological (Cabassa, 2003) changes that must be made in a new classroom. This process of acculturation has an impact upon shaping prior knowledge. In the transcript extract below (part of this transcript extract also appears on page 186), we see that children are not used to number stories as they are distracted by wider events of school routine and associate these mathematical questions to those routines to support the calculation required.

Extract from transcript of seventh lesson by Mrs Jill Thomas at St Paul First School

Teacher: Umm now we're going to see how good you are at listening and how you can try and work out the answers to these number stories … you could use adding … or taking away so let's try … ready ok? … Ok let's think I had ten cakes and I ate three of them … how many cakes did I have left … Lucy?

Child: From the cake sale yesterday … but you were helping at the table miss.

Teacher: Yes at the cake sale … I had ten cakes and I ate three of them … how many cakes did I have left …

Child: Seven

Teacher: Seven good girl … I have five pencils … if I put five more in my tin … five pencils in my tin I put five more in my tin how many altogether Molly

Child: That's my job to sort the pencils..

Teacher: Ok can we just work out the answer to the number stories … I have five pencils … if I put five more in my tin

Child: It is ten that is how many you have in there now …

Teacher: How did you work out that the answer was ten?

Child: I can see them from here … hehe … we had to tidy up yesterday … remember?

In simplistic terms how children approach a task, e.g. adding, is influenced to some extent by how this has been explained or taught and understood in their previous classroom experiences. Children may have to do 23 + 9 by putting 23 in their head first and then counting on 9 more in their previous classroom experience, and in their new classroom they may be taught or expected to carry out the same process as 23 + 10 – 1 which requires a different structural understanding of the relationship between +

and –. This change in process and the underlying understanding can be equated to a change in the culture and values of the classroom which they will need to adjust to. Also it could be that the practical tools used by the previous teacher had a constructivist pedagogical philosophy. Children bring that to their new learning. Therefore, as Bishop (2002) states, a child is experiencing a "cultural conflict" and it is this conflict that requires understanding and supporting. Wolcott (1974) further clarifies the process of acculturation as "the modification of one culture through continuous contact with another" (p. 136). Throughout the data, we see that one of the areas that are present prior to the task is a process that has been developed through being in a formal setting that has to be modified in order to assimilate into their new classroom culture where these methods may be very different. Overall this cultural tension between child, teacher, classrooms, past formal educational experiences and present formal educational experiences is one which forms a part of prior knowledge.

To consider in a little more depth, the cultural conflicts which are inevitably present between not only different settings, but also by the virtue of children having different teachers each year and being on the whole in different spaces complicates the transition process. The transition process is a slow but essential process which understands that in order to shift an individual's thinking, they must understand the reasoning behind the change and this reasoning depends upon children's prior experiences. Within schools, there is some effort to overcome these "cultural" differences in mathematics by implementing strategies such as a calculation policy or a whole school progression plan within mathematics. The sound principles of these strategies are based upon recognising that the way in which children develop understanding is dependent upon the way in which their teaching and learning is structured. If we are accepting the premise that this has key influence upon the individual's prior knowledge, then the change in the nature of this is a high cultural shift for individual children. It is crucial to be explicit in that the data show not only change in children to a new culture in their current class, but also all the teachers developing an understanding of the way in which children are thinking and processing and adjusting to this process. As has been evidenced by the data, the notion that children can attempt a task without any influence of their prior experience in a formal setting seems clearly improbable. Though the data did not show this to be clearly the case in every event, we cannot rule out the influence in the construction of their prior knowledge as children's understanding and processing of a task in some form has been influenced by being part of a formal educational setting, which at times is so woven into their understanding of mathematics that it is difficult to always tease out.

6.4.2 Definition

In my prior knowledge model, I am defining acculturation as the events related to the experiences of children within formal educational settings, e.g. the classroom. The previous formal educational experiences that children have had have an impact upon their understanding and knowledge of mathematics. The cultures of schools, nurseries and pre-school environments have a unique effect on children's ability to understand and attempt mathematical tasks.

6.4.3 Further Empirical Evidence

In the transcript extract below, children talk about having done the task before in school. Children are bringing a wider educational culture and what they learn from it to the task. This has an effect on how and what they have to help support them in doing a mathematical task. In this example, acculturation refers to the talk that teachers engage in, the rules and routines of how mathematics is approached, and the ethos of the teacher. The teacher is choosing to focus children into a particular method for calculating one more and one less than. However children remember one less than as take away, so there is a compromise made and both approaches are used.

Extract from transcript of first lesson by Mrs Jo Fishily at Greenville Park Community School

Teacher: And he'd be very pleased to hear that, won't he? … now … yesterday in number … put your hand up if you can remember what we were doing yesterday in number? … Hannah

Child: Ummm, counting

Teacher: Can you remember? Is it coming? … Shall I ask somebody else? Martha

Child: Taking away and

Teacher: Taking away and? … nearly nearly there, what were you going to say Richard?

Child: Adding one more

Teacher: Adding one more orrrr?

Child: Taking away we did this before

Teacher: Taking away one more … we were working out one more or one less … and do you remember yesterday in numeracy, we started off … just sit for a little bit Logan … by using our number lines from nought to twenty, didn't we? and we said … oh Gemma can you point to the number one less than nine? … one less, one less than nine … so take away one … what should she point to?

Child: Eight

Some of the ideas, as can be seen in the transcript extract below, have nothing to do with formal mathematics, but to do with the environment and culture of the classroom created by the games that children have recalled from previous classroom experiences.

Extract from transcript of third lesson by Mrs Jennie Brooks at Draycott First School

Teacher: Well done are we ready? if I have got 10p and somebody gives me another 6p how much will I have

Child: 16p … I remembered the p from before we played shops there with Mrs Jones

Teacher: You didn't forget the p well done … Oh this one is much too hard … let me see if you can do this today … ten add zero

Each classroom observed had a definite set of routines and processes for the way in which mathematics was approached. The transcript extracts below show how, in each of the lessons, the teacher negotiated the way in which children would approach new challenges in the tasks. For example, a clear routine can be seen which consists of children regularly counting to start each lesson.

Extract from transcript of third lesson by Mrs Sally Crane at Hatton First School

Teacher: Good well done … we had the twenty instead of the twelve … good you are getting the hang of that really well … Ruth try and I know you don't feel very well but see if you can join in with us ok remember to move your hands helps you remember how many you are counting … have a little look at our hundred square ok … Nicholas would you like to stand up and point to number ten for me … ok Nicholas is going to be in charge then … can you count down the numbers with Nicholas in ten's as he points to them for me … off you go … ten

Most children: Twenty thirty forty fifty sixty seventy eighty ninety a hundred

Teacher: Wonderful … thank you sit down then … Richard would you like to stand up and do you think you could point to them as we count backwards

Child: Ohhh

Teacher: Ah yes

Child: Easy

Teacher: Oh easy jolly good right … let's see if everybody can do it with Nic Richard then ready … a hundred

Most children: Ninety eighty seventy sixty fifty forty thirty twelve

Teacher: Ah I caught somebody saying twelve

Child: Ten

Extract from transcript of fourth lesson by Mrs Sally Crane at Hatton First School

Teacher: And thirty will stop there … well done ok let's see if we can remember our counting in tens we tried last half term … ready with your hands

Most children and teacher: Zero ten twenty thirty forty fifty sixty seventy eighty ninety a hundred

Teacher: Well done … let's see if we can go backwards … ready

Teacher: Right let's start going backwards from fifty

Most children: Fifty forty thirty twenty ten zero

Teacher: Now who can remember the robot from last time

Most children: Yeah yeah

Teacher: Now we are going to be doing some robot maths today

Extract from transcript of seventh lesson by Mrs Sally Crane at Hatton First School

Teacher: Oh dear I think we've had all sorts of numbers

Child: He did eight

Teacher: What number is it?

Child: Ten

Child: Eight

Teacher: It's number eight … let's do it together ready

[Children start clapping]

Teacher: No we are all going to start together Richard … ready and

[Teacher and children clapping]

Few children: One two three

The interaction between teacher and children, and between children themselves forms part of the culture of the classroom, and influences the way in which children are able to approach mathematical tasks and what they are drawing upon to support their understanding of the tasks. The data further show that children bring to the task ideas they have gathered in different settings. In the transcript extract below, the child recalls a mathematical technique that they considered in their previous school year.

Extract from transcript of eighth lesson by Mrs Sally Crane at Hatton First School

Teacher:	Eight all right … can anyone tell me let's write it down what the … difference
Child:	What the difference
Teacher:	Between is … what the difference between those two numbers (8 and 6) … Josh
Child:	Six you write 6 like this we practiced this with Mrs Wilson in handwriting.
Teacher:	You think it's six … would you like to come and try and see if you were right … can you remember how we did it
Child:	Oh I know
Teacher:	Let him see
Child:	It's the same two numbers as yesterday
Child:	Jumps like we used to do with Mr Ellis
	[After discussion with Mrs Crane, it was noted that Mr Ellis was their reception teacher last year]
Teacher:	Jump we did jump yes see if you've got the right jump … count as you do it … out loud
Teacher and child:	One two three four five
Teacher:	Ah how many jumps?

Conversations which occur in a classroom about mathematics shape what is available to children in supporting them with a task. Different classroom cultures not only cultivate different ideas, but also shape the memory for children to continue their mathematical development. In the transcript extract below (part of this transcript extract appears earlier on page 203), the teacher is keen and has reinforced many times for children to draw upon facts and methods (counting on their fingers) they may already know to support with the new task. This changes the way in which prior knowledge is shaped and brought to bear upon this task. There is greater emphasis on what has been learnt in this classroom and limited acknowledgement of other ideas that children may have.

Extract from transcript of fifth lesson by Mrs Jane Marshall at Argyle Common First School

Teacher: Let's try this one? … fourteen add what makes twenty? so you put fourteen in your head shhh … put it down you can't have number fans in your hands cause you need them for counting … fourteen in your heads and count on till you get to twenty … *(long pause)*

Child: Mrs Marshall it is easy it's

Teacher: I'll come to you in a moment I know what you're going to say … Liam?

Child: Umm six

Teacher: You are well on the ball now you've got it haven't you Emily … it is six Devon what are you going say?

Child: It's changing the fourteen over to a four and then it's easy

Teacher: You mean like that … put that there … well done remember when we did some work with families it's the thing I've got it up here bargain basement if you know one thing you get a lot of other things free … if you know that sixteen and four is twenty all you've got to do is swap it around … ok if you know that six and four is ten you should be able to work that six and fourteen is twenty … and six and twenty-four is thirty … one more

Child: We had that in our speedy maths

Teacher: We have done it in our speedy maths … Emily what were you going to say?

Child: Thirteen add seven is twenty you get the seven and take away one and add one you get four

Teacher: Right last one … *(long pause)* … twelve add I can see James and Jay can't listen this morning twelve add what makes twenty … *(long pause)* … think about what number's going to go in your head … I am going to ask someone I haven't heard from today … twelve in your head and count on to twenty … *(long pause)* … Ashley?

There is a great deal of variation in the acculturation experiences children have had and this leads to variation in the shapes of individual memories, and thus prior knowledge. Children bring what they understand and remember based on their formal educational experiences of how they were taught to approach mathematical tasks. This shapes memory and also is a key element of prior knowledge. The data do not indicate which classroom culture is better for mathematical development, merely that part of what is used to address mathematical tasks by children is this notion of acculturation and specifically, data point to acculturation of formal educational settings.

To summarise, the data show that memory is shaped by the nature and culture of the formal educational experiences that children have had, shaping what children may be using in terms of addressing the mathematics they are engaged in. There is great influence on other elements of prior knowledge as a result of acculturation.

6.5 Metacognition

6.5.1 Theoretical Perspective

My data show that children bring some sense of their own prior understanding – a level of self-awareness and an understanding of what knowledge is already there and the connections that they have already made (metacognition) – to mathematical tasks. It is not important whether this self-awareness is erroneous or limited. However it is vital to understand that as part of the tools that are employed to approach mathematical tasks, children have an internal vocabulary that they refer to in order to think through approaches they have that can be used or knowledge that is familiar and understood. The data also show that there is some element of individual thinking occurring before, during and after performing a task. Children have some understanding of their thoughts. They may not be able to verbalise these thoughts, but they do have a sense of their thinking.

In the transcript extract below, we notice that Mary is aware that she does not know how to count in sequence of two's and offers a strategy that will support her in carrying out the task. Also we can see that Scott has established that the task is well below his competence and requests further challenge by insisting on moving to higher numbers, thus demonstrating a clear awareness of his own thinking.

Extract from transcript of eighth lesson by Mrs Jennie Brooks at Draycott First School

Teacher: Three … right well done right stand still and let's keep going … the next one is … remember you've got to miss one and say the next one

Child: Four … umm no it's … umm five …

Teacher: Ok good let's keep going next one Mary?…

Child: Are we allowed to count out to work it out … five … six [child talks quietly] … seven

Teacher: Next?

Child: This is easy I can do them all … three five seven … … can we go … high … I can count really high

Teacher: Well you will have to wait … now I know you can count … you've got to listen … Harry Harry listening … right you've got to miss one and say one … now there are … Scott … you've got to listen …

Child: Mrs Brooks this is boring can we do bigger numbers …

Teacher: You've got to listen … you think you've got to miss one … and say one and listen … this is going to be harder … Zeno won't know what to do cause he's not listening … Hannah's going to start and she's got to miss one … so she can't say number?

There are aspects of the data that demonstrate knowledge of having carried out similar tasks before, the level of understanding that was established the last time it was carried out, and the impact this may have on the task being presented, as can be seen in the transcript extract below.

Extract from transcript of ninth lesson by Mrs Jo Fishily at Greenville Park Community School

Teacher:	Can anyone think of another word that means add we have had plus add
Child:	Adding
Teacher:	That is add another word …
	[Then the teacher goes on to explore some more properties of addition … adding more than two numbers, the number gets bigger … then she moves on to what is meant by taking away]
Teacher:	What do we mean when we take away?
Child:	I know…. Oh oh… make it smaller…
Teacher:	Can you see a word on the board that also means take away
Child:	I know the word… but I can't read it … what does subtract look like
Teacher:	It's on the board it begins with a s s
Child:	No what does it look like … I remember the word but can't work out the one it is …

Metacognition is defined by Schoenfeld (1992), on a simplistic level, as knowledge about one's thought process and self-regulation. Flavell (1979) defined metacognition as "thinking about thinking" (p. 906).

> 'Metacognition' refers to all processes about cognition, such as sensing something about one's own thinking, thinking about one's thinking and responding to one's own thinking by monitoring and regulating it.

(Papaleontiou-Louca, 2003, p. 12)

Metacognition needs to be deconstructed in order for me to understand and apply it correctly in ideas that emerge through the data. There are a limited number of studies considering the meaning of metacognition. However educational psychologists have understood the value of metacognition to support pupils' development.

Kuhn and Dean (2004) define metacognition as "awareness and management of one's own thought" (p. 270). This aspect is visible through the data. While children consider the tasks they are presented with, they evaluate the abilities they had to tackle the task as can be seen in the transcript extract below.

Extract from transcript of seventh lesson by Mrs Jo Fishily at Greenville Park Community School

Teacher:	She's taken away a cuboid … right Hannah have a seat … umm Josh can you come and take away a cube a 3D shape you're so smart this morning … a 3D shape can you take away a 3D shape please … good boy you've taken away?
Child:	Peasy a cuboid … let's cover our eyes so we don't look … so it is harder
Teacher:	Umm looks like you are finding all these shapes easy ok … let try this one …
Child:	With our eyes closed … pleeeeeease …
Teacher:	Ummm … ok fine with your eyes closed there you go pick one
Child:	Ooh it feels like a … tricky … umm is it a pyramid?
Teacher:	Why do you think it is a pyramid?
Child:	I can feel the sides … there is one which feels like a square and I poked myself on the pointy bit …
Teacher:	Ok open your eyes and check
Child:	Yes (*fist in air*) I knew it … easy

Using these definitions, I can see two aspects of metacognition – one which is likened to knowing how to do something, and other which is the ability to choose the best strategy to achieve a task (Carr, Alexander &

Folds-Bennett, 1994). Researchers have examined and considered the strategies that children use in mathematics and this "has indicated that children possess and use metacognition to their advantage" (Carr et al., 1994, p. 584).

Further research states that children possessing metacognition know about mathematical strategies (Garofalo & Lester, 1985). It is the reflective nature of this aspect of prior knowledge that has emerged through the data. There is much connection between cognition and metacognition and between metacognition and the impact it has on individual motivation. The ability to reflect, select and act upon one's own engagement in a mathematical task is an intrinsic part of the prior knowledge that children bring to the task, as evident in my data. Carr et al. (1994) have suggested that the influence of metacognition upon mathematical tasks is "instrumental when the task demands challenge the child but do not overtax cognitive capacity and existing skills" (p. 584). Schraw (1998) further states that "metacognition differs from cognition, is multi-dimensional, and domain-general in nature" (p. 118).

My data show that one of the factors which children are bringing to resolving and understanding mathematical tasks is this multi-dimensional thinking and connecting of ideas and experiences. The ability to evaluate and internalise how they will approach a task is clearly shaped by an individual's thinking and understanding of themselves – the ability to be self-aware.

The idea of metacognition being domain-general implies in terms of prior knowledge that the metacognition used to address mathematical tasks is not specifically mathematical metacognition and is developed through the whole of a child's experience. The data show us that a child's thinking about their own knowledge and thinking cannot be partitioned into their understanding of a particular aspect of mathematics. Children are thinking through all areas of their knowledge in order to support and decipher the mathematical tasks they are presented. The mere fact that the data have demonstrated the children are thinking through what they already know, understand and have experienced and are using it as a tool to develop new understanding means that, by definition based on research by others, metacognition is a part of prior knowledge and is there before the task is attempted.

To summarise, metacognition is an element of prior knowledge as it is developed from individual experiences and is present before the task. Also throughout engaging in the task, children are using their strategies to reflect upon their approaches to the task.

