Primary teachers' epistemological beliefs about the teaching and learning of mathematics : the link with and implications for their classroom pedagogy

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Primary Teachers' Epistemological Beliefs about the Teaching and Learning of Mathematics: The Link with and Implications for their Classroom Pedagogy

by

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A THESIS
Submitted to the
UNIVERSITY OF DURHAM
in partial fulfilment of the requirements for the degree of
DOCTOR OF EDUCATION

Abstract

This research describes an attempt to investigate the nature of primary teachers' epistemological beliefs and epistemological world views concerning the teaching and learning of mathematics and the potential relationship these may have with their teaching practice. The research sits within the paradigm of critical realism and employed a multi-phase approach using both methodological triangulation and respondent validation for verification of findings. During Phase I a postal questionnaire was designed, piloted and sent to all relevant primary teachers in all primary schools in one Local Education Authority (LEA) in the north east of England. This phase of the research was viewed as exploratory and aimed to survey a wide range of primary teachers' epistemological beliefs about the teaching and learning of mathematics. As such this phase represented a way of 'testing the ground' before the focus of the research was narrowed down in subsequent phases.

Phase II and III of the research selected three very different primary teachers for a much closer examination of the epistemological beliefs about the teaching and learning of mathematics. These three teachers differed according to their epistemological beliefs about mathematics (as measured in Phase I) but also according to age, experience, qualification, type of school, year taught, and gender. In Phase II this closer examination involved four observations of each teacher's teaching of mathematics. It is well documented that what teachers say they believe and do is not always consistent with what they actually believe and do. Consequently, this phase of the research was deemed an important way of attempting to verify or otherwise teachers' previously stated and inferred beliefs with their practice. Classroom observations were non-participative and unstructured.

Phase III involved semi-structured interviews with the same teachers to probe further their epistemological world views. Data analysis in Phase I involved a quantitative exploration of the relationship between variables deemed amenable to such analysis. Field notes from Phase II and interview transcripts from Phase III were analysed using the constant comparative method associated with Grounded Theory.

Key findings included: that there exist no neat world views but that teachers can sometimes hold epistemological beliefs that have traditionally been found to be characteristic of opposing world views; the link between teachers' epistemological world views and their teaching practice is at best indirect and mediated by other, more important, contextual factors deemed important to the teachers at the time. These findings are discussed within the context of previous research and the implications for primary teachers and primary teaching of mathematics are explored. A conceptual model of the relationship between teachers' epistemological beliefs/world views and their teaching practice is offered. The limitations of the research are also discussed and possible avenues for further research are proposed.

Acknowledgements

This work would not have been possible without the help of a number of people. I would like to thank all the teachers that took the time to respond to the questionnaire in Phase I of the research. I am particularly grateful to the teachers I have called Lisa, John, and Mary for allowing me access to their classrooms and the time they so generously gave at all times.

I would also like to acknowledge the unstinting support and supervision of Professor Lynn Newton throughout the course of the research.

I owe special thanks to three colleagues past and present for their support both before and during this study; Professor Hilary Constable, Professor Pat Broadhead, and Professor Patrick Easen.

Finally, I would like to thank my wife, Lynn, and my two young children, Max and Tara for their unwavering understanding and support throughout.

Contents

Page

List of Figures vi

List of Tables vii

Preface viii

Chapter 1: Teachers' Beliefs About Teaching and Learning **1**

1.1 Background to Epistemology and Epistemological World Views 6
1.2 Models of Teaching and Learning 18
Behaviourism
Constructivisms
1.3 Implications of these Models for Teaching and Learning 30
Implications for Curricula
Implications for Assessment
Summary 42
Research Questions 45

Chapter 2: Methodological Overview - In Support of Eclecticism **46**

2.1 Overview of the Research Process 47
Phase I
Phase II
Phase III
2.2 Sampling Methods 64
2.3 Data Analyses 66
2.4 Ethics and Rigour 70
Conclusions 75

Chapter 3: Phase I - The Survey **76**

3.1 The Survey Method 77
3.2 Survey Design and Implementation 82
The Questionnaire
Piloting the Questionnaire
The Sample
Data Collection
Data Analysis
3.3 Results 100
3.4 Discussion 107
Conclusions 110

Chapter 4: Phase II - The Case Study Observations **112**

4.1 The Case Study Approach but Observational Method 113
4.2 The Case Studies 118

The Sample
Teacher 1 - Lisa
Teacher 2 - John
Teacher 3 - Mary
Data Collection
Data Analysis
4.3 Results 138
Aspects of a Constructivist Approach to Teaching
Aspects of a Behaviourist Approach to Teaching
A Tension?
4.4 Discussion 146
Conclusions 148

Chapter 5: Phase III - The Interviews **150**

5.1 The Interviews 152
5.2 Data Collection and Related Issues 157
The Sample
Data Collection
Data Analysis
5.3 Results 162
Evidence of Relativist World Views
Evidence of Realist Epistemological Beliefs
The Didactic Tension
Restrictive Aspects of the National Curriculum
Tacit Beliefs/Epistemological World Views
5.4 Discussion 189
Conclusions 190

Chapter 6: Discussion of Findings **192**

6.1 Research Question One 194
6.2 Research Question Two 196
6.3 Research Question Three 198
6.4 Research Question Four 200
6.5 Research Question Five 205
Summary 208

Chapter 7: Conclusions and Suggestions for Further Research **209**

7.1 Conclusions 213
7.2 Limitations of the Research 219
7.3 Suggestions for Further Research 222
7.4 Concluding Remarks 226

Appendices **229**

Appendix A: Final Draft of Questionnaire 230
Appendix B: Three Examples of Pilot Groups' Responses 234
Appendix C: First Draft of Questionnaire 246
Appendix D: Second Draft of Questionnaire 247

Appendix E: Descriptive Statistics for Questionnaire Items 250
Appendix F: Covering Letter to Head Teachers 251
Appendix G: Coding Frame for Variable in SPSS 252
Appendix H: Recoded Variables in SPSS 255
Appendix J: The Raw Survey Data 256
Appendix K: The Subscales 267
Appendix L: Lisa's Questionnaire 268
Appendix M: John's Questionnaire 271
Appendix N: Letter from Criminal Records Bureau 274
Appendix O: Interview Transcript Consent Form 275
Appendix P: Emails to Phase II and III Participants 277
Appendix Q: Voluntary Informed Consent Form 279
Appendix R: Structured Observation Schedule (First Draft) 281
Appendix S: Structured Observation Schedule (Second Draft) 283
Appendix T: Details of Lisa's Lessons 285
Appendix V: Details of John's Lessons 294
Appendix W: Details of Mary's Lessons 305
Appendix X: Transcripts of Interviews with Lisa 312
Appendix Y: Transcripts of Interviews with John 325
Appendix Z: Transcripts of Interviews with Mary 342
Appendix AA: Example of Coding System 350

References **367**

List of Figures

		Page
Fig 1.1.1	A model of the interplay and relationship between beliefs, knowledge and classroom practices.	15
Fig 1.3.1	Fig 1.3.1 Models of assessment based on behaviouristic and constructivist views of teaching and learning.	38
Fig 1.3.2	A chronology illustrating how changing conceptions of curriculum, learning theories, and scientific measurement explain the tension between current use of tests and testing and the central ideas of constructivism.	39
Fig 2.1.1	Technical and epistemological versions of the quantity-quality debate.	53
Fig 2.2.2	Proposed timeline of the research.	57
Fig 3.2.1	Stages in planning the questionnaire.	84
Fig 3.2.2	Gender proportions of sample compared to the gender proportions of population in 2004.	97
Fig 3.2.3	Age distributions for sample compared to population in 2004	98
Fig 3.2.4	Length of service distributions of sample compared to population in 2004.	99
Fig 3.3.1	Extent of teachers' agreement/disagreement with the two epistemological world views.	101
Fig 3.3.2	Box and whisker plots for the three epistemological belief sub-scales.	103
Fig 3.3.3	Distribution of highest mathematics qualification held by teachers in the sample.	105
Fig 4.2.1	My approach to grounded theory.	136
Fig 7.1.1	A model of the relationship between teachers' beliefs/world views and their classroom practice.	216

List of Tables

		Page
Table 1.1.1	A comparison of some beliefs across the three epistemological world views	10
Table 3.2.1	Timeline of questionnaire distribution and corresponding response rates	94
Table 3.3.1	Descriptive statistics for the variables *age* and *length of service (years).*	100
Table 3.3.2	Descriptive statistics for the two epistemological world views.	101
Table 3.3.3	Descriptive statistics for the three epistemological belief sub-scales.	102
Table 3.3.4	Correlation coefficients between quantitative questionnaire items.	103
Table 4.2.1	A summary of Lisa's responses to relevant questionnaire items compared to sample means.	122
Table 4.2.2	A summary of John's responses to relevant questionnaire items compared to sample means.	123

Preface

This thesis reports on research investigating primary teachers' epistemological beliefs concerning the teaching and learning of mathematics. It attempts to address several important questions. First, what epistemological beliefs do primary teachers' hold about the teaching and learning of mathematics? Second, it asks whether these epistemological beliefs constitute distinct and mutually exclusive epistemological world views as defined by previous research or whether hybrid positions are possible. Third, are primary teachers' epistemological world views held in such a way that enables them to be easily communicated to others? Fourth, what is the relationship, if any, between primary teachers' epistemological world views about the teaching and learning of mathematics and their classroom pedagogy, i.e. do primary teachers' personal philosophies - their epistemological world views - concerning the very nature of the teaching and learning of mathematics match their classroom practice? And finally, what are the theoretical and practical implications of any relationship that may be found to exist?

The research was exploratory in nature and used a multi-phased, multi-method approach within the paradigm of critical realism. Phase I of the research involved a postal survey targeted at primary teachers within one Local Education Authority in the northeast of England. The questionnaire aimed to survey a wide range of primary teachers' beliefs concerning the teaching and learning of mathematics. Phase II involved case studies of three volunteer teachers from Phase I. Each teacher's classroom practice was then observed on four occasions using non-participant observation. Phase III involved interviews with the same teachers immediately after each observation. Interviews employed the technique of stimulated recall to probe teachers' rationale for some of their decisions made during the previous teaching session. The purpose of Phase II observations was to investigate whether teachers' classroom practice matched their epistemological world view espoused in Phase I and III.

Chapter one sets the scene by first introducing the reader to the field of research on teachers' epistemologies or epistemological world views (EWS). It then goes on to outline and critically discuss major models of teaching and learning. Behaviourism and Constructivism are discussed in more detail since they are thought to represent the two extreme models. The areas of assessment and curricula are used to draw out the differences between these models and to discuss their respective implications for teaching and learning. It finishes with a summary reminding the reader of the main thrust of the research and presents the five research questions.

Chapter two provides a rationale for my methodological stance to the overall study. It discusses the decision to adopt a multi-phased, multi-method approach within the paradigm of critical realism. Much of this rationale comprises a critical discussion of the quantitative/realist v qualitative/relativist debate including a critical discussion of the polarised views of researchers in the past, e.g. the epistemological *versus* technical standpoints concerning the use of methods from the different theoretical positions. There is also a brief discussion of my use of methodological triangulation in general and the specific methods I used within that technique. It also provides the reader with a very brief overview of each of the three phases or the research and discusses the different sampling methods and data analyses used in each phase. It finishes by outlining my commitment to ethically responsible research and my search for rigour.

Chapter three sets out the dual aims of Phase I of the research. i.e. to design a postal questionnaire to survey a wide range of primary teachers' beliefs about the teaching and learning of KS2 mathematics in their classrooms, and to identify a number of teachers willing to participate in classroom observations and interviews in Phase II and III of the research. The rationale for the decision to use a postal survey in Phase I of the research is given. Details are also presented concerning the survey design and implementation, i.e. details about the questionnaire itself, piloting, reliability, validity, the sample, data collection and data analysis. This is followed by a section outlining the results from exploratory and confirmatory data analyses and a critical discussion of these. In conclusion, the chapter draws together the findings and their implications.

Chapter four sets out the rationale for my decision to use non-participant classroom observations within a multiple case study approach. Details are given concerning the initial decision to use a semi-structured observation schedule and details are given about its design, construction, and piloting. It goes on to describe the rationale for the eventual decision to abandon the semi-structured observation schedule in favour of detailed field notes. Details of the sample follow this, including biographies of the teachers involved. Details concerning data collection and data analysis are then given followed by a section outlining the results from the data analysis and a critical discussion of these. Lastly, a conclusion section draws together the findings and their implications and signposts the following chapter.

Chapter five sets out the rationale for the decision to use a semi-structured interview technique in an attempt to accurately elicit teachers' epistemological world views concerning the teaching and learning of mathematics. Within this semi-structured interview method several approaches were used. One approach was to ask teachers direct questions about their views concerning specific teaching and learning issues that were thought would reveal insights into their epistemological world view. The second approach used a stimulated recall technique in order to elicit their thought processes during teaching just observed. Details were given concerning the design and implementation of the semi-structured interview schedule, the sample, and data collection and data analysis using the constant comparison method associated with grounded theory. This is followed by a section outlining the results from the data analysis and a critical discussion of these. Lastly, a conclusion section draws together the findings and their implications and signposts the following chapter.

Chapter six begins a discussion of the overall research findings in light of the stated research questions, and relates these findings to previous research. This involves a discussion of the potential theoretical and practical implications for primary teachers and primary teaching. Finally, chapter seven sets out the overall conclusions from the research and presents a conceptual model of the relationship between teachers' epistemological beliefs/world views and their teaching practice. It acknowledges some of the limitations of the research and offers suggestions for further research that the author thinks would lead to further insights into teachers' thinking and the possible associations with their practice.

Finally, a note of caution is necessary at this point. Although this research employs a postal survey using a sample of primary teachers of mathematics, the research is viewed as very much inductive, and therefore, exploratory in nature. It was never my primary intention to generalise the findings from the sample to any wider theoretical settings. Consequently, it will not be possible to substantiate any claims of either generalisability or cause and effect. Rather, I merely hope that the findings presented in the following chapters will add something useful to the extant knowledge concerning teachers' epistemological world views and their possible relationship with classroom practice. The findings should be viewed in that light.

David Bolden
October 2006

Chapter 1: Background - Teachers' Beliefs About Teaching and Learning

> **In writing a problem down or airing it in conversation we let its essential aspects emerge. And by knowing its character, we remove, if not the problem itself, then its secondary, aggravating characteristics: confusion, displacement, surprise.**
> *(de Botton, 2000)*

The last ten years within educational research has seen an explosion in the amount of research investigating epistemological beliefs and personal epistemologies (Calderhead, 1996; Hasweh, 1996; Hofer, 2000; 2001; Sinatra, 2001; Hofer and Pintrich, 2002; Schoenfeld, 2002; Speer, 2005). Although many of these studies have led to significant insights into epistemological beliefs and personal epistemologies, most have focussed on the student while very few have had any thing to say about teachers and their epistemological beliefs and what implications these beliefs may have for their classroom practice (Putnam and Borko, 2000).

Schraw and Olafson, writing as recently as 2002, argued that:

> Oddly, few studies have examined this issue, focusing instead on students' epistemological beliefs and their relationship to learning. Although there is limited data at this point in time, we believe it is of the utmost importance to raise questions about teachers' epistemological beliefs and their relationship to teaching practices. (Schraw and Olafson, 2002: 100)

Moreover, most of those studies that have focussed on the epistemological beliefs of teachers have been either largely conducted in American schools and/or have not had a subject-specific emphasis. Those few studies identified during the literature search phase of this research that had focussed on mathematics in UK schools (Lerman, 1990; Jaworski, 1994) were conducted before the introduction of the National Curriculum in September 1989. This research attempts to redress the balance by investigating primary teachers' epistemological beliefs about the teaching and learning of mathematics in English schools post-National Curriculum. It will also attempt to explore the nature of any link that may exist between teachers' epistemological beliefs and their classroom pedagogy.

This research then attempts to explore the epistemological beliefs held by a wide range of primary teachers concerning the teaching and learning of mathematics. It will then investigate at close hand the epistemological beliefs held by a small number of primary teachers. It will go on to investigate whether any relationships exist between those primary teachers' epistemological beliefs and their classroom practice by observing and evaluating that practice.

There are several reasons why such an investigation of primary teachers' epistemological beliefs about the teaching and learning of mathematics and the relationship these may have with their classroom practice is thought to be educationally significant. As early as 1972 Thom had claimed that:

> All mathematical pedagogy, even if scarcely coherent, rests on a philosophy of mathematics (Thom, 1972: 204)

Consequently, if this is found to be true then it is thought vitally important that teachers' classroom practice should correspond with their conception of their subject if they are to have the opportunity to develop professionally and improve their practice. For instance, if primary teachers of mathematics support a particular model of teaching and learning (See Section 1.2 below) but their classroom practice fails in any way to correspond with this model then it would seem almost impossible for them to be able to reflect accurately on their style of teaching in an attempt to improve it (Kagan, 1992b; Potter and Badiali, 2002). Of course, finding such a discrepancy between beliefs and practice may necessitate further research to identify the reasons or the barriers to teachers successfully implementing their philosophy in the classroom.

Secondly, such an investigation would seem significant in light of the plight of mathematics in England and Wales as represented by rankings in international league tables over the last decade (Harris, Keys and Fernandes, 1997; Mullis, Martin, Gonzalez and Chrostowski, 2004). These league tables may suggest that the teaching and learning of mathematics in this country is in need of revision.

Thirdly, if evidence is found that suggests that children do learn better via the principles of a particular model of teaching and learning and teachers mistakenly believe their practice to be based predominantly on the same principles (but it is based on some other model) it seems vitally important that teachers and trainee teachers are made aware of this if we are not to do children's learning a major disservice.

Lastly, it is also thought significant because what lies at the heart of this research is a concern for children's learning of primary mathematics. The primary aim of the research was not to set out to provide any empirical support for any particular theoretical perspective discussed in this research. Rather, it is a sincere hope of the author that the findings of primary teachers' epistemological beliefs will add something to the body of extant knowledge in this area. In doing so it is also hoped that the findings discussed here will both help shed light on the complex nature of the teaching and learning of primary mathematics and add something to the corpus of research knowledge that is used to inform programmes of teacher education. Calderhead (1996b) stressed the need for such investigations when, in 1996, he wrote:

> How to make sense of their professional world, the knowledge and beliefs they bring with them to the task, and how teachers' understanding of teaching, learning, children, and their subject matter informs their everyday practice are important questions that necessitate an investigation of the cognitive ... aspects of teachers' professional lives. (Calderhead, 1996b)

The view of Schraw and Olafson (2002) presented in the quotation at the beginning of this chapter suggests that this need is as great today as it was then.

This first chapter then aims to set out the following. Firstly, it outlines the background to the concept of epistemology and the field of personal epistemologies or what will be referred to as epistemological world views. Secondly, it critically examines prominent models of teaching and learning, namely; behaviourism and constructivism. It then goes on to use the areas of assessment and curricula to draw out the differences between these two models and critically discusses the different implications these models have for teaching and learning of primary mathematics in schools. Lastly, it sets out my research questions.

1.1 Background to Epistemology and Epistemological World Views

Epistemology is defined by Hofer and Pintrich (1997: 88) as '...an area of philosophy concerned with the nature and justification of human knowledge'. The term *epistemological belief* has been used in the past to refer to an individual's specific belief about knowledge implying that such a belief is only one constituent part of that individual's wider epistemology. Schommer (1990) has suggested that individuals may hold as many as five independent epistemological beliefs concerning different aspects of knowledge. She conjectures that these different aspects relate to: *simple knowledge,* which relates to the belief about the relative complexity of knowledge, i.e. the extent of the belief that knowledge is comprised of discrete facts; *certain knowledge,* which relates to the belief about the relative certainty of knowledge, i.e. the extent of the belief that absolute knowledge exists independently of the knower and will eventually be known; *omniscient knowledge,* which relates to the belief about the extent to which knowledge emanates from authoritative sources, i.e. the extent of the belief that those in authority have access to otherwise inaccessible knowledge; *quick learning,* which relates to the belief about the speed of learning (i.e. learning is quick or it does not occur); and *innate ability,* which relates to the belief about the source of the ability to acquire knowledge (i.e. the ability to acquire knowledge is determined at birth) (Schommer, 1990).

Schraw and Olafson (2002) have coined the term *epistemological world view* to refer to that personal construct that is constituted by a wider set of individual epistemological beliefs held by one individual concerning the nature and acquisition of knowledge and image of social reality. They define an epistemological world view as '... a broad intellectual perspective that serves as a lens to see the world that transcends individual beliefs about knowledge' (Schraw and Olafson, 2002: 104). Other researchers have used different terms to refer to essentially the same concept. For instance, Fitzgerald and Cunningham (2002) used the term *epistemological stance* whereas Hofer (2002) has used the term *way of knowing*. However, throughout this work I will refer to *epistemological beliefs* and *epistemological world views* to refer to teachers' individual beliefs about knowledge and their wider philosophy that these individual beliefs collectively represent.

The research that has been conducted in the field of teacher epistemological beliefs over the past ten to fifteen years has given some support for the existence of three broadly different epistemological world views; the *realist*, the *contextualist*, and the *relativist* world views (Kuhn, 1991; Prawat and Floden, 1994; Cunningham and Fitzgerald, 1996; Fielstein and Phelps, 2001; Kincheloe, Slattery, and Sterberg, 2001; Schraw and Olafson, 2002)[1]. The *realist world view* assumes that knowledge is *absolutist*. That is, it assumes that there is a direct one-to-one relationship between epistemology and ontology, i.e. there exists independently of the knower an objective and unchanging body of knowledge. Such a view would assume that this knowledge is best acquired via a teacher-centred approach using the 'transmission' of facts from the expert teacher to the passive learner. This is what Steinbring (2005) has recently called the 'sender-receiver model'.

[1] Some of these researchers use different terminology but the central ideas are broadly the same. For instance, Prawat and Floden (1994) distinguish between the *mechanistic*, *organismic*, and *contextualist* world views but these match the assumptions of the *realist*, *relativist*, and *contextualist* world views respectively. Askew *et al* (1997) distinguish between ideal teacher types they call *transmission*, *connectionist*, and *discovery* but they too have much in common with the taxonomy described here.

Teachers that hold such a world view tend to employ drill and practice as ways of transmitting this knowledge and are likely to prefer norm-referenced and externally produced, standardised tests as a way of assessing the extent of students' learning. This epistemological world view can be linked to a *behaviouristic* model of the teaching and learning of mathematics (Burton, 1994). (See Section 1.2 below for a fuller discussion of the *behaviouristic* conception of the teaching and learning of mathematics).

The *contextualist world view* assumes that there is no direct one-to-one relationship between epistemology and ontology and that knowledge is consensually agreed upon and shared between individuals within communities. However, knowledge is viewed as changeable over time and learners need to develop skills to be able to acquire this new knowledge. Teachers that hold such a world view act as facilitators in the classroom and are more concerned with the processes with which students construct knowledge. Consequently, they often use scaffolding techniques and are likely to prefer criterion-referenced assessment over the use of standardised assessment and emphasise that knowledge should have an application to everyday life. This epistemological world view can be linked to a *social constructivist* model of the teaching and learning of mathematics.