6.5.2 Definition

In my prior knowledge model, metacognition refers to children's ability to reflect and think about mathematical tasks and the methods they are using. The data showed how children, while engaged in mathematical tasks, were thinking of the following:

- thoughts about the mathematical concepts needed and what they mean;
- how they would approach the task;
- how well they were doing the task;

- the ease or difficulty of the task;
- the outcome of the task.

All of these processes, as evident in the data, are aligned with the established theoretical base presented earlier. When looking at the transcripts, it emerged that there were many events within which children were being introspective and this introspection would affect the approach taken by the children to complete the task. Therefore within my prior knowledge model, metacognition is the introspection and self-evaluation that children engaged in while attempting a mathematical task. This is further supported by the data when I look at the transcripts.

Through the analysis of the data, there was a recurrence of events which indicated reflection and construction of understanding based on self-questioning by children. Though children did not always verbalise this thinking and filtering through their ideas and thoughts before attempting mathematical tasks, anecdotally there were many occurrences when children would pause to evaluate how they should proceed forward. Though there is no concrete evidence to support this as being metacognition, it raises the question about what process was being employed to result in the choices they made. We could speculate that in order to descend upon a path forward, children must be thinking about what they know and how they would be able to carry out the task, therefore thinking about their own knowledge and understanding. There is further support for this in concrete data gathered as we will see in the transcripts to follow. The data support the theoretical perspective which is integrated into this definition of metacognition.

6.5.3 Further Empirical Evidence

Having considered the theoretical base which was supported by what was emerging in my data, the definition developed above is a shorthand overview to understanding the element of prior knowledge which is metacognition. In order to develop and clarify this definition, it is of value to look at the evidence upon which it is based. When listening to children, while they were using many aspects of prior knowledge as evident in this whole dataset, metacognition was one aspect which was not apparent at first viewing and one which needed some teasing out.

There were many events where children expressed their inability to attempt a task, as we have seen in the transcript extract in Section 5.5.4 on page 181. This raised the following question – how do children make the decision that they cannot do a task? What factors are they taking into consideration? I can argue this in many ways – they have never seen such a task before; when they tried it previously, they were unsuccessful; they are not familiar with all aspects of the task e.g. they may not understand how to start it or know all the steps to develop the outcome needed. We could hypothesise and conjecture the many different reasons why a child states their inability to perform a task or indeed the choices they make to perform the task. However that would not resolve the simple fact that the child has made a choice. The child has, through their ability to think about their skills, knowledge and thinking, come to conclude the choices they had made, or put simply they have metacognated.

It is this that is of importance. Without this ability to think about their thinking (metacognition), as emerged from the data, children would not be able to make choices in relation to approaches in the way they perform mathematical tasks. Metacognition forms a crucial facet of prior knowledge. The extent of a child's ability to metacognate is very much dependent on other areas of their prior knowledge and interlinked to other facets. However we could extrapolate that the extent to which individuals can assess their thinking has an impact upon their approach to the task.

In the transcript extract below, the child has considered what would be easier for him and what they had already engaged in i.e. 9 + 2 and how this links to the question being asked i.e. 9 + 3. Furthermore when asked about the process, he explains what he felt he could do or not do. The child has understood the needs of the questions through some process of evaluation and thinking about their own knowledge base which has enabled them to address the questions. The question is considered and processed with some thoughts about what one's own capacity is to answer and address the questions, and an evaluation through metacognition of what may be the correct direction is made for the individual. The child is struggling to vocalise their thinking process clearly. However there is some choice made to start from their previous answer of 9 + 2 = 11 and then build on this to adding 1 more. Though not expressed, some internal thinking has led to the choice of adding 1 more to 11 and not counting from 9 in 1's to get to the answer. It is this internal process which is manifested in the way in which the child is expressing the puzzle that they face.

Extract from transcript of third lesson by Mrs Jill Thomas at St Paul First School

Teacher: Eleven … right I am sorry that was my fault I forgot come on I'll change that then … right you should be able to get this really quickly then … nine add three … nine add three … nine add three ready … steady … show … nine add three is … ?

Few children: Twelve

Teacher: Twelve right Greg how did you work that out?

Child: Umm I know that I am good at this

Teacher: Oh shhh will you be quiet I cannot hear what Greg is saying so neither will anyone else be able to … sorry Greg

Child: I started from nine and counted on three

Teacher: Counted on three did anyone else work it out in a different way? Chris?

Child: I counted in three's

Teacher: You counted in three's why did you count in three's?

Child: To make it a little bit easier

Teacher: Right well did anybody when I said the one before nine add two

Child: I added one

Teacher: Is that what you did?

Child: I put twelve because I thought I can't put eleven so I might as well put twelve then when you said nine and three I did twelve again

Teacher: So you thought nine add two was twelve? … no

Child: Well because I couldn't do eleven I thought I might as well do twelve but then

Teacher: What do you mean you might as well?

Child: Umm

Teacher: Why did you say why did you think twelve why did you know it was twelve?

Child: I didn't think it was twelve but there wasn't any eleven so

Teacher: No but then I changed it didn't I? I didn't say nine plus two … I said nine plus three

Child: I counted on one from eleven because it was 2 and now it is number 3

In the next transcript, Liam has considered the task carefully and is able to answer the numerical question, and also further clarified independently about the knowledge he does not have in the question relating to pounds and pence. This indicates that there are some thoughts about what children know in terms of what is being presented. Here Liam is able to control his own choices through his metacognitive process.

Extract from transcript of seventh lesson by Miss Lora Hunter at St Paul First School

[The class are asked to tell each other what they were looking at in the lesson yesterday … they were looking at money]

Teacher: What were we doing … what were we thinking about when doing money … *(long pause)*

Child: Will you give us some money? … wow

[The class did not know … after a long pause one child was able to read the target on the board … finding many ways to make different amounts of money … the teacher was able to then ask individual children what they did in relation to the target … the answers were slow in coming … the class was told that they were going to do something similar … she shows them how she is going to do this … on the board she has created a shop front and the children are asked to go shopping with her … she asks questions about how much each item in the shop costs]

Teacher: How much does the guitar cost me

Child: Umm 5p

Teacher: I asked Liam

Child: 5p

[The teacher goes on to ask about each of the items in the shop … first about the cost of each item on their own then she goes on to combining items and calculating the cost]

Child: When you know it's money how do you know what is pounds and what is pence?

Liam was able to think and link to other parts of his understanding to take control of how the task is resolved, or in the case of the next transcript, what does not make sense to the individual and ask further questions as he does here in terms of really understanding the clock face. The engagement with the teacher in the transcript has an impact upon the shape that memory will take, and therefore is essential to prior knowledge.

Extract from transcript of seventh lesson by Miss Lora Hunter at St Paul First School

	[The lesson starts with clocks and the teacher asking different times to be shown by the children on their clocks]
Teacher:	How can I check that that's right … is there any way of knowing that that's right? does anybody know what time it actually is now … what is the real time … ?
Child:	Half past nine
Teacher:	If you look at the clock and check and see you'll see it is actually half past nine … so we can check that we've got the small hands pointing to nine and
Child:	It's not half past see
Teacher:	It is half past nine right now on the clock …
Child:	Well it isn't on the nine or the six
Teacher:	Well it's just past the nine because it's gone past the hour it would be … *(long pause)* … when it comes to ten o'clock we'll look at the clock we'll see what ten o'clock looks like
Child:	It is near ten I am not sure why?
	[What we see here is a child who is trying to establish what the task demands in relation to his understanding and has a clear idea that his knowledge is limited. Furthermore he is able to express which parts of this question he needs to understand. There is self-awareness and thinking about the way in which personal knowledge is constructed and what needs to be the next step in understanding these mathematical ideas. A clear sense of self-awareness.]
Teacher:	It's just gone past the nine cause in the past the hour it would be when we come to ten o'clock we'll have a look at it and we will have a look at half past ten as well
Child:	What do you mean by past the hour?

There is some element of metacognition in all tasks approached in the next transcript. Ellie is actively thinking about what she has been asked, going through the process of trying alternates and rejecting them through some form of evaluation before picking an answer.

Extract from transcript of eighth lesson by Mrs Sally Crane at Hatton First School

Teacher: Now do you remember when we looked at our number line yesterday … we only had it going up to ten didn't we … and can anyone remember what we were doing with the number line yesterday … what were we actually doing? we were doing some number work and it was slightly different we hadn't done it before

Child: We were like rolling a dice

Teacher: No we're thinking about the number line Richard that's the other part of the lesson good boy but which what did we do with the number line Rowena?

Child: Umm we put dots by how many umm … it was away from it

Teacher: Yes that's a very good try … Ellie can you remember the words that we used?

Child: Is it … no … wait let me think I know … it is a bit like … I can work it out … umm its difference between

[This interchange between not knowing and having some notion of knowing the answer is more than just the skill of recollection. It is a sense in Ellie and her thinking that the answer is something she is aware of, but cannot recall. There is thinking about what knowledge she has and how this links to what is needed.]

Teacher: The difference between that's right we put two spots didn't we and we chose those numbers and then we worked out Charlotte I'll have that please … what the difference between the two numbers was … right let's stick to the line that's between one to ten to start with and see if you can remember how to do it from yesterday … right I am going to put my stops by that number which is which number?

Few children: Three

Metacognition is the active process of introspection and self-evaluation of what is being asked and what is required to complete the task. Children are questioning within themselves and using this to support the completion of mathematical tasks. This notion of metacognition is a facet of prior knowledge as it considers the cognition and will also be linked to the other elements in order to shape these ideas and meaning. Within the data, children bring this need to evaluate and consider how best to approach a mathematical task.

6.6 Other Emerging Categories

My data revealed the emergence of further categories – individual motivation, perception, cognition, social group and abstraction – which also form prior knowledge of children. In the subsections to follow, I will explore these categories through a similar structure as done for the three categories discussed so far – theoretical perspective, definition and empirical evidence.

The data do not make it possible to conclude that the three categories considered earlier and the further emerging five categories being considered in this section are a finite list of components that constitute prior knowledge.

6.6.1 Individual Motivation

6.6.1.1 Theoretical Perspective

Despite the existence of an immense body of research in the field of motivation, there is no agreed common definition. Research in the psychology of motivation and what affects individual motivation states that children are motivated by tasks that they feel are important to them, measure their value as individuals, enable them to express their views, or provide them with a sense of ownership (Lovell, 1973).

> The author has suggested a new definition for motivation: a potential to direct behaviour through the mechanisms that control emotion.
>
> (Hannula, 2006, p. 175)

This definition of motivation helps me to realise the value of motivation in children's choice in their level of engagement in mathematical tasks. Motivation is broadly distinguished into intrinsic and extrinsic motivation.

> The most basic distinction is between *intrinsic motivation*, which refers to doing something because it is inherently interesting or enjoyable, and *extrinsic motivation*, which refers to doing something because it leads to a separable outcome.
>
> (Ryan & Deci, 2000, p. 55)

Children bring a level of motivation to some tasks and are, to some extent, intrinsically motivated by the task they see. What is it that drives this intrinsic motivation? Children enjoy the task for its own sake as they feel they can be successful or are externally motivated by the experience of rewards (Middleton & Spanias, 1999). Whatever the cause of individual motivation, researchers widely agree that there are many knock-on effects of children being motivated.

> When individuals engage in tasks in which they are motivated intrinsically, they tend to exhibit a number of pedagogically desirable behaviours including increased time on task, persistence in the face of failure, more elaborative processing and monitoring of comprehension, selection of more difficult tasks.
>
> (Middleton & Spanias, 1999, p. 66)

These effects upon a task are crucial to my research as individual motivation impacts on the choices that children make and how they engage in mathematical tasks, and hence shape prior knowledge.

6.6.1.2 Definition

In my prior knowledge model, the key features which define individual motivation are the approach and attitude with which children tackle mathematical tasks. These are both positive and negative attitudes and feelings towards the task. When children first look at some mathematical tasks, they have a response which controls the degree to which they are willing to engage in the task presented to learn mathematics. Individual motivation also comprises children's desire to get the correct answer and the consequent enjoyment which is produced. Furthermore individual motivation includes events that allude to children's self-confidence, both at the beginning and during mathematical tasks.

6.6.1.3 Empirical Evidence

When I consider the data, I can see that the individual motivation that children have towards any particular task is influenced by the prior knowledge (by prior knowledge, I mean the emerging partial model that I am constructing through this thesis and not the narrow common definition) state of the child before embarking upon the task. In the transcript extract below (this extract also appears on page 213), the child has a positive attitude towards the game being played. This in turn increases his desire to engage in the mathematical task and has the effect of further shaping his memory through the experiences gained. This desire to join in is there prior to the task being set. Therefore individual motivation is not only there prior to the task, but has further influence on future prior knowledge.

Extract from transcript of first lesson by Mrs Jo Fishily at Greenville Park Community School

[Children are using a 100 square playing various games]

Teacher: Right who could roll the dice for me? … then we're gonna move the button … that many times ok … we're going forwards …counting … Josh would you like to roll? just stay where you are, stay where you are and see if you can roll it onto the floor … oh what's it landed on?

Some children: *(shout)* Six

Teacher: Right, who can put their hand up and guess where I'm going to have to move button to? … uh let me ask somebody with their hand up … Louise

Child: Six

Teacher: Yeah, shall we see if you are right? Can you count with me?

Some children: One two three four five six

Teacher: Good girl Louise, right … *(whispers)* who can roll the dice this time? … *(normal)* shh … let's have Kealee can you roll it onto the dice onto the snake, ready? … ok … oops pass it to Kealee … ok don't worry, you're gonna have your own dice in a minute if you don't get a turn now … ooh … what's that landed on?

Some children: *(shout)* Four

Child: Easy … are we going to get to play this today?

Teacher: Yes four *(child makes a fist and punches the air with a smile)* … right put your hand up if you can work out already where my blue bead's going to be? … let me ask somebody with their hand up … let me ask Aiden

Child: Worked it out already its ten …

The next transcript (this transcript extract appears earlier on page 212 as well) reveals the lack of desire which causes lack of connections to be made with the tasks. This emotional response is a direct result of the individual's prior knowledge and the shape of prior knowledge to support understanding of the task.

Extract from transcript of sixth lesson by Mrs Jo Fishily at Greenville Park Community School

Teacher: Cylinder … right can you put your hand up if you notice anything about what is left on my white board this morning … Jack … what do you notice about what is left on my white board [the question put on the board was 9+3 =11 children were asked to consider the question] this morning cause you're talking … *(long pause)* … what do you notice Jack?

Child: Umm I don't know…it's too hard… I don't know…

Teacher: Make a guess

Child: I don't know

Teacher: Right anyone help … Jack right Hannah what do you notice

Data seem to show that the degree of motivation that individuals have influences the extent to which memory is drawn upon as can be seen in the transcript below. Where there is little desire to draw upon any previous experiences, the shape of the memory will be limited in its effect. When I look at the example below, I can see that individual motivation has an influence on shaping memory. The fact that the child is unmotivated to join in the task limits the degree to which memory may be modified. The shape of prior knowledge has led to this child perceiving the mathematical task as being one he cannot do.

Extract from transcript of third lesson by Miss Lora Hunter at St Paul First School

Teacher: Are we ready … when you found the answer Harry hold it here … haven't asked the question yet … going to ask the question … don't talk about it … it is what you know … not what the person next to you knows … Oliver … right seven subtract two … seven subtract two … shhh … going to ask you how you did it Oliver not how Matthew did it … how did you work it out … shhh … well … Abbie do it yourself please … I think that this table is ready … nearly ready red table … Oliver

Child: I don't know how to do it … I can't do it

Teacher: Well just wait till we have all finished … have a guess … shhh … ha Hannah … nearly ready? show me … remember if you get it right you just put a thumb up … ok no shouting just a thumb up … seven subtract two is five … put your hand up if you can tell me what you had to do? what did that word subtract mean what was it telling you to do or asking you to do? Jordan

Child: Oh ok that's easy Take away

Teacher: Good boy it was a take away … so Oliver what does subtract mean?

Child: Don't know…I am not sure ... I can't remember.

In the next transcript, I see that the child is very keen to consider the mathematical task in front of him. This individual desire to consider the mathematics being presented has a changing effect upon memory in terms of allowing new experiences to enter. Both positive and negative motivations have an effect upon the memory of a child and therefore the overall shape of prior knowledge.

Extract from transcript of first lesson by Mrs Jane Marshall at Argyle Common First School

Teacher: Well done three and that number goes here … what have I got to put next in my sum … Henry

Child: Equals I know what the answer is I've counted you count the top line. I know what to do can I show can I

Therefore individual motivation is an essential element of prior knowledge as it has great impact upon shaping of memory, but furthermore is interconnected with the other elements that make up prior knowledge. As can be seen from the example in the last transcript, the confidence with which the child wants to answer is linked to the child's cognition and perception of the question presented. Without prior knowledge containing individual motivation within it, there would be no engagement with the mathematical tasks presented and thus limiting reshaping and developing of ideas. The shape of prior knowledge before tasks influences what takes place during the task.

6.6.2 Perception

6.6.2.1 Theoretical Perspective

When looking at what research has to tell me in terms of perception and mathematics, I am hindered by the many meanings and uses of the word perception. There is research which has considered perception or views of teachers and children about the subject of mathematics (Borthwick, 2011; Burton, 2009). There is also much research about social perception of mathematics (Malkevitch, 1997; Steele & Ambady, 2006). Perception is considered in one of two ways – as a feeling and opinion or views of mathematics, or as a physical aspect of self and how we use our senses to understand the world around us. It is this latter use of the word perception that has emerged from my data.

It is of little value to consider the established research on how our senses perceive as that is not reflected in my data, but more so what children perceive and how are they making sense of this information. Therefore I am not looking at pure psychological research on perception, but considering the applied psychological views of how we develop our understanding of the world through our perception.

I need to consider two aspects of perception – one which looks at the sensory modes of how we make sense of the world, and the other which looks at the cognitive processes to use this sensory understanding and formulate thought. Though I have given these as separate ideas, they are very much linked.

Pertinent to this understanding of perception are the ideas surrounding enrichment and differentiation theory (Gibson & Gibson, 1955; Piaget, 1954).

> Piaget's view of enrichment suggests that we impose meaning on our sensory data, either by making it fit in with pre-existing schemas or by generating new ones. ... Gibson's differentiation theory proposed that sensory stimulation is all we need.
>
> (Flanagan, 1996, p. 29)

Children are able to take in the vast amount of sensory information similar to adults, but just do not have the ability to consider these data due to lack of experiences (Bower, 1982; Gibson, 1987). Developing this argument further means that the level of experience of the world is key to the way in which children make sense of mathematics. That is, children learn to perceive mathematics (enrichment theory) as opposed to just considering mathematics as it appears to them without any link to anything they have experienced before (differentiation theory). It is of little value to make distinctions between these two ideas as they both have contributions to make in terms of the perceptions that children bring to mathematical tasks. That is to say, children go through a combination of differentiation, i.e. experiencing many repeated stimulations and beginning to distinguish between them, and enrichment, i.e. through the development of schemas to allow for more sophisticated understanding and perception of mathematics.

Researchers into perception all agree that it is the awareness of the world through five senses that develops, shapes and influences how we perceive the world around us. There is further development on this understanding of perception.

> Perception is not determined simply by stimulus patterns; rather it is a dynamic searching for the best interpretation of the available data … perception involves going beyond the immediately given evidence of the senses.
>
> (Gregory, 1978, p. 13)

This is confirmed by Coon (1989) who defines perception as "the process of assembling sensations in a useable mental representation of the world" (p. 137). Therefore the way in which children perceive mathematical tasks is dependent upon how they have experienced and interpreted the world.

6.6.2.2 Definition

In my prior knowledge model, perception is the set of sensory experiences that children bring to mathematical tasks and the interpretations that they have already established from these experiences in line with the theoretical understanding debated earlier.

The interpretation children make of each mathematical task they are set is linked to what they are using to perceive these tasks. The perspective of the child is based on the exposure they have had in the past or are recalling from memory. Transcripts show that it is not just exposure to mathematics that has influenced the perception of children, but more so their exposure to many different things, some being sensory and some being ideas they have explored. It seems that on approaching a task, children look at it from a particular viewpoint and this is linked to what they are recalling that they feel helps to understand what they are presented with.

The transcripts show children perceiving the mathematical tasks from many vantage points:

- the physical patterns on the page;
- numbers written and what they mean to a child;
- having seen this before and the form it took;
- perception of the challenge of the task;
- the inference a child has made from the task set.

6.6.2.3 Empirical Evidence

The transcript below shows that children have the need to put unknown ideas into a format that is supported by something they have experienced before. The perception of one child is very different to that of another.

Extract from transcript of first lesson by Mrs Jane Marshall at Argyle Common First School

Teacher: If Sharna said none if Sharna said none that's the answer what

Child: It isn't a shape

Teacher: What would the question be?

Child: Umm

Teacher: The answer none the answer is nothing so what would the question be Devon?

Child: *(whispers)* zero?

Child: What is it?

Teacher: No … the answer isn't zero cause you know we are thinking about shapes … Sharna gave the answer none … what would the question be Lauren?

Child: What have I got in my hand with none in it?

Perception influences the shaping of memory to support the understanding and achievement of the mathematical task presented. As can be seen in the transcript below, one child perceives diagonal lines folded on a square as making a diamond while another child perceives the same as two triangles. This in itself does not change the outcome of the task, but is a factor in how children will approach the task. The approach taken shapes prior knowledge and hence memory, which in the long term affects the approaches and methods children use in their understanding of shapes.

Extract from transcript of first lesson by Mrs Jane Marshall at Argyle Common First School

Teacher: Brilliant excellent that's it there … that's it and Ashley said it's got a point we are not sure whether it's a point or a corner … right … right everybody looking this way … James shh we've got to look and listen … I've a piece of paper shh

Few children: Oh

Teacher: And I've folded my

Child: In half

Teacher: Piece of paper in half

Child: Like a square

Teacher: Yes it does look a bit like a square now … and this … is the fold ok … so if I open it out can you see the crease down the middle? … .now … shh excuse me … on my piece of paper I am going to draw two lines … from the fold

Child: One two … a triangle

Teacher: What shape have I drawn Lauren?

Few children: Triangle

Teacher: Triangle ok right

Child **Child** **<u>Child</u>** **(three children speaking simultaneously):** *She is going to cut it out* … she'll end up two triangles … <u>she'll end up with a diamond</u>

[The three girls in this conversation are sitting and talking quite actively as to what is going to be the outcome of what they are seeing. There is a sense that they all want to be right and perceive vehemently that their estimation of the outcome will be correct.]

Teacher: Shh … excuse me … why will I end up with two Lauren?

Child: Because … because … if you … she'll end up with a diamonds

Teacher: Shh Lauren's talking

Child: Because if you folded it up it would make a diamond and if you chop it at the bottom you'll have triangles … because when you folded it over it had two pieces so when you cut it'll still have two pieces

Teacher: Ok … I understood ok … if I open it out what shape have I got Damian?

Child: Two triangles

The function of perception within the partial prior knowledge structure is to support memory modification. But furthermore there are influences between how tasks are perceived and how this perception affects the other elements of the prior knowledge model such as individual motivation and the context that they draw upon.

The transcript below illustrates how the phrasing of a task is perceived so differently compared to the intention of the task. The child has perceived the task as one and four, and has concluded fourteen and not five. This was a common occurrence in my data in terms of the different perceptions of language used and implemented by children. The difference in perception of the vocabulary used by teachers to describe the task and how children perceive these words is shown here.

Extract from transcript of second lesson by Mrs Sally Crane at Hatton First School

Teacher: One add four makes … good boy Richard you're working it out really well I want everybody … what answer do you think it is Elly?

Child: 14 *(child is holding up 1 and 4)*

There is a constant change in perception of children as time passes and this change in perception has both influence upon memory and memory has an influence upon perception. This can be seen through the transcript extract below.

Extract from transcript of sixth lesson by Mrs Rebecca Rice at St Paul First School

Teacher:	9 and what make 10 … write it on your white board
Child:	*(using his fingers)* umm ... 9, 10 … ooh its 1
Teacher:	Show me … good … Now … ready … ok ... 8 and what make 10
Child:	*(again using his fingers)* 8, 9, 10…..
Teacher:	Good 2 … now let see if you can do 7 and what make…10
Child:	This is going 1 and 2 then 3… *(child just writes the answer without the use of his fingers)*
Teacher:	Ok then ... let's look at 6 and what make 10
Child:	*(shouts)* 4 it's going 1 2 3 4 …

In the transcript above, the child starts the task looking at ideas of number bonds using his fingers to support a solution and perceiving it as a problem to solve using this method. However by the end there is a change in this perception to doing these questions as a pattern that has a logical order to it. Along with this visual change in perception, the inference made by the child of how best to achieve the task has also changed. In the transcript below, another child has approached a similar task in a contrasting manner. Here the child has perceived this as a problem which requires a number line to support a solution and one where counting back from 10 is required as opposed to the previous example where the child was counting on from 10.

Extract from transcript of eighth lesson by Miss Lora Hunter at St Paul First School

	[The class is working on the carpet and they are looking at number bonds to 10]
Teacher:	The next one ... are we ready? … what do I have to add to 4 to make ten?

Child: *(points to the number line on the wall)* 10, 9, 8, 7, 6 … its 6
Teacher: Well done 6

My data have shown the subjective and individual nature of perception that children bring to each task. In part therefore, the perception of children has an impact on their ability to achieve the task.

In terms of my prior knowledge model, perception forms an element which shapes memory. As the data have demonstrated, the perception of children influences their approach to the given task. Also it is the flexible nature of perception that supports children's approach to a mathematical task and functions as a facet of prior knowledge.

6.6.3 Cognition

6.6.3.1 Theoretical Perspective

There are a plethora of perspectives in relation to how individuals cognate and what this process entails. Throughout history there have been many themes about this seemingly unique ability that individuals have to learn and comprehend. It is of little value for me to consider in any great detail all the various views and opinions which have been put forward by many eminent researchers on cognition. I feel that in terms of understanding what role cognition has as an element of prior knowledge, it is important to consider the key concepts and ideas in terms of the role they have to play in the development of prior knowledge. Cognition, in very simplistic terms, is a way to understand the world.

Tait-McCutcheon (2008) states that "cognition refers to the process of coming to know and understand; the process of storing, processing, and retrieving information" (p. 507). This idea of cognition and what its functions are must not be confused with theories provided by many such as Thorndike, Schoenfeld, Piaget, Anderson, and Bruner which consider how individuals cognate. This distinction is critical in my model as the role of cognition within my prior knowledge model is as an element of prior knowledge which depicts that knowledge which is already known.

Ashcraft (1982) states that there are many methodologies used by children for retrieval, e.g. number facts from memory, which have been conceptualised as being automatic skills which do not require any reflection. Theories of cognition have demonstrated that after processing understanding of mathematical tasks through various processes such as Dienes' (1971) perspective of cognition through practical tasks or Piaget's (1954) view that we construct knowledge through our experiences, the ultimate outcome is that within mathematics, there are concepts that we eventually realise into our memory and they remain there unchallenged and unchanged and become intuitive.

For example, if we consider how we calculate 12+1 is 13, adults may find it very difficult to explain the mental stages involved in arriving at the answer. However in the past, prior to knowing that 12+1 is 13, there would have been a series of experiences to allow you time to revisit the question and explore the ideas and concepts which allow an understanding of why 12+1 is 13. Thus over time it becomes intuitive. It is this ability to access answers without any prompts that manifests itself in the transcripts. In prior knowledge, cognition is knowledge which has become tacit through experience. Children bring an element of tacit knowledge as part of their prior knowledge.

6.6.3.2 Definition

In my prior knowledge model, cognition is the efficiency and level of accuracy with which children complete mathematical tasks. It is not to be mistaken for the process used to complete the task. Throughout the observations, there were some tasks or parts of mathematical tasks that the children seemed to be able to do with little or no reference to anything. It appears as if there are some things that children intuitively know. These events have been classified in my prior knowledge model as cognition. Cognition is the ability to carry out a task or series of tasks in as few steps as possible giving the appearance of intuition or being tacit.

6.6.3.3 Empirical Evidence

Looking at the first transcript below, it can be seen that children are able to attempt with clarity, accuracy and little link or acknowledgement of any other idea to support the formulation of an answer. In the second transcript, I observed a child who is not only very able to solve the mathematical problem, but also able to explain his answer with clarity.

Extract from transcript of second lesson by Mrs Jane Marshall at Argyle Common First School

Teacher: Eighty and two … how many tens in eighty Lauren?

Child: Eight

Teacher: How many ten pences would I need?

Child: Eight

Teacher: And how many pennies would I need?

Child: Two

Extract from transcript of third lesson by Mrs Jennie Brooks at Draycott First School

Teacher: Three … ten take away something makes seven … are you ready think what Matthew has just done …let us try another … ten take something makes eight … Matthew

Child: Two

Teacher: How did you know that because I didn't see you doing it?

Child: You know that eight add two make ten so ten take away two is eight

In the next transcript, children are also able to identify with speed, accuracy and without any prompting errors that they make.

Extract from transcript of eighth lesson by Mrs Jo Fishily at Greenville Park Community School

Teacher: Give me a take away sum where the answer is six

Child: 25–16 no I mean umm nine

Teacher: Ok we need a take away sum where the answer is six?

Child: Umm twenty-six take away twenty

In the following transcripts, children are able to provide answers without any hesitation or further steps.

Extract from transcript of third lesson by Mrs Jill Thomas at St Paul First School

Teacher: Right let's see if we can remember the different words we used for … addition and subtraction … remember all those different words so you have got to listen very carefully … remember you are not going show until I say ready steady show … right three plus four … three plus four … ready steady show … three plus four is … ?

Most children: Seven … *(hold up their white boards)*

Teacher: Seven … let's do another one nine add two … nine add two … nine add two

Child: Eleven …… (holds up his white board)

Extract from transcript of ninth lesson by Mrs Sally Crane at Hatton First School

Teacher: What is one less than eleven?

Child: Ten

Teacher: Brilliant how did you do it?

Child: I just put one finger and took it away and I knew it was ten

Teacher: You just did it in your head did you ... you just did it?

Child: Yes

The structure of prior knowledge contains elements of pre-understood cognition. In common definitions of prior knowledge, it is this ability to cognate that is mistakenly called prior knowledge. Looking at the data, children appear to already have the relevant subject knowledge without any indication showing the need to learn this subject knowledge. There is a sense that this knowledge has always been part of the children, waiting for the correct moment for it to be part of an individual's approach to a task. Where has this knowledge come from? The transcripts reveal that the knowledge has been built up as a result of past experiences which have changed or modified past memory. When considering the overall range of data, a theme to come through is a notion of practice and repeated exposure to mathematical ideas. This repetitious exposure to the same mathematical concept explains the eventual efficiency, fluency and accuracy with no further changes to that aspect of memory which I have labelled as cognition. From other sections of this chapter, I have seen that this repetitious engagement involves children using other elements of prior knowledge in order to comprehend and make sense of mathematical tasks and eventually gaining fluency. The process of repetitious practice removes knowledge from its original context as it becomes tacit.

When engaged in some familiar tasks, cognition appears to be the dominant element of prior knowledge. The development of cognition is very much influenced by all other elements of prior knowledge. However in some mathematical tasks, it is the one which has been brought to bear upon the task. Cognition is not about measuring ability, it represents the aspect of prior knowledge where children have become efficient. Prior knowledge has, for any given aspect, been built up through different elements playing a lead role, and in the case of cognition this has been manifested through the lack of need to reference to any other external framework to understand the task. The children's prior knowledge has been shaped so that it can be applied to the task with efficiency. Cognition must not be confused with intelligence, but more so with the structure of prior knowledge at that moment. Each time children engage in mathematical tasks, they bring uniqueness in how each element of prior knowledge influences their understanding and approach to the mathematical tasks.

6.6.4 Social Group

6.6.4.1 Theoretical Perspective

The element of prior knowledge which has caused the greatest complexity in defining, though we all understand when we read the words, is social groups. What is roughly meant by this expression? We all have a very different interpretation of who constitute our social groups. However we can agree that there is a common understanding.

> A social group can be defined as two or more individuals who share a common social identification of themselves.
>
> (Turner, 2010, p. 15)

Furthermore researchers offer ideas of how to classify social groups in terms of common characteristics, though these do not support my thesis (Cooley, 1909; Sumner, 1907). Ellwood's (1919) classification of social groups offers some clarity in terms of the groups that manifested themselves in my research – permanent/temporary. Permanent groups consist of parents and siblings, and this can be extended to any individuals that form longer relationships such as grandparents, and in terms of the modern family unit, extended family such as half-siblings and so on. In Ellwood's terms, temporary groups, in contrast to permanent groups, are individuals who have limited relations in terms of length of time such as friends, friends of siblings, and so on. Over time some members may move from temporary to permanent. However in terms of my data, this classification suffices.

Of greater importance are the functions of social groups as stated by Park and Burgess (1921).

> The individual is influenced in differing degrees and in a specific manner, by the different types of group of which he is a member.
>
> (Park & Burgess, 1921, p. 52)

This influence of groups upon children as members of a social group shapes what children bring to their mathematical tasks and influences the way in which they are able to engage with mathematical tasks.

6.6.4.2 Definition

In my prior knowledge model, the experiences that children have with other people and how those experiences have shaped their ability to understand and approach mathematical tasks are what I am calling social groups. The transcripts below provide some examples which help to define social groups in terms of my model. These transcripts show how children use the ideas that they have established through their interactions with other people to support understanding and achievement of tasks.

The data show that the people that children have had experience of fall into two groups – family and friends. All of the analysis which was marked as belonging to social group belongs to these two groups. Not included in this area of social group are teachers as these would form part of acculturation (Section6.4).

6.6.4.3 Empirical Evidence

In the transcript below, this child's understanding and familiarity with money is linked to the experiences and conversations she has already had with her mother. Prior knowledge has been shaped by the ideas explored in the past with her mother.

Extract from transcript of third lesson by Mrs Jennie Brooks at Draycott First School

Teacher:	Money sums that's right … right sit in a circle please … umm you two are talking to much … don't … up the top James well spotted come on Holly … over by Scott … right let's see what I've got
Child:	Looks like money … lots of money… I have 100 pennies in my piggy bank. Mummy says I can spend it when I am big.

In the transcript below, the impact on this child's tackling of this question is influenced by how he has experienced the reduction of numbers in terms of balloons being burst. In this case, there is an overlap between the element of social group and the element of context represented by balloons.

Extract from transcript of sixth lesson by Miss Lora Hunter at St Paul First School

	[Children are looking at a card with balloons on it and crossing out balloons to do a subtraction sum]
Teacher:	It was it was a take away … how do we know? how do you know it was a take away? … Kieran?
Child:	Balloons burst and went… my brother does that … he jumps on balloons and they pop. I don't like the noise and I lose my balloons *(child looks down and is sad)*
Teacher:	That's it the balloons burst so they went away

In the next transcript, it can be seen that ideas developed about addition are associated with siblings and their ages. This child has used a chronological number line in order to complete the question asked.

Extract from transcript of sixth lesson by Miss Lora Hunter at St Paul First School

Teacher:	And four more how many do six and four more make … count them
Child:	Nine
Teacher:	Count it
Child:	One two three four five six seven eight nine
Teacher:	How many does it make?
Child:	Umm
Teacher:	She's not sure let's ask somebody else to see if we can have a clue how they worked it out … Abbie what did you do?
Child:	I got six on the number line like me then I jumped on four more like my sister who is a baby… so six first cos I am bigger then my baby sister four

Another factor derived from the transcripts which links to social groups and affects how prior knowledge is structured are the ideas and concepts children have about attitudes and approaches of other members of the social group towards mathematics. As can be seen in the transcript below, in this case the child has linked his understanding and ability to complete this task to the notion that this is as a result of his father's abilities in mathematics. I can extrapolate from this example that attitudes of individual members of the social group have an influence on the approach and outcome children achieve on mathematical tasks.