The *relativist world view* assumes that no objective body of knowledge exists. It is very similar to the contextualist world view above in that it assumes that there is no direct one-to-one relationship between epistemology and ontology and that knowledge is viewed as subjective and very changeable. However, it differs from the contextualist world view in that it assumes that each learner constructs a unique representation of that knowledge base. Consequently, teachers that hold such a view see themselves as merely facilitators in helping the learner to achieve autonomy and self-regulation in learning and are likely to favour criterion-referenced assessment tailored, as far is practicably possible, to each individual learner. This epistemological world view can be linked to a *radical constructivist* model of the teaching and learning of mathematics. (See Section 1.2 below for a fuller discussion of the constructivist conception of the teaching and learning of mathematics). Table 1.1.1 below summarises a number of differences in the beliefs of the three world views. The focus of this research however is on the two extreme positions represented within the three world views discussed above. As such, for the purposes of this research the *contextualist* and *relativist* world views are conflated. The main justification for this decision is that it is uncertain what difference holding a *contextualist* or *relativist* world view would have for a teacher teaching in the classroom. Prawat (2002) came to a similar conclusion after years of research in the field. He wrote:

> The fact of the matter is, as I understand now in hindsight, there is not a dime's worth of difference between what ... [we call] ... 'contextualism' and 'relativism' when it comes to *pedagogical practice*. (Prawat, 2002: 212)

Past research on teachers' epistemologies has also provided a body of knowledge concerning the nature of the epistemological world views they hold - if not always how they impact on teaching practice - and this has allowed researchers to make a number of assumptions which they have used to guide their work. The first of these assumptions is that at any one point in time teachers' epistemological beliefs are largely consistent with one or other of the three epistemological world views

Beliefs About:	*Realist*	*Contextualist*	*Relativist*
Knowledge	Objective, unchanging, and universal; independent of knower.	Situational; adapted by knower to fit contextual demands; changes consensually	Subjective and particular; unique to knower; highly changeable
Curriculum	Acquisition of previously identified knowledge base and learning skills	Acquisition of situationally relevant knowledge and skills	Emphasises multiple perspectives and analysis of knowledge adapted to meet individual needs and interests
Pedagogy	Transmission approach; teacher-centred	Transactional; group centred instruction	Autonomous; individual centred instruction
Assessment	External standards; norm-referenced	Group standards; criterion-referenced	Individual standards; criterion-referenced
Truth	Objective reality; truth corresponds to external reality and universal standards	No objective reality; consensual truth using negotiated standards	No objective reality; no consensual truth but personal truth
Role of teacher	Expert who actively disseminates knowledge	Collaborator; actively guides learning by modelling and scaffolding	Facilitator; actively provides feedback to learner
Role of learner	Passive recipient of knowledge	Active constructor; self regulation acquired autonomously	Active constructor; self regulation acquired autonomously
Role of peers	Play small role	Play important role via modelling	Play small role

Table 1.1.1 A comparison of some beliefs across the three epistemological world views (adapted from Schraw and Olafson, 2002).

outlined above and that fusion or hybrid positions are rare (Prawat and Floden, 1994). However, this is not to suggest that teachers' epistemological world views are unchanging over time though. Although there is research to suggest that epistemological beliefs and epistemological world views generally are not easy to change (Borko, Mayfield, Marion, Flexer, and Cumbo, 2002) there is evidence that both individual epistemological beliefs (Schommer, 1993) and epistemological world views generally (Bendixen, 2002; Baxter-Magolda, 2002) can change over time, albeit slowly.

The second assumption is that epistemological world views are consistent across academic subject domains although the research here is ambiguous. For instance, Samuelowicz and Bain (1992) have produced evidence to suggest that teachers' conceptions of teaching in tertiary education in the UK are very much context-dependent. Schraw and Olafson on the other hand argue that teachers' epistemological world views are stable across subject domains, although they produce no evidence for this claim.

The third assumption that guides research is that epistemological world views and the individual epistemological beliefs that comprise them are often tacit. Kagan (1992a), in light of this, defined teacher beliefs as '... broadly tacit, often unconsciously held assumptions about students, classrooms, and the academic material to be taught' (Kagan, 1992a: 65). This assumption is based upon quite a large degree of consensus in the research literature investigating the epistemological beliefs of teachers. For instance, research conducted by Schraw and Moshman (1995), Calderhead (1996b), and Patrick and Pintrich (2001) all suggest that teacher beliefs may not always be held in a form that can be readily communicated to others or even verbalised to themselves. Schraw and Olafson (2002) suggest that although teachers may be able to vocalise individual epistemological beliefs about teaching and learning they are often unaware of their own overarching philosophy or epistemological world view. This has led some researchers to distinguish between professed beliefs and attributed beliefs, i.e. those beliefs that teachers themselves profess to hold and those beliefs that teachers are assumed to hold by others (Putnam and Borko, 2000; Speers, 2005).

A fourth assumption is that particular world views are associated with or constituted by a particular set of individual beliefs about knowledge. For instance, Prawat and Floden (1994) have argued that the realist world view is associated with a set of less sophisticated beliefs about knowledge, i.e. a belief in simple rather than complex knowledge, certain rather than changing knowledge, and authoritative rather than self-emanating knowledge. Research in the UK by Askew, Brown, Rhodes, Johnson, and Wiliam (1997) investigating what makes effective teachers of numeracy also suggests that different world views (they call them belief systems and propose a slightly different taxonomy to the one discussed above) are constituted by individual beliefs about what it means to be numerate, how best to teach it, and how pupils learn numeracy most effectively.

The last assumption, and perhaps the one most central to the research described here, is that a teacher's epistemological world view of the teaching and learning of a particular subject leads to a different style of teaching in the classroom. Some research has shown such a link to exist, in the field of mathematics (Lerman, 1983;

Thompson, 1984; Marks, 1987; Dougherty, 1990; Askew *et al*, 1997), wider subject areas like science (Brickhouse, 1989, 1991; Hasweh, 1996; Hofer and Pintrich, 1997; Newton and Newton, 2000; Patrick and Pintrich, 2001; Johnston, Woodside-Jiron, and Day, 2001; Lunn, 2002), science and history (Newton and Newton, 1997; Newton, Newton, and Oberski, 1998), and sectors of education other than primary, e.g. tertiary (Biggs, 1990; Dall'Alba, 1990; Martin and Balla, 1990; Samuelowicz and Bain, 1992). As early as 1972 Thom wrote that:

> All mathematics teaching rests on a philosophy of mathematics however poorly defined or articulated it might be. Even bearing in mind constraints imposed by being compelled to teach particular content, the way in which it is approached can be seen as a manifestation of a particular philosophy. (Thom, 1972: 204)

More recently Calderhead (1996b) wrote that:

> ...beliefs about teaching ... may be closely related to beliefs about learning and the subject. If a teacher believes mathematics to be about the application of techniques ... this might itself imply certain beliefs about how the subject is most appropriately taught and learned and what the role of the teacher should be. (Calderhead, 1996b)

Kagan (1992a: 73) cites research by Grossman, Wilson and Shulman (1989) where teachers with a conceptual understanding of their subjects tended to use conceptual explanations and to modify textbooks according to this view whereas teachers with a more superficial understanding tended to rely on textbooks unchanged. More recently, Hasweh (1996) found that those teachers who supported a constructivist world view (similar to the relativist or contextualist world views above, depending on whether we are discussing radical or social constructivism – see Section 1.2 below) had a different teaching style than those teachers who supported an empiricist (similar to the realist) world view.

Thompson's (1984) research in the United States suggested that teachers' beliefs concerning the nature of mathematics teaching is related to their teaching practice. In a study involving just three teacher case studies Thompson concluded that:

> Examination of the relationship between conceptions and practice showed that the teachers' beliefs, views, and preferences about mathematics and its teaching played a significant, albeit subtle, role in shaping their instructional behaviour. (Thompson, 1984: 105)

Others in the field suggest a much more definite relationship between epistemology and practice. For instance, Ernest (1989), in proposing a theoretical model of the knowledge, attitudes and beliefs of the mathematics teacher, argued that teachers' conceptions concerning the teaching and learning of mathematics are reflected in their models of teaching and learning and that they have been shown to have a powerful influence on the way in which the subject is taught in the classroom. He wrote that:

> The importance of the teacher's mental model of mathematics teaching is that it is the key determinant of how mathematics is taught, given the contextual constraints which must be accommodated in any school situation. It is likely to

be closely related to and influenced by the teacher's conception of the nature of mathematics. (Ernest, 1989: 22/23)

Askew *et al* (1997) in their UK-based investigation of what makes an effective teacher of numeracy, proposed a working model of how a teacher's practice is impacted on by their beliefs and other factors. This model is reproduced below as Figure 1.1.1.

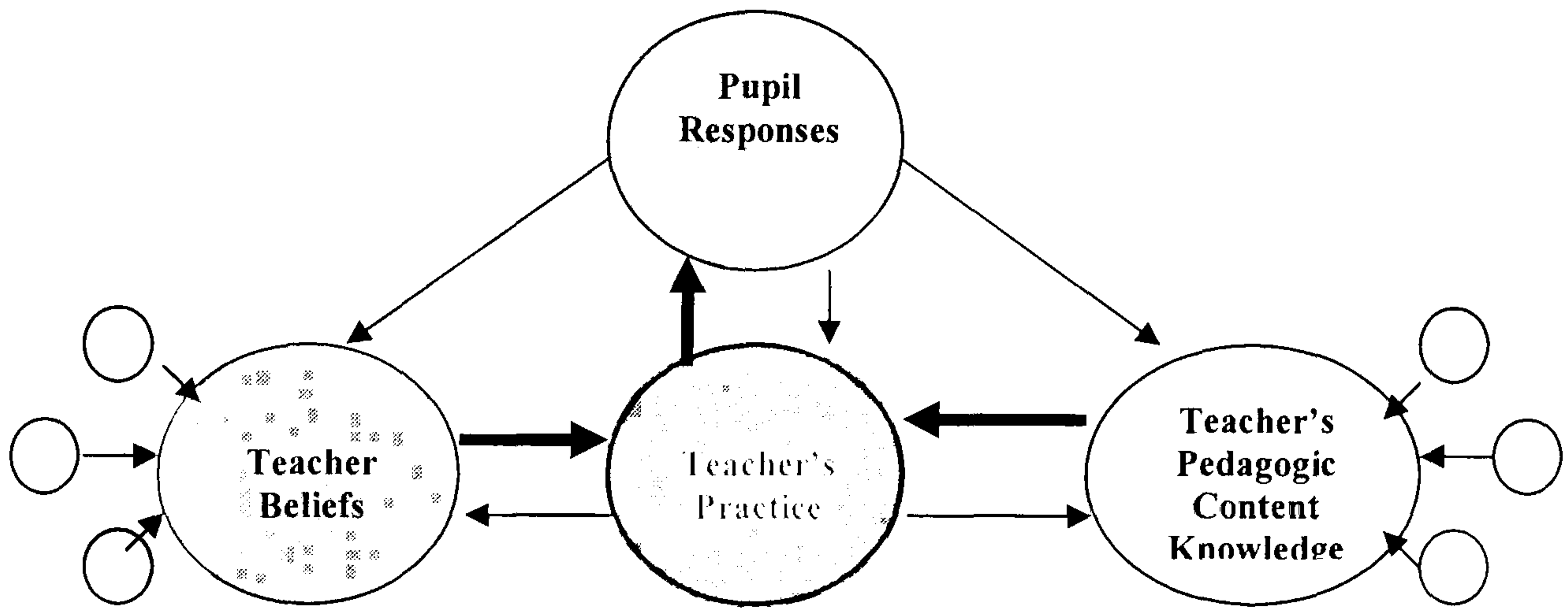

Fig. 1.1.1 A model of the interplay and relationship between beliefs, knowledge and classroom practices (After Askew *et al*, 1997: 24).

Askew *at al* (1997) argue that each of the constructs both informs and is informed by the others, although the arrows suggest varying degrees of impact, and that an understanding of why some teachers may be more effective than others requires an examination of each. I return to this model in *Chapter Seven.*

Burton (1994) has argued that the widespread difficulties that have been apparent in the teaching and learning of mathematics in recent times is a direct result of the tension that exists between those teachers adopting an *absolutist* epistemology of mathematics and those adopting a *relativist* epistemology and the different teaching practices which result. In attempting to explain the gender differences that are apparent in English and mathematics achievement he writes that:

> I wish to argue that, far from being explained by recourse to biology, and not to diminish the importance of the socio-cultural environment and the power of 'power', there are fundamentally different epistemological factors which dominate the disciplines and which lead to different pedagogical practices. (Burton, 1994: 203/4)

We must not lose sight also of the fact that the assumptions discussed above are merely that, assumptions, and so remain very much contestable issues. Contrasting research findings suggest that the link between teachers' epistemological world views and their pedagogy has still to be firmly established. The wider research picture concerning this link is not unequivocal (Cohen, 1990; Lederman, 1999; Simmons *et al*, 1999; Levitt, 2001; Wilcox-Herzog, 2002). Wilcox-Herzog (2002), for instance, concluded that teachers' epistemological world views do not directly impact on teachers' choice of instructional activity or curricula but simply serve as contextual filters. Moreover, what teachers say they believe and do in the classroom and what they actually do in the classroom have been shown in numerous studies to be completely different things (Galton, Simon and Croll, 1980; Berliner, 1989; McNamara, 1990, Cohen, 1990, Calderhead, 1996a; Schraw and Olafson, 2002; Schoenfeld, 2002). From their recent research, Schraw and Olafson (2002) concluded that:

> … there are few clear links between epistemological world views and teaching practices. Our view is that most teachers adopt a teacher-centred, transmissional

view of teaching even though they rarely support this position in theory (Schraw and Olafson, 2002: 127).

1.2 Models of Teaching and Learning

The following discussion attempts to make clear the link that exists between the characteristics of the epistemological world views as outlined in the previous section and prominent models of teaching and learning. It does so by discussing several of the most prominent models of teaching and learning to have emerged and held sway over educational practices during their day. These models can be grouped broadly into three family categories differentiated by their underlying philosophical assumptions, namely; *rationalist*, *associationist*, and *constructivist* theories. However, its main focus is on behaviourism and constructivist theories. Firstly, I attempt to delineate each model. I then discuss these in general educational terms before discussing what these models may imply for the teaching and learning of mathematics specifically. Later the discussion uses the areas of *assessment* and *the curriculum* as topics for drawing out the differences that exist between the models discussed and their respective implications for teaching and learning. The discussion also necessarily deals with models of teaching *and* learning simultaneously because the two are so closely linked.

There have been many theories which have sought to explain children's learning and which have then impacted on what was regarded as good teaching practice. These can be grouped into three broad categories defined by the fundamental presuppositions underlying them; *rationalism*, *associationism*, and *constructivism*. In their simplest form the ideas of rationalists like Froebel, Pestalozzi, and Montessori assumed that learning was about the revealing of innate knowledge and abilities. Growing and learning were thought to be maturational processes. However, as a parsimonious explanation of the entire learning process it has been largely discredited.

The central principle of *associationism* is that learning is an incremental and an associative process whereby experiences linked together in time will be represented together in the mind. As such, complex ideas are built up from simpler ideas and learning represents the depositing of these 'chunks' of associations in memory. This view of learning can be traced back through John Stuart Mill and Locke to Aristotle but its most powerful incarnation came in the form of *behaviourism* and the work of Watson, Thorndike, and Skinner. Their view is that *all* behaviour is learned and that all learning constitutes the making and breaking of associations between stimuli and responses via the principles of reinforcement and punishment (Adey & Shayer, 1994).

Although there are many forms of *constructivism*, as a general theory, its central claim is that human knowledge and learning is acquired through the process of active construction via experience. According to constructivism, children are born with some very basic ways of sorting and responding to sensory information so as to formulate mental constructions and mental models (or schemata) about the world. Through constant interaction with the environment these mental constructions are adapted and become more co-ordinated and more inclusive. Unlike rationalism, which brings out what, more or less, is already there, or associationism, which views the learner as a largely passive receiver of knowledge, constructivism involves a dynamic interaction between learner and environment (Fox, 2001).

Each of these theories has contributed in its own ways to deepening our collective understanding of teaching and learning and influenced educational practice to a greater or lesser extent. *Behaviourism* and *constructivist* theories will be discussed in more detail in the following section because they are seen to be located at opposite extremes of the teaching and learning spectrum and are thought most relevant to the research described here.

Behaviourism

It was Thorndike (1922) after his experiments with animals, who first extended this theory to human behaviour and then to education in general and mathematics in particular. In line with the general theory, all behaviour - including learning - is thought to be a response to stimuli in the environment. Learning then was viewed as the bonding of associations between appropriate stimuli and responses which are then strengthened or weakened via the processes of reinforcement and punishment respectively. In terms of teaching, the child was thought to passively respond to the expert teacher's stimuli and appropriate responses are 'stamped in' and inappropriate responses are 'stamped out' via the principles of reinforcement and punishment respectively. Behaviourists accounted for the transfer of this learning to new situations by the process of *generalisation*, which refers to the process whereby the response to one stimulus in one situation is also produced in response to a similar stimulus in another situation, i.e. learning in one context is reproduced in a different but similar context.

One way in which behaviourism influenced educational practice was that it legitimised the adoption of certain types of curricula and assessment procedures that viewed knowledge as the accumulation of specific responses. Within these models of curricula and assessment, knowledge was often expressed as detailed behavioural objectives. That is, learning tasks were thought best arranged in a linear order of complexity where the simpler stimuli were necessary prerequisites for the learning of more complex tasks (Greeno, Collins, and Resnick, 1996; Harries and Spooner, 2000). Skinner (1954) explained it thus:

> The whole process of becoming competent in any field must be divided into a very large number of very small steps, and reinforcement must be contingent on the accomplishment of each step. (Skinner, 1954: 94)

The behaviouristic view of the teaching and learning of mathematics assumes a conception of the subject with an *absolutist* epistemology (what Lakatos, 1976, called a *formalist view*), i.e. objective truth exists independently of the knower. Within this view mathematics is seen as 'the paradigm of knowledge – certain, absolute, value-free, abstract' (Lerman, 1990: 54). As such learning was viewed as best achieved via the direct transmission of knowledge from the expert teacher to the passive student via practice and drill. Thorndike applied his principles of stimulus-response learning to mathematics in a series of books, *The Psychology of Arithmetic* (1922) and *The Psychology of Algebra* (1923). These had a profound effect on the teaching of mathematics in the United States in that it legitimised as appropriate the behaviourist teaching methods they promoted. Classroom activities often took the form of displaying the correct procedure on a certain task and then allowing students the opportunity to rehearse the task where their performance was monitored, with appropriate feedback given. Such tasks are best presented in their simplest form first to enable students to achieve success before more complex tasks of the same type are introduced.

Many criticisms of behaviourism as an all-inclusive theory of learning have centred round the notion that it lacks explanatory power, that is, as a theory it cannot account for all instances of learning. For instance, it was shown as early as 1925 that there are instances of learning that do not 'fit' the gradual, step-by-step nature expounded by behaviourists (Köhler, 1925). There are instances of 'insight learning' in children and animals that suggest that learning of more complex concepts can occur in huge leaps rather than gradual steps as though the child (or animal) has suddenly had some 'insight' or sudden cognitive restructuring of the problem or concept (ibid). One such area of human behaviour that behaviourism was unable to account for was that of language acquisition, i.e. the ease with which we acquire language and the novel sentences we utter almost every time we communicate with others (Fox, 1998). However, this more complex view of learning runs into its own criticisms, e.g. see discussion of the learning paradox below.

In terms of education then, the breakdown of the to-be-learned tasks into a linear hierarchy from simple to more complex as a way of learning has been questioned by those advocating a more complex model of learning. There is a concern that teaching that simply presents learning as the acquisition of simpler and then more complex tasks risks developing in students knowledge that is more mechanical than conceptual (Resnick and Resnick, 1991). However, this is not to deny that such techniques have a place in certain kinds of mathematical learning, such as the rote learning of mathematical terms and tables.

Constructivisms

This once dominant behaviouristic view of teaching and learning has, according to some, undergone a dramatic shift over the last fifteen years (Richardson, 1996) and constructivism is now the most dominant view of teaching and learning (Gadanidis, 1994; Fox, 2001). Although the many different forms of constructivism that co-exist, share more or less, the same central underlying idea that knowledge is actively constructed by the knower, they do differ somewhat on some of the finer details of epistemology and ontology. Since the family of constructivist theories is broad it is felt necessary to discuss three variations of constructivism here. These variations represent 'weaker' and 'stronger' versions of the philosophy respectively; namely, *information-processing approach, radical constructivism* and *social constructivism.*

To accept the principle that knowledge is not passively received but actively built up as the *only* central principle of constructivism is, according to von Glasersfeld, to be an exponent of *trivial constructivism,* sometimes referred to as weak constructivism (Ernest, 1994). Such a weak form of constructivism is represented by the *information processing approach.* This approach has its origins in the birth of cognitive psychology in the 1960s and the psychology of Ausubel (1963) and Mayer (1982) and offers the metaphor of a computer to describe the workings of the brain, i.e. the brain of the learner is likened to a computer actively accepting information, performing routines and analyses, using memory to retrieve earlier analyses, and creating outputs.

Radical constructivism[2] on the other hand represents a stronger form of constructivism and can be said to have its origins in the work of Piaget and his ideas about learning and cognitive development. Ernst von Glasersfeld, perhaps its staunchest defender, although accepting of the principle stated above, asserts a second, stronger underlying principle. Thus, for him, the two main principles of radical constructivism are:

1. Knowledge is not passively received but actively built up by the cognising subject [as that stated above]; and
2. The function of cognition is adaptive and serves the organisation of the experiential world, not the discovery of ontological reality. (von Glasersfeld, 1987)

What this second principle argues is twofold; that knowledge construction is the result of cognitive restructuring and hence what a person knows is the accumulation of what was previously 'known' and what is subsequently experienced (this process is adaptive in a biological sense) and that the result of all of this is the organisation for that person of *their own* experiential world, not a reflection of some external 'real' world. This is because there is assumed to be no one-to-one relationship between epistemology and ontology. This is where the word 'radical' in the term radical constructivism originates. Von Glasersfeld explains:

> Radical constructivism, thus, is radical because it breaks with convention and develops a theory of knowledge in which knowledge does not reflect an

[2] There are a number of different forms of Radical Constructivism but the scope of this work means they cannot be dealt with here. The interested reader is directed to Ernest (1991b).

'objective' ontological reality, but exclusively an ordering and organisation of a world constituted by our experience. (von Glasersfeld, 1987: 199)

Rather like behaviourism, information processing constructivism is based on the traditional, Newtonian view of the world, which brings with it an *absolutist* scientific epistemology that assumes the world is an absolute physical entity containing material objects, i.e. there exists an 'objective' ontological reality, or what Prawat and Floden (1994:38) call a '... correspondence theory of truth'. Knowledge here is seen to reflect an objective ontological reality and so it involves achieving a *match* with that reality. In contrast, although radical constructivism does not deny the existence of an objective, 'real' world, it does have a different underlying view of epistemology and of the relationship between epistemology and ontology. It assumes that it is only possible to know the 'real' world through experience. Consequently, since each person's knowledge is individually constructed we are unable to know anything about objective reality even though that reality is acknowledged to exist (von Glasersfeld, 1987). It therefore assumes a *fallibilist* or *relativist* epistemology, or what Prawat and Floden (1994: 38) call a '... coherent theory of truth'.