Extract from transcript of fifth lesson by Mrs Jennie Brooks at Draycott First School

Teacher:	Well done … how did you do it … Harry if I see bits all over the floor I shall be cross … ready listen to what I am saying … four p Harry four p add three p add … five p four p add three p add five p
Child:	I can't do it on here
Teacher:	Shhh shhh yes you can
Child:	How do you do it?
Teacher:	Have a go Bethany … hold it up … shhh who is going to be first four p add three p add five p
Child:	That is one two three
Teacher:	Well done Nathan well done Bethany … no Matthew well done Chloe
Child:	I know four five
Teacher:	Shhh … all right add it up Scott … well done Jack … no Matthew … shhh shhh
Child:	It's
Teacher:	No I haven't asked a number yet
Child:	It's twelve
Teacher:	Well done Zeno you are good at these
Child:	My daddy is good at these

The next transcript illustrates another aspect of how social groups have an impact upon children's ability and methods used to address mathematical tasks. In the transcript below, the child has recalled counting in four's through experiencing his friend's singing.

Extract from transcript of sixth lesson by Mrs Jane Marshall at Argyle Common First School

	[The children build up the pattern of fours to ten]
Child:	I know it ends at forty
Teacher:	Why
Child:	I counted up in four's … you know Joe (child whispers to his friend) Poppy sings her counting in four's …

Children's level of confidence and security is dependent upon the encouragement children have experienced from members of their social group. In the transcript below, the child is comfortable in making further attempts to answer a question as she has had positive experiences from her mother even when she has made an error. In this case, this ability and emotion to attempt the question again impacts upon prior knowledge and memory. Conversely the impact still exists even when there are negative experiences from social groups. In terms of shaping prior knowledge, all experiences have some form of impact upon it.

Extract from transcript of fourth lesson by Mrs Rebecca Rice at St Paul First School

	[The teacher is talking about a worksheet children did at home and brought into school. The task was to identify odd and even numbers by colouring them red and blue.]
Teacher:	Number fifteen Sam is
Child:	Even…
Teacher:	Are you sure?
Child:	Umm… its 5 and 0…so…can I have another go….?
Teacher:	Not fifty … fifteen … yes…
Child:	I did this with mummy and said I need to keep trying… it is…odd?
Teacher:	Well done…

Children often formulate the question in terms of a scenario they have already experienced as in the second transcript above where the disappearance or bursting of balloons and his big brother left the child with fewer balloons. Furthermore the link to taking away or simple understanding of numbers is connected to personal factors such as age and size onto the order in which numbers should be added. Children's understanding of numbers is in part linked to actual people. This use of social groups to formulate understanding is not limited to just numbers, but also to how concepts in mathematics are formulated.

The social groups that children belong to are all unique and different and, as seen in the transcripts above, have a huge impact upon how children approach mathematical tasks. Therefore the influence of social groups upon children's prior knowledge was determined by the factors below:

- Using their social group as a frame of reference to understand and conceptualise the mathematical tasks they are set;
- Time that members of the social group spend with the child engaged in mathematical activities and conversations;
- The attitudes and approaches of individual members of the social group towards mathematics;
- The level of security that children feel within this social group to make mistakes.

The other feature of social groups is the interaction between children while working on mathematical tasks. The co-construction of understanding has an impact on the effect social groups have on development of understanding and shaping of memory. These ideas are reflected through elements of Vygotsky’s (1978) work on social construction of learning and development.

> Every function in the child’s cultural development appears twice: first, on the social level, and later, on the individual level; first, between people..., and then inside the child. This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher [mental] functions originate as actual relations between human individuals.
>
> (Vygotsky, 1978, p. 57)

6.6.5 Abstraction

6.6.5.1 Theoretical Perspective

Ferrari (2003) states that “abstraction is a fundamental process in mathematics ... abstraction is a basic step in the creation of new concepts” (p. 1225). Mitchelmore and White (2007) provide further information by stating that “abstraction has been a frequent discussion topic since the days of Aristotle and Plato” (p. 1).

Therefore it is vital that I consider what this term means, so that there can be development in understanding the structure of prior knowledge. Mathematics, by its very nature, demands abstraction as “mathematics uses everyday words, but their meaning is defined precisely in relation to other mathematical terms and not by their everyday meaning” (Mitchelmore & White, 2004, p. 329).

Within the primary classroom, this duality of language is ever-present and the children make many interpretations. The process of abstraction is important to consider as within mathematics children go through a transition from something they find quite complex and very specific to a generalised idea, e.g. from counting and only being able to count objects by touching them to being able to count anything without needing to have it even physically present.

This notion that an element of abstraction is about being able to generate and formulate rules is important in terms of what I have seen in my data. This idea does have a link to the cognitive processes that children have acquired and a concept that has been abstracted may appear as cognition in the classroom as we have seen with the counting example (being able to count fluently).

The other process which must be considered as a way in which we abstract is this notion of decontextualisation. Ferrari (2003) states that "generalisation implies a certain degree of decontextualization" (p. 1226).

The German mathematician Hilbert's idea that all mathematical tasks must be eventually stripped of everything that is not essential causes some difficulty in terms of young children's acquisition of mathematical understanding. It is necessary for them to have some degree of generalisation and application of their understanding. Often children use contexts to gain a form of abstraction and the memory they glean from the task to support them in applying ideas to other situations.

Skemp (1987) offers an alternative view of abstraction being empirical abstraction.

> Abstraction is an activity by which we become aware of similarities ... among our experiences. *Classifying* means collecting together our experiences on the basis of these similarities. An *abstraction* is some kind of lasting mental change, the result of abstracting, which enables us to recognize new experiences as having the similarities of an already formed class. ... To distinguish between abstracting as an activity and an abstraction as its end-product, we shall hereafter call the latter a *concept*.

(Skemp, 1987, p. 21; italics in original)

To summarise therefore, the individual journey towards mathematical abstraction is going to be very different for each child and each mathematical task they face. The ways in which children abstract is part of prior knowledge as the data have shown that it has an influence upon how children approach their tasks.

6.6.5.2 Definition

In my prior knowledge model, the ideas that children use to make meaning of mathematical tasks and support their understanding of and engagement in the task are what I am calling abstraction. It is when children demonstrate an understanding of similarities between two or more ideas, and further can use these ideas to develop and understand new concepts within mathematics.

6.6.5.3 Empirical Evidence

The transcript below shows how a child has used the definition and characteristics of a shape given by the teacher and linked them to an ice cream cone. This extrapolation and association of the description to something which the child has experience of has allowed her to relate to the mathematics being discussed. Further she has been able to take the concrete example of an ice cream cone and abstract it to a generalised definition of a geometrical shape.

Extract from transcript of third lesson by Mrs Jo Fishily at Greenville Park Community School

Teacher: Don't worry about anyone else just worry about your own answer please … Shakar can you sit up nice and straight … well what is that one?

Child: Cone

Teacher: Yes it is a slanty cone that doesn't matter it's got one flat surface and a point

Child: Ice-cream cone … so that is a cone …

Abstraction is also the understanding of symbols and their operations. Within mathematics, the ability to manipulate numbers without actually doing the task physically is required. In the transcript below, children are asked to change numbers to formulate new valid sums. The child shows the ability to move numbers around in a meaningful manner. He also understands the notions and ideas of operations as symbols having meaning in a physical sense without really carrying out these tasks physically. There is initially some confusion in terms of the symbol of division and multiplication and also the understanding of numbers.

Extract from transcript of third lesson by Mrs Jo Fishily at Greenville Park Community School

[Children are asked to make new valid sums based on these numbers (12 ÷ 6 = 2 or 12 ÷ 2 = 6) … taking the opposite operation of the one above asking the children to deduce from the knowledge they have to apply it to a new fact and create a multiplication sum]

Child: 6 ÷ 12

Teacher: Ok 6 ÷ 12 … what will the answer be

Child: Oops no it's six times

Teacher: Hang on shh shh Andrew you have a go

Child: Six times two equals twelve

The data show the children used visual ideas to understand mathematical tasks through the use of symbolic representation to understand the tasks they are being asked to engage in. In the transcript below, children are working on patterns. The fact that this child is able to abstract from this pattern to one which is symmetrical and is like looking in a mirror helps children to visualise the pattern without ever having to use an actual mirror.

Extract from transcript of eighth lesson by Mrs Jennie Brooks at Draycott First School

[The teacher has arranged a few children in a pattern (without telling the children why she is arranging them in this particular way as a symmetrical pattern) and they are now asked to explain what they see. Children pick up on the pattern there is much talk amongst the children.]

Child: Two boys are facing the two boys on that side and one girl is facing a girl on that side

Child: Oh *(shouts)* it's just like a mirror!!!

Teacher: Go on … only it's not like a mirror because look at him and look at you

Child: Cause it's all a bent line

Teacher: What do you mean?

Child: A mirror is like this [child expresses a straight line with her hand]

[The children are split in half by the teacher and positioned in a different pattern and asked to look at the others and see if they can make sure they are standing in the same way … each child is looking closely and tries to replicates what they see on the other side the line]

Teacher: Now Matthew said it was like a mirror … what do we call it when it's like a mirror what's that big word? S SS

Child: Similar

Teacher: Nearly Jack

Child: Symmetry

Teacher: Yes that's right … it is symmetrical

In the next transcript, children have understood the ideas involved in addition and finding numbers that help reach a particular value. They demonstrate the ability to combine two sets of numbers together. This ability to use number facts in the task demonstrates the ability to abstract and understand features of numbers and values.

Extract from transcript of eighth lesson by Mrs Jill Thomas at St Paul First School

[The children all have number fans on the table they are going to use those to carry out some questions on number bonds of ten … the teacher has instructed that she will say one or hold a number and the children are to find another they think when added will make ten]

Teacher: When I hold up say umm the number two you will hold up number

Child: Eight

Teacher: Right you will hold up number eight … well done

Child: So you've got to get the number to ten

Teacher: Yes … you don't need to say the number you don't need to say eight or anything else … you need to keep it to yourself till I say ready steady show … all right … I am not going to say what my number is I think you can read the number

[The children are given a few examples first by the teacher saying the number … then she just shows the number … the children all are trying to work independently but there are still some who like to see if their answer is correct in relation to others and lack confidence in their answer … once the children have shown their answer the number bond is said out loud]

Teacher: Three and

Most children: Seven

Children and teacher: Seven make ten

The notion of abstraction is dependent upon other elements of prior knowledge and later formulates the ability to abstract more widely as in the third transcript or in Piagetian terms:

> Piaget (1977) made a distinction between abstraction on the basis of superficial

> characteristics of physical objects *(abstraction à partir de l'objet)* and abstraction on the basis of relationships perceived when the learner manipulates these objects *(abstraction à partir de l'action)*. But both are based on the child's physical and social experience, and in both similarity recognition is essential. In using the term *empirical abstraction* to cover both cases, we are making the distinction between abstraction on the basis of experience and what we shall call *theoretical abstraction*.

(Mitchelmore & White, 2004, p. 332)

Abstraction based on physical objects like a mirror or abstraction based on relationships established when the learner manipulates objects as in the second transcript leads to abstraction of theoretical concepts as in the fourth transcript.

6.7 Summary

Having considered the elements emerging from the data that form a possible structure of prior knowledge and how they influence the central category of memory, it is essential to finally look at my partial model, how the elements all fit together and form a possible structure of prior knowledge, and how may the model function when children are engaged in mathematical tasks.

Before that is possible, it is essential to consider the lenses which have been used to carry out this study or, in Glaserian terms, theoretical sensitivity.

> Theoretical sensitivity is the ability to recognize what is important in data and to give it meaning. It helps to formulate a theory that is

> faithful to the reality of the phenomena under study.
>
> (Strauss & Corbin, 1990, p. 46)

There are many sources of alignment I have used, all of which have shaped my understanding and inclination to consider the data in a very particular manner. Ironically it is the process of researching that has shaped my senses and allowed me to understand data through reading, experiences in the classroom, and crucially having spent a long time thinking about the question *"What is prior knowledge?"* and looking for an answer. The desire to understand this phenomenon has heightened my determination to look for ideas and use many variations to try and fit and find solutions to the questions. The mere fact that I have spent a large amount of time thinking about the solution to my question and looking for an answer means that unusual and creative processes are at work to make connections which will address the puzzle I am faced with. The stages of research and the process of analysis itself have shaped the thinking and evaluations I am able to carry out. Literature for example has allowed me to consider ideas which may not have been developed in relation to prior knowledge but could be applied to its understanding. It allows for the individual creative nature of qualitative analysis to take hold. It acknowledges that analysis and understanding of data requires a degree of creativity, problem solving and imagination as the solution is not concrete, and therefore must be visualised and then put into concrete form. Like an architect, the researcher is only limited by lack of imagination and creative thinking, and is also limited by the lack of practical know how. This idea of being able to link events and concepts in creative new ways to make connections that are not limited by the past is quite exciting. Furthermore the more I look at the data and interact with the data, the better I understand what the data are trying to tell me. Together with reading and exploring through experiences in the classroom, the emerging model developed has a rich layer of process and imagination based in conceptual experiences.

As each element was being explored and defined through what the data showed, one of the key themes to emerge was the marked influence of each element upon the shape of memory.

An essential point to note is that the structure of prior knowledge is not static, but one that is moving and changing shape through the interaction between the elements. Like a snowflake made up of oxygen and hydrogen and changing shape as it passes through the environment, prior knowledge also functions in a similar manner. Also what has become apparent through the process of analysis is that there may be other categories which make up prior knowledge. It is not possible for me to definitive in the claim that these are the only constituents of prior knowledge. The vastness of human understanding and its ever-changing nature make it problematic to insist that the eight categories I have proposed are definitive and there may be no more additions to the model.

The interconnected nature of each element is key to understanding how prior knowledge functions. With every task, children bring different aspects of prior knowledge to help them complete or understand solving the mathematical challenges that they face. The choice of which element they bring to bear is dependent on the shape of their memory. The shaping of one element influences that of all others. For example, when a child is working out, as in the transcript below, what half of a circle is, they have a perception that they bring to bear upon the task, that of a pizza which they have linked to toys they played with in the nursery – the acculturation experiences they have had. Also they further used their motivation and ability to metacognate in terms of their approach when a child states "I have done this before", "it's easy". All of this occurs before the task is even attempted or becomes possible and on attempts made by the child.

Extract from transcript of sixth lesson by Mrs Helen Fellows at Greenville Park Community School

Teacher: What shape do we get if we cut this circle in half … like this?
Child: A moon
Child: It's like that pretend pizza my sister plays with in nursery
Child: Ooh yes … I have played with that when I was a baby…
Teacher: Do we know what the name of the shape is?
Child: It's easy
Teacher: Ok any guesses
Child: Umm a chopped circle
Teacher: A good guess but no … anyone else…

Through all the data analysed, there are many different combinations of each element being used to attempt mathematical tasks. The pattern of prior knowledge changes in a kaleidoscopic manner. As in a kaleidoscope, the elements are the same, but keep changing in shape. This will in turn affect all the other elements, as there are new experiences to alter the memory, and this in turn reshapes the elements of prior knowledge. In this case, prior knowledge is more than just prior knowledge of fractions, it is a series of elements which link together to form modifiers of memory and thus the process of how tasks are managed. Hence each time children engage in mathematical tasks, they bring their own unique prior knowledge which is composed of these eight elements, and possibly others that were not revealed through my data, but in different proportions for different children as illustrated in Figure 6.2.

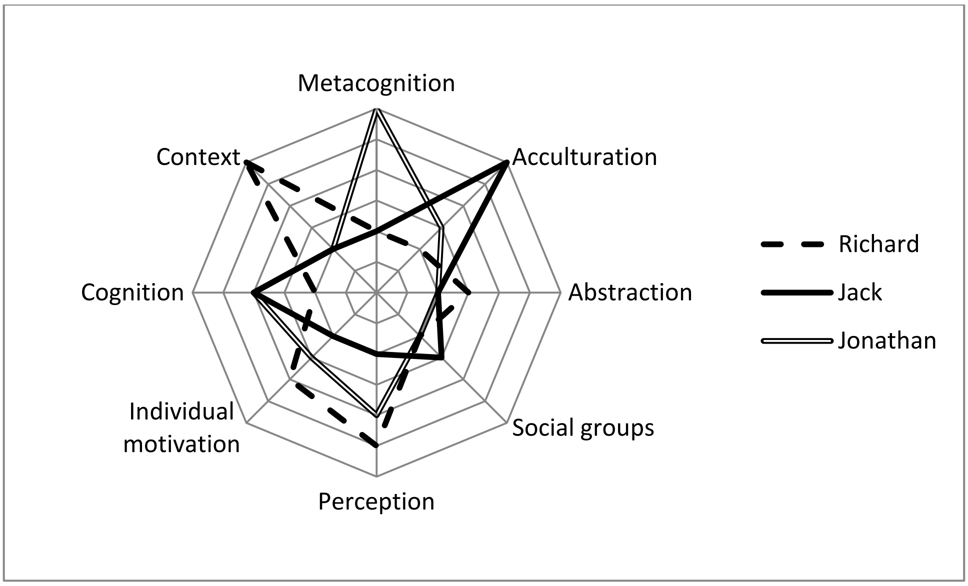

Figure 6.2 Composition of three children's prior knowledge

Figure 6.2 depicts the prior knowledge of three children – Richard, Jack and Jonathan – as they engage in mathematical tasks related to shapes.

In the transcript extract below, Richard is engaging in the task of naming shapes. In order to achieve this task, Richard is recalling some ideas from past experience in terms of the properties of a circle and how this related to having seen the shape before in the *context* of an object he has at home. There is some element of *perception* in terms of similarities with a frame for making pompoms, but the context of having used it before at home has allowed him to name the shape. In the process, he does reflect elements of *individual motivation* when he is unable to name the shape right away.

Extract from transcript of second lesson by Mrs Sally Crane at Hatton First School

Teacher: Elly and Charlotte go and sit back please … now then let's have a look at these shapes … now then I am going to ask you some questions about these shapes … I am going to choose somebody … to start … to start us off … now then let me see Richard … would you like to choose one shape? all right and then see what you can tell me about it? … just choose one shape and see what you can tell me about it? … which one would you like to choose? … right now what can you tell us about that shape?

Child: Umm it's yellow

Teacher: Turn around and let's see everybody … show everyone … right it's yellow … very good

Child: It's yellow and it'sss round andddd it's got no endss and ummm it's quite

Teacher: That's a very good start … a very good start

Child: Umm

Teacher: Do you know what that shape is called?

Child: No

Teacher: Have a try what is it called?

Child: It's a pompom… It looks like the one my hat

Teacher: No it isn't … have another go

Child: Its squashed … but has a bit of a side… (child points to the edge of the plastic shape)

Teacher: Is it a square, triangle or circle?

Child: Circle…. why has it got fat bits at the bottom then like the thing I've got to make pompoms where you have to circle round to make it … just no hole?

In the transcript extract below, Jack is engaging in the task of identifying shapes. But in contrast to Richard, he has used *acculturation* in that he identifies that he has done this in school with the teaching assistant. Also there is an element of *cognition* in that he was able to recall the fact that they had done 2D shapes. With this, he has also noted that he has played with something similar at home with a parent (*social group*). All these elements to some extent support the way in which Jack tackles the task.

Extract from transcript of second lesson by Miss Lora Hunter at St Paul First School

Teacher: That was in the afternoon … what were we doing yesterday morning in maths?

Child: Shapes

Teacher: Look at this … what kind of shapes Jack?

Child: 2D shapes

Teacher: Well done Jack … 2D flat shapes now I am….Right I am thinking of a shape and I am going to describe that 2D shape and I want you to

Child: This is cool the same as we played in pairs before and with Mum … outside with Mrs Jones. [Mrs Jones is the TA]

Teacher: Put your hand up in the air if you have guessed what that shape Harry Harris is holding … ok

Child: Mrs Jones had that one … triangle

In the transcript extract below, Jonathan is engaging in the task of identifying properties of shapes. In this case, there is a large element of *metacognition* which is supporting Jonathan. He acknowledges that the answer he has given is wrong and needs to be corrected. Using his sense of what a square and rectangle are in order to address the task, we see in this extract there are a few occurrences where he notes his error and tries to correct them (*metacognition*). He does perceive the difference between the square and rectangle and talks about the square being pulled (*perception*), and goes on to tackle the question with the support of metacognition. His ability to identify and count corners quickly without any errors or explanation indicates elements of *cognition*.

Extract from transcript of second lesson by Mrs Rebecca Rice at St Paul First School

Teacher:	Look at my shape Jonathan what can you tell me about what's special about it? … why is it different to the square?
Child:	It's got four corners
Teacher:	Four corners that's the same as a square it's got four corners hasn't it? … Connor what's different about a square and a rectangle?
Child:	It's a bit different … I know what I mean … I remember … it is pulled …
Teacher:	What's different about it?
Child:	It hasn't got the same shape … no that is wrong … I know ummm (child waves hand)
Teacher:	What do you mean by it hasn't got the same shape?
Child:	Cause that one's different than that … before I said corners … not corners its
Teacher:	It is different isn't it? sides on the top are not the same are they? … Daniel Harvey and Thomas … what's different Jonathan? I know it's different but I don't what know you mean by different
Child:	It's … that one hasn't got the same corners
Teacher:	Not got the same corners it's got four corners though hasn't it?
Child:	No not corners … … one two three four one two three four … it the same but it's not quite the same shape I got that word
Teacher:	It still has four corners but it's not quite the same shape … Ellis can you tell what is the difference between these two? Jonathan has just told us it's got four corners but it's not the same shape … what's different about it? … go on Jonathan
Child:	Cause that one is a rectangle and that one's a square
Teacher:	Yes that one is a rectangle and that one a square but how do you know what's different about them? … what makes that one a rectangle and that one a square?
Child:	Cause they're not the same
Teacher:	You are quite right they are not the same so what's different about them?
Child:	All the other squares are not the same … I am in a muddle
Teacher:	They are not the same all the squares are not the same
Child:	That one's bigger
Teacher:	Well you can get large squares and small squares can't you but that's not … can you see Jonathan? can you tell me what the difference is between these two shapes?

Child: Well that one's got longer corners and shorter corners … I know what I mean (child points to sides) … made a mistake with the word

Teacher: Oh did you hear what Philip said? … listen Connors … Shh shh

Child: Mrs Rice I have found a big square

Teacher: Listen to what Jonathan said … he said this one's got longer corners … does he mean longer corners do you think James?

Child: Umm yes

Teacher: Let's see here are the corners are they longer? then those corners … Jonathan those are the corners where my fingers are touching are they longer?

Child: Nope

Teacher: The corners aren't longer something else is longer …

Child: … … oh oh I know it is … sides

Teacher: Ahh we got there … good boy well done Jonathan …

Child: Yeah

These three examples illustrate how different children bring different elements of prior knowledge to support their tackling of similar tasks. Though in each case there were various degrees of different elements of prior knowledge, there were individual dominating factors.

To conclude, the structure of prior knowledge based on my research is eight interlinked elements which impact upon the shape and structure of memory and is present when children engage in mathematical tasks. We must consider that my proposed partial model comprising eight elements is a starting point in the journey to develop a complete and finite understanding of prior knowledge, as further data may allow for the emergence of other elements which were not detected in my data.

7 RESEARCH IMPLICATIONS

7.1 Introduction

Through this research, I have developed a partial structure for prior knowledge. By using a combination of grounded theory and content analysis, my research has resulted in a partial model from a range of contributory elements defining the prior knowledge of children present when engaging in mathematical tasks. The partial model turns rhetoric into reality by giving a deeper understanding to a common and, to a great extent, widely misunderstood term. There are many implications as a result of this development for practice and pedagogy. This chapter brings this research a full circle and considers the value and place of this partial model in practice; and furthermore examines what the next steps should be as a result of this deeper understanding of prior knowledge. Without considering the question *"so what is the value of this research?"* there is little point in having developed this partial model. Therefore in this chapter, I summarise the key findings and then look at the impact, implications and value of this research on schools, teachers, children and curriculum.

7.2 Key Findings

- The partial prior knowledge model is made up of three interlinked elements –acculturation, context and metacognition – which shape memory, and further five emerging elements – abstraction, cognition, individual motivation, perception, and social group;

- Prior knowledge may contain further elements;
- Prior knowledge is not the same as subject knowledge;
- Each individual has their own prior knowledge profile consisting of a combination of a range of contributory elements of prior knowledge present each time they consider a mathematical task;
- The contributory elements of prior knowledge influence individual memory and shape what children draw upon when approaching mathematical tasks;
- Any child's prior knowledge profile is constantly changing due to the continuous experiences that children have;
- Prior knowledge is shaped by all of a child's experiences and not just by classroom experiences;
- Experiences are absorbed very differently by children due to the individual nature of their prior knowledge.

7.3 Schools

The central mission of schools has always been the activity of developing both learning and learners. The Cambridge Primary Review proposes "twelve core educational aims which schools might pursue through the way they organise themselves, through the curriculum, through pedagogy, and the relationships they daily seek to foster and enact" (Alexander, 2010, p. 197).

The proposed aims are organised into three groups – the individual (well-being; engagement; empowerment; autonomy); self, others and the wider world (encouraging respect and reciprocity; promoting independence and sustainability; empowering local, national and global citizenship; celebrating culture and community); and learning, knowing and doing (exploring, knowing, understanding and making sense; fostering skill; exciting the imagination; enacting dialogue) (Alexander, 2010, p. 197-199). My prior knowledge model forces us to consider a new way of developing strategies to support these aims.

If, as has emerged from this research, each individual is dependent on the shape of their prior knowledge and the elements of this prior knowledge are made of constituent components, maybe the way to meet the aims set out above is not to group children in either age or ability, but to consider their experiential base and gather evidence from the way in which they approach tasks and the aspects of prior knowledge that are leading thinking in a particular area.

The partial prior knowledge model offers a way to start understanding the individual child and support their development in a mass system. Understanding offered by this structure forces teachers to rethink the way in which they listen to children and view their actions in the classroom and consider the complexities of each learner, enabling a process by which focused informed planning can take place. For example, looking at Figure 6.2, we note that the three children have different aspects of prior knowledge that they are using to support understanding of a similar task. Therefore consideration should be given to whether grouping them in ability groups would be of any benefit or whether considering grouping in a way that allows them to use areas of prior knowledge to support greater understanding and engagement would allow them to progress more.

Knowing what individuals are using to understand the task helps in presenting other tasks that will allow relational understanding to take place. E.g. Jonathan is using his metacognition and perception to understand the task. Therefore allowing him to consider the task in a more challenging way which requires him to sort through a range of outcomes may be the way forward in supporting the way he is using his metacognition skills to decode the task.

Giving a structure to something that did not previously have any definition (as seen in Chapter 2) in itself is useful as it empowers teachers to verbalise and categorise the notion of prior knowledge, giving them a language for communicating the prior knowledge of children. My partial model offers schools a starting point for the process of thinking about how children will be accessing the learning that takes place. Having partly defined a structure for prior knowledge allows us to know what to look for in children while they perform a task. Knowing the way in which children are thinking not just allows us to determine what they are learning, but also know how they may be using it to make meaning of each task. Knowing this is powerful as it allows teachers to present material that maximises the rate at which individuals make sense of the task.

The partial model forces teachers to consider, in terms of mathematical teaching, a much wider base in children's understanding. This research has brought to light the diverse nature of children's knowledge in mathematics and how they approach tasks. The discourse for schools is widened as the realisation that prior knowledge is not based and fixed in the classroom has been clarified. Also knowing what some of the constituents of prior knowledge are allows us to start thinking of a range of experiences that we can expose children to in order to develop a bank of ideas that provide greater tools to access difficult areas of mathematics.

Understanding gained from this research and the emergence of this partial model raises questions about the way we organise learning within schools. There is currently, to some extent, a formulaic approach to mathematics lessons and the knowledge that must be taught. My partial prior knowledge model suggests that there must be a shift in thinking away from a one-size-fits-all solution for organising classrooms to an individualised personalised model of delivery. We need to move towards an evidence-based teaching model – one which takes a diagnostic approach to choice of pedagogy, planning and development of curriculum and delivery. This is supported by the partial model developed through this research as the emerging model offers a framework through which evidence can be gathered.

Using this partial prior knowledge model as a way to gather information for individualised planning would be ideal. However, as we are constrained by the current education model, there needs to be a way to implement this profiling and gathering of evidence. There is little value in planning within schools without taking into account the new understanding of prior knowledge offered in this thesis as it offers the ability to start from where the children already are and opens the door that many learning theories have relied upon to inculcate learning.

7.4 Teachers

The greatest impact of this partial model will be felt by the teachers. Teachers are the dominant force in the improvement of a child's ability to relationally understand mathematics, and therefore form a bridge between children and knowledge. Understanding of prior knowledge and its impact upon learning is ingrained in pedagogical dialogue, and with it is the limited definition – prior knowledge is what children already know about a subject. This is easy to evaluate as subject knowledge can, to some extent, be tested. However, my research has demonstrated that children come to any mathematical task not only with prior subject knowledge, but also a deeper relationship with the mathematics they are encountering. My research offers a way to start understanding this deeper relationship. Being able to listen to children while engaged in mathematical tasks with some emerging pegs to hang ideas about the child is incredibly useful in supporting, planning, differentiation, assessment and personalisation of learning and thus support individual progress. The partial model offers a way to listen to children and make meaning of how they think who they are and how to move them forward. It opens the scope to have greater precise fluid differentiation. Also understanding prior knowledge through the evidence gathered from this partial model allows teachers to question children in a more focused manner to direct their daily learning experiences.

In order to support the development of children, teachers need to know the real picture of prior knowledge within children. My partial model supports teachers in gaining a truer picture of individual children.

Therefore teachers need to establish a new pedagogy – one which integrates this emerging structure of prior knowledge within it. This partial model offers teachers a template with which to begin gathering information about children, to develop a more accurate detailed picture of prior knowledge, and to enhance, use and develop to better effect the critical role that prior knowledge plays in learning. This partial model takes prior knowledge out of the dark domain of pedagogical rhetoric into a useable meaningful map to enhance relational understanding and learning.

Thinking about prior knowledge in terms of my model will require a huge paradigm shift in the mindset of teachers, from the pre-assumed linear structure of mathematics teaching to considering mathematics as a more organic process that needs thoughtful construction of experiences to support children's learning. Teachers could argue that this seems like an onerous task adding to their already heavy workload. However my partial model offers a starting point to unlocking some of the difficulties that teachers face on a daily basis. The 2009 House of Commons Public Accounts Committee Report has highlighted that though, through the implementation of the National Numeracy Strategy, there have been improvements in planning and delivery of primary mathematics, there has been little improvement in attainment (House of Commons Public Accounts Committee, 2009). This report further highlights a fall in mathematical knowledge and skills. These outcomes could be due to teachers' lack of understanding of the prior knowledge of the children they are teaching. As already considered in Chapter 2, there is a link between prior knowledge and learning, and my partial model fills this gap in understanding. Through the use of the partial model, teachers will be able to gain a better understanding of the prior knowledge of the children they are teaching and put their strong pedagogical knowledge to better use to enrich and enhance development of children in mathematics. As most teachers carry out many activities which will support them in developing this understanding of the child, it is not a question of implementing a new process, but using best practice in a more mindful way to understand children. For each area of my partial model, Table 7.1 and Table 7.2 contain some practical ideas for gaining this information. Table 7.1 focuses on the first three elements of the partial prior knowledge model, while Table 7.2 focuses on the five other emerging elements of the partial prior knowledge model. It must be noted that these are only one of a myriad of possible practical methodologies that can be developed by teachers to dovetail with existing practice for the understanding of children's prior knowledge.

Table 7.1 Possible methods for understanding children's prior knowledge

Prior knowledge element	**Possible methods**
Context	• Talking and listening to children's stories; using circle time to understand and listen to each child • Working with parents to develop a mathematics diary (similar to reading records) • Homework which ensures using contextual tasks e.g. counting in pairs for sorting shoes • Supporting mathematics through outdoor learning
Acculturation	• Looking at records from previous settings • Talking to past class teachers to gain an understanding of children • A comprehensive progression map within school which allows all teachers to establish processes

	• (e.g. calculation) which are consistent throughout the school • Having a clear system of established vocabulary throughout the school
Metacognition	• Choices in the methods in what children do while engaging in mathematical tasks • Taking part in self-assessment e.g. traffic lighting • Choosing own targets • Lessons where children spend time "marking" their own work and giving explanations of their own next steps • Use of rich tasks and time for children their approaches

Table 7.2 Possible methods for understanding children's prior knowledge

Prior knowledge element	**Possible methods**
Individual motivation	• Look at how they wish to challenge themselves; consider length of time that children spend on a task • Choice in how children record their work
Perception	• Problem solving and how they use their logic • Reading and writing number symbols
Cognition	• Through observation, noting mathematical tasks that children achieve with great efficiency • "Fact finding" lessons looking at what children's subject knowledge is before starting
Social group	• Information from parents through pre-existing structures such as homework diaries
Abstraction	• Through written work, considering children's understanding of mathematical symbols • Using and applying their knowledge in a range of problem solving contexts

On a practical level, one way in which this partial model can be used is at the start of every school year for teachers, through observations, consultation with both parents and past teachers, and setting mathematical tasks, to build a prior knowledge profile constituting elements of the partial model and to use this in order to plan their lessons and set targets. Furthermore constantly updating this prior knowledge profile of children can support development. This deepened understanding will allow teachers to use their skills to plan in a more informed manner.

For example, when we consider the three children's prior knowledge described in Figure 6.2, we see a detailed picture of the way in which these children think and have developed their understanding and knowledge of shapes. We are given many clues as to the network of ideas that the children have used to support this understanding. Listening to the children, as illustrated by the transcripts, we can see that Richard uses his ideas of other physical objects to understand different shapes. Therefore in future planning, teachers should build new learning on these existing ideas. For example, using everyday objects to consider properties of shapes. In the case of Jonathan, he clearly understands that he is lacking some vocabulary to express and explain his mathematical concepts. Though he has an accurate idea of the shape he is looking at, he needs some guidance to identify its name. Therefore one idea could be to use resources which link different shapes to names and sharing these with Jonathan to help build on his existing knowledge which is a clear understanding of the properties of a rectangle.

7.5 Children

When considering how this partial structure of prior knowledge affects children, I need to declare that my discovery of this structure does not require any action from children. They are not being asked to consider how they behave or act when faced with a mathematical task. They will continue to behave and respond in the ways they always have. However the impact of my partial prior knowledge model will be felt by children through the actions of teachers, and in turn their response to these actions. Starting to understand the structure of prior knowledge as it has emerged from children, teachers will be equipped to teach in a more informed manner, and not feel the restrictions imposed upon them by the current teaching discourse.

> The emphasis in almost all cognitive developmental theories has been on identifying sequences of one-to-one correspondences between ages and ways of thinking or acting, rather than on specifying how the changes occur.
>
> (Siegler, 1994, p. 1)

Understanding the categories of prior knowledge which have already emerged or may emerge through further research allows teachers to understand how the changes they see in children occur. It is the emerging categories within prior knowledge and the effect that being in the world has upon each of these categories that develops and supports learning within children. Knowing this ensures that teachers should be more mindful of these emerging categories and should understand how to support appropriate change which will enhance children's engagement with mathematical tasks.