What becomes important in understanding a concept here is not that we achieve a *match* with reality - this is impossible because there is no direct access to ontological reality - but that we achieve a *fit*, i.e. our knowledge or understanding of a particular object or concept is not contradicted by our experience of 'reality'. However, the fact that our knowledge or understanding does 'fit' and so survives tells us nothing about the 'real' world (von Glasersfeld, 1987). Ernest (1998: 80) describes this aspect of radical constructivism as '... experienceable but not knowable in any ultimate sense'. The use of the terms 'fit' and 'survival' indicates the theory's close association with Darwin's theory of natural selection. Piaget's notion of adaptation of schemata to environmental pressures is modelled on Darwin's theory of survival of the fittest.

If radical constructivism is seen to reflect Piaget's view of learning, social constructivism can be seen to reflect the work of Vygotsky and his view of learning. One of the biggest criticisms of Piaget's work and the theory of radical constructivism in general is that he viewed knowledge construction as essentially an individual rather than a group or cultural exercise. Piaget thought a child's learning resulted from his or her interaction with the external world and that the teacher's instruction only served to impede the child's journey to a potentially full understanding of that particular concept. Vygotsky, on the other hand, placed great emphasis on the social nature of knowledge; on the impact of the teacher and instruction on the child's learning. Vygotsky (1962) explained his opposition to Piaget's view like this:

> Our disagreement with Piaget centres on one point only, but an important point. He assumes that development and instruction are entirely separate, incommensurate processes, that the function of instruction is merely to introduce adult ways of thinking, which conflict with the child's own and eventually supplant them. Studying a child's thought apart from the influence of instruction, as Piaget did, excludes a very important source of change and bars the researcher from posing the question of the interaction of development and instruction peculiar to each age level. (Vygotsky, 1962, quoted in Jaworski, 1994: 26)

For Vygotsky then, knowledge construction is social in nature; it is similar to radical constructivism in that it does not reflect an objective ontological reality but different from radical constructivism in that knowledge can be consensually agreed upon by individuals and, therefore, shared amongst the individuals within that community. Ernest (1991a) explains a social constructivist's view of mathematics:

> Social constructivism views mathematics as a social construction. It [is] accepting that human language, rules and agreement play a key role in establishing and justifying the truths of mathematics. It takes ... [a] fallibilist epistemology, including the view that mathematical knowledge and concepts develop and change. (Ernest, 1991a: 42)

And later that:

> Objective knowledge of mathematics is social, and is not contained in texts or other recorded materials, nor in some ideal realm. Objective knowledge of mathematics resides in shared rules, conventions, understandings and meanings of the individual members of society, and in their interactions. (ibid: 82)

Social constructivism then assumes a fallibilist epistemology and a relativist ontology, i.e. there is assumed to be a world out there but we can have no certain knowledge of it (Ernest, 1998). Within this view mathematics is seen as a social construction, relative according to time and place and subject to change as much as any other form of knowledge (Lerman, 1990).

Bereiter (1985) argues that attempts to explain learning in terms of a constructive process need to be able to account for what has become known as *the learning paradox* (Pascuale-Leone, 1980). That is, the problem of having to attribute to the learner prior knowledge that is at least as complex as the new learning to be acquired. Examples of 'insight learning' are very common in young children's learning and, as was discussed in a previous section, have been shown to occur in chimpanzees and other animals (Köhler, 1925). For instance, Bereiter (1985) cites an example of pre-school children being able to make the transition from one addition algorithm to a more complex one without any instruction of how to do so. According to the first algorithm, the problem of $4+3 = ?$ is solved by the child counting out four blocks, then counting out three blocks, and then counting the combined set of all seven blocks. The more complex algorithm consists of *beginning* with four blocks and simply counting on three more so making the first step of the first procedure redundant. He argues that to attribute this to some 'insight' runs into the problem of the learning paradox because it presupposes an understanding of the more complex algorithm in advance of discovering it.

The likes of Chomsky (1970) and Fodor (1975; 1980) suggested an alternative theory to constructivism based on the 'innateness' of cognitive structures where learning is viewed as maturational. For instance, Fodor (1980) writes that:

> There literally isn't such a thing as the notion of learning a conceptual system richer than the one that one already has; we simply have no idea of what it would be like to get from a conceptually impoverished to a conceptually richer system by anything like a process of learning. (Fodor, 1980: 149)

One might ask why such a paradox is worth spending time considering when it is plainly obvious that such 'insight learning' does take place. Bereiter (1985) suggests that one important reason is the possibility that:

> ... in making learning out to be a much simpler process than it is, educators have overlooked important factors in the promotion of learning. Thus the practical payoff in taking the learning paradox seriously is that it may lead to the development of educational strategies that are commensurate with the complexity of the task that learners face. (Bereiter, 1985: 202)

1.3 Implications of these Models for Teaching and Learning

Much of the current discourse in the educational research literature on teaching and learning in the National Curriculum assumes that both are predicated on a constructivist model. That is, many within the educational literature argue that constructivism is now the most dominant view of teaching and learning (Gadanidis, 1994; Richardson, 1996; Fox, 2001). Some even suggest that many teachers now not only accept the ideas of constructivism (Ernest, 1994; Irzik, 2000) but also implement these ideas in their classroom pedagogy (Philips, 1995; Prawat, 1996; Strauss, 1996). Although it is true to say that the Plowden Report (CACE, 1967), with its emphasis on the broadly constructivist idea of activity-based learning, had some influence on primary classroom practice, other research has suggested that many teachers show little or no awareness of the ideas of constructivism (Naylor & Keogh, 1999; Roelofs & Terwel, 1999; Jaworski, 1994; Clements & Battista, 1990; Sutherland, 1989) and that more traditional, didactic teaching still predominates in the classroom (Terwel, 1999; Driver & Oldham, 1986).

This view that constructivism is currently accepted by teachers as the most dominant conception of teaching and learning and that teachers' pedagogy is based upon its ideas is questionable. To find that constructivism even dominates the current discourse in the way that it does is a little surprising given that many of its central claims have been called into question. For instance, some believe that many of the central claims of constructivism are reactive, misleading, or simply untrue. For instance, two of constructivism's most important claims are that learning is active and constructed rather than innate or passively absorbed. However, these two claims about the way learning occurs are said by some to be gross oversimplifications of what is actually going on when learning is taking place. For instance, Fox (2001) argues that although it is true that children are often actively involved when learning, it is also true that children can learn by being acted upon, i.e. children *act* and *react* and learn from both types of experience. The reason for constructivism's emphasis on only one end of the active/passive spectrum can perhaps be found in its origins as a reaction to the once dominant *behaviourism* and its passive view of children's learning. Fox (2001) agrees and argues that constructivism has become:

> … a somewhat uncritically accepted textbook account of learning … in danger of becoming a general term of approbation with but little content and an incoherent underlying epistemology. (Fox, 2001: 23).

Phillips (1995) too, although not dismissive of all that constructivism has to offer, is sceptical of constructivism's seeming omnipotence of the teaching pedagogy describing it as becoming '… something akin to a secular religion.' (Phillips, 1995: 5).

Whatever philosophy/learning theory teachers currently believe their classroom practice to be based upon - whether this can be explicitly communicated or not - it seems important that their classroom practice should be consistent with both that belief and the theory itself. The rest of this section discusses the contrasting implications of a behaviouristic *versus* a constructivist model of teaching and learning for teaching and learning in general and of mathematics in particular. The discussion uses *curricula* and *assessment* as areas for drawing out the different implications of adopting a behaviouristic and constructivist view of teaching and learning and reviews some of the research and arguments in this area.

Implications for Curricula

A behaviouristic conception of teaching and learning, a view that I have linked to the *realist* epistemological world view, has certain implications for the type of curriculum adopted. For instance, it implies that the learning environment should be highly organised by the teacher and set out clearly with identifiable goals. It should also set out a linear hierarchy of the material to be learned such that simple tasks are presented first and in unambiguous contexts to allow the pupil the opportunity to give a correct response. The learning of these simpler tasks is a prerequisite of learning the more complex tasks to be presented later and the learning of these should be monitored before these more complex tasks are presented. Within this process, appropriate feedback in the form of reinforcement is seen as very important in shaping the pupil's learning behaviour.

Although constructivism is not strictly a theory of teaching (Goldin, 1998), many constructivists have argued that it has important implications for teaching and the teaching of mathematics (von Glasersfeld, 1987). A curricula predicated on radical constructivist principles, a view linked with the relativist world view, should be organised such that pupils are able to ultimately understand its major overarching principles by absorbing the content to be learned into their pre-existing cognitive structures. The pupil's previous knowledge and understanding are taken into account in this and sequences of learning activities are presented that allows the pupil to reorganise their cognitive structures, which, in turn, further extends and develops that knowledge and understanding (Greeno, Collins, and Resnick, 1996). Teachers will also emphasise differentiation by outcome over differentiation by task within their teaching style as this allows the pupils a more open-ended activity where they take more control for their own learning (Davis, 1994). In essence, a curriculum based on constructivist principles would view learning as a personal and private activity but teaching as a public and social one (Watts and Jofili, 1998). Selley (1999) sums it up like this:

> The more the children's own learning (rather than the content of the curriculum) is given priority, the more successful will be the adoption of constructivist teaching. (Selley, 1999: 13)

Von Glasersfeld (1987) outlines more explicitly the possible implications of a constructivist approach to teaching by contrasting it with a behaviouristic approach. He writes that:

> In education and educational research, adopting a constructivist perspective has noteworthy consequences:
>
> 1. There will be a radical separation between educational procedures that aim at generating understanding ('teaching') and those that merely aim at the repetition of behaviours ('training').
> 2. The researcher's and to some extent the educator's interest will be focused on what can be inferred to be going on inside the student's head, rather than on overt 'responses'.
> 3. The teacher will realise that knowledge cannot be transferred to the student by linguistic communication but that language can be used as a tool in the process of guiding the student's construction.
> 4. The teacher will try to maintain the view that students are attempting to *make sense* in their experiential world. Hence, he or she will be interested in the

> student's 'errors' and indeed, in every instance where students deviate from the teacher's expected path because it is these deviations that throw light on how the students … are organising their experiential world. (von Glasersfeld, 1987: 123)

Knowledge as a whole is problematised. Moreover, a curriculum predicated on the principles of social constructivism would necessitate the addition of a further consequence to the list above; one that emphasises the importance of the social nature of knowledge and understanding. As such, there should be a greater emphasis on discussion, negotiation, and shared meanings (Ernest, 1998).

I have already argued that much of the current discourse in the educational research literature on teaching and learning in the National Curriculum assumes a constructivist model. I have also cautioned against an unquestioning acceptance of the assumption within that discourse that teachers' current pedagogy is predicated on a constructivist epistemology. Greeno (1991) seems also to question whether teachers' pedagogy is currently predicated on constructivism. He summarised the learning activities that most children still receive as follows:

> In most schools, what students mostly do is listen, watch, and mimic things that the teacher and textbook tell them and show them. If students' epistemologies are influenced at all by the experiences they have, then most students probably learn that mathematical knowledge is a form of received knowledge, not something that is constructed either personally or socially. (Greeno, 1991: 81)

In discussing a 'transmission' view of teaching Davis and Pettitt (1994) write:

> … its model of learning still persists. Many people, including some politicians think that learning is a kind of copying. There are items to be copied; 'facts' about number, or historical events, or gravity, for instance. The learner takes a copy of these facts into her head. She can then easily demonstrate her learning: on request, she can say or write it … to attack transmission theories of learning is scarcely original … nevertheless, we are conscious that criticism of such theory has had frustratingly little effect on educational policy or classroom practice in the last fifteen years. (Davis, 1994: 1/2)

Ernest (1998) argues that the 'transmission' view is deeply entrenched:

> [The] passive-reception view of learning [is not] dead amongst professionals and administrators in education. Many government driven curriculum reforms, in Britain at least, assume that the central powers can simply transmit their plans and structures to teachers who will passively absorb and then implement them in 'delivering the curriculum'. Such conceptions and strategies are deeply embedded in the public consciousness. (Ernest, 1998: 74)

These quotations suggest that the teaching and learning of mathematics is still largely mediated by the transmission of information from the expert teacher to the passive learner; an approach we have already seen is underpinned by a behaviouristic view of teaching and learning. This has been reinforced by more recent studies (Burton, 1994; Boaler, 1997). For instance, Burton (1994), writing specifically about the teaching and learning of mathematics argued that:

> Strong voices such as David Bloor, Sandra Harding and Thomas Kuhn, and an increasing number of feminist philosophers of science, have challenged the absolutist position of mathematics ... drawing attention to its socio-cultural biases and their effects. However, there is no great, indeed noticeable, impact on syllabi at any level, from reception class to university. (Burton, 1994: 207)

He goes on to argue that there exists a confusion between those teachers who hold a *realist* epistemological world view and those that hold a *relativist* epistemological world view (although he uses different terminology) and that this confusion permeates the teaching and learning of mathematics at every stage of education. He distinguishes, using terminology first employed by Polya (1981), between the personal philosophies of those teachers that value *information* (or *know what*) and the personal philosophies of those who value *know-how*. Polya (1981) argued that:

> Our knowledge about any subject consists of information and of know-how. If you have any genuine bona fide experience of mathematical work on any level, elementary or advanced, there will be no doubt in your mind that, in mathematics, know-how is much more important than mere possession of information. (Polya, 1981, quoted in Burton, 1994: 208).

This distinction has been shown to exist more recently by Liping Ma's (1999) work on the cultural differences between teachers of primary mathematics in China and the United States.

Burton goes on to argue that:

> Nonetheless, syllabi, including those to be found in many national curricula or in the texts which carry much the same force, continue to be defined in terms of information. (ibid)

Gadanidis (1994) views this discrepancy between what is dominant in current discourse and what actually happens in practice to suggest that mathematics education suffers from a condition resembling schizophrenia, with one of its personalities evident in academic journal articles, in-service presentations, etc. (a constructivist view of teaching and learning) and the other exhibited in the day-to-day realities of classroom pedagogy (a behaviouristic view of teaching and learning).

Implications for Assessment

If we want to know what an assessment system predicated on a behaviouristic view of teaching and learning looks like then we need look no further than that currently used in the centralised National Curriculum for England (DfES, 1999). Assessment of learning by paper-and-pencil, 'objective' tests, with the aim of determining *how much* of the core curriculum has been learned from the teacher, the results of which are norm-referenced against national trends, is an important part of the National Curriculum in England. Part A of Figure 1.3.1 below could be said to be an accurate illustration of how current assessment in the National Curriculum in England is thought to work. It illustrates assessment based on a behaviouristic view of teaching and learning. It portrays the teacher as the expert, knowing all that the learner knows, and more. During teaching the learner acquires more of the teacher's knowledge and so knows more than before but with the teacher's knowledge remaining unchanged.

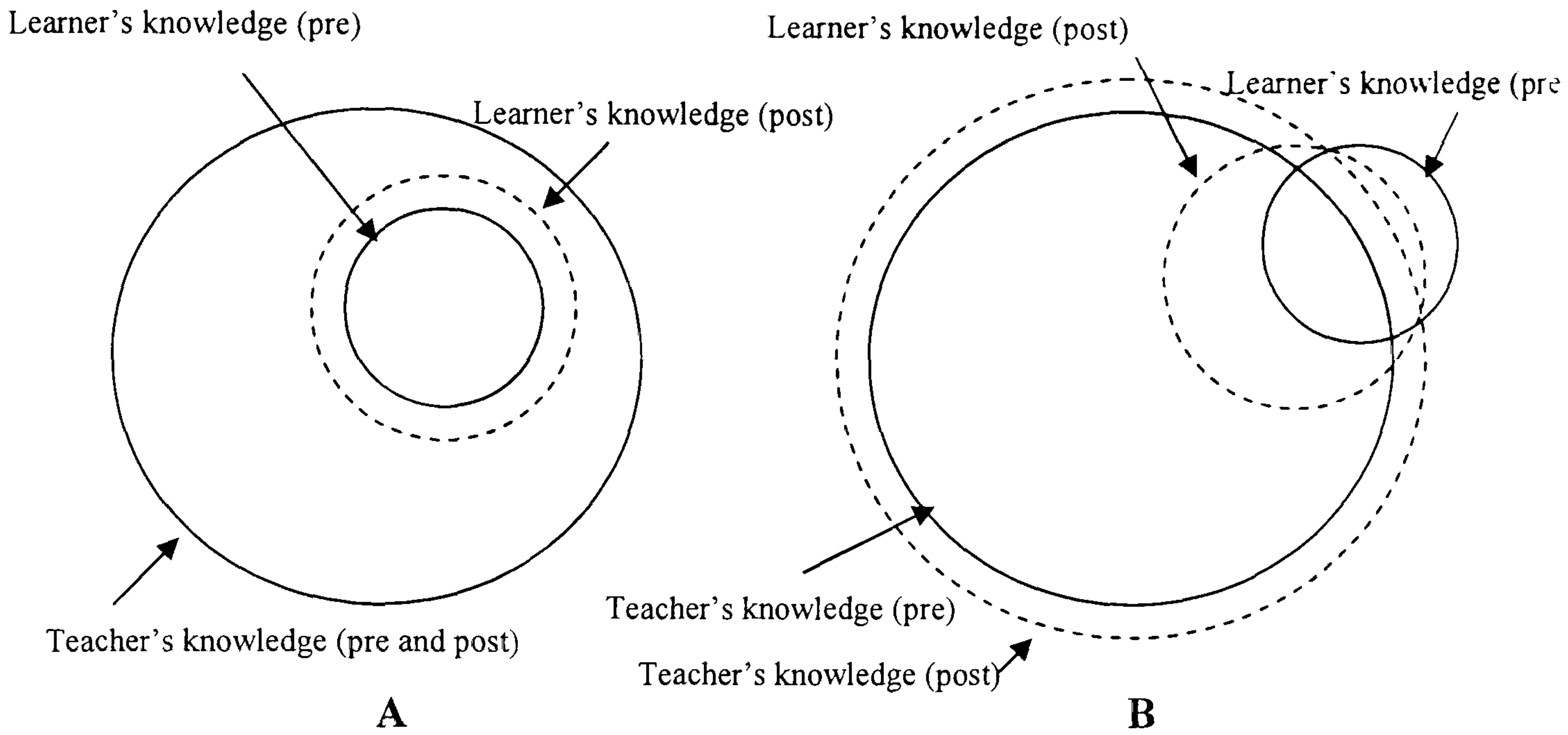

Fig 1.3.1 Models of assessment based on behaviouristic and constructivist views of teaching and learning (Adapted from White, 1992: 160).

However, this model appears to be strangely at odds with the apparent dominant force of constructivism and its central claims. Part B of Figure 1.3.1 represents assessment based on a constructivist view of teaching and learning. It portrays the learner as sharing some of the teacher's knowledge pre-learning but as also having some extra knowledge that the teacher does not have. However, post-learning the leaner shares more of the teacher's knowledge, which may have also increased.

A closer analysis of the epistemologies and ontologies underpinning the behaviouristic and the constructivist models discussed above lends support to this idea. For instance, although behaviourism and information processing constructivism bring with them an *absolutist* epistemology, which implies that ultimate knowledge is possible, radical and social constructivism bring with them a *fallibilist* epistemology; one which rejects any possibility of absolute knowledge (Lerman, 1990; Ernest, 1994). As a result, behaviourism assumes a quantitative measurement approach to learning within which assessment simply estimates the degree to which a student has acquired the knowledge by taking a sample of that knowledge.

Shepard (1991; 2002) argues that this measurement approach to classroom assessment reflected by standardised tests and teacher-made emulations of those tests is essentially incompatible with the central ideas of constructivism and only serve as a barrier to the implementation of the ideas of constructivism. This scientific measurement approach is more theoretically consistent with earlier forms of the curricula and their associated beliefs about learning, e.g. rationalism and behaviourism. Figure 1.3.2 below shows a chronology of the influences of the models of teaching and learning discussed above, and the changing conceptions of the curriculum during the last two centuries.

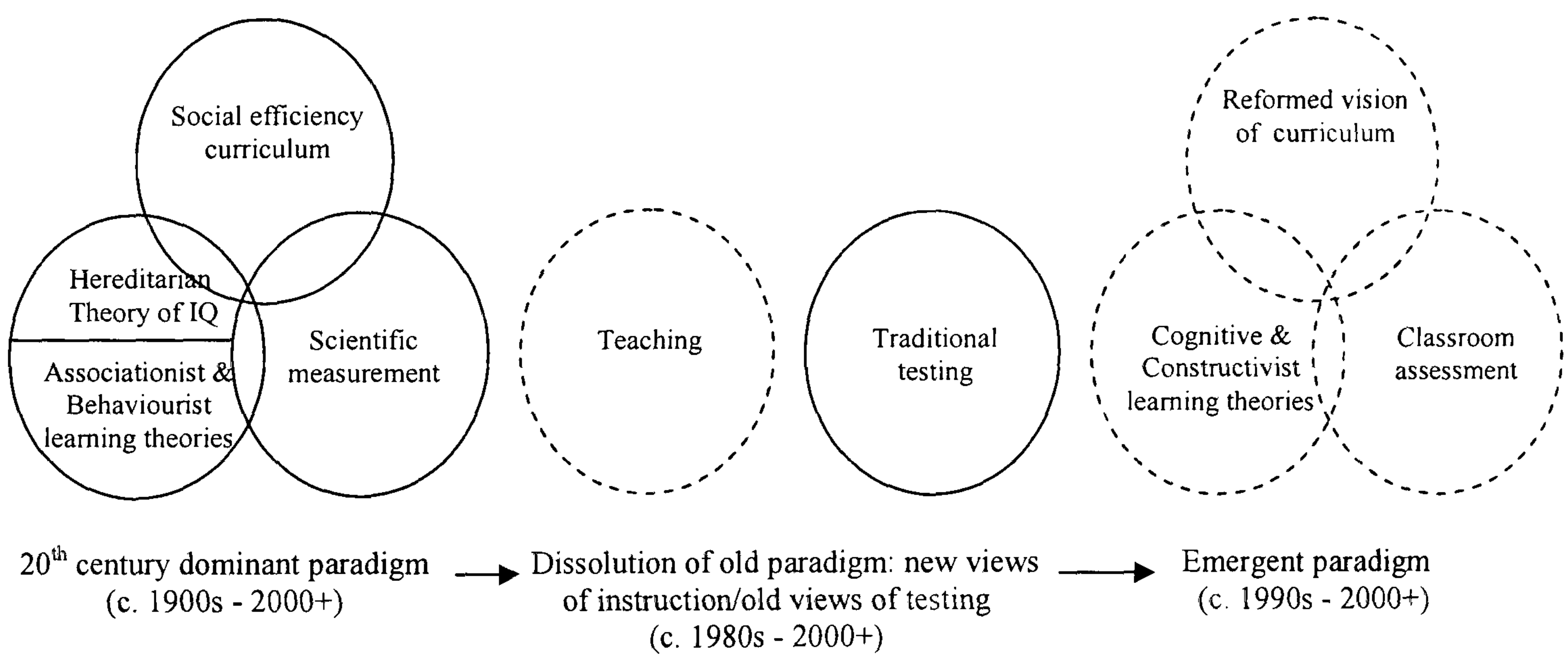

Figure 1.3.2 A chronology illustrating how changing conceptions of curriculum, learning theories, and scientific measurement explain the tension between current use of tests and testing and the central ideas of constructivism (from Shepard, 2002: 230).