Within the system of schools, currently there is great deal of focus on mechanisms which are perceived to be good teaching such as targets, AfL, APP, cross-curricular planning through a creative curriculum and topic plans, but little mindful targeted focus on what individual children need. When starting this journey, I was prompted by a simple question. What does it mean when teachers say *"I want to get to know my class"* or *"You should always go from where children are and then build on this"*. In terms of supporting learning and development, both these desires make perfect sense. However I feel that till now, I was not given any direction to achieve this understanding which in turn meant that my support was very mechanical. Knowing the emerging structure of prior knowledge allows me to start to develop and use a framework to build this picture of the child and be more targeted in my support. Also this structure forces teachers to acknowledge that there is more to an individual than just subject knowledge which has an impact upon their learning and understanding of mathematics. It allows teachers to observe children as people and listen to what they are telling teachers about themselves. It is only by listening and observing that teachers are able to understand the uniqueness of each child and thus teach children and not just instruct them. The partial prior knowledge model evolved in this research supports this process of listening by having a structure for interpreting children's responses and ensuing pedagogical choices. It allows the start of a structure that supports evidence-based practice.

7.6 Curriculum

The biggest challenge facing the current system of education is how to personalise learning and ensure individual progress. There is much debate in current educational corridors about the need to ensure progress for every child and to develop strategies which allow for this progress to be planned. The dominant theme, for the focus of Ofsted (2012) inspections in the new framework, is the progress of pupils and how well teachers manage this progress and development to ensure that "tasks matched to pupils' learning needs" (p. 15).

In order to meet this sea of change, the focus is back on the teacher's ability to evaluate and understand how each child is learning and the prior knowledge they bring to each situation. This puts the demand upon understanding the structure of an individual's prior knowledge at the forefront of the dialogues developed around good teaching and learning in schools.

Though we find ourselves in limbo in terms of the current curriculum for primary mathematics, it provides me with an ideal opportunity to construct a utopian ideal of the curriculum I would want to see in our schools. The great number of changes in the curriculum has had some effect upon how teaching is implemented within schools. I must be clear in my debate of the practical possibilities for implementing a creative curriculum. However if I go back to the start of this thesis and consider the central premise that good teaching is based upon understanding children's prior knowledge, and that effective learning is based upon links made to prior knowledge, then a curriculum must be designed that allows for this process of developing and considering for each individual child's prior knowledge using the partial structure proposed and then developing learning needs based on this. This new dialogue in education fills me with hope as there is an appetite for moving away from the mechanical process of consuming knowledge to a more considered organic process – one which on the face of it has a prominent place for prior knowledge.

Having uncovered some elements that each child brings to every task and knowing that it is these elements that may have an effect upon the way in which learning can be organised, the greatest change that should take place is to change from a linear curriculum to a more organic curriculum. The curriculum needs to allow for these non-linear ideas and knowledge to form the central premise of curriculum development.

Throughout conducting this research, I have been privileged in observing children and learning from them what they have to tell us about what they already know and how this could support their future learning. The partial structure of prior knowledge developed through this research allows teachers to structure their thoughts, to observe and listen mindfully to children, to understand each child individually and thus to teach the child and not children, and to have an evidence-based approach to teaching.

7.7 Moving Forward

This journey has been long and one which has taken many interesting turns. However throughout the process, I have learnt a lot about the way in which we should teach and the power of children to share openly their thoughts. Children bring such a cornucopia of dimensions to their learning, and it is the teachers' role to listen, observe, understand, support and guide children through the many mazes they will find in their learning journey, so that they may eventually be able to work out their own struggle and path to follow. For me, all theory aside, empirically there is no other way forward but to continue to search for further elements of prior knowledge and to start using this framework for my teaching and understanding of children's mathematics.

It will be naive of me to think that this was the end of the road. There is much more to be done and much to learn from children. I have listed below three areas that I think need further exploration, now that a partial structure for prior knowledge has been developed.

- Application – ask teachers to use this structure in order to see how it works in practice and develop a toolkit;
- Effects – what are the factors that affect prior knowledge?
- Extension – conduct research to uncover further possible categories of prior knowledge.

7.8 Summing Up

The goal and intention of this research process was simple – to understand why children in schools had such varying ability in mathematics. The journey to understand this has been fascinating and led me to the key for learning – prior knowledge. Exploring and unpicking this established concept has enabled me to gain an all-round view of education and the process of learning. The result of all this exploration is an emerging partial model for prior knowledge – a structure which exists in us all – which has been established from a range of contributory elements. My contribution to the understanding and teaching of children is this partial structure of prior knowledge which has not been discovered before.

REFERENCES

Ajello, A. M., & Belardi, C. (2002). Acquiring abilities within informal contexts: recognition and accreditation. *Paper presented at the Learning Communities and Assessment Cultures Conference*, EARLI Special Interest Group on Assessment and Evaluation, University of Northumbria, 28-30 August 2002. Retrieved from http://www.leeds.ac.uk/educol/documents/00002241.htm.

Alexander, P. A., Kulikowich, J. A., & Jetton, T. L. (1994). The role of subject-matter knowledge and interest in the processing of linear and non-linear texts. *Review of Educational Research, 64* (2), 201-252.

Alexander, P. A., Pate, E. P., Kulikowich, J. M., Farrell, D. M., & Wright, N. L. (1989). Domain-specific and strategic knowledge: effects of training on students of differing ages or competence levels. *Learning and Individual Differences*, *1* (3), 283-325.

Alexander, R. (Ed.). (2010). *Children, their world, their education: final report and recommendations of the Cambridge Primary Review.* London, UK: Routledge.

Anderson, J. R. (1995). *Cognitive psychology and its implications* (4th ed.). New York, NY: W. H. Freeman.

Anderson, L. W., & Burns, R. B. (1989). *Research in classrooms: the study of teachers, teaching and instruction.* Oxford, UK: Pergamon.

Apple, M. W. (1979). *Ideology and curriculum.* London, UK: Routledge.

Ashcraft, M. H. (1982). The development of mental arithmetic: a chronometric approach. *Development Review, 2* (3), 213-236.

Asimov, I. (1991). Foreword. In C. B. Boyer, & U. C. Merzbach, *A history of mathematics* (2nd ed.) (pp. vii-viii). New York, NY: John Wiley.

Askew, M., Millett, A., Brown, M., Rhodes, V., & Bibby, T. (2001). Entitlement to attainment: tensions in the National Numeracy Strategy. *The Curriculum Journal, 12* (1), 5-28.

Atkinson, S. (1992). *Mathematics with reason: the emergent approach to primary maths.* London, UK: Hodder & Stoughton.

Ausubel, D. P., Novak, J. D., & Hanesian, H. (1978). *Educational psychology: a cognitive view* (2nd ed.). New York, NY: Holt, Rinehart & Winston.

Baker, C., Wuest, J., & Stern, P. N. (1992). Method slurring: the grounded theory/phenomenology example. *Journal of Advanced Nursing, 17* (11), 1355-1360.

Baldwin, B. T., & Stecher, L. I. (1925). *The psychology of the preschool child.* New York, NY: D. Appleton.

Baroody, A. J. (1987). *Children's mathematical thinking: a developmental framework for pre-school, primary and special education teachers.* New York, NY: Teachers' College Press.

Bartlett, F. C. (1932). *Remembering: a study in experimental and social psychology.* Cambridge, UK: Cambridge University Press.

Becker, H. S. (1990). Generalizing from case studies. In E. W. Eisner, & A. Peshkin (Eds.), *Qualitative research in education: the continuing debate* (pp. 233-242). New York, NY: Teachers' College Press.

Berry, J. W. (2005). Acculturation: living successfully in two cultures. *International Journal of Intercultural Relations, 29* (6), 697-712.

Bishop, A. (2002). Mathematical acculturation, cultural conflicts, and transition. In G. De Abreu, A. J. Bishop, & N. C. Presmeg (Eds.), *Transitions between contexts of mathematical practices* (pp. 193-212). Dordrecht, Netherlands: Kluwer Academic Publishers.

Bjorklund, D. F. (1985). The role of conceptual knowledge in the development of organization in children's memory. In C. J. Brainerd, & M. Pressley (Eds.), *Basic processes in memory development: progress in cognitive development research* (pp. 103-142). New York, NY: Springer-Verlag.

Blanck, G. (1996). Vygotsky: the man and his cause. In L. C. Moll (Ed.), *Vygotsky and education: instructional implications and applications of sociohistorical psychology* (pp. 31-58). Cambridge, UK: Cambridge University Press.

Bloom, B. S. (1976). *Human characteristics and school learning.* New York, NY: McGraw-Hill.

Bogdan, R. C., & Biklen, S. K. (2007). *Qualitative research for education: an introduction to theory and methods* (5th ed.). Boston, MA: Allyn & Bacon.

Borasi, R. (1986). On the nature of problems. *Educational Studies in Mathematics, 17* (2), 125-141.

Borko, H., & Livingston, C. (1989). Cognition and improvisation: differences in mathematics instruction by expert and novice teachers. *American Educational Research Journal, 26* (4), 473-498.

Borthwick, A. (2011). Children's perceptions of, and attitudes towards, their mathematics lessons. In C. Smith (Ed.), *Proceedings of the British Society for Research into Learning Mathematics* (pp. 37-42)*, 31* (1), London, UK, 11 March 2011.

Bower, T. G. R. (1982). *Development in infancy* (2nd ed.). New York, NY: W. H. Freeman.

Brightman, H. J. (1982). Teaching statistics through advance organizers. *The American Statistician, 36* (3), 217.

British Educational Research Association. (2004). *Revised ethical guidelines for educational research.* London, UK: British Educational Research Association.

Briton, D., Gereluk, W., & Spencer, B. (1998). Prior learning assessment and recognition: issues for adult educators. In *Proceedings of the 17th Annual Conference of the Canadian Association for the Study of Adult Education* (pp. 24-28), University of Ottawa, 29-31 May 1998.

Bugelski, B. R. (1962). Presentation time, total time, and mediation in paired-associate learning. *Journal of Experimental Psychology, 63* (4), 409-412.

Burrell, G., & Morgan, G. (1979). *Sociological paradigms and organisational analysis: elements of the sociology of corporate life*. London, UK: Heinemann.

Burton, M. (2009). Exploring the changing perception of mathematics among elementary teacher candidates through drawings. In S. L. Swars, D. W. Stinson, & S. Lemons-Smith (Eds.), *Proceedings of the 31st Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 363-370), Georgia State University, Atlanta, GA, 23-26 September 2009.

Cabassa, L. J. (2003). Measuring acculturation: where we are and where we need to go. *Hispanic Journal of Behavioral Sciences, 25* (2), 127-146.

Cameron, L. (2003). *Metaphor in educational discourse*. London, UK: Continuum.

Campbell, D. T., & Stanley, J. C. (1963). Experimental and quasi-experimental designs for research on teaching. In N. L. Gage (Ed.), *Handbook of research on teaching* (pp. 171-246). Chicago, IL: Rand McNally.

Carr, M., Alexander, J., & Folds-Bennett, T. (1994). Metacognition and mathematics strategy use. *Applied Cognitive Psychology, 8* (6), 583-595.

Carspecken, P. F. (1996). *Critical ethnography in educational research: a theoretical and practical guide.* London, UK: Routledge.

Charmaz, K. (2007). *Constructing grounded theory: a practical guide through qualitative analysis.* London, UK: Sage Publications.

Chi, M. T. H., & Ceci, S. (1987). Content knowledge: its role, representation, and restructuring in memory development. In H. W. Reese (Ed.), *Advances in child development and behavior* (Vol. 20) (pp. 91-142). Orlando, FL: Academic Press.

Chi, M. T. H., Glaser, R., & Farr, M. J. (Eds.). (1988). *The nature of expertise.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Clemson, D., & Clemson, W. (1994). *Mathematics in the early years.* London, UK: Routledge.

Cobb, P., Perlwitz, M., & Underwood-Gregg, D. (1998). Individual construction, mathematical acculturation, and the classroom community. In M. Larochelle, N. Bednarz, & J. Garrison (Eds.), *Constructivism and education* (pp. 63-80). Cambridge, UK: Cambridge University Press.

Cockcroft, W. H. (1982). *The Cockcroft Report: Mathematics counts: report of the Committee of Inquiry into the teaching of mathematics in schools.* London, UK: HMSO.

Cohen, L., Manion, L., & Morrison, K. (2001). *Research methods in education* (5th ed.). London, UK: Routledge.

Cooley, C. H. (1909). *Social organization.* New York, NY: Scribner's.

Coon, D. (1989). *Introduction to psychology: exploration and application* (5th ed.). St. Paul, MN: West Publishing Company.

Cooper, B., & Dunne, M. (1988). Anyone for tennis? social class differences in children's responses to National Curriculum mathematical testing. *The Sociological Review, 46* (1), 115-148.

Coulby, D. (2000). *Beyond the National Curriculum: curricular centralism and cultural diversity in Europe and the USA.* London, UK: RoutledgeFalmer.

Cronbach, L. J. (1975). Beyond the two disciplines of scientific psychology. *American Psychologist*, 30 (2), 116-127.

Denzin, N. K. (1989). *The research act: a theoretical introduction to sociological methods* (3rd ed.). Englewood Cliffs, NJ: Prentice Hall.

Department for Education. (1995). *Mathematics in the National Curriculum.* London, UK: HMSO.

Department for Education. (2008). DCSF: School Workforce in England (including Local Authority level figures), January 2008 (Revised). London, UK: Department for Education. Retrieved from http://www.education.gov.uk/rsgateway/DB/SFR/s000813/index.shtml.

Department for Education and Employment. (1999). *The National Numeracy Strategy: framework for teaching mathematics from Reception to Year 6.* Sudbury, UK: DfEE Publications.

Department for Education and Skills. (2006). *Primary framework for literacy and mathematics.* London, UK: DfES Publications.

Department of Education and Science. (1985). *Better schools.* London, UK: HMSO.

Dey, I. (1993). *Qualitative data analysis: a user-friendly guide for social scientists.* London, UK: Routledge.

Dickson, L., Brown, M., & Gibson, O. (1984). *Children learning mathematics: a teacher's guide to recent research.* London, UK: Cassell.

Dienes, Z. (1971). *Building up mathematics* (4th ed.). London, UK: Hutchinson Educational.

Dochy, F. J. R. C. (Ed.). (1992). *Assessment of prior knowledge as a determinant for future learning: the use of prior knowledge state tests and knowledge profiles.* London, UK: Jessica Kingsley.

Dochy, F., Segers, M., & Buehl, M. M. (1999). The relation between assessment practices and outcomes of studies: the case of research on prior knowledge. *Review of Educational Research, 69* (2), 145-186.

Donaldson, M. (1989). *Children's minds* (16th ed). London, UK: Fortuna.

Draucker, C. B., Martsolf, D. S., Ross, R., & Rusk, T. B. (2007). Theoretical sampling and category development in grounded theory. *Qualitative Health Research, 17* (8), 1137-1148.

Dudai, Y. (2007). Memory: it’s all about representations. In H. L. Roediger, Y. Dudai, & S. M. Fitzpatrick (Eds.), *Science of memory: concepts* (pp. 13-16). New York, NY: Oxford University Press.

Duncker, K. (1945). On problem solving (L. S. Lees, Trans.). *Psychological Monographs*, *58* (270), 1-113.

Education Reform Act 1988 (c.40). London: HMSO.

Edwards, A. (2002). Responsible research: ways of being a researcher. *British Educational Research Journal, 28* (2), 157-168.

Edwards, A. D., & Westgate, D. P. G. (1994). *Investigating classroom talk* (2nd ed.). London, UK: The Falmer Press.

Ellwood, C. A. (1919). *Sociology and modern social problems.* New York, NY: American Book Co.

Ely, M., Anzul, M., Friedman, T., Garner, D., & Steinmetz, A. M. (1991). *Doing qualitative research: circles within circles.* London, UK: RoutledgeFalmer.

Erickson, F., & Schultz, J. (1981). When is a context? some issues in the analysis of social competence. In J. Green, & C. Wallat (Eds.), *Ethnography and language in educational settings* (pp. 147-160). Norwood, NJ: Ablex.

Ernest, P. (1999). Forms of knowledge in mathematics and mathematics education: philosophical and rhetorical perspectives. *Educational Studies in Mathematics, 38* (1), 67-83.

Evans, K. (2002). The challenges of 'making learning visible': problems and issues in recognising tacit forms of key competences. In K. Evans, P. Hodkinson, & L. Unwin (Eds.), *Working to learn: transforming learning in the workplace* (pp. 79-94). London, UK: Kogan Page.

Ferrari, P. L. (2003). Abstraction in mathematics. *Philosophical Transactions: Biological Sciences, 358* (1435), 1225-1230.

Finlay, L. (2008). Introducing phenomenological research. Retrieved from http://www.lindafinlay.co.uk/An%20introduction%20to%20phenomenology%202008.doc.

Flanagan, C. (1996). *Applying psychology to early child development.* London, UK: Hodder & Stoughton.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: a new area of cognitive-developmental inquiry. *American Psychologist, 34* (10), 906-911.

Gardiner, T. (2000). *Reference levels in school mathematics education in Europe: national presentation: England.* Helsinki: Committee on Mathematics Education, European Mathematical Society.

Garofalo, J., & Lester, F. K. J. (1985). Metacognition, cognitive monitoring, and mathematical performance. *Journal of Research in Mathematics Education, 16* (3), 163-176.

Gelman, R. (1980). What young children know about numbers. *Educational Psychologist, 15* (1), 54-68.

Gibson, E. J. (1987). Introductory essay: what does infant perception tell us about theories of perception? *Journal of Experimental Psychology: Human Perception and Performance, 13* (4), 513-523.

Gibson, J. J., & Gibson, E. J. (1955). Perceptual learning: differentiation or enrichment? *Psychological Review, 62* (1), 32-41.

Gillard, D. (2004). The Plowden Report. In *The encyclopaedia of informal education.* London, UK: infed. Retrieved from http://www.infed.org/schooling/plowden_report.htm.

Ginsburg, H. P. (1989). *Children's arithmetic: how they learn it and how you teach it* (2nd ed.). Austin, TX: PRO-ED.

Glaser, B. G. (2001). *The grounded theory perspective: conceptualization contrasted with description.* Mill Valley, CA: Sociology Press.

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: strategies for qualitative research.* New York, NY: Aldine.

Glaser, R. (1984). Education and thinking: the role of knowledge. *American Psychologist, 39* (2), 93-104.

Glaser, R., & De Corte, E. (1992). Preface. In F. J. R. C. Dochy (Ed.), *Assessment of prior knowledge as a determinant for future learning: the use of prior knowledge state tests and knowledge profiles* (pp. 1-2). London, UK: Jessica Kingsley.

Glaser, R., Lesgold, A., & Lajoie, S. (1987). Toward a cognitive theory for the measurement of achievement. In R. R. Ronning, J. A. Glover, J. C. Conoley, & J. C. Witt (Eds.), *The influence of cognitive psychology on testing and measurement* (pp. 41-85). Hillsdale, NJ: Lawrence Erlbaum Associates.

Gold, R. L. (1958). Roles in sociological field observations. *Social Forces, 36*, 217-223.

Gregory, R. L. (1978). *Eye and brain: the psychology of seeing* (3rd ed.). New York, NY: McGraw-Hill.

Groen, G., & Resnick, L. B. (1977). Can preschool children invent addition algorithms? *Journal of Educational Psychology, 69* (6), 645-652.

Hadow, H. (1931). *The Hadow Report: the primary school: a report of the Consultative Committee.* London, UK: HMSO.

Haenggi, D., & Perfetti, C. A. (1992). Individual differences in reprocessing of text. *Journal of Educational Psychology, 84* (2), 182-192.

Hammersley, M., & Atkinson, P. (2007). *Ethnography: principles in practice* (3rd ed.). London, UK: Taylor & Francis.

Hannula, M. S. (2006). Motivation in mathematics: goals reflected in emotion. *Educational Studies in Mathematics, 63* (2), 165-178.

Harris, J. (2000). Re-visioning the boundaries of learning theory in the assessment of prior experiential learning (APEL). *Paper presented at 30th Annual Standing Conference on University Teaching and Research in the Education of Adults (SCUTREA) Conference,* University of Nottingham, 3-5 July 2000. Retrieved from http://www.leeds.ac.uk/educol/documents/00001448.htm.

Hatch, J. A. (2002). *Doing qualitative research in education settings*. Albany, NY: State University of New York Press.

Hayes, J. R. (1985). Three problems in teaching general skills. In S. F. Chipman, J. W. Segal, & R. Glaser (Eds.), *Thinking and learning skills: research and open questions* (Vol. 2) (pp. 391-406). Hillsdale, NJ: Lawrence Erlbaum Associates.

Haylock, D., & Cockburn, A. (1989). *Understanding early years mathematics.* London, UK: Paul Chapman.

Hazel, E., Prosser, M., & Trigwell, K. (2002). Variation in learning orchestration in university biology courses. *International Journal of Science Education, 24* (7), 737-751.

Hitchcock, G., & Hughes, D. (1995). *Research and the teacher: a qualitative introduction to school-based research* (2nd ed.). London, UK: Routledge.

Hoepfl, M. C. (1997). Choosing qualitative research: a primer for technology education researchers. *Journal of Technology Education*, *9* (1), 47-63.

House of Commons Public Accounts Committee. (2009). *Mathematics performance in primary schools: getting the best results. Twenty-third report of session 2008-09. HC 44.* London, UK: TSO.

Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, *15* (9), 1277-1288.

Hughes, M. (1986). *Children and number: difficulties in learning mathematics.* Oxford, UK: Blackwell.

Hume, D. (2010). *A treatise on human nature* (Vol. 1). Charleston, SC: Forgotten Books. (Original work published in 1739)

Jaworski, B. (1994). *Investigating mathematics teaching: a constructivist enquiry.* London, UK: Falmer Press.

Jones, A., Todorova, N., & Vargo, J. (2000). Improving teaching effectiveness understanding and leveraging prior knowledge for student learning. In *Proceedings of the 15th Annual Conference of the International Academy for Information Management* (pp. 205-209), Brisbane, Australia, 6-10 December 2000.

Kant, I. (2010). *The critique of pure reason* (J. M. D. Meiklejohn, Trans.). Charleston, SC: Forgotten Books. (Original work published in 1781)

Kaplan, A. S., & Murphy, G. L. (2000). Category learning with minimal prior knowledge. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26* (4), 829-846.

Kincheloe, J. L. (2003). *Teachers as researchers: qualitative inquiry as a path to empowerment* (2nd ed.). London, UK: RoutledgeFalmer.

Kirk, J., & Miller, M. L. (1986). *Reliability and validity in qualitative research.* Newbury Park, CA: Sage Publications.

Kitcher, P. (1984). *The nature of mathematical knowledge*. New York, NY: Oxford University Press.

Krathwohl, D. R. (1993). *Methods of educational and social science research: an integrated approach*. New York, NY: Longman.

Kuhn, D., & Dean, D. (2004). A bridge between cognitive psychology and educational practice. *Theory into Practice, 43* (4), 268-273.

Lakoff, G., & Johnson, M. (2003). *Metaphors we live by.* Chicago, IL: The University of Chicago Press.

Laurillard, D. (1993). *Rethinking university teaching: a framework for the effective use of educational technology.* London, UK: Routledge.

Lave, J. (1988). *Cognition in practice: mind, mathematics, and culture in everyday life.* Cambridge, UK: Cambridge University Press.

Lave, J., Murtaugh, M., & de la Rocha, O. (1984). The dialectic of arithmetic in grocery shopping. In B. Rogoff, & J. Lave (Eds.), *Everyday cognition: its development in social context* (pp. 67-94). Cambridge, MA: Harvard University Press.

Lavine, T. Z. (1984). *From Socrates to Sartre: the philosophic quest.* New York, NY: Bantam Books.

LeCompte, M. D., & Preissle, J. (1993). *Ethnography and qualitative design in educational research* (2nd ed.). San Diego, CA: Academic Press.

Levitas, M. (1974). *Marxist perspectives in the sociology of education.* London, UK: Routledge.

Lincoln, Y. S., & Guba, E. E. (1985a). *Naturalistic inquiry.* Mountain Oaks, CA: Sage Publications.

Lincoln, Y. S., & Guba, E. E. (1985b). Research, evaluation, and policy analysis: heuristics for disciplined inquiry. *Review of Policy Research, 5* (3), 546-565.

Little, D. (2008). *What is hermeneutic explanation?* Dearborn, MI: University of Michigan. Retrieved from http://www-personal.umd.umich.edu/~delittle/Encyclopedia%20entries/hermeneutic%20explanation.htm.

Lovell, K. (1973). *Educational psychology and children* (11th ed.). London, UK: University of London Press.

Malkevitch, J. (1997). Discrete mathematics and public perceptions of mathematics. In J. G. Rosenstein, D. S. Franzblau, & F. S. Roberts (Eds.), *Discrete mathematics in the schools* (pp. 89-97). Providence, RI: American Mathematical Society.

Marshall, S. P. (1993). Assessment of rational number understanding: a schema-based approach. In T. P. Carpenter, E. Fennema, & T. A. Romberg (Eds.), *Rational numbers: an integration of research* (pp. 261-288). Hillsdale, NJ: Lawrence Erlbaum Associates.

Merriam, S. B. (1995). What can you tell from an n of 1?: issues of validity and reliability in qualitative research. *PAACE Journal of Lifelong Learning, 4*, 51-60.

Merttens, R., & Head, J. (2000). Series editors' preface. In D. Coulby, *Beyond the National Curriculum: curricular centralism and cultural diversity in Europe and the USA* (p. viii-x). London, UK: RoutledgeFalmer.

Meyer, H. (2004). Novice and expert teachers' conceptions of learners' prior knowledge. *Science Education, 88* (6), 970-983.

Middleton, J. A., & Spanias, P. A. (1999). Motivation for achievement in mathematics: findings, generalizations, and criticisms of the research. *Journal for Research in Mathematics Education, 30* (1), 65-88.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.). Newbury Park, CA: Sage Publications.

Mitchelmore, M., & White, P. (2004). Abstraction in mathematics and mathematics learning. In M. J. Hoines, & A. B. Fuglestad (Eds.), *Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Educations* (Vol. 3) (pp. 329-336). Bergen, Norway, 14-18 July 2004. Cape Town, South Africa: International Group for the Psychology of Mathematics Education.

Mitchelmore, M., & White, P. (2007). Abstraction in mathematics learning. *Mathematics Education Research Journal, 19* (2), 1-9.

Moon, B. (2001). *A guide to the National Curriculum* (4th ed.). Oxford, UK: Oxford University Press.

Mouly, G. J. (1978). *Educational research: the art and science of investigation.* Boston, MA: Allyn & Bacon.

Nickson, M. (1994). The culture of the mathematics classroom: an unknown quantity? In S Lerman (Ed.). *Cultural perspectives on the mathematics classroom* (pp. 7-35). Dordrecht, Netherlands: Kluwer Academic Publishers.

Novak, J. D., & Canas, A. J. (2007). Theoretical origins of concept maps, how to construct them, and uses in education. *Reflecting Education, 3* (1), 29-42.

O'Donnell, A. M., Dansereau, D. F., & Hall, R. H. (2002). Knowledge maps as scaffolds for cognitive processing. *Educational Psychology Review, 14* (1), 71-86.

Ofsted. (2012). *The framework for school inspection.* Manchester, UK: Ofsted.

Onions, P. E. W. (2006). Grounded theory applications in reviewing knowledge management literature. *Paper presented at Leeds Metropolitan University Innovation North Research Conference,* Leeds Metropolitan University, 24 May 2006. Retrieved from http://www.patrickonions.org/docs/academic/2006%20Grounded%20theory%20from%20literature%20review.pdf.

Papaleontiou-Louca, E. (2003). The concept and instruction of metacognition. *Teacher Development, 7* (1), 9-30.

Park, R. E., & Burgess, E. W. (1921). *Introduction to the science of sociology.* Chicago, IL: University of Chicago Press.

Parkerson, J. A., Lomax, R. G., Schiller, D. P., & Walberg, H. J. (1984). Exploring causal models of educational achievement. *Journal of Educational Psychology, 76* (4), 638-646.

Peterson, P. L., Marx, R. W., & Clark, C. M. (1978). Teacher planning, teacher behavior, and student achievement. *American Educational Research Journal, 15* (3), 417-432.

Piaget, J. (1954). *The constructing of reality in the child* (M. Cook, Trans.). New York, NY: Basic Books.

Plowden, J. P. (1967). *The Plowden Report: children and their primary schools: a report of the Central Advisory Council for Education (England).* London, UK: HMSO.

Pressley, M., & McCormick, C. B. (1995). *Advanced educational psychology for educators, researchers and policymakers.* New York, NY: HarperCollins College Publishers.

Rand, A. (1965). Who is the final authority in ethics? *The Objectivist Newsletter, 4* (2), 7.

Rand, A. (1979). *Introduction to objectivist epistemology.* New York, NY: Mentor.

Resnick, L. B. (1981). Instructional psychology. *Annual Review of Psychology, 32*, 659-704.

Resnick, L. B., & Ford, W. W. (1981). *The psychology of mathematics for instruction.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Reynolds, D. (1998a). *Implementation of the National Numeracy Strategy: the final report of the Numeracy Task Force.* London, UK: Department for Education and Employment (DfEE).

Reynolds, D. (1998b). *Numeracy matters: the preliminary report of the Numeracy Task Force.* London, UK: Department for Education and Employment (DfEE).

Roschelle, J. (1995). Learning in interactive environments: prior knowledge and new experience. In J. H. Falk, & L. D. Dierking (Eds.), *Public institutions for personal learning: establishing a research agenda* (pp. 37-51). Washington, DC: American Association of Museums.

Rose, J. (2009). *Independent review of the primary curriculum: final report.* Nottingham, UK: DCSF Publications.

Rosengren, K. E. (1981). Advances in Scandinavian content analysis: an introduction. In K. E. Rosengren (Ed.), *Advances in content analysis* (pp. 9-19). Beverly Hills, CA: Sage Publications.

Rumbold, A. (1990). *The Rumbold Report: starting with quality: the report of the Committee of Inquiry into the quality of the educational experience offered to 3 and 4 year olds.* London, UK: HMSO.

Ryan, A. B. (2006). Methodology: analysing qualitative data and writing up your findings. In M. Antonesa, H. Fallon, A. B. Ryan, T. Walsh, & L. Borys (Eds.), *Researching and writing your thesis: a guide for postgraduate students* (pp. 92-108). Maynooth, Ireland: MACE Publications.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: classic definitions and new directions. *Contemporary Educational Psychology, 25* (1), 54-67.

Schmidt, H. G., De Volder, M. L., De Grave, W. S., Moust, J. H. C., & Patel, V. L. (1989). Explanatory models in the processing of science text: the role of prior knowledge activation through small-group discussion. *Journal of Educational Psychology, 81* (4), 610-619.

Schneider, W., Körkel, J., & Weinert, F. E. (1989). Domain-specific knowledge and memory performance: a comparison of high- and low-aptitude children. *Journal of Educational Psychology, 81* (3), 306-312.

Schneider, W., & Pressley, M. (1989). *Memory development between 2 and 20.* New York, NY: Springer-Verlag.

Schofield, J. W. (1993). Increasing the generalizability of qualitative research. In M. Hammersley (Ed.), *Social research: philosophy, politics and practice* (pp. 171-204). Thousand Oaks, CA: Sage Publications.

Schoenfeld, A. H. (1992). Learning to think mathematically: problem solving, metacognition, and sense-making in mathematics. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 334-370). New York, NY: MacMillan.

Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science, 26* (1-2), 113-125.

Schwandt, T. J. (2001). *Dictionary of qualitative inquiry* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Shrager, L., & Mayer, R. E. (1989). Note-taking fosters generative learning strategies in novices. *Journal of Educational Psychology, 81* (2), 263-264.

Siegler, R. S. (1994). Cognitive variability: a key to understanding cognitive development. *Current Directions in Psychological Science, 3* (1), 1-5.

Skemp, R. R. (1987). *The psychology of learning mathematics*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Smith, J. K., & Hodkinson, P. (2002). Fussing about the nature of educational research: the neo-realists versus the relativists. *British Educational Research Journal, 28* (2), 291-296.

Sotto, E. (1994). *When teaching becomes learning: a theory and practice of teaching.* London, UK: Cassell.

Spencer, B. (2005). Defining prior learning assessment and recognition. In L. M. English (Ed.), *International encyclopaedia of adult education* (pp. 508-512). New York, NY: Palgrave MacMillan.

Spindler, G., & Spindler, L. (1992). Cultural process and ethnography: an anthropological perspective. In M. D. LeCompte, W. L. Millroy, & J. Preissle (Eds.), *The handbook of qualitative research in education* (pp. 53-92). San Diego, CA: Academic Press.

Spradley, J. P. (1979). *The ethnographic interview*. New York, NY: Holt, Rinehart & Winston.

Stake, R. E. (1995). *The art of case study research.* Thousand Oaks, CA: Sage Publications.

Starkey, P., & Gelman, R. (1982). The development of addition and subtraction abilities prior to formal schooling in arithmetic. In T. P. Carpenter, J. M. Moser, & T. A. Romberg (Eds.), *Addition and subtraction: a cognitive perspective* (pp. 99-116). Hillsdale, NJ: Lawrence Erlbaum Associates.

Starr-Glass, D. (2002). Metaphor and totem: exploring and evaluating prior experiential learning. *Assessment & Evaluation in Higher Education, 27* (3), 221-231.

Steele, J. R., & Ambady, N. (2006). "Math is hard!" The effect of gender priming on women's attitudes. *Journal of Experimental Social Psychology, 42* (4), 428-436.

Strauss, A. L., & Corbin, J. M. (1990). *Basics of qualitative research: techniques and procedures for developing grounded theory.* Thousand Oaks, CA: Sage Publications.

Sturman, L., Ruddock, G., Burge, B., Styles, B., Lin, Y., & Vappula, H. (2008). *England's achievement in TIMSS 2007: national report for England.* Slough, UK: National Foundation for Educational Research.

Sullivan, P., Zeverbergen, R., & Mousley, J. (2003). The contexts of mathematics tasks and the context of the classroom: are we including all students? *Mathematics Education Research Journal, 15* (2), 107-121.

Sumner, W. G. (1907). *Folkways: a study of the sociological importance of usages, manners, customs, mores, and morals.* Boston, MA: Ginn.

Sutton, J. (2010). Memory. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy (Summer 2010 edition).* Stanford, CA: The Metaphysics Research Lab, Stanford University. Retrieved from http://plato.stanford.edu/archives/sum2010/entries/memory/.

Taber, K. S. (2001). The mismatch between assumed prior knowledge and the learner's conceptions: a typology of learning impediments. *Educational Studies, 27* (2), 159-171.

Tait-McCutcheon, S. L. (2008). Self-efficacy in mathematics: affective, cognitive, and conative domains of functioning. In M. Goos, R. Brown, & K. Makar (Eds.), *Navigating currents and charting directions (Proceedings of the 31st Annual Conference of the Mathematics Education Research Group of Australasia)* (pp. 507-513). The University of Queensland, Brisbane, 28 June-1 July 2008. Brisbane: MERGA.

Tesch, R. (1990). *Qualitative research: analysis types and software tools.* London, UK: RoutledgeFalmer.

Thomas, D. R. (2006). A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation, 27* (2), 237-246.

Thomas, W. I. (1923). *The unadjusted girl: with cases and standpoint for behaviour analysis.* Boston, MA: Little, Brown, and Company.

Thompson, I. (1995). "Pre-number activities" and the early years number curriculum. *Mathematics in School, 24* (1), 37-39.

Tizard, B., & Hughes, M. (1984). *Young children learning.* Cambridge, MA: Harvard University Press.

Tobias, S. (1994). Interest, prior knowledge and learning. *Journal of Education Psychology, 87* (3), 399-405.

Toffler, A. (1970). *Future shock.* New York, NY: Random House.

Turner, J. C. (2010). Towards a cognitive redefinition of the social group. In H. Tajfel (Ed.), *Social identity and intergroup relations* (pp. 15-40). Cambridge, UK: Cambridge University Press.