The different circles in the figure illustrate how the scientific measurement mindset is still prevalent within current pedagogical practice. It also shows neatly the tension that exists between current teaching practice and traditional tests and testing.

It suggests that current teaching is underpinned by constructivism and so belongs with the right hand side of the diagram whereas traditional tests and testing is more a remnant of the past and so belongs on the left (Shepard, 2002). The measurement of students' learning in terms of the question 'how much have they learned?' only makes sense if one holds a behaviouristic view of teaching and learning which assumes that knowledge is the accumulation of bits of information.

It seems then that the epistemology and ontology underpinning a behaviouristic model of teaching and learning has implications for assessment. Similarly, a constructivist model of teaching and learning too has implications for the type of assessment it supports. For instance, the underlying epistemology and ontology of radical constructivism implies that what each child knows is different from the next because what is known is individually constructed from experience. This raises serious problems for current methods of assessment in UK's National Curriculum because, as Ernst von Glasersfeld (1983) writes:

> If experience is the only contact a knower can have with the world, there is no way of comparing the products of experience with the reality from which whatever messages we receive are supposed to emanate. The question, how veridical the acquired knowledge might be, can therefore not be answered. (von Glasersfeld, 1983: 24)

This underlying epistemology of radical constructivism reinforces the view, therefore, that current assessment practices are in need of revision because, since each individual builds their own construction of reality no appropriate means of comparison between individuals can exist. This represents a potential problem for proponents of radical constructivism because it places the knower in a vacuum. As a criticism of radical constructivism's *fallibilist* epistemology Thomas writes:

> Some …seem to consider that we can check our constructions against those of others. If, however, one adopts the [radical] constructivist point of view of knowledge, then one is forced to admit that this is impossible. (Thomas, 1994: 36) (word in parentheses is mine)

A similar argument is adopted by Harries and Spooner (2000) in their criticism of radical constructivism as a useful theory. They write that:

> The difficulty with this view [Radical Constructivism] is that identifying what real knowledge is becomes a problem. If it is different for each individual does it even cease to be a useful concept with which to explore ideas about learning? (Harries and Spooner, 2000: 26).

Ernest (1994) agrees and warns against the danger, as the theory of radical constructivism's popularity widens, of it leading to '… an overly child-centred, romantic progressivism … [which then] …naively assumes that the child can discover much of conventional school knowledge on its own.' (Ernest, 1994: 337).

If current assessment practices are to better reflect the epistemological assumptions of constructivism then they are in need of revision. When knowing is viewed as an understanding of the overarching principles of a subject domain then assessment practices will need to assess that understanding across a wider range of the domain, which means assessments will need to be larger in their scope. For instance, some alternative assessments that are being devised in the United States include on-demand examination questions and larger projects that may take several days or weeks to complete (Greeno, Collins, and Resnick, 1996).

Summary

Any view of teaching and learning would seem to have major implications for teachers and their pedagogic practice in the classroom. The once dominant view concerning teaching and learning has undergone a dramatic, some would say a paradigmatic, shift over the last ten to fifteen years (Richardson, 1996a). It is argued by many in the educational literature that *behaviourism* has given way to *constructivism* and that *constructivism* is now the most dominant view of teaching and learning, especially within the discourse of the educational literature on the subject (Gadanidis, 1994; Fox, 2001). Some even suggest that many teachers now accept the ideas of constructivism (Ernest, 1994; Irzik, 2000) and implement these ideas in their classroom pedagogy (Philips, 1995; Prawat, 1996; Strauss, 1996). However, other research has suggested that many teachers show little or no awareness of the ideas of constructivism (Naylor & Keogh, 1999; Roelofs & Terwel, 1999; Jaworski, 1994; Clements & Battista, 1990; Sutherland, 1989) and that more traditional, didactic (behaviouristic) teaching still predominates in the classroom (Terwel, 1999; Driver & Oldham, 1986).

Past research has suggested that teachers' pedagogy can be understood by reference to their beliefs or implicit theories about teaching and learning (Clark, 1988; Pajares, 1992; Thompson, 1992; Calderhead, 1996; Richardson, 1996b;

Philippou and Christou, 2002). If this is true it seems plausible to expect that teachers' pedagogy should match this accepted philosophy. Jaworski (1994) argues that:

> ... it seems important that the theory and ultimately the practice of teaching be consistent with theories of knowledge and leaning held by the practitioners. (Jaworski, 1994: 32)

I would argue that it is important that teachers' practice does reflect their view of teaching and learning because only then would it be possible for teachers to reflect accurately on that practice in an attempt to improve it. My study will attempt to shed some light on this subject. It is thought to be educationally significant research because, although there has been much research conducted on teachers' classroom practice and some research conducted investigating teachers' beliefs and theories concerning teaching and learning, there appears to have been little past research investigating the two in combination, i.e. the relationship that may exist between teachers' epistemological beliefs about teaching and learning and their classroom practice. Most of the research that has been conducted in this field has either been largely conducted in the United States or has not had a mathematics specific focus. Only two studies were identified as being conducted in the UK (Lerman, 1990; Jaworski, 1994) but both were conducted before the introduction of the National Curriculum. Schraw and Olafson (2002) identified the dearth of research in this area and its ultimate importance. They write:

> Oddly, few studies have examined this issue, focussing instead on students' epistemological beliefs and their relationship to learning. Although there is

> limited data at this point in time, we believe it is of the utmost importance to raise questions about teachers' epistemological beliefs and their relationship to teaching practice. (Schraw and Olafson, 2002: 100)

They illustrate their own beliefs about this possible relationship when they write that:

> An epistemological world view is a set of beliefs about knowledge and knowledge acquisition that influences the way teachers think and make important instructional decisions. We assume that different epistemological world views lead to different choices about curriculum, pedagogy, and assessment. (ibid: 99)

However, there exists a mixed picture in the available literature on this subject. For instance, evidence from studies by Hasweh (1996) and Johnston, Woodside-Jiron, and Day (2001) seem to support Schraw and Olafsons' assumption by suggesting that teachers' beliefs and world views do directly affect their teaching practice. In contrast however, Wilcox-Herzog (2002) found no direct link between teachers' beliefs and their classroom pedagogy. It could be argued to be doubly important in light of the discrepancy I outlined above concerning the constructivist-dominated discourse of the educational literature and the behaviouristic-dominated practice of everyday classroom activity.

The aim of this study then is to investigate the nature of primary teachers' epistemological beliefs and epistemological world views concerning the teaching and learning of mathematics, what relationship these beliefs may or may not have with their classroom practices, and to explore the theoretical and practical implications of any such relationship found to exist.

Research Questions

1. What epistemological beliefs do primary teachers' hold about the teaching and learning of mathematics?

2. Do these epistemological beliefs constitute distinct and mutually exclusive epistemological world views as defined in this chapter, or are hybrid positions possible?

3. Are primary teachers' epistemological world views held in such a way that enables them to be easily communicated to others?

4. What is the relationship, if any, between primary teachers' epistemological world views about the teaching and learning of mathematics and their classroom pedagogy?

5. What are the theoretical and practical implications of any relationship (or non-relationship) that may be found to exist?

Chapter 2: Methodological Overview - In Support of Eclecticism

> **Somebody was arguing with Picasso that he ought to make pictures of things the way they are – objective pictures. Picasso mumbled that he wasn't quite sure what that would be. The person that was bullying him produced a photograph of his wife from his wallet and said 'There, you see, that is a photograph of how she really is'. Picasso looked at it and said 'She is rather small, isn't she? And flat?'.**
> *(Bateson, 1983)*

This section aims to set out the rationale for my chosen methodology or paradigm and its relationship with my chosen methods of research. The story related above was meant to give the reader some insight into my own view of the nature of social reality and therefore my own thoughts concerning methodology. The story is apt because it warns of the danger of assuming any single view is, or can be, the 'correct' one and so it captures my own feeling about the complex nature of the research process. Consequently, in research terms it hints at the need to view the researched at different angles or through multiple perspectives if the findings are to do justice to that complex nature.

Following a justification of the rationale for the methodology the chapter goes on to describe the methods employed in each of the three phases of the research. Lastly, it outlines my search for an approach to the research that was both ethically responsible and rigorous.

2.1 Overview of the Research Process

The research described here was conducted within the paradigm of critical realism and employed multiple methods following a multi-phase approach using methodological triangulation and respondent validation for verification of findings. These terms are thought important in understanding the methodological approach adopted here and so will be discussed in greater detail in the sections that follow.

Methodological triangulation has been defined and championed by many writers within educational research (Denzin, 1985; Cohen and Manion, 1985; Denzin and Lincoln, 1998). For instance, Cohen and Manion (1985) define triangulation as:

> The use of two or more methods of data collection in the study of some aspect of human behaviour ... [It is an] attempt to map out, or explain more fully, the richness and complexity of human behaviour by studying it from more than one standpoint. (Cohen and Manion, 1985: 254)

Denzin and Lincoln (1998) agree but go further. They suggest that:

> ... the use of multiple methods, or triangulation, reflects an attempt to secure in depth understanding of the phenomenon in question [but that] objective reality can never be captured. We can know a thing only through its representations. Triangulation is not a tool or strategy of validity, but as an alternative to validity. The combination of multiple methodological practices, complementary materials, perspectives, and observers in a single study is best understood, then, as a strategy that adds rigour, breadth, complexity, richness and depth to any enquiry. (Denzin and Lincoln, 1998: 22)

Cohen and Manion (1985) later champion it by writing that:

> It is a technique of research to which many subscribe in principle, but which only a minority use in practice. The use of multiple methods, or the multimethod approach as it is sometimes called, contrasts with the ... generally more vulnerable single method approach ... the technique is particularly appropriate ... with[in] the field of education. So complex and involved is the teaching-learning process in the context of the school that the single method approach yields only limited and sometimes misleading data. (Cohen and Manion; 1985: 254 & 260)

As the above suggest, the single method approach to research is thought more vulnerable than triangulation because it offers the researcher little or no opportunity to verify or cross check their findings gleaned via any single method. In effect, the use of methodological triangulation reduces the possibility of the research findings being misinterpreted or a biased product of the particular research method used. In so doing, methodological triangulation mitigates against the threats to validity (or what I will call credibility) that each individual method poses and so increases the probability of producing a close or rounded account of the topic or phenomena under study. In using methodological triangulation it is hoped that the research findings from the different methods used will provide mutually reinforcing results that will lead to greater credibility[1] and therefore greater confidence in the conclusions reached. As such, the advantage of such a combination lies in the need for results to be corroborated. Stake (2000) sums up this idea when he writes that:

[1] See the discussion in *Section 1.2 Models of Teaching and Learning* in Chapter 1 concerning constructivism and the fact that is says nothing about reality.

> To reduce the likelihood of misinterpretation, researchers employ various procedures. Triangulation has been generally considered a process of using multiple perceptions to clarify meaning, verifying the repeatability of observations or interpretations. But, acknowledging that no observations or interpretations are perfectly repeatable triangulation serves also to clarify meaning by identifying different ways the phenomenon is being seen. (Stake, 2000: 443-4)

Triangulation has not always been in vogue however. During the latter half of the twentieth century issues concerning the differences between quantitative and qualitative research generated a prominent debate within the social sciences. Central to this debate was a spectrum of researchers and philosophers of science. At one end of this spectrum were those that argued that the quantitative and qualitative approaches were actually different paradigms because they were underpinned by very disparate and incompatible philosophical assumptions concerning epistemology and ontology (Rist, 1977; Filstead, 1979; Smith, 1984; Lincoln and Guba, 1985; Scott, 2000). Scott (2000) describes this debate thus:

> The field of education is riven with disputes, not least about the veracity of different research approaches. These are usually conducted at the level of method and strategy with little attention paid to epistemology and ontology. And yet it is only at these levels that the real issues are foremost. (Scott, 2000: 11)

For many of those holding this view it meant too that the different research methods were incompatible. At the opposite end of the spectrum were those that believed the quantitative and qualitative methods of research were simply different tools to be employed where and when their respective advantages were needed (Bryman, 1988; Hammersley, 1997).

The first of these positions has been called the 'paradigm view' by Hammersley (1997). The different paradigms represent very different epistemological and ontological positions. That is, there exists a deep split between the methods each adopts, how each one views the world and reality, what warrants legitimate knowledge, and how we should set about attempting to attain that knowledge. For instance, quantitative research methods are said to be highly structured and produce quantifiable, 'hard' data, often from very large samples. The use of statistics in the analysis and presentation is also a strong characteristic of quantitative research. The use of experiments, a favoured method of psychologists, also illustrates the need for structure, control of and distance from the subject matter within the quantitative field. These characteristics are said to result in data that are free from bias, repeatable and therefore verifiable by others. i.e. these research methods are said to be characterised by *objectivity and internal validity*. They also often involve the testing of theory using hypotheses via deduction and its research deals with causal relationships that are generalisable to other research situations or contexts, i.e. they have *external validity*.

Qualitative methods on the other hand tend to reject structure but instead search for rich, in-depth, sometimes referred to as 'soft' data by achieving a close, insider relationship with the subject matter. The emphasis is often on the uncovering of theory via induction[2]. Its proponents reject terms such as *validity* in favour of terms like *credibility*. This paradigm view is illustrated by Rist (1977) when he writes:

> When we speak of 'quantitative' or 'qualitative' methodologies we are in the final analysis speaking of an interrelated set of assumptions about the social world which are philosophical, ideological, and epistemological. They encompass more than simply data gathering techniques. (Rist, 1977: 62)

The scientific method, sometimes called the hypothetico-deductive method, arose out of the positivist school of thought within philosophy and is associated with August Comte. It is essentially a Newtonian view of the world and consequently has at its core an *absolutist epistemology*, i.e. the assumption that objects in the natural world are objective, real and exist independently of human beings as knowers. This view, also called the *realist view*, had very much become the 'received view' throughout the nineteenth century and much of the twentieth century. Its methods are heavily borrowed from those of the natural sciences because the natural sciences were seen to making great leaps in understanding during this time (although see Hammersley (1997) for a fuller discussion of this). Such a view argued that only those questions answerable from the application of observation and verification through replicability, i.e. via the processes of induction and deduction could be legitimately approached.

[2] The quantitative – qualitative dichotomy has more recently been superseded by different labels, e.g. *post-positivism* and *constructivism* respectively (Robson, 2002: 26).

However, as Kuhn's (1971) idea of scientific revolutions predicted, this 'received view' of the social sciences and how scientific investigation should be conducted underwent a shift with the rise in popularity and use of qualitative methodology. Proponents of qualitative methodology argued that the 'received view' was misleading. Scott (2000) sums up the major criticism levelled at this 'received view'. He writes that:

> The ... criticism which has been made concerns the proposed relationship between epistemology and ontology ... the epistemological given is deemed to represent reality; that is, epistemology and ontology are conflated. What is given to our senses when our senses are cleansed of any notion of preconception, constitutes the world as it is. (Scott, 2000:12)

What has been suggested instead is a *fallibilist epistemology*[3], i.e. the idea that what is known about reality is uniquely constructed by each individual and that, therefore, there is no straightforward one-to-one ontological relationship between objects in the real world and what is known. This position later became known as *constructivism.* Henwood (1997) describes it thus:

> Researchers construct versions of the world through their activities as social and political subjects, and do not merely reflect facts with a self-evident objective reality. (Henwood, 1997: 27)

[3] Others attach different labels to the *absolutist* and *fallibilist* epistemologies. For instance, Smith (1984) refers to them as the *realist* and *idealist* epistemologies respectively. Scott (2000) refers to them as *naïve realism* and *radical relativism* respectively.

Increasingly, social science researchers have paid little heed to these apparently antagonistic philosophical, ideological, and epistemological differences between the two traditions and proposed the alternative, technical standpoint on this debate. They simply viewed the methods from the different traditions as differing research techniques whose differing advantages in certain contexts could be used to complement one another in an attempt to gain a fuller insight or answer to some research question (Bryman, 1988; Brewer and Hunter, 1989; Datta, 1994; Hammersley, 1997; Tashakkori and Teddlie, 1998). Consequently, more and more research studies saw quantitative and qualitative methods as simply approaches to be used and so attempted to combine both types of research methods in an effort to study the social world. Walker seems to adopt such a stance when he writes that '... certain questions cannot be answered by quantitative methods, while others cannot be answered by qualitative ones' (Walker, 1985: 16). Figure 2.1.1 below shows a schematic view of this epistemological versus technical debate.

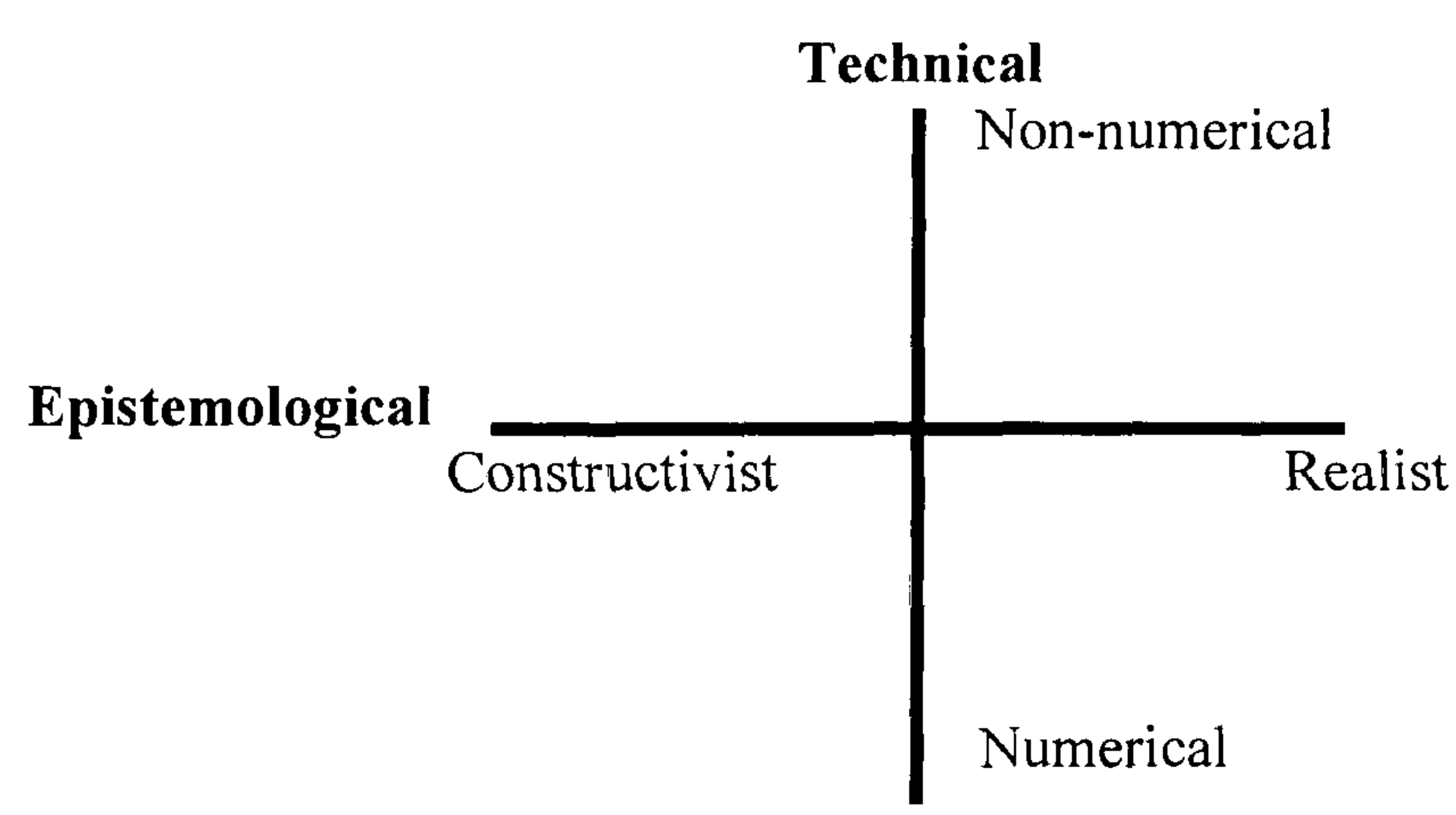

Fig 2.1.1 Technical and epistemological versions of the quantity-quality debate (after Bryman, 1988)

If we view the quantitative - qualitative debate as a technical one rather than an epistemological one then it is entirely possible to combine research methods from the different traditions. Research methods then simply become a set of tools; we simply choose the best tool for the job at hand. Bryman seems to agree with this approach when he writes that:

> ... methods are probably much more autonomous than many commentators (particularly those who espouse the epistemological versions of the debate) acknowledge. (Bryman, 1988: 12)

Brewer and Hunter (1989), Datta (1994), Hammersley (1997), and Tashakkori and Teddlie (1998) have all argued that the paradigm view is unhelpful. Hammersley (1997) states his view like this:

> ...it is misleading in its portrayal of the options available to researchers: it implies that we are faced with two homogenous traditions that are internally coherent and based upon opposed philosophical views. In fact, there is a considerable range and variety of techniques for data collection and analysis ... in the social sciences; and there is no fixed relationship between particular philosophical views and the use of particular methods ... We need to recognise the diversity of methodological options available and to note that these arise not just from differences in philosophical views but also from variations in substantive theoretical ideas and in practical goals. (Hammersley, 1997: 167)

However, my own stance on this matter, which results, to a large extent, in my choice of methods, considers both the technical and the epistemological arguments outlined above. I cannot accept the *absolutist epistemology* assumed by the quantitative/realist tradition but neither can I bring myself to abandon its scientific approach and all that that implies and become a fully fledged relativist/constructivist. Consequently, I cannot help but find myself agreeing with Karen Henwood's view on the way in which a researcher's methodology is formed. She writes that:

> ... all discussions of methodology in the human and social sciences ... are influenced by the esteem afforded to detachment, objectivity and rationality – the guiding principles of Western science. (Henwood, 1997: 26)

My choice of research methods then were predicated on the above rationale and reflected to a large degree the pragmatic approach of *critical realism* espoused by writers such as Bhaskar (1986; 1989), Pawson and Tilley (1997), and Sayer (2000). Robson (2002) describes *critical realism* as:

> A way forward, acknowledging that positivism has been discredited but avoiding the divorce from science implied by a thoroughgoing relativist approach. It seeks to achieve a détente between the different paradigms of the post-positivist approach within the empirical tradition on the one hand, and less thoroughgoing versions of relativism found in some constructionist approaches on the other. (Robson, 2002: 42/3)

This methodologically eclectic, pragmatic approach is what Reason and Rowan (1994) call being 'objectively subjective' (Reason and Rowan, 1994: xiii). Such an approach also has the added advantage of reflecting what actually happens in practice when much research is conducted. That is, few researchers seem to base their choice of methods on any *a priori* philosophical commitment. Hammersley (1997: 168) believes this to be a mistaken view and sees it as '... a form of linear rationality', where researchers first decide on their philosophical stance and then choose their methods of research accordingly. Rather, we tend to pick up our methodological allegiances and any philosophical predilections from those significant others working with us and around us and usually at the same time (Hammersley, 1997). This is not to suggest that I have merely dismissed the philosophical assumptions of my chosen methods, I have not. It is important to remember that, whilst supporting a methodological eclecticism and adopting this pragmatic approach, I have done so with the philosophical assumptions of each method very much in mind.

A note of caution is necessary at this point. Although this research employs a postal survey using a sample of primary teachers of mathematics, the research is viewed as very much inductive, and therefore, exploratory in nature. That is, even though I have attempted to reduce sources of error in Phase I of the research and show that the sample drawn is broadly representative of the larger population it was never my primary intention to generalise the findings from the sample to any wider theoretical settings. Rather, I simply hoped to add something useful to the debate on the theory of teachers' epistemologies and the findings should be viewed in that light.

Phase I

Figure 2.2.2 below shows a diagrammatic timeline of the research. The aims of Phase I of the research were twofold. Firstly, a postal questionnaire was designed to survey the beliefs of a wide range of primary teachers about the teaching and learning of mathematics in their classrooms. Secondly, it was hoped that the survey

Timeline for Phases of the Research

Timeline	Phase I	Phase II	Phase III
Jan' 2004	Begin literature search Contact gatekeepers at LEA		
May 2004	Begin survey construction and piloting process		
Jan' 2005	Send out surveys and monitor returns		
Mar' 2005	Send reminders		
Apr' 2005	Close survey and begin analysis		
May 2005		Contact teachers in schools to arrange observations & interviews	
Sep' 2005		Begin 5 semi-structured, non-participant observations per teacher	Semi-structured interviews follow each observation
		Tentative analysis begins	Tentative analysis begins
			Interview transcripts sent to teachers for respondent validation
Mar' 2006		End observations	End interviews
Jun' 2006		Analysis Continues	Analysis Continues
			Complete write-up of findings

Fig 2.2.2 Proposed timeline of research.

results would help in the identification of a number of teachers willing to participate in classroom observations and interviews in Phase II and III of the research. Chapter 3 and Chapter 4 outline in detail these phases of the research in more detail. (See *Chapter 3: Phase I - The Survey* and *Chapter 4: Phase II - The Case Study Observations*).

Part of the questionnaire was adapted from the Epistemic Belief Inventory (EBI) developed by Bendixen, Schraw and Dunkle (1998) and Schraw, Bendixen and Dunkle (2002) (See *Appendix A* for the final draft of the questionnaire). The EBI is a thirty-two item, five-point, Likert-type scaled questionnaire and was designed to elicit teachers' beliefs about knowledge. It offers respondents simple statements with which they are asked to indicate the extent of their agreement or disagreement. The thirty-two item inventory consists of a number of epistemological belief sub-scales but following the approach adopted by Schraw and Olafson (2002) only three of the available scales were thought pertinent to this research; *the simple knowledge sub-scale*, *the certain knowledge sub-scale*, and *the omniscient knowledge sub-scale*.

Although no pencil-and-paper test alone could hope to adequately measure teachers' beliefs about the teaching and learning of mathematics, the Epistemic Belief Inventory has been shown to be useful in combination with other approaches (Schraw, Bendixen, and Dunkle, 2002). It has also been shown to have better predictive validity and better test-retest reliability than scales previously devised to measure the same constructs, e.g. the Epistemological Questionnaire devised by Schommer (1990) (ibid).

See *Chapter 3: Phase I - The Survey* for a more detailed discussion of the EBI as an appropriate measure of primary teachers' epistemological beliefs.

Phase II

Scheffler (1965) defined beliefs as merely predispositions to act in a certain way. This implies that what teachers think, and therefore, say they do in the classroom is not always consistent with what they *actually* do in the classroom. Research studies by Galton, Simon, and Croll (1980), Hanson (1980), Berliner, (1989), McNamara, (1990), Cohen, (1990), Louden (1992); Calderhead, (1996a); Putnam and Borko (2000), Schraw and Olafson (2002), Schoenfeld (2002), and Speer (2005) have all shown that teacher behaviour is not always consistent with their previously stated beliefs. Consequently, Phase II of the research set out to explore the extent to which teachers' rhetoric in the form of their 'professed' beliefs, as measured by the EPI in Phase I, matched reality by investigating the relationships between primary teachers' views concerning the teaching and learning of mathematics and their classroom pedagogy. It did so by adopting a case study approach with the intention of using semi-structured non-participant classroom observations.

Findings from Phase I showed that, *inter alia*, some primary teachers of mathematics hold different, sometimes polarised epistemological world views concerning the teaching and learning of mathematics. Phase II of the research initially intended to purposively select for observation teachers with polarised world views concerning the teaching and learning of mathematics. However, of the twelve teachers that volunteered their time for Phase II and III of the research by adding their names to *Phase I* questionnaires only two (the teachers I have called John and

Lisa) were quick to reply to my initial attempt to contact them in May 2005 (*See Appendix P* for this initial email). Given the time constraints on the research timeline and the fact that teachers were very soon to enter the summer break it was felt necessary to select these teachers and put in place some organisation for September of the same year where *Phase II* and *III* of the research could continue quickly and without any further delay. One other teacher (I have called her Mary) had been introduced to me much earlier in the research process as an experienced teacher who was willing to consider being involved in research into primary mathematics. Consequently, the three teachers involved in Phase II and III were largely self-selected. However, a subsequent analysis of the Phase I questionnaire responses from the two primary teachers involved in Phase II and III of the research showed that that they held somewhat different (although not polarised) world views concerning the teaching and learning of mathematics (See the teacher biographies in *Chapter 4: Phase II - The Case Study Observations.*

Two of the three teachers requested, via email, some further information concerning what their continued participation would involve. Consequently, further details were sent to all three teachers, via email, outlining the methods involved, their involvement in those methods, the likely timescale, and the need for them to gain the permission of their head teacher (See *Appendix P* for a copy of this second email). The primary concern was to obtain the agreement of the three teachers and their respective head teachers for the teacher's participation in approximately four or five observations of their teaching of mathematics lessons during the six-month period between September/October 2005 and March 2006.

The semi-structured observation schedule was piloted through several cycles of improvement (See *Appendices R* and *S* for the first and second drafts respectively). However, I was still not happy with the behavioural categories and so decided to pilot its use in the very first observation I conducted, in mid-October 2005. This first use of the schedule only confirmed my suspicions that it failed to capture many of the complexities of the classroom behaviour I observed. I subsequently decided to abandon the structured schedule in favour of taking detailed field notes. This decision to adopt a much more unstructured approach to classroom observations by taking field notes was taken in the hope that this would capture more of the rich and complex type of behaviour I saw in that first observation. The process that led to this decision is discussed in more detail in *Chapter 4: Phase II - The Case Study Observations.*

I also gathered other contextual information thought relevant to the research. For instance, I asked teachers for the lesson plans and details of the resources they used in the lessons I observed. I also noted details about the classrooms and the number and gender mix of pupils in each class.

Phase III

Following observations of their classroom practice the primary teachers selected for Phase II were interviewed using a semi-structured approach. The exact questions asked of each teacher were similar across the four interviews but varied across teachers within individual interviews. That is, the questions asked depended to some extent on what was observed in the preceding lesson. Interviews involved questions presented in an informal style but which attempted to probe teachers' epistemological world views in two ways: by directly asking questions about specific teaching and learning issues that would reveal insights into their epistemological world view and by asking questions concerning specific instances of teaching just observed. This latter approach took the form of the stimulated recall procedure to probe their thinking concerning the chosen aspects of their teaching (Calderhead, 1981). The field notes taken during classroom observations were used in interviews with primary teachers in an attempt to elicit, *inter alia*, the rationale behind some of their pedagogic decisions. A triangulation process on the meaning and interpretation of words in these sessions was used in an attempt to develop a shared vocabulary with all teachers (Schoenfeld, 2002; Speer, 2005). This was done in an attempt to avoid the criticism raised by some in the field recently that the discrepancies found in some research between the teacher's rhetoric and practice may be the result of inadequacies in the methodology employed, and specifically the lack of shared understandings among researchers and teachers, rather than a true reflection of the phenomenon under investigation (Speer, 2005).

Interviews were transcribed and sent to the relevant teacher before any real analysis was begun (See *Appendix O* for the letter used in the respondent validation process). This served several purposes. Firstly, to obtain a degree of respondent validation from the teacher. Secondly, to inform my own thoughts and ideas for subsequent observations and interviews in line with the chosen method employed during this Phase of the research. And lastly, I felt it was important to try to contribute in some way to the continuing professional development of the teachers concerned. That is, I hoped that the discussions I had with teachers would help them to gain some deeper insight into their epistemological world view of the teaching and learning of mathematics or at least some of the individual epistemological beliefs that constituted their largely unknown epistemological world view. In this respect Sieber (1998) states that 'the benefits of research include its educational or therapeutic value for participants.' (Sieber, 1998: 134).

Transcripts of interviews were analysed using the constant comparison method associated with grounded theory (Glaser and Strauss, 1967). The term 'grounded theory' was coined by Glaser and Strauss (1967) to express their new idea of theory that is inductively generated by, or that emerges out of, data gained from qualitative methods gathered from concrete settings rather than theory preceding the data gathering process (Pidgeon, 1997). The constant comparison method leads to a 'fracturing' and rearranging of the data into categories that facilitate comparison between things in the same category or between categories (Maxwell, 1998).

See *Chapter 4: Phase II - The Case Study Observations* for a more detailed discussion of grounded theory in general and the constant comparison method in particular.

2.2 Sampling Methods

The limited resources of time and money available to a part-time research student in full-time employment, as well as the well-documented problems of gaining access to busy teachers in busy schools, meant that all samples used in this research were non-probability samples. Henry (1998) describes non-probability sampling as:

> ... actually comprising a collection of sampling approaches that have the distinguishing characteristic that subjective judgements play a role in sample selection. (Henry, 1998: 104)

Moreover, the different phases of the research involved different non-probability sampling techniques. Phase I of the research attempted to access *all* primary teachers of Key Stage 2 mathematics in one chosen Local Education Authority (LEA) in the north east of England. To this end and because I was unable to identify the exact number of relevant teachers working in each school, four questionnaires were dispatched to every head teacher of the seventy-one primary schools in the chosen LEA. Participation in this stage of the research relied on the goodwill of head teachers in passing on the questionnaires to the relevant teachers in their school and also on the classroom teachers themselves voluntarily completing and returning their questionnaires (self-addressed, prepaid envelopes were provided).

Phase II and III of the research initially intended to purposively select for observation teachers with polarised world views concerning the teaching and learning of mathematics. However, constraints of time meant that the three involved were eventually self-selected.

However, sampling was not limited simply to participating teachers but followed, as closely as was practicably possible, the more comprehensive 'naturalistic sampling' described by Ball (1990:102). Ball describes naturalistic sampling as covering places and times as well as people. Consequently, the eventual sample of primary teachers involved in Phase I of the research included those of different gender, age, ethnicity, length of service, year group taught and type of school. Moreover, those teachers included in Phase II and III sample were observed and interviewed on different days and at different times of the day. It is hoped that this allowed, as far as was possible given the constraints of the research, a more representative and holistic sample of views and behaviours of primary teachers of mathematics. One obvious limitation to this approach however was that, due to the constraints referred to above, all participating teachers were recruited from one Local Education Authority (LEA) in the north east of England. However, a comparative analysis of the demographics of the primary teaching sample gathered from this LEA with known demographics of the primary teaching population nationally suggested that the sample was broadly representative (See *Chapter 3: Phase I - The Survey* for a detailed discussion of this comparative analysis).

2.3 Data Analyses

The type of analysis chosen differed in each phase of research. These are outlined briefly below but covered in more detail in subsequent chapters.

Phase I

Much of the data from the Phase I questionnaire were quantitative. Consequently, the data were manually entered into one of the computer software package for the Windows operating system that allows the user to enter, store, and analyse large amounts of quantitative data. The Statistical Package for the Social Sciences (SPSS) Version 11 was the computer package chosen for this purpose.

The data from Phase I underwent two different types of analysis; an exploratory data analysis (EDA) and a confirmatory data analysis (CDA). Robson describes exploratory data analysis as a process that 'explores the data, trying to find out what they tell you' and confirmatory data analysis as a process that ' seeks to establish whether you have actually got what you expected to find' (Robson, 2002: 399). The former fits perfectly with the exploratory nature of the research but the latter is more problematic. However, I viewed the confirmatory data analysis not as a deductive testing of hypotheses but more of an inductive uncovering of theory by confirming or otherwise some of the research questions listed in Chapter One.

The exploratory data analysis served two purposes. The first was to check the available data for response errors, i.e. errors originating either from the teacher respondents themselves or from the process of inputting the data into the statistical computer package SPSS. The second was to give some estimate of the representativeness of the sample gathered to the population from which it came. This involved a comparative analysis of the demographics of the primary teaching sample with the known demographics of the primary teaching population nationally using the Chi-square Goodness of Fit test. This test was used to test whether or not the observed sample data differed significantly from that which should be expected given the proportions that exist in the population.

The principle aim of the confirmatory data analysis was to explore any statistical differences and relationships between teacher characteristics amenable to this type of analysis, the three epistemological belief sub-scales (simple knowledge, certain knowledge, and omniscient authority knowledge) and the two epistemological world views (realist and relativist).

See *Chapter 3: Phase I – The Survey* for a detailed account of the data analysis and results from Phase I of the research)

Phase II

In Phase II of the research the analysis of the classroom observations was intended to be a combination of quantitative and qualitative. For instance, the quantitative analysis was meant to focus on the structured aspect of the semi-structured observation schedule. However, after the decision was made to abandon the semi-structured observation schedule in favour of field notes the analysis of all data during this stage of the research was exclusively qualitative. The qualitative analysis took the form of identifying emerging categories or themes from field notes from different individual observations using the constant comparison method associated with grounded theory (Glaser and Strauss, 1967). The term 'grounded theory' was coined by Glaser and Strauss (1967) to express their new idea of theory that is generated by, or that emerges out of, data gained from qualitative data gathered from concrete settings (Pidgeon, 1997). It is an iterative process that continually moves between data gathering and data analysis, and back again, where the findings from each stage inform the decisions taken in the next stage. As such, the grounded theory approach was perfectly suited to this Phase of the research because it was always envisaged that this phase would be lengthy and involve a repetitive process of moving between data gathering and data analysis.

See *Chapter 4: Phase II - The Case Study Observations* for a more detailed discussion of the method used in this phase of the research.

Phase III

In Phase III of the research all interviews with teachers were transcribed and sent to the relevant teacher for respondent validation. This process involved sending the transcript out to the relevant teacher with a request to confirm or otherwise that it represented a fair and accurate account of the conversation as they remembered it. The letter also offered the teacher the opportunity to delete any sections of the transcription that they felt uncomfortable with or with which they would feel uncomfortable with me reproducing in quotation form (See *Appendix O* for a copy of the letter used in the respondent validation process).

Although some tentative analysis of the transcripts began immediately after the interviews had been transcribed, in line with the principles of grounded theory, this was only further developed and confirmed after the transcripts were validated and received back from teachers. Transcripts of interviews were analysed using the constant comparison method discussed above (Glaser and Strauss, 1967). See *Chapter 4: Phase II - The Case Study Observations* for a more detailed discussion of grounded theory in general and the constant comparison method in particular.

2.4 Ethics and Rigour

An important aspect of my work was a commitment to engage in ethically responsible research and every attempt was made to conform and uphold the ethical guidelines laid down by the British Educational Research Association (BERA, 1992). BERA was founded in 1974 and although membership is not compulsory for educational researchers it is now widely held to be the premier learned society for educational research and educational researchers in the UK.

The BERA guidelines set out the responsibility that educational researchers have for the research profession and for the participants that make up the research. Their guidelines state that as a society it believes that:

> All educational research should be conducted within an ethic of respect for persons, respect for knowledge, respect for democratic values, and respect for the quality of educational research. (BERA, 1992: Guideline 1)

This section discusses some of the steps taken to ensure that the BERA guidelines were met.

BERA guideline number 7 outlines the need for researchers to gain the informed consent of all participants involved in the research. In order to achieve this I followed the advice of Sieber (1992; 1998), who talks of *voluntary informed consent* where the word voluntary means without threat or undue inducement. She outlines what this involves in practical terms:

> The consent statement should explain the research to be undertaken and should fulfil legal requirements. It should be simple and friendly in tone, and should translate a scientific proposal into simple, everyday language, omitting details that are unimportant to the subjects, but including details that are important to them. (Sieber, 1998: 130)

Although I had already obtained permission from a senior member of staff from the Local Education Authority concerned to contact teachers in schools, at all subsequent stages of my research, teachers (and their respective head teachers) were reminded of the voluntary nature of their participation and given full details of what was involved for them individually and for their school if they did agree to participate. For example, in Phase I, teacher questionnaires were sent to class teachers via their respective head teacher with an explanatory covering letter (See *Appendix F* for covering letter to head teachers). This served several purposes; to inform head teachers that permission had been granted from their governing LEA, to assure them of the steps taken to assure confidentiality and anonymity, and to enlist their *active* co-operation in distributing the questionnaires to relevant teachers in their school. The teacher questionnaire too was prefaced by an explanatory covering letter that set out similar points (See *Appendix A* for covering letter to teachers).

In Phase II and III of the research, participating teachers were reminded of the voluntary nature of their participation, given details of what was involved for them and their schools, and their right to withdraw at any time (See *Appendix P*). In addition to this, at the very first observation session with each teacher an informed voluntary consent form was presented which again outlined these issues. Each teacher was asked to sign a copy as a way of agreeing to participate but assured that it did not represent a binding contract (See *Appendix Q* for voluntary informed consent form). I felt this approach to the research was important in itself but it also adhered to two other ethical guidelines set out by BERA;

> Honesty and openness should characterize the relationship between researchers, participants and institutional representatives. And, participants have the right to withdraw from a study at any time (BERA, 1992: Guidelines 9 and 10).

Sieber (1998) warns of a potential risk of not adopting this two-way communication with research participants:

> Voluntary informed consent is not simply a consent form. It goes beyond the statement that is prepared and administered in the so-called consent procedure. It is an ongoing, two-way communication process between research participants and the investigator, as well as a specific agreement about the conditions of the research participant. Often, questions and concerns occur to the participants only after the research is well under way. Sometimes it is only then that meaningful communication and informed consent can occur. If the researcher is not open to continuing two-way communication, participants may become uncooperative and drop out of the study. (Sieber, 1998: 130)

I initially also intended to gain the informed consent of the parents of school children involved in classroom observations. The BERA guidelines suggest that:

> Care should be taken when interviewing children and students up to school leaving age; permission should be obtained from the school, and if they so suggest, the parents (BERA, 1992: Guideline 8)

Although the research did not require any interviews with the children the possible need to obtain the voluntary informed consent of children's parents was discussed with all three teachers and their head teachers very early on in the research and before any observations had begun. However, after teachers discussed the matter with their respective head teachers, it was felt not to be necessary. There were several reasons for this decision. Firstly, in the current climate of accountability it was felt that children, and therefore parents, were used to observers being present in classrooms and that special consent for my presence was not required given that I had already gained permission from a senior member of staff in the LEA. Secondly, the research did not involve direct discussions with children or the necessity to be alone with children. I also informed teachers and head teachers of participating schools that I had recently undergone the Criminal Record Bureau's (CRB) police checks into my background that is now a necessary requirement for all individuals (including teachers themselves) seeking to work with children (See *Appendix N* for a copy of the letter from the CRB).

In pursuit of methodological rigour, I also adopted a reflexive approach at all stages of the research. That is, although researchers involved in using more quantitative research methods traditionally attempt to minimise the effects of the researcher on the researched there was no attempt in this research to ignore completely these inevitable effects (See *Section 2.1 Overview of the Research Process* in this chapter for the rational for my chosen methodology). On the contrary, I acknowledged that such effects can never be completely eliminated and that the best policy is to accept that they are an inevitable part of the research process, and I attempted to understand them as such. Researchers are part and parcel of the social world of which the researched is also part. Consequently, it was thought futile to attempt to break free from the social world in order to study it. This reflexive approach began before the research started and continued throughout the research process and throughout the write-up of the research findings. Consequently, a continuous process of reflection on all aspects of the research was adopted. Hopefully this approach resulted in a piece of research with minimal reactivity and maximum plausibility and validity/credibility (Hammersley, 1990).

Of course, reflexivity alone is not sufficient to ensure internal and external validity. Internal validity is determined by both a reflection on the extent to which any distortion occurred in the process of the research itself, and the researcher's part in that distortion, and the careful choice of who is being researched so that they are roughly representative of the bigger population from which they come. External validity is the extent to which the research findings can be generalised to similar individuals in similar situations and contexts. However, the scope and exploratory nature of this research means that it will not be possible to substantiate any claims of either generalisability or cause and effect but it is hoped that such a reflexive approach to the research process will hopefully go some way to gain a better insight into the beliefs and pedagogy of primary teachers of mathematics and the relationships that may exist between the two.

Conclusions

This chapter has set out both the objectives of the research and the rationale for the multi-phase, multi-method, pragmatic methodology employed. The following chapters outline in more detail all aspects of the research process involved in each of the three research phases. These include a justification of the method employed in each phase as well as a critical discussion of the results found.

Chapter 3: Phase I - The Survey

The best way to get a good idea is to get a lot of ideas.
(Pauling, 1985)

Consistent with the exploratory nature of the research, the primary aim of Phase I was to design a postal questionnaire to survey a wide range of primary teachers' epistemological beliefs about the teaching and learning of mathematics in their classrooms. As the quote above is meant to suggest, this approach represented a way of 'testing the ground' on a wide variety of teachers' epistemological beliefs before narrowing down the investigation in Phase II and Phase III.

It was also hoped that the survey results from Phase I would help in the identification of several teachers willing to participate in classroom observations and interviews in Phase II and III of the research. These teachers were to be identified by their diverse ways of conceptualising the learning and teaching of primary mathematics. That is, it was hoped that the survey would provide the researcher with mathematics teachers who held polarised epistemological world views. This chapter outlines a justification of the rationale for the choice of the survey method, a description of the survey design and implementation, and a critical discussion of the results.

3.1 The Survey Method

Cohen and Manion (1985) describe the survey technique as 'perhaps the most commonly used descriptive method in educational research...' (Cohen and Manion, 1985: 94), and a way of gathering data at:

> ... a particular point in time with the intention of (a) describing the nature of existing conditions, or (b) identifying standards against which existing conditions can be compared, or (c) determining the relationship that exists between specific events. (ibid)

Lynn (2004: 575) defines the survey as '... the scientific collection and analysis of quantitative information regarding a sample from a population.'

There were three main reasons why a postal questionnaire was chosen as the method of gathering data in Phase I of the research. These were:

1. It was the most time-efficient way of gathering information about and from a large set of people;
2. It was also the most cost-effective way in that it provided large amounts of data for a relatively low cost; and
3. The method also insulates respondents from the researcher's expectancies (Mangione, 1998) and allows participants to remain anonymous if they wish. These characteristics can only encourage both the numbers responding and the frankness with which they respond (adapted from Robson, 2002).

Robson proffers the argument that some researchers view surveys as simply:

> ... generating large amounts of data often of dubious value. Falsely prestigious because of their quantitative nature, the findings are seen as a product of largely uninformed respondents whose answers owe more to some unknown mixture of politeness, boredom and a desire to be seen in a good light than to their true feelings, beliefs or behaviour. (Robson, 2002: 231)

Such a view represents more of a concern for internal validity than the survey instrument *per se*. My own view is that this argument represents a rather pessimistic outlook on what the survey method is able to achieve, especially when used in methodological triangulation with other techniques. Perhaps it is a view of the survey method used in isolation. Few would disagree with the view that when used alone the survey is weaker than when used in conjunction with other techniques. I would argue that survey instruments and internal validity are not mutually exclusive concepts provided that they are used in triangulation with other techniques and that some matters of detail are attended to. For instance, there are four potential sources of survey error that need to be addressed if the data gathered is to be relatively free from error and so provide confidence in the precision of any estimates produced (Groves, 1989; Henry, 1998). These four areas are concerned with:

- Coverage - this source of error springs from the failure to ensure that all the units in the defined population have a known and equal non-zero probability of being included in the drawn sample.
- Sampling - this is the error that is an inevitable product of surveying a sample rather than the whole population.

- Measurement - the result of inaccurate responses as a result of poorly constructed question items and/or questionnaire design.
- Non-response - the error that results in the data gathered if the people who failed to respond are different from those who do in some respect important for the research.

Any survey, if it is to be viewed with any sort of confidence, needs to include attempts to reduce all four sources of error. Dillman and Bowker (2000) sum up nicely these four sources of error when they write that:

> Unless all members of the population are given a known non-zero chance of being included in the survey, then a sample, no matter how large, cannot be said to represent them. The precision of any survey estimate, or sampling error, typically stated as plus or minus X percent, is based on the number of randomly sampled respondents who are surveyed. Yet, complete coverage, and a very large number of respondents, cannot substitute for poorly worded questions that result in inaccurate answers. Moreover, if respondents to a survey differ from non-respondents on the variable(s) of interest, then non-response error occurs and cannot be compensated for by "doing well" on the other three dimensions of survey error. (Dillman and Bowker, 2000: 159)

Coverage and sampling error were to a certain degree unknown quantities. All primary schools within the LEA boundary were included in the survey. That is, all seventy-one primary schools received four questionnaires. Seventy-five primary teachers responded which represents a response rate of just over twenty-six per cent of the questionnaires dispatched. However, the sampling units were not primary schools but primary teachers and I could not be certain that all units had an equal chance of seeing and responding to the questionnaire. It is entirely possible that the response rate is much higher than the twenty-six per cent reported here. In fact, an analysis of the number of schools from which teachers returned questionnaires indicated a forty-eight per cent response rate. The potential source of measurement error was addressed by a careful and thorough process of testing and piloting both the question design (Fowler, 2002) and the survey instrument before it was dispatched (Mangione, 2002). See Section *3.2 Survey Design and Implementation* below for more details.

Surveys generally are associated with problems of non-response but this is true more so for the postal survey. However, my research was very much exploratory in nature and my primary intention in using a postal survey was never to attempt to produce research that was characterised by a high degree of external validity, i.e. that the results should be generalisable to wider theoretical contexts. However, in the interests of producing research that had a high degree of *internal* validity and rigour I did set out to attempt to address these four sources of error, and the ways in which I did so are discussed in the next section. Although the research was exploratory in nature a comparative analysis was still performed. That is, an analysis was conducted to check the extent of the similarity or difference between the personal characteristics (demographics) of the sample of primary teachers and the known characteristics of the primary teaching population in England (from official government statistics). This analysis suggested that the two were broadly similar on all but one demographic characteristic (See *Data Analysis* section in this Chapter for more details on this comparative analysis).

In addition to the problems discussed above there was another that needed to be addressed; the problem of what teachers say they believe or do is not always what they *actually* believe or do. This problem is discussed in more detail in *Chapter 5: Phase III – The Interviews.* Moreover, the use of methodological triangulation mitigates against many of these problems. For instance, using multiple methods can lead to corroboration of findings from the different methods and therefore a greater confidence in the findings and conclusions drawn. The use of observational techniques along side a postal survey also allows for verification of whether teachers 'practice what they preach'.

3.2 Survey Design and Implementation

Each step in the design and implementation of the postal survey proceeded through a careful, thorough, tried and tested process of testing and piloting (See Figure 3.2.1). The main stages in this process will be discussed in the sections that follow.

The Questionnaire

The questionnaire itself (See *Appendix A* for the final draft) comprised four main sections. The first section comprised a short, one-page, detachable covering letter setting out for the teacher the aims of the questionnaire, its importance in broader educational terms, and assurances concerning the confidentiality of any information they supplied.

The second section requested personal information concerning the teacher's demographics and information concerning their school. This type of demographic data is essential if subsequent data analyses require the comparison of the responses from different subgroups of the sample to be conducted. Information on such concepts as age, sex, type of degree held, specialist v generalist, route into teaching, etc. can split the sample into interesting subgroups and act like independent variables across which the subgroups can be compared.

The third section of the questionnaire was adapted from the work of Schraw, Bendixen and Dunkle (2002) and their Epistemic Belief Inventory. This thirty-two item, five-point, Likert-type scaled questionnaire is designed to elicit teachers' beliefs about knowledge. It offers respondents simple statements with which they are asked to indicate the extent of their agreement or disagreement (1-*strongly disagree*, 2-*disagree*, 3-*neutral*, 4-*agree*, 5-*strongly agree*). The inventory consists of a number of sub-scales but following the approach adopted by Schraw and Olafson (2002) only the following were used in subsequent analyses; *the simple knowledge sub-scale*, *the certain knowledge sub-scale*, and *the omniscient knowledge sub-scale*.

The *simple knowledge sub-scale* measures teachers' beliefs about the relative complexity of knowledge, i.e. the extent of the belief that knowledge is comprised of discrete facts. This sub-scale is comprised of seven items; 1, 10, 11, 13, 18, 22, and 24*[1] and so is scored out of a total of thirty-five with a high score indicating a belief in simple knowledge. The *certain knowledge sub-scale* measures teachers' beliefs about the relative certainty of knowledge, i.e. the extent of the belief that absolute knowledge exists independently of the knower and will eventually be known. This sub-scale is comprised of six items; 2*, 14*, 19, 23, 25*, and 31* and so is scored out of a total of thirty with a high score indicating a belief in certain knowledge. The *omniscient sub-scale* measures teachers' beliefs about the extent to which knowledge emanates from authoritative sources, i.e. the extent of the belief that those in authority have access to otherwise inaccessible knowledge. This sub-scale is comprised of four items; 4, 7, 27, and 28 and so is scored out of a total of twenty with a high score indicating a belief in omniscient authority knowledge.

[1] Items marked * are reverse scored.

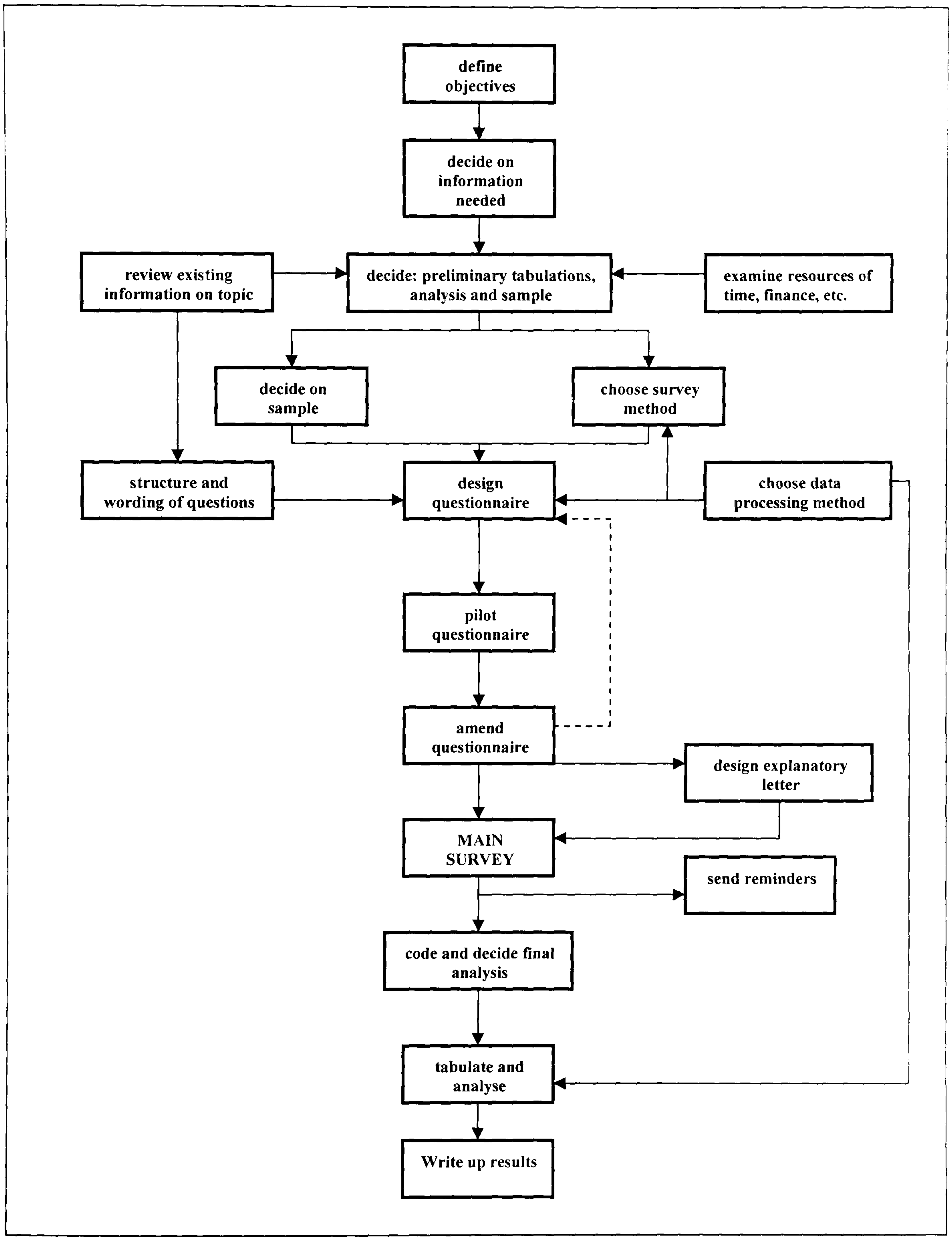

Figure 3.2.1 Stages in the planning of the questionnaire (adapted from Davidson, cited in Cohen and Manion, 1985: 95)

Past research has suggested that a more sophisticated epistemological world view, i.e. a relativist world view, which was linked with constructivism in Chapter One, is associated with beliefs in complex rather than simple knowledge, changing rather than certain knowledge, and internally-generated rather than externally-generated knowledge (Schraw and Olafson, 2002, Hofer, 2000; Kuhn, Cheney, and Weinstock, 2000).

A factor analysis of the EBI by Bendixen, Schraw and Dunkle in 1998 revealed evidence to indicate that the EBI has five factors which were closely linked to Schommer's (1990) five epistemic beliefs discussed earlier and of which simple knowledge, certain knowledge, and omniscient authority knowledge are three. More recent work by Schraw, Bendixen and Dunkle (2002) has shown these three epistemological belief sub-scales to have more than moderate levels of internal reliability as measured by Cronbach alpha (α) scores and external reliability as measured by test-retest correlation coefficients. The degree of both internal and external reliability is measured by correlation coefficients where a correlational coefficent of 0.8 is traditionally accepted as a good indicator of high reliability (Anastasi, 1982; Bryman and Cramer, 2001; Pallant, 2001).

Internal reliability is a measure of whether a questionnaire or each sub-scale of a questionnaire is measuring a single construct and Cronbach alpha (α) is the measure most commonly used. It is a particularly important measure for any questionnaire that purports to measure several dimensions or sub-scales (Peers, 1996; Bryman and Cramer, 2001). Bryman and Cramer (2001) explain it thus:

> When a concept and its associated measure are deemed to comprise underlying dimensions, it is normal to calculate reliability estimates for each of the constituent dimensions rather than for the measure as a whole. Indeed, if a factor analysis confirms that a measure comprises a number of dimensions the overall scale will probably exhibit a low level of internal reliability ... (Bryman and Cramer, 2001: 63)

Schraw, Bendixen and Dunkle (2002) reported Cronbach alpha (α) scores of 0.62, 0.62, and 0.68 for the simple knowledge sub-scale, the certain knowledge sub-scale, and the omniscient authority knowledge sub-scale respectively (just below the traditionally accepted 0.8)[2]. Their research included one hundred and sixty participants which makes even the lowest coefficient of 0.62 highly significant.

External reliability is a measure of the degree of consistency of the questionnaire or sub-scale over time and is most commonly assessed using the test-retest procedure. Schraw, Bendixen and Dunkle (2002) reported test-retest correlation coefficients after a one-month period of 0.64, 0.81, and 0.66 for the simple knowledge sub-scale, the certain knowledge sub-scale, and the omniscient authority knowledge sub-scale respectively. These scores suggest the EBI to be more than moderately reliable.

The same research also reported that the EBI has better predictive validity than scales previously devised to measure the same constructs, e.g. the Epistemological Questionnaire devised by Schommer (1990). From this research Schraw, Bendixen and Dunkle (2002) went on to argue that:

[2] Peers (1996) suggests a lower coefficient of 0.7 as a good indicator of reliability.

> It is unclear how well any paper-and-pencil instrument will measure epistemic beliefs … [and suggest that future research] … should examine in much greater detail the relationship among self-related epistemic beliefs [and] epistemic beliefs measured through in-depth verbal interviews (Schraw, Bendixen and Dunkle; 2002: 272/3).

What they appear to be arguing for is a test of the consistency or reliability of teachers' epistemological beliefs via a number of methods. The advantage of the research reported here is that it uses a self-report questionnaire and semi-structured interviews (as well as semi-structured classroom observations) as part of the technique of methodological triangulation and in so doing mitigates against the inherent weaknesses of any one particular method (See *Chapter 2 Methodological Overview: In Support of Eclecticism* for a discussion of the methods used within the triangulation process in this research).

A search of the literature revealed few criticisms of the EBI. However, Hofer (2002), someone that is prominent in the field of personal epistemology, has identified one problem in particular with the EBI. She views as problematic the issue of measuring a construct by a lack of agreement with its opposite. That is, she argues, the simple knowledge sub-scale purports to measure teachers' beliefs about the relative complexity of knowledge but does so by using items that refer to simplicity. She asks '… can we accept that complexity is the same thing as the rejection of simplicity?' She goes on to add that:

> As someone who has also laboured with colleagues to develop a similar instrument, I am more than sympathetic with the difficulties inherent in this work. We are in need of better and more precise ways of measuring epistemological thinking with written instruments, and need to continue to provide one another with feedback about this developmental work (Hofer, 2002: 170).

My personal belief is that the answer to the limitations of such pencil-and-paper instruments lies not just in the further development of the pencil-and-paper measuring instruments themselves but also in the use of complementary methods of gathering data on the same construct via the process of methodological triangulation, as discussed above.

The fourth and final section of the questionnaire requested teachers to read brief summaries or *vignettes* of two epistemological world views held by two fictional teachers. These world views represent the *realist* and *relativist* epistemological world views used in Schraw and Olafson's (2002) research discussed earlier, and they relate closely to a *behaviouristic* and *constructivist* view of teaching and learning respectively. Teachers were asked to indicate the extent to which they agreed or disagreed with each one using a five point scale ranging from strongly disagree to strongly agree. Following Schraw and Olafson (2002), the summaries of the epistemological world views were labelled *Fictional View 1* and *Fictional View 2* so as not to bias teachers' responses by producing socially desirable answers.

Piloting the Questionnaire

As a way of addressing the potential source of measurement error discussed above a careful and thorough process of designing and piloting of the survey instrument was undertaken before it was dispatched to schools. This time spent on design and piloting represented a concerted effort to perfect the questionnaire as an instrument and to meet the criteria set out by Cohen and Manion (1985) for the ideal questionnaire. They state that the ideal questionnaire is:

> … clear, unambiguous and uniformly workable. Its design must minimise potential errors from respondents … and coders. And since people's participation in surveys is voluntary, a questionnaire has to help in engaging their interest, encouraging their co-operation, and eliciting answers as close as possible to the truth. (Cohen and Manion, 1985: 103)

Consequently, the questionnaire progressed through several drafts during the pilot stage. My contact at the LEA who had previously given permission for me to approach primary school teachers requested sight of the initial covering letter. However, he made no suggestions for possible improvement to the questionnaire itself.

An initial draft of the complete questionnaire document was then presented to a pilot group consisting of a number of senior colleagues at my own educational institution. All these colleagues had had many years of experience of teaching, conducting research in general and of using questionnaires. They were asked essentially to assess the face validity of the questionnaire. Sapsford (1999) identifies face validity as one of several important ways of assessing a measuring instrument's construct validity and defines it as:

> A measure [that] looks, on the face of it, as if it should be a valid one. Sometimes this is a strong and sufficient argument ... more often it is weak (Sapsford, 1999: 139).

Colleagues within the pilot group were asked to spend some time independently to study the questionnaire and to comment on issues of presentation, layout, wording, appropriateness to primary mathematics and primary teachers of mathematics, and to identify any other areas of the questionnaire they felt needed improvement. Research has suggested that details concerning the layout of the questionnaire are important, e.g. a structured and well-designed questionnaire can produce very good response rates, even in postal surveys (Hoinville and Jowell, 1985).

The pilot groups' suggestions steered the questionnaire through two cycles of improvement. (See *Appendix B* for three examples of the pilot groups' responses to these early versions of the questionnaire instrument and *Appendices C* and *D* for the first and second drafts of the questionnaire and their covering letters). In particular, a number of areas for improvement were identified. It was felt that although the covering letter included all the appropriate components in terms of aims, instructions, and ethics, the wording and layout could be improved. To maximise responses I was advised to omit the reference to myself as a student undertaking a doctoral thesis and to include instead the name of my institution. It was felt that this would carry more weight with busy teachers and make them less inclined to regard the questionnaire as unimportant. Several of the questions within section two of the questionnaire requesting teacher and school details were also highlighted for change by the pilot group. The font size of section three was identified as a potential problem for those attempting to complete the questionnaire. The font size was originally so small because I felt it was important that all thirty-two questionnaire statements remained on the same page. However, after taking advice from a colleague I was able to increase the font size whilst keeping all the questions on one page. I did this by altering the page layout and making the margins somewhat smaller. No other problems were identified within section three. Within section four one member of the pilot group advised that I request more contact details and to place more emphasis on the end details, i.e. thanking the participants for returning the questionnaire.

All questionnaires were given consecutive serial numbers as a way of identifying returned questionnaires and to facilitate the sending of subsequent reminders to schools whose teachers had not responded. Teacher respondents were asked to supply their name and contact address at the end of the questionnaire if they felt they would be interested in participating further in the research.

The Sample

In Phase I of the research all primary schools within the LEA boundary were included in the survey (N=71). That is, every head teacher of every primary school received a package consisting of a covering letter to the head, and four questionnaires with covering letters to the primary teacher. In total two hundred and eighty-four questionnaires were sent out. Seventy-five primary teachers responded which represents a response rate of just over twenty-six per cent of the questionnaires dispatched to head teachers. However, the sampling units were not primary schools but primary teachers and I could not be certain that all units had an equal chance of seeing and responding to the questionnaire. Given that many of the targeted primary teachers may not have seen the questionnaire and so may not have had the opportunity to respond it is possible that the response rate could be much higher. A subsequent analysis of the number of schools from which teachers returned questionnaires indicated a forty-eight per cent response rate (See *Table 3.2.1* below). A comparative analysis of the demographics of the primary teachers in the sample with the known demographics of primary teachers in the national population suggested that the two were broadly similar in all but one respect (See *Data Analysis* Section below for details of this comparative analysis).

Phase I of the research saw questionnaires dispatched to all primary schools in the LEA but participation in this stage of the research relied exclusively on, firstly, head teachers passing on the questionnaires to their relevant members of staff and, secondly, teachers voluntarily completing and returning their questionnaires. Consequently, Phase I of the research involved a self-selecting sample. Robson (2002) argues that with non-probability sampling, of which self-selection is one type, it is not possible to make statistical inferences from the sample to the wider population. However, he also goes onto acknowledge that:

> It may still be possible to say something sensible about the population from non-probability samples... (Robson, 2002: 261)

In essence, what Robson is arguing is that non-probability sampling produces an external validity problem. External validity is concerned with the correctness of any generalisations from the research findings to other, often wider, theoretical settings (Campbell and Stanley, 1966). As previously mentioned, the primary aim of the research was never to produce results that could be characterised by a high degree of external validity and as such a self-selecting sample was thought sufficient.

Although I never set out to produce generalisable results I felt it informative to produce a comparative analysis of the demographics of the teachers that returned questionnaires to known demographic characteristics of the national population of primary teachers. This analysis suggested that the sample were broadly similar to the population of primary teachers nationally on all but one demographic characteristic (See *Data Analysis* section in this Chapter for more details on this comparative analysis).

Data Collection

The postal questionnaire was piloted in December 2004 and sent out to schools in January 2005 (See *Appendix A* for the final draft of the complete questionnaire). Each questionnaire was introduced by a covering letter addressed to each primary teacher explaining the rationale for the research and seeking his or her participation in at least the survey phase of the research (See *Appendix A* for the covering letter to teachers). Four questionnaires with covering letters were sent to each of the seventy-one primary schools in the chosen Local Education Authority. For reasons of ethics it was necessary to send each batch of questionnaires to the head teacher of each school with a covering letter requesting their permission and cooperation in distributing the questionnaires to their relevant primary teachers (See *Appendix F* for the covering letter to head teachers). Table 3.2.1 below details the phases of the distribution process and shows, after each phase, the percentage returns of both the questionnaires dispatched and the number of schools from which teachers responded.

Phase		Cumulative N questionnaires returned	Cumulative % questionnaires returned	Cumulative N schools responding	Cumulative % schools responding
Phase I Sent: Jan 2005					
	+ 1 week	25	8.8%	14	19.7%
	+ 2 weeks	44	15.5%	23	32.4%
	+ 3 weeks	51	18.0%	25	35.2%
	+ 4 weeks	58	20.4%	28	39.4%
Phase II Reminder: Mar 2005					
	+ 1 week	70	24.6%	32	45.1%
	+ 2 weeks	75	26.4%	34	47.8%
Total		**75**	**26.4%**[3]	**34**	**47.8%**[4]

Table 3.2.1 Timeline of questionnaire distribution and corresponding response rates.

Data Analysis

Reducing the large mass of unedited data that comes from completed postal questionnaires to a manageable and analysable dataset is a process called *data reduction* (Cohen and Manion, 1985). In the case of this research this process involved *editing* each questionnaire and then *coding* the different responses to each question. Editing the questionnaires comprised checking each questionnaire for potential response errors. This editing process was also carried out on the dataset after it had been entered into a computer software package for analysis (see below). Coding involved assigning a code number to each possible answer to each question. However, since most sections of the questionnaire were precoded (i.e. using the five-

[3] This percentage is calculated using 284 as the denominator, i.e. the total number of questionnaires distributed to schools.
[4] This percentage is calculated using 71 as the denominator, i.e. the total number of schools to which questionnaires were distributed.

point, Likert scale) coding was only required for some parts of the personal details section of the questionnaire where answers to the demographic variables could not be known in advance (See *Appendix G* for coding frame used with SPSS variables).

Much of the data from the questionnaire were quantitative. Consequently, the data were manually entered into one of the computer software package for the Windows operating system that allows the user to enter, store, and analyse large amounts of quantitative data. The Statistical Package for the Social Sciences (SPSS) Version 11 was the computer package chosen (SPSS Inc, 2001) for this purpose. Once the data were entered, several of the demographic variables were recoded to correspond with corresponding government statistics data available for the primary teaching population nationally and so facilitate the comparative analysis. For instance, the *age* and *length of service* variables were recoded from interval level variables into categorical variables of an ordinal nature to correspond with the categories in government statistics (See *Appendix H* for details of recoded variables in SPSS).

The final step in completing the SPSS dataset was to reverse score the five items requiring this procedure (See items 2, 14, 24, 25, and 31 in *Appendix A*). Once the data were entered and all recoding was finalised the SPSS software was used to conduct analyses on the data from the questionnaires. The data underwent two different types of analysis; an exploratory data analysis (EDA) and a confirmatory data analysis (CDA). Robson, describes exploratory data analysis as a process that 'explores the data, trying to find out what they tell you' and confirmatory data analysis as a process that 'seeks to establish whether you have actually got what you expected to find' (Robson, 2002: 399):

The exploratory data analysis served two purposes. The first was to check the available data for response errors, i.e. errors originating either from the teacher respondents themselves or from the process of inputting the data into the statistical computer package SPSS. The second was to give some estimate of the representativeness of the sample gathered to the population from which it came. The first part of this exploratory analysis involved checking the completed questionnaires before inputting began (where no errors were revealed) and then checking the electronic dataset once the data had been entered into the programme to ensure the data included no instances of 'illegal' data. The latter part of this checking process involved producing simple frequency tables for each variable amenable to such an analysis. Simple frequency tables show all codes entered for each variable and so any 'illegal' codes are easily identified. This process revealed several inputting errors that were then corrected.

The second part of the exploratory analysis involved a comparative analysis of the demographics of the primary teaching sample with the known demographics of the primary teaching population nationally. This analysis suggested that the sample was broadly representative of the population from which it came. The Chi-square Goodness of Fit test was used to test whether or not the observed sample data differed significantly from that which should be expected given the proportions that exist in the population. For instance, given that the gender split in the primary teaching population in England in 2004 was eighty-eight per cent female to twelve per cent male (Database of Teacher Records, 2004) it is possible to test whether the sample gender split is significantly different. The use of the Chi-square Goodness of Fit test is justified in these instances because it is a non-parametric test and so makes no assumptions about the shape of the underlying distribution of the population from which the sample is drawn. The following sections show this comparative analysis. In these sections the Chi-square Goodness of Fit test has been used to test whether the sample differs significantly from the corresponding population proportions on the variables *gender*, *age*, and *length of service*.

Gender

Of the teachers that responded to the questionnaire, the vast majority were female (eighty-four per cent female compared to only sixteen per cent male). However, it is well known that the primary teaching sector has long been populated by a greater proportion of female teachers (Newton, L., 1996) and more recent government statistics show this still to be the case (Database of Teacher Records, 2004). Figure 3.2.2 below shows the proportion of male and female teachers in the primary teaching population in 2004 compared to the proportion of male and female respondents in the sample.

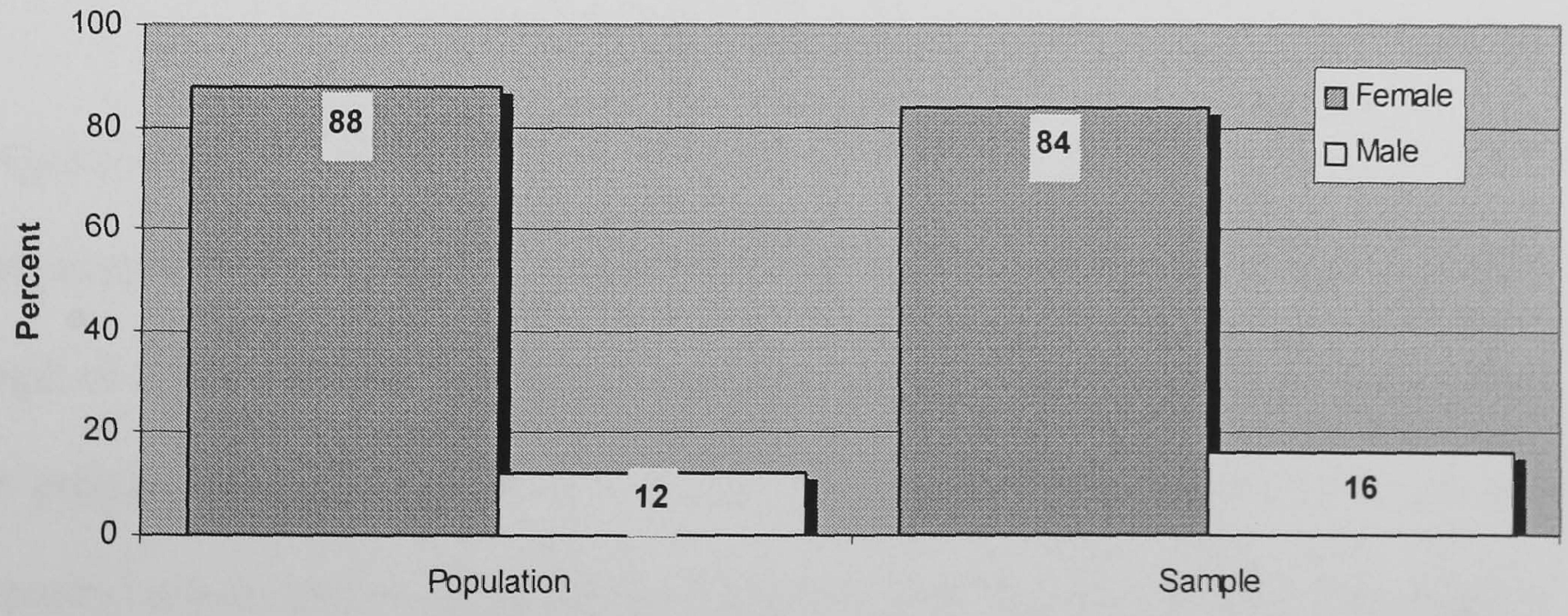

Figure 3.2.2 Gender proportions of sample compared to the gender proportions of population in 2004.

The Chi-square Goodness of Fit test revealed that the gender split in the sample did not differ significantly from that in the population ($\chi^2 = 1.136$, df 1, $p < 0.286$).

Age

Statistics from the Database of Teacher Records in 2004 indicated that the distribution of the primary teaching population across the age range was bi-modal. An analysis of the distribution of the primary teaching sample showed it to have broadly the same characteristics and the Chi-square Goodness of Fit test revealed that the age distribution in the sample did not differ significantly from that in the population ($\chi^2 = 8.64$, df 7, $p < 0.28$). See Figure 3.2.3 below.

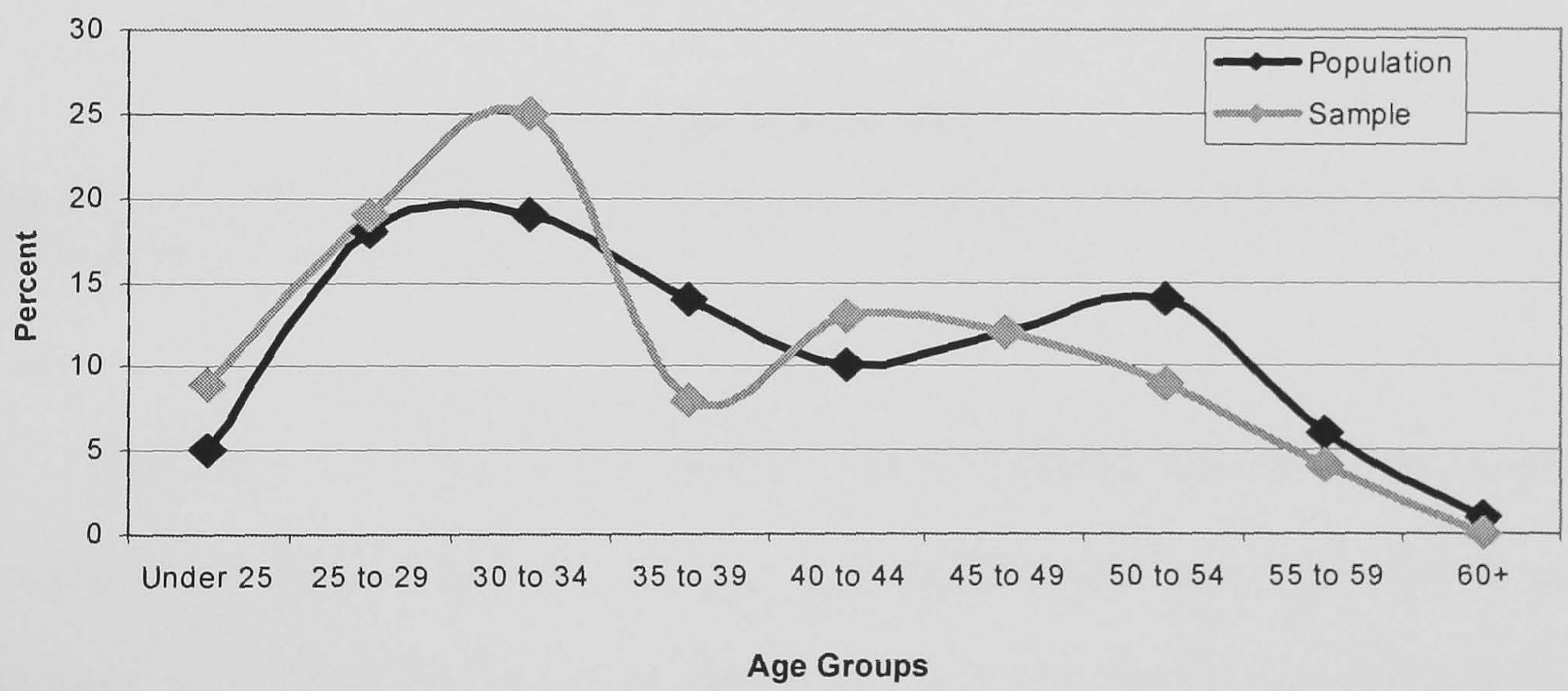

Figure 3.2.3 Age distributions of sample compared to population (Database of Teacher Records, 2004).

Length of Service

The sample differs from the population somewhat in terms of its distribution of length of service. Figure 3.2.4 below shows the length of service distributions of both the primary teaching population and the primary teaching sample. The greatest disparity between the two is in the 20+ years length of service category. According to the Database of Teacher Records (2004) just over thirty per cent of the primary teaching population have more than twenty years service. However, the corresponding proportion within the sample was only eight per cent. Not surprisingly then the Chi-square Goodness of Fit test revealed that the distribution of length of service in the sample was significantly different from that in the population (χ^2 = 24.278, df 4, p< 0.000).

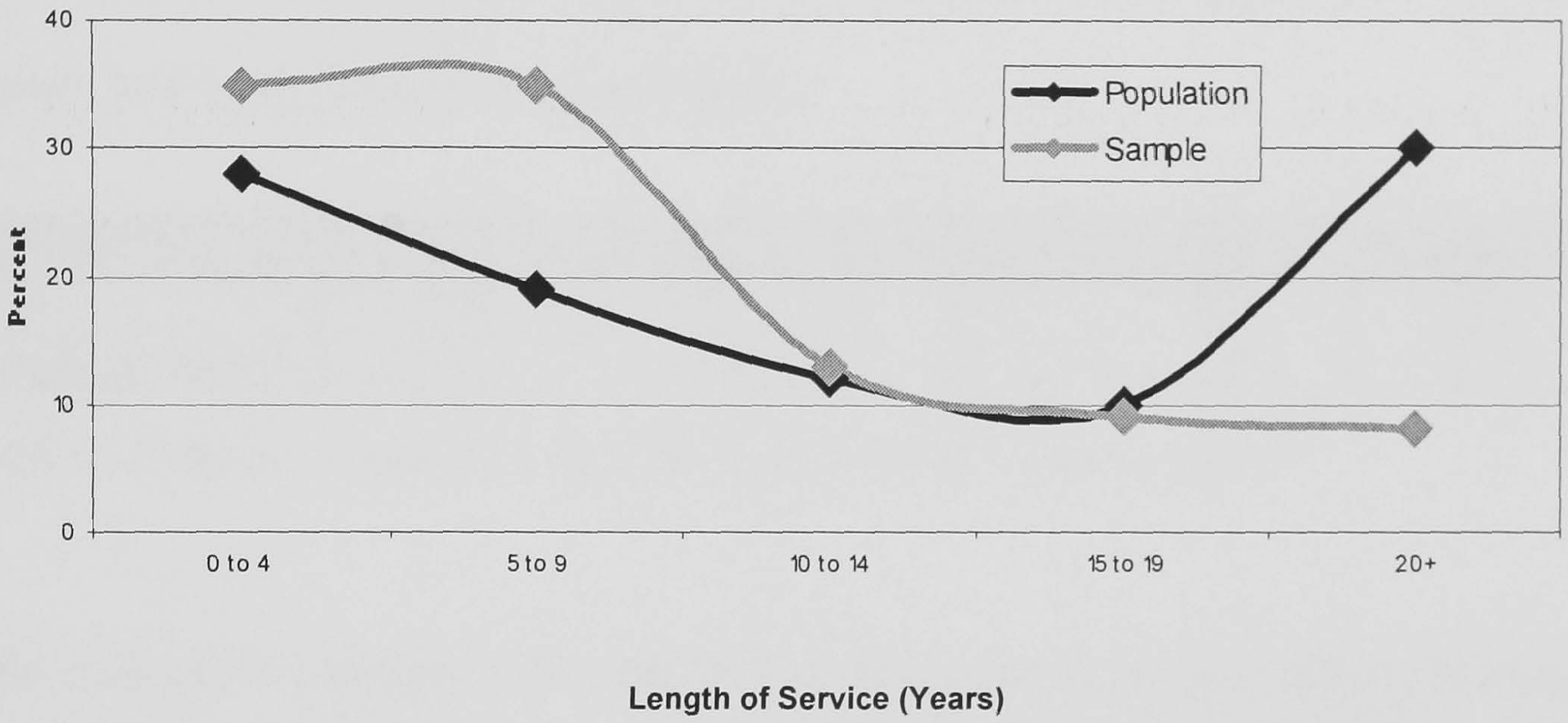

Figure 3.2.4 Length of service distributions of sample compared to population (Database of Teacher Records, 2004).

The exact reason for this disparity is not known but there are several possibilities for such a difference. Firstly, it is possible that the sample drawn was unrepresentative of the LEA overall and that the *actual* length of service distribution in the LEA was closer to the national population distribution than that shown above. Secondly, it is possible that the sample drawn was representative of the LEA overall and that it is simply the case that more experienced teaching staff in the LEA have been re-deployed into other posts, e.g. advisors.

Qualifications

No national data were available on primary teachers' highest held mathematical qualification and so no comparison could be made.

3.3 Results

The comparative analysis outlined in the previous section set out a great deal of descriptive statistics for the sample and will not be repeated here (See *Appendix E* for means and standard deviations for all individual questionnaire items). However, previously unseen descriptive statistics for the teaching sample for the variables *age* and *length of service* can be seen in Table 3.3.1 below (See *Appendix J* for raw survey data in the form of frequency tables).

Variable	*N*	Min	Max	Mean	St Dev
Age	75	21	58	36.2	9.93
Length of Service	75	0	30	8.2	7.37

Table 3.3.1 Descriptive statistics for the variables *age* and *length of service (years).*

The comparative analysis in the previous section showed that the primary teaching sample was broadly similar to the primary teaching population nationally.

Teachers in the sample were asked to indicate the extent to which they agreed or disagreed with the realist world view (a behaviourist view of teaching and learning) and relativist world view (a constructivist view of teaching and learning) using a five point, Likert-type scale (1 - *strongly disagree*, 2 - *disagree*, 3 - *neutral*, 4 - *agree*, and 5 - *strongly agree*). These two views were labelled Fictional View 1 and Fictional View 2 respectively to avoid any response bias from teachers in the form of socially desirable responses. The results of statistical tests showed that overall, the teachers in the sample were significantly more likely to agree with the relativist world view than the realist world view (Wilcoxon $Z = -3.65$, $p<.000$), although the statistics in the table hide some extreme individual differences (See Fig 3.3.1 below).

Table 3.3.2 below gives the number of teachers responding to the question (*N*), mean agreements and standard deviations for both the realist and relativist world views.

Epistemological World View	*N*	Mean	St Dev
Realist World View (behaviouristic)	75	2.91	1.02
Relativist World View (constructivist)	75	3.59	1.00

Table 3.3.2 Descriptive statistics for the two epistemological world views.

Figure 3.3.1 below shows the distributions of teachers' responses to these two questions. It illustrates the above point that although primary teachers generally were significantly more likely to agree with the relativist (constructivist) world view, there were primary teachers that agreed very strongly with the realist (behaviouristic) world view.

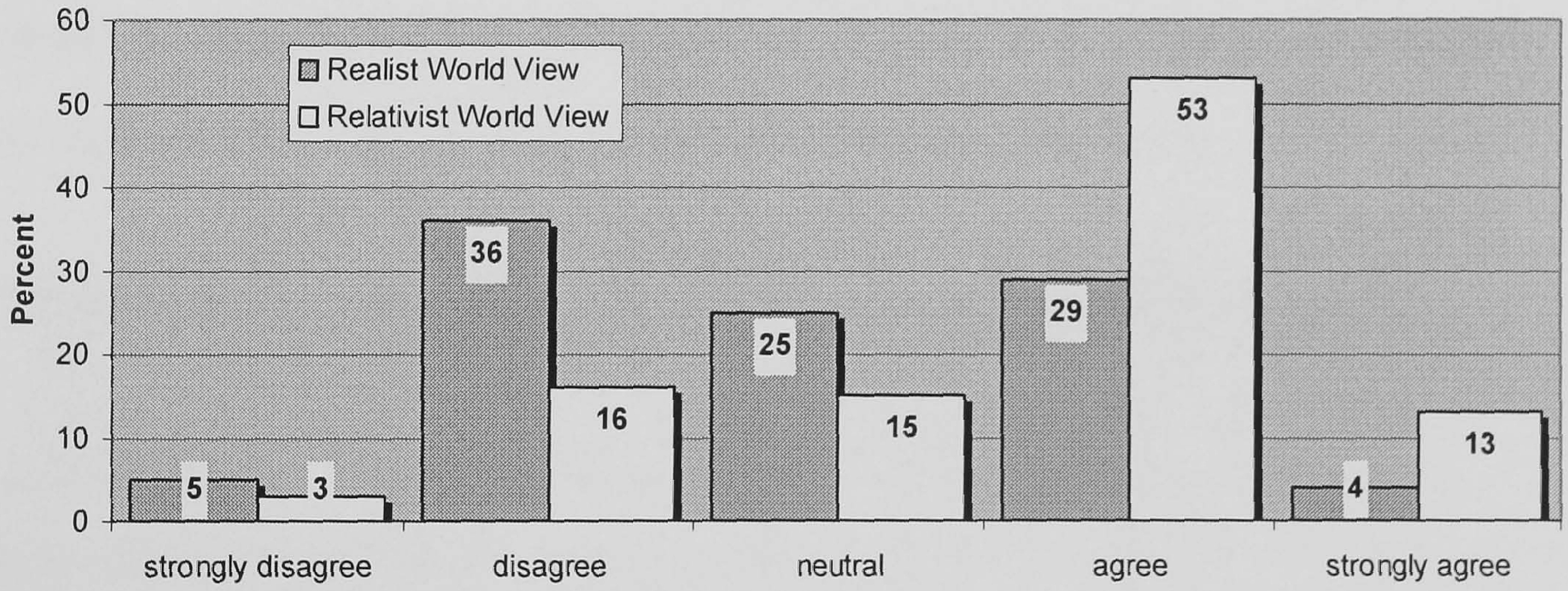

Figure 3.3.1 Extent of teachers' agreement/disagreement with the two epistemological world views.

Descriptive statistics were also produced for the three epistemological sub-scales relevant to this research; the *simple knowledge sub-scale*, the *certain knowledge sub-scale*, and the *omniscient knowledge sub-scale* (See Table 3.3.3 below).

By way of a brief reminder of the meaning of the sub-scales and their scoring, the *simple knowledge sub-scale* measures teachers' beliefs about the relative complexity of knowledge, i.e. the extent of the belief that knowledge is comprised of discrete facts. This sub-scale is comprised of seven items and so is scored out of a total of thirty-five such that a high score indicates a belief in simple knowledge. The *certain knowledge sub-scale* measures teachers' beliefs about the relative certainty of knowledge, i.e. the extent of the belief that absolute knowledge exists independently of the knower and will eventually be known. This sub-scale is comprised of six items and so is scored out of a total of thirty such that a high score indicates a belief in certain knowledge. The *omniscient sub-scale* measures teachers' beliefs about the extent to which knowledge emanates from authoritative sources, i.e. the extent of the belief that those in authority have access to otherwise inaccessible knowledge. This sub-scale is comprised of four items and so is scored out of a total of twenty such that a high score indicates a belief in omniscient authority knowledge.

Epistemological Beliefs Sub-Scale	*N*	**Mean**	**Out of:**	**St Dev**
Simple Knowledge sub-scale	75	20.43	35	2.30
Certain Knowledge sub-scale	75	14.59	30	2.18
Omniscient Knowledge sub-scale	75	12.41	20	2.17

Table 3.3.3 Descriptive statistics for the three epistemological belief sub-scales.

(See *Appendix E* for means and standard deviations for individual items constituting Part 2 of the questionnaire, i.e. the EBI. See *Appendix J* for all statistical raw data from SPSS).

Figure 3.3.2 below shows the range of scores within each of the epistemological belief sub-scales in the form of box and whisker plots.

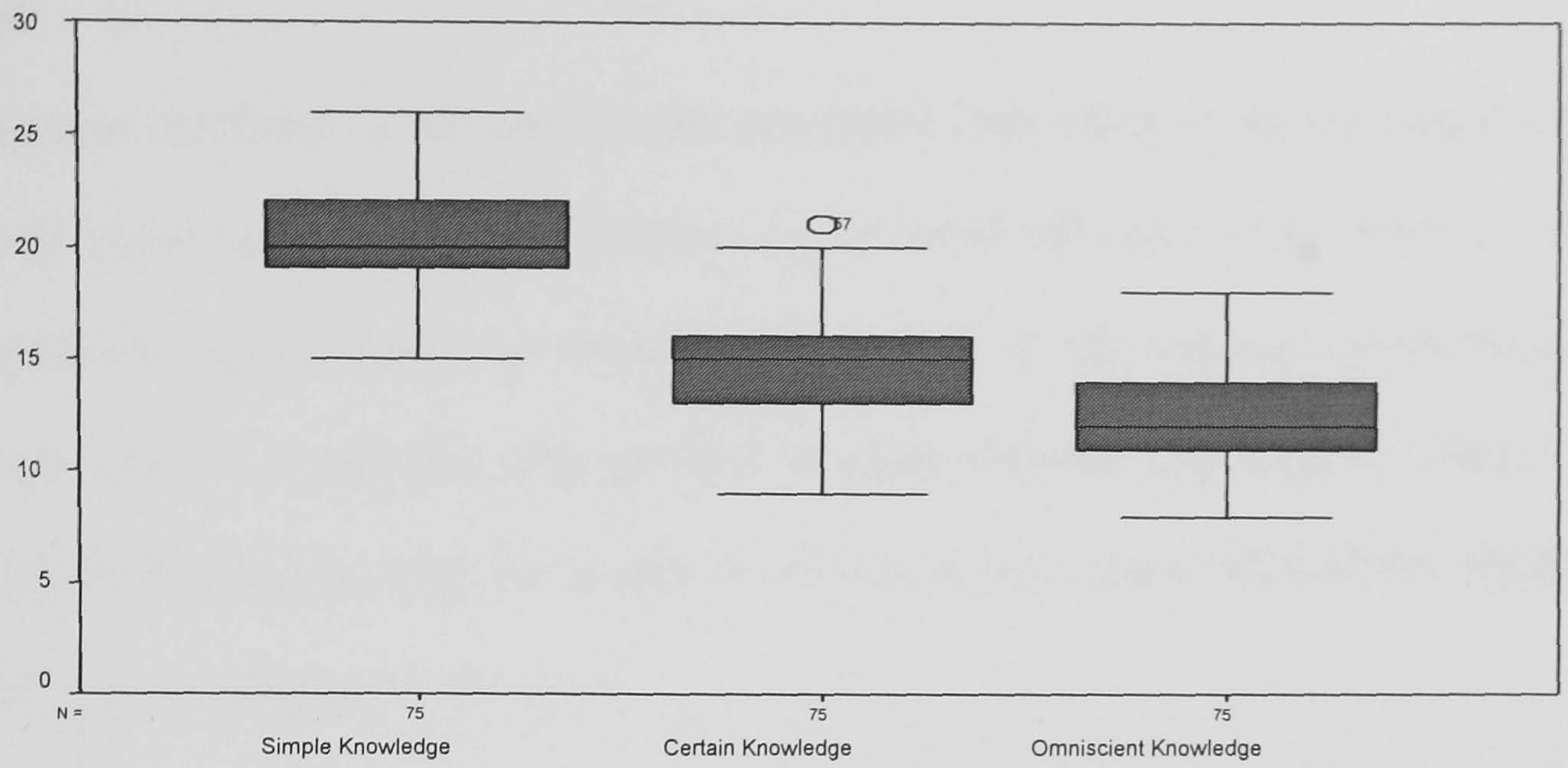

Fig 3.3.2 Box and whisker plots for the three epistemological belief sub-scales.

One of the principle aims of this phase of the research was to reveal any statistical differences and relationships between the three epistemological belief sub-scales described above (*simple knowledge*, *certain knowledge*, and *omniscient authority knowledge*) and the two epistemological world views (*realist* and *relativist*) and the teacher characteristics amenable to this type of analysis, e.g. *age*, *length of service* and *highest mathematics qualification held.* No statistically significant differences were found to exist between male and female teachers on either of the epistemological world views or any of the three epistemological belief sub-scales (See *Appendix J* for statistical raw survey data from SPSS). Correlations were computed and these can be seen in Table 3.3.4 below.

	Age	LoS	Qual	Real WV	Rel WV	SK	CK	OK
Age	-	.698*	-.076	.079	.05	.038	.021	-.019
Length of Service		-	-.151	.234*	-.035	.079	-.018	.083
Qualification			-	.089	.007	-.098	-.003	-.044
Realist World View				-	-.106	.099	.049	.266*
Relativist World View					-	-.04	-.042	-.175
Simple Knowledge						-	.092	.203*
Certain Knowledge							-	.194*
Omniscient Knowledge								-

Table 3.3.4 Correlation coefficients between quantitative questionnaire items (significant correlations at $p< 0.05$ are marked *).

Age

Age was not found to be significantly correlated with either of the epistemological world views or any of the three epistemological belief sub-scales. The absence of any significant relationships here between the variable of *age* and the epistemological world views is consistent with previous research (Schraw and Olafson, 2002) and suggests that age in itself plays little or no role in the process of teachers adopting their epistemological world view.

Length of Service

Length of teaching service was found to be significantly positively correlated with the realist world view suggesting that as teachers progress through their teaching career they are more likely to adopt a realist epistemology. This contradicts research by other research in the field. For instance, Schraw and Olafson (2002) found teachers were more likely to endorse a relativist (constructivist) world view as their teaching experience increased whereas beginning teachers were more likely to endorse a realist (behaviouristic) world view.

Oddly though, age, which was obviously positively correlated with length of service, was not found to be similarly correlated with the realist epistemology. This supports the finding above that teachers' age is not correlated with the realist epistemology and so suggests that it is not teachers' age in itself that leads to the adoption of a realist epistemology but that teachers' length of service in some way mediates between the two.

Highest Mathematics Qualification Held

Figure 3.3.3 below shows the distribution of the highest mathematics qualification held by teachers in the sample. Although GCSE/O Level was by far the most common highest qualification held by teachers in the primary sample no significant correlations were found between the level of qualifications generally and either of the epistemological world views or any of the epistemological belief sub-scales.

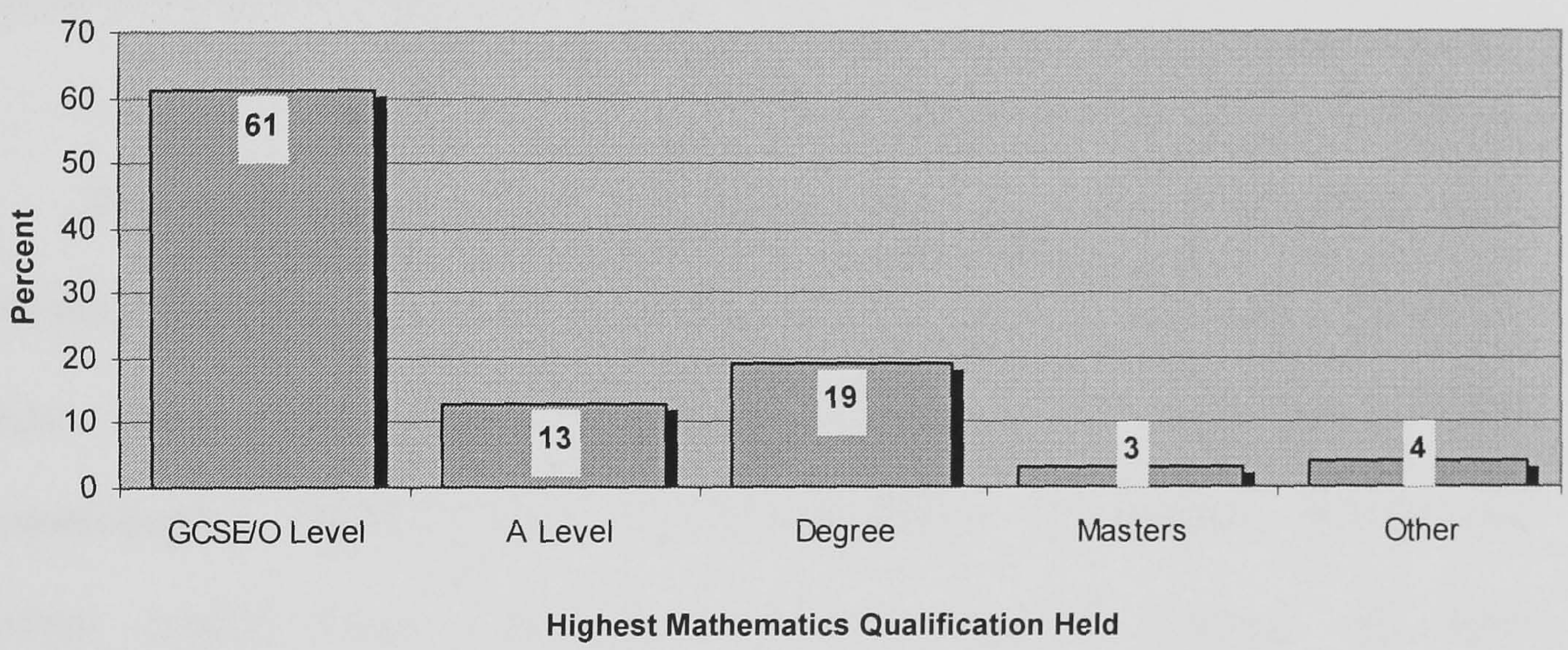

Figure 3.3.3 Distribution of highest mathematics qualification held by teachers in the sample.

Epistemological World Views and Epistemological Belief Sub-Scales

Prawat and Floden (1994) have argued that teachers' epistemological beliefs are largely consistent with only one of the world views and that hybrid positions are rare. If this were indeed the case we would expect to see the two epistemological world views to be negatively associated with each other. The results of such an analysis showed that realist and relativist epistemological world views were indeed negatively correlated with each other but the relationship was not significant, $r = -.106$.

The realist world view was found to be significantly positively correlated with the belief in omniscient authority knowledge ($r = .226$, $p < 0.05$). The realist world view was also found to be positively correlated (although not significantly) with beliefs in simple knowledge and certain knowledge. Moreover, these three epistemological belief sub-scales were negatively correlated (although not significantly) with the relativist world view. All this is consistent with the idea that both the realist and the relativist epistemological world views are constituted by distinct sets of epistemological beliefs. That is, the evidence suggests that teachers with a realist world view differ from those teachers with a relativist epistemology, at least to some extent, in the type of epistemological beliefs that they hold.

Previous research has shown a similar relationship between the realist world view and a belief in omniscient knowledge (Schraw and Olafson, 2002; Schommer-Aikins, 2002; Hofer, 2000) and between the realist world view and all three epistemological beliefs (Schraw and Olafson, 2002). For instance, Schraw and Olafson (2002) found significant positive correlations between all three epistemological beliefs and the realist world view. Schommer-Aikins (2002) has argued that because of these relationships the realist world view represents a less sophisticated epistemology.

3.4 Discussion

Although the research has been described as exploratory in nature and the primary aim of the research was not to produce generalisable results it was interesting to note that the comparative analysis of the samples' demographics with the populations' known demographics showed the two to be broadly similar on most relevant variables. That is, the primary teaching sample was shown to be similar to the population in terms of the gender split and the age distribution. There was a difference between the sample and the population in terms of length of service with the sample having significantly less teachers in the 20+ years category. However, it is possible that a known recent redeployment of senior members of the teaching staff in the LEA into more senior, non-teaching positions resulted in a falsely exaggerated difference between the sample and population on this category.

The main goal of the quantitative analyses of the survey results detailed in this chapter was to investigate phenomena related to the first two research questions set out at the end of Chapter 1. That is, what epistemological beliefs do primary teachers' hold about the teaching and learning of mathematics and do these epistemological beliefs constitute distinct and mutually exclusive epistemological world views as defined by previous research or are hybrid positions possible?

Firstly, the research findings showed that primary teachers overall were significantly more likely to agree with the relativist world view, a view associated with a constructivist approach to the teaching and learning of mathematics, although this hid some extreme individual differences. Overall, the data lends some support to the previous research suggesting the existence of such world views and that teachers hold different, sometimes polarised, epistemological world views concerning the teaching and learning of mathematics (Kuhn, 1991; Prawat and Floden, 1994; Cunningham and Fitzgerald, 1996; Fielstein and Phelps, 2001; Kincheloe, Slattery, and Sterberg, 2001; Schraw and Olafson, 2002).

The results of the quantitative analyses of the survey results also lend some support to another previously reported finding, i.e. that the existence of a realist (behaviourist) world view is associated with or constituted by a particular set of individual, less sophisticated beliefs about knowledge and that the existence of a relativist (constructivist) world view is associated with or constituted by a particular set of more sophisticated epistemological beliefs (Schraw and Olafson, 2002; Schommer-Aikins, 2002; Hofer, 2000). The survey results showed that a realist (behaviouristic) world view was positively linked with a belief in simple knowledge (the belief that knowledge is comprised of discrete facts), *certain* knowledge (the belief that absolute knowledge exists independently of the knower and will eventually be known), and omniscient knowledge (the belief that knowledge emanates from authoritative sources and that those in authority have access to otherwise inaccessible knowledge). The statistical associations between the realist (behaviouristic) world view and beliefs about simple knowledge and certain knowledge were not strong but the association between this world view and the belief in omniscient knowledge was particularly strong. That is, teachers that held a realist (behaviouristic) world view were significantly more likely to also believe in omniscient knowledge.

In contrast to previous research teachers' length of service was also found to be significantly positively linked to a more realist (behaviouristic) world view. However, age was not found to have the same positive association. This may suggest that it is teachers' exposure to the demanding nature of teaching as they progress through their teaching careers that results in the adoption of a realist (behaviouristic) world view of the teaching and learning of mathematics. Alternatively, it may suggest that current programmes of teacher education in this country are inculcating in trainee teachers a relativist (constructivist) world view concerning teaching and learning.

Prawat and Floden (1994) have argued that teachers' epistemological beliefs are largely consistent with one *or* the other of the world views and that hybrid positions are rare. In relation to this, the evidence from the survey results was inconclusive. On the one hand, there was some evidence, albeit weak, that suggested that this may be the case. For instance, not only were the three epistemological belief sub-scales positively associated with the realist (behaviouristic) world view, as described above, but they were also negatively correlated with the relativist (constructivist) world view. This is consistent with the idea that the two epistemological world views are distinct in the type of epistemological beliefs that constitute them. Moreover, the two epistemological world views were found to be negatively correlated with each other; again, consistent with the above idea. This evidence suggests that teachers who hold a realist world view differ from teachers who hold a relativist world view in the beliefs they hold about knowledge. However, not all of the correlations between the epistemological world views and the epistemological beliefs were strong. Moreover, a deeper look at the data showed that some primary teachers did agree strongly with both a relativist world view and with a realist world view, suggesting that hybrid positions may be possible. Consequently, the question of whether epistemological world views are in fact mutually distinct remains largely unanswered by the survey data alone. However, this will be explored further in Phase II and III of the research.

Conclusions

This chapter has outlined a justification of the rationale for using the survey method in this research and drawn out some of its inherent strengths and limitations. Although the research was described as exploratory, a comparative analysis of the demographics of the primary teaching sample with the known demographics of the primary teaching population showed the sample to be broadly representative. The chapter also gave details of the survey's construction, piloting, and implementation. Particularly relevant here were the details concerning that part of the survey based on the Epistemic Belief Inventory (Schraw, Bendixen, and Dunkle, 2002) since this was used to investigate teachers' epistemological beliefs.

The research findings suggested that the picture of primary teachers' epistemological beliefs about the teaching and learning of mathematics is a complex one. The findings suggest that, *inter alia*, primary teachers hold different, sometimes polarised, views concerning the teaching and learning of mathematics. That is, some hold a realist (behaviouristic) world view whilst others hold a relativist (constructivist) world view. The findings also lend some support to the idea that the realist world view is associated with some individual, less sophisticated beliefs about knowledge, especially the belief in omniscient knowledge, i.e. that knowledge emanates from authoritative sources, although it will be interesting to discover what teachers' verbal reports reveal in Phase III of the research. Teachers' length of service was also found to be positively linked to a more realist world view. However, the question of whether epistemological world views are mutually distinct with hybrid positions impossible or rare has not been unequivocally answered by the survey results. This and other issues are explored further in Phase II and III of the research, which are described in the following chapters.

Chapter 4: Phase II - The Case Study Observations

> **... whilst the question of what we are to look at is by no means a trivial one, it is a little less important than the question of how we are to look at whatever we do look at.**
> *(Sharrock and Anderson, 1982)*

This phase of the research presented the researcher with problems that the previous phase did not; that is, how to manage the inherent difficulties in observing behaviour *in situ*, i.e. teachers' practice in the classroom. The problems associated with observations in general and in classrooms in particular are well documented and the epigraph above reflects the significance attached and consideration given to this aspect of the research.

The findings of Phase I of the research showed that, *inter alia*, some primary teachers of mathematics hold different, and sometimes polarised epistemological world views concerning the teaching and learning of mathematics. This chapter sets out to explore further these different epistemological world views and the possible impact they may have on the classroom practice of the teachers concerned. It does so by adopting a multiple case study approach using unstructured non-participant classroom observations of three primary teachers. The chapter begins by outlining the rationale for this choice of method and a description of the research processes involved. Following this are brief biographies of the three teachers involved in the sample of this phase of the research and a critical discussion of the results from these observations.

4.1 The Case Study Approach but Observational Method

Research by Cohen (1990), Schraw and Olafson (2002), and Schoenfeld (2002) has shown that teacher behaviour is not always consistent with previously stated beliefs and attitudes. Schoenfeld (2002) describes this phenomenon thus:

> ... in education ... people's professions of belief don't necessarily match their description of their actions, which don't necessarily match what they actually do ... People's descriptions of what they do, and what they actually do, can be something else altogether. (Schoenfeld, 2002: 218)

He subsequently argues that:

> If you want to link anything - be it epistemological world views or anything else - to people's practices, then you have to look directly at their practices. (ibid)

Consequently, and in line with the rationale set out in Chapter 2, this Phase of the research, informed by the findings from Phase I, employed a multiple case study approach using unstructured non-participant observations of teachers' classroom practice. I had initially planned to use a semi-structured observation schedule but this was subsequently abandoned as unworkable. The processes that led to this decision are discussed later in this chapter. Observations were to be used to confirm or otherwise the extent to which the teacher's pedagogic practice was consistent with their stated epistemological beliefs about the teaching and learning of mathematics - given via questionnaires in Phase I of the research and to be given in interviews in Phase III of the research. Although it is acknowledged that teachers' classroom practice is determined by more than simply their epistemological world view it is expected that their epistemological world view should play a contributory role in those classroom practices.

Yin (1994) defines a case study as:

> ... a strategy for doing research that involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence. (Yin, 1994: 56)

The important points to note from this definition of case study research are: that it is a *strategy*, i.e. an approach to research rather than a method of research; and that it is usually done using *multiple sources of evidence*. Although now accepted by some as a legitimate research strategy in its own right it has traditionally been viewed in the past as useful only as a way of complementing some other data gathering approach. This is perhaps linked to another of the major criticisms levelled at the case study strategy in particular and qualitative approaches generally; that is, that the data it produces is open to an interpretation that is aligned with the research objectives (Miles and Huberman, 1994).

Despite these criticisms, Calderhead (1996), in defence of the strategy, states that:

> Detailed case studies of teaching using a variety of observational and interview procedures have frequently resulted in well-documented and insightful accounts of teachers' thoughts and practices (Calderhead, 1996: 712)

Cook and Campbell (1979) too defend the case study strategy and view it as equally as legitimate as the experiment and Yin (2002) argues that case studies can gather both quantitative and qualitative data.

In a way all research involves observations of case studies and this is perhaps the reason why observations have been characterised as 'the fundamental base of all research methods' in the social sciences (Adler and Adler, 1994: 389). This research uses non-participant observation which is defined by Cohen and Manion (1985: 122) as a method where the observer '... stands aloof from the group activities he is investigating and eschews group membership'.

The use of non-participant observational method within the case study approach is perfectly suited to this research for several reasons; both related to the complementary nature of the technique. Firstly, this approach comprised an important part of my commitment to methodological triangulation outlined in Chapter 2. That is, it allowed me the opportunity to view the same phenomenon from a different perspective. Secondly, because one of the great advantages of the observational method is that it does not rely on what the actors say they do but what they actually do, the approach allowed me to reconcile or otherwise teachers' practice with their rhetoric, i.e. to verify or otherwise what teachers said they did in practice in Phase I of the research.

One of major issues concerning the observational method is the degree to which the presence of the observer effects the behaviour being observed; what

Lincoln and Guba (1985) have called *reactivity*. Angrosino and de Perez (2000) describe the importance of attempting to address this issue of reactivity:

> Conscious ethnographers have ... long been aware that in naturalistic settings the interaction of the researcher and the subjects of study can change behaviours in ways that would not have occurred in the absence of such interaction ... however, it is both possible and desirable to develop standardised procedures that can maximise observer efficacy, minimise investigator bias and allow for repeatability and/or verification to check out the degree to which these procedures have enabled the investigator to produce valid and reliable data. (Angrosino and de Perez: 2000: 534)

This research attempted to reduce this reactivity from a number of fronts; the use of *minimal interaction*, *habituation*, and the intended use of a semi-structured observation schedule (Robson, 2002). Firstly, my role in the observations was meant to be one of *minimal interaction* with teachers and pupils, that is, my role was one of non-participant observer and it was made clear to teachers at the outset that I did not intend nor wish to participate in any of the class activities but simply to observe the teacher's teaching and interactions with the children. This did not always occur in the way that I had envisaged at the outset. On several occasions I was involved in classroom discussions but this was always instigated by the teacher and I kept my involvement on these occasions to the absolute minimum. If a pupil spoke to me or sought my attention in another way I dealt with their query as best I could or directed them to the teacher but I did not actively engage children in any conversation.

Secondly, I used *habituation*, that is, I observed each teacher delivering mathematics lessons to largely the same class on all occasions. This allowed teachers and pupils to become increasingly familiar with my presence. Thirdly, I also initially intended to employ a semi-structured observation schedule that aimed to identify instances of predetermined behaviour thought relevant to the study across samples of time. This would have the advantage of imposing some structure on the observations whilst still allowing the freedom to observe other pertinent aspects of teachers' classroom practice during the time samples. However, the structured observation schedule devised failed to live up to my expectations in being able to adequately capture the richness and complexity of the classroom activity on display and it was subsequently abandoned for a less structured but richer approach. This is discussed in more detail later in this chapter (See *Data Collection*).

It was not possible to measure the extent to which these aspects of my approach to classroom observations actually reduced reactivity. However, several indicators suggested that each of these aspects did indeed lend something to reducing the reactivity in classrooms. Teachers but more so pupils appeared to become increasingly accepting of my presence in their classroom. This was evidenced by both teachers explicitly verbalising this in subsequent interviews and by the decreasing frequency with which pupils sought my attention.

4.2 The Case Studies

This section presents details of the three teachers included in the sample before discussing issues concerned with data collection and analysis.

The Sample

Phase II of the research initially intended to purposively select for observation teachers with polarised world views concerning the teaching and learning of mathematics. Purposive sampling is defined by Cohen and Manion (1980) thus:

> The researcher handpicks the cases to be in his sample on the basis of his judgement of their typicality. In this way, he builds up a sample that is satisfactory to his specific needs. (Cohen and Manion, 1980: 100)

However, of the seventy-five primary teachers that returned their questionnaires in *Phase I* of the research, only twelve teachers volunteered their time for *Phase II* and *III* of the research by adding their names to the *Phase I* questionnaires. Of these twelve only two were quick to reply to my initial attempt to contact them in May 2005 (See *Appendix