Turner, J. H., Beeghley, L., & Powers, C. H. (2012). *The emergence of sociological theory* (7th ed.). Thousand Oaks, CA: Sage Publications.

UCAS. (2011). Applications (choices), acceptances and ratios by subject group 2011. Cheltenham, UK: UCAS. Retrieved from http://www.ucas.com/about_us/stat_services/stats_online/data_tables/subject/2011.

UNESCO. (2002). *Cultural diversity, common heritage, plural identities.* Paris: UNESCO.

Vygotsky, L. S. (1978). *Mind in society: the development of higher psychological processes*. M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.). Cambridge, MA: Harvard University Press.

Wakeley, R. A. (2002). *Early mathematical development in low birth-weight children.* (Unpublished doctoral dissertation). University of California, Berkeley, CA.

Walker, C. H. (1987). Relative importance of domain knowledge and overall aptitude on acquisition of domain-related information. *Cognition and Instruction*, *4* (1), 25-42.

Walkerdine, V. (1990). Difference, cognition and mathematics education. *For the Learning of Mathematics, 10* (3), 51-56.

Ward, S. (2004). Government policy on education in England. In S. Ward (Ed.), *Education studies: a student's guide* (pp. 81-91). London, UK: RoutledgeFalmer.

Weber, R. P. (1990). *Basic content analysis* (2nd ed.). Newbury Park, CA: Sage Publications.

Weinert, F. (1989). The impact of schooling on cognitive development: One hypothetical assumption, some empirical results, and many theoretical implications. *EARLI News*, (8), 3-7.

West, L. H. T., & Fensham, P. J. (1974). Prior knowledge and the learning of science. *Studies in Science Education, 1* (1), 61-81.

Wiersma, W., & Jurs, S. G. (2005). *Research methods in education: an introduction* (8th ed.). Boston, MA: Allyn & Bacon.

Williams, P. (2008). *Independent review of mathematics teaching in early years settings and primary schools.* Nottingham, UK: DCSF Publications.

Windschitl, M. (2002). Framing constructivism in practice as the negotiation of dilemmas: an analysis of the conceptual, pedagogical, cultural, and political challenges facing teachers. *Review of Educational Research, 72* (2), 131-175.

Winter, G. (2000). A comparative discussion of the notion of 'validity' in qualitative and quantitative research. *The Qualitative Report, 4* (3 & 4). Retrieved from http://www.nova.edu/ssss/QR/QR4-3/winter.html.

Woods, P. (1979). *The divided school.* London, UK: Routledge & Kegan Paul.

Wolcott, H. F. (1974). The teacher as an enemy. In G. D. Spindler (Ed.). *Education and cultural process: towards anthropology of education* (pp. 136-150). New York, NY: Holt, Rinehart & Winston.

Yinger, R. J. (1978). *A study of teacher planning: description and a model of preactive decision making.* (Research Series No. 18). East Lansing, MI: The Institute for Research on Teaching, Michigan State University.

Yinger, R. J. (1980). A study of teacher planning. *The Elementary School Journal, 80* (3), 107-127.

Yuret, D. (1995). *A brief review of memory research in cognitive neuroscience.* (Working Paper No. 343). Cambridge, MA: Artificial Intelligence Laboratory, Massachusetts Institute of Technology.

Zeitoun, H. H. (1989). The relationship between abstract concept achievement and prior knowledge, formal reasoning ability and gender. *International Journal of Science Education, 11* (2), 227-234.

APPENDICES

Appendix A – Data Collection Schools' Ofsted Reports

This appendix contains *Information about the School* and/or *Description of the School* and *Main Findings* and/or *Overall Effectiveness of the School* sections from the recent Ofsted inspection reports for each of the five schools used in the data collection.

Hatton First School

This information comes from an Ofsted inspection carried out in 2009.

Information about the School

> This small school stands in a rural location some distance from Hatton village. About a third of the pupils come from the village, others travel in from a wide area. The great majority are of White British backgrounds, and the very small number from other ethnic backgrounds all speak English as their first language. Few pupils are entitled to free school meals. The proportion of pupils with special educational needs and/or disabilities is low. The Early Years Foundation Stage comprises of a Reception class.
>
> Several teaching staff have been appointed since the last inspection, including the head teacher who has been in post for two years.
>
> The school holds an Activemark award.

Main findings

> This is a good school that equips pupils with a love of learning, happy memories and firm foundations for their future education and life beyond. Behaviour and attendance are excellent and pupils are very well supported by first-rate links between the school and their parents and carers. The school is firmly at the centre of the village community and has strong links with the church, craft centre and Hatton Hall. Parents and carers value the school's warm family ethos where their children feel very safe and secure, and make good progress in their learning and personal development.

The Early Years Foundation Stage gives children a good start, enhanced by outdoor activities, especially when they learn in a local woodland area known as the 'Forest School'. Pupils achieve well throughout the school and attain above average standards by the time they leave. Good teaching and rigorous monitoring ensure that no-one falls behind. Boys and girls progress equally well but school assessment data indicate some differences; boys do not reach similar standards to girls in writing, and girls do not match the boys in mathematics.

Good teaching and well planned lessons challenge all groups of pupils. Pupils are confident learners, know they are expected to work hard and say lessons are interesting. They know what they will learn in each lesson but are not always aware of their next steps in learning, for example what they are aiming for in mathematics or writing. Well managed provision, and skilled support from the teaching assistants, enables pupils with special educational needs and/or disabilities to progress well and participate fully in all activities. Local links and partnerships provide extra learning activities for able, gifted and talented pupils, for example, a music day at Hatton Hall.

The school cares well for all pupils. They say bullying is not a problem and are certain that staff will sort out any problems. Pupils understand how to be healthy and willingly contribute to the school and local community. They participate eagerly in all opportunities presented by the good curriculum and exciting range of extra activities and clubs; sports activities are recognised in an Activemark award. Links and visits beyond the immediate locality, for example to a city synagogue, give pupils a good awareness of other ways of life within our society. However, this does not extend to the range of lifestyles and cultures in the wider world.

Senior leaders, staff and governors are strongly united in their commitment to a shared vision for school improvement. Leaders at all levels evaluate the school's performance accurately and inspection findings match their judgements of the school's effectiveness. Improvements since the last inspection include staff involvement in leadership, more accurate assessment and wider professional development. Value for money is good. Consequently, there is good capacity for sustained improvement.

St Paul First School

This information comes from an Ofsted inspection carried out in 2009.

Information about the School

This is a large school. Most pupils come from White British families living within the local town, although a significant number travel from nearby towns and villages. Few pupils do not speak English as their first language. Many pupils have experience of other educational settings before they begin school. The proportion of pupils with special educational needs and/or disabilities is below national average. There has been a period of higher than usual staff mobility but this has stabilised. The head teacher has been in post for two years.

Main findings

St Paul's C of E First School is a good school that promotes high quality care for the well-being of all pupils, together with a stimulating learning environment that enables pupils to achieve well. Behaviour and relationships are good and this contributes to the calm, safe, industrious and happy atmosphere within the school. Pupils are comfortable expressing their opinions to adults, and this demonstrates their growing independence and confidence. They enjoy their learning and the opportunities available to help them find out about other places, people and cultures. Their spiritual, moral, social and cultural development is outstanding. This is evident in the mutual respect and understanding shown by everyone. Pupils appreciate the wide range of creative and sports that enrich their education, including visits to places of interest and working closely with other schools. There are dose links with the local church and pupils also have an understanding of other faiths and cultures. Pupils are engaged in fundraising and charity work locally, nationally and in Africa.

Pupils make good progress in their academic work. They enter school with skills and understanding above the level expected for their age and make good progress, so that by the time they transfer to the next stage of their education their attainment is well above average. In the Early Years Foundation Stage the outdoor learning area is used well to provide interesting activities but the indoor experiences are less stimulating. The headteacher and senior management team acknowledge that staffing issues in the past have slowed the pace of learning for some pupils but this has been rectified. As a result, pupils are generally making good progress in their lessons. Strategies have recently been introduced to improve the mathematical ability of all pupils, particularly in calculation and problem solving, but there has been insufficient time for them to have had an impact on standards which for the more-able pupils are not as high as they could be.

The quality of teaching is good and there are some examples of outstanding teaching. Teachers know the pupils very well. Detailed assessments inform lesson planning so that tasks are usually matched to the individual needs of pupils. High quality support is used well to support pupils in lessons. Marking is good, particularly in writing, and guides pupils well so that they know what to do to improve the quality of their work. Where teaching is less effective, pupils have too few opportunities to engage in discussions and to become actively involved in their learning, and in mathematics in particular, the more-able pupils are not always fully challenged.

Pupils have a very good knowledge and understanding of factors which contribute to their physical and emotional well-being so that they are keen to adopt healthy lifestyles. Pupils assume responsibilities within school, including organising the music for assemblies and looking after younger children through a mentoring programme. Attendance is satisfactory, but not enough has been done to motivate the few pupils who do not attend school regularly into doing so.

The school has shown that it has good capacity to improve. The senior leadership team have accurately identified areas for development aid effective action has been taken to address the issues raised in the last inspection. Innovative strategies have been introduced to raise attainment in writing. The curriculum has been reviewed and revised so that pupils can consolidate their literacy, numeracy and information and communication technology skills across different subject areas. Work is progressing well to provide appropriate opportunities for more-able pupils through more accurate target setting and planning individual learning opportunities in mathematics.

Argyle Common First School

This information comes from an Ofsted inspection carried out in 2009.

Information about the School

This is a smaller than average primary school which draws its pupils from the local village and the surrounding area. Almost all pupils are of White British origin and they are taught in five mixed-age classes. The proportion of pupils with special educational needs and/or disabilities is below average but increasing. There is Early Years Foundation Stage provision for children from the age of four who share their classroom with pupils in Year 1. The school has very spacious outdoor areas.

Main findings

This is a good school. It has improved markedly since its last inspection because the headteacher's strong leadership has successfully encouraged the staff to have high aspirations for themselves and pupils. Improvement in the way leaders monitor and evaluate teaching and learning outcomes has strengthened pupils' progress. Pupils achieve well, and standards are above average and improving. Evidence from the standardised assessments in 2009 and from the work of current pupils, shows there is more to do to improve writing, particularly for boys of all ages. However, a good start has been made to encourage pupils to write by making writing activities more meaningful and relevant and developing word banks so that the pupils can be more independent. Good progress has been made in improving the level of challenge provided for the more able pupils, especially at Key Stage 1, which was a key area for improvement from the last inspection. The curriculum has also been strengthened and is now good. The inclusion of themes such as being healthy, recycling and climate change ensure that it reflects a changing world. The school is rightly proud of its recently acquired 'green flag' award for its eco work. Success is celebrated through good quality displays across the school which also reflect the global dimension of the curriculum. The school is well placed to improve even further.

Most pupils behave well in and around the school and have very positive attitudes which make a considerable contribution to their learning. However, there is a very small minority in one class who find it difficult to maintain their concentration in lessons and display immature attitudes. This is a barrier to their learning. The pupils have a good understanding of how to keep safe and lead healthy lives. Their spiritual, social and moral development is good and is shown in their friendly manner, cooperative working and in the way that older pupils support and help younger ones. Their cultural development is satisfactory. Although attendance is above average, too much time is lost for some pupils because they are taken on holidays in term time. The school council has a positive influence on how the school develops. Pupils have a good understanding about keeping themselves safe and trust the adults who look after them. At break times, the pupils are very active in the spacious play areas. Most express their views and opinions with great confidence and maturity.

Teaching and learning are good because lessons are well planned to meet the full range of pupils' needs. Teaching assistants make a good and sometimes outstanding contribution to those with special educational needs and/or disabilities. While lessons have clear objectives for learning, these are occasionally too This is a good school. It has improved markedly since its last inspection because the headteacher's strong leadership has successfully encouraged the staff to have high aspirations for themselves and pupils. Improvement in the way leaders monitor and evaluate teaching and learning outcomes has strengthened pupils' progress. Pupils achieve well, and standards are above average and improving. Evidence from the standardised assessments in 2009 and from the work of current pupils, shows there is more to do to improve writing, particularly for boys of all ages. However, a good start has been made to encourage pupils to write by making writing activities more meaningful and relevant and developing word banks so that the pupils can be more independent. Good progress has been made in improving the level of challenge provided for the more able pupils, especially at Key Stage 1, which was a key area for improvement from the last inspection. The curriculum has also been strengthened and is now good. The inclusion of themes such as being healthy, recycling and climate change ensure that it reflects a changing world. The school is rightly proud of its recently acquired 'green flag' award for its eco work. Success is celebrated through good quality displays across the school which also reflect the global dimension of the curriculum. The school is well placed to improve even further.

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Teaching and learning are good because lessons are well planned to meet the full range of pupils' needs. Teaching assistants make a good and sometimes outstanding contribution to those with special educational needs and/or disabilities. While lessons have clear objectives for learning, these are occasionally too general and of limited benefit in helping pupils understand what is expected. The marking of writing is consistently good, providing comments to commend good work and set further challenges. Pupils have regular opportunities to share how well they think they are doing. However, the use of individual pupil targets during lessons is at an early stage of development.

Provision for children in the Early Years Foundation Stage is good. The children enjoy school and join in confidently with all the activities offered. They respond well to the good range of opportunities to make choices and decisions for themselves. Leadership has continued to be well focused since the time of the last report. Staff have an accurate view of the school's strengths and weaknesses, which they openly debate. This is enabling them to refine and further develop their practice. Governors have a visible presence around the school and have helped to forge strong links with parents. They provide a satisfactory challenge to the headteacher and other leaders to account for the success of changes being made.

Draycott First School

This information comes from an Ofsted inspection carried out in 2007.

Description of the School

Draycott is a very small rural school with 37 pupils on roll. The school draws most of its pupils from the surrounding villages. The school's social and economic context is relatively favourable and very few pupils are eligible for free school meals. A small number of pupils are registered by the school as having learning difficulties and disabilities. There are no pupils with a statement of special educational need. All pupils are of White British origin.

Overall Effectiveness of the School

Draycott is a good school which is distinguished by a caring, family-centred ethos where everyone works together. Pupils enter the Reception class with standards expected for their age. As a result of the good provision, which is reflected in careful assessment, and a good appreciation of the individual needs of the pupils, a higher-than-average proportion of them gain the early learning goals. Pupils continue to make good progress in Key Stage 1 and Year 4, achieving above-average standards. In Year 3, the pupils' progress in mathematics and writing is too slow and standards are average.

All the pupils are well cared for in a safe, secure and welcoming school community which successfully promotes the school's Christian ethos. The school has very strong links with the village church. The pupils' personal, social, emotional development and well-being are given high priority and are good. Secure academic guidance supports the pupils to achieve well in most year groups. The pupils' behaviour and attitudes to learning are good. Pupils are enthusiastic, respectful and well mannered. They know about healthy eating and the importance of leading a healthy lifestyle. The school council are good ambassadors for the school. They greatly appreciate their school and have confidence in the adults who work with them.

Almost 80% of the parents returned inspection questionnaires and the responses were overwhelmingly positive. One parent said: 'My child loves this school. She has thrived in the friendly, one big happy family atmosphere.'

The quality of teaching and learning is good. Expectations are high and relationships are positive. On occasions, there are too many objectives in lessons, which results in a lack of clarity to drive forward the learning at a fast enough pace, for example, in mathematics and writing in Year 3. Pupils with learning difficulties and disabilities make satisfactory progress in light of their often complex difficulties and low starting points. The curriculum is good because it is carefully tailored to the needs of the pupils, and has a wide range of enrichment activities.

Leadership and management are good. The headteacher has a passionate commitment to improving the life chances of the pupils, which is clearly shown through a good team spirit and a common sense of purpose in all aspects of the school's day-to-day life. Whole-school self-evaluation is satisfactory but is not sufficiently evaluative. The outcomes of monitoring the quality of teaching do not always result in the identification of clear targets for improvement or show the links between good teaching and effective learning.

Greenville Park Community School

This information comes from an Ofsted inspection carried out in 2008.

Description of the School

The school serves an area that has many social and economic disadvantages. When pupils enter the Foundation Stage, their knowledge and skills are usually well below what is expected for their age. Basic skills in language are weak and social, emotional and behavioural skills are underdeveloped. The proportion of pupils who are eligible for free school meals is well above the national average. The proportion of pupils who are on the school's register of learning difficulties and/or disabilities well above the national and local authority averages

Overall Effectiveness of the School

The overall effectiveness of the school and pupils' achievements are satisfactory although standards are too low, particularly in Years 3 to 6 and in English. Over the last 18 months, there have been The pupils' personal development and well-being, including their behaviour, are satisfactory. Pupils' attitudes to school life and learning are consistently satisfactory and often good. The provision and outcomes for pupils on the school's register of learning difficulties and/or disabilities and for those who speak English as an additional language are good.

The quality of teaching and learning is satisfactory with an increasing proportion that is good. Nevertheless, a few weaknesses remain, particularly the lack of challenge in some lessons, where pupils' work is either too easy or too difficult and not matched well enough to their different capabilities. The curriculum is satisfactory and there is a good range of enrichment activities, which improve the pupils' self-esteem. The quality of care, guidance and support is good. Pupils are well looked after and feel safe and secure. The school is successful in helping them to understand their emotions and appreciate the importance of respecting each other, themselves and the adults who work with them.

The pupils' attendance is well below the national average for primary schools. In addition, the attendance of just over 10% of the pupils is poor, and below 85%. The school is working hard with parents and external agencies, including the education welfare officer, to raise attendance levels, but is not yet making sufficient inroads into improving overall attendance. Most of the pupils whose attendance is poor make slow progress and attain low standards.

Collective leadership and management are secure. The headteacher is resilient, has successfully raised expectations and given the school a sense of purpose and clarity about what it can achieve. There is a good team spirit and senior teachers know there is still much to do to raise standards and the achievement of all pupils. For example, while monitoring is satisfactory, the guidance teachers receive to help improve their work is not always sharp enough and timescales for improvement are sometimes too long. The school provides sound value for money and has a satisfactory capacity to improve further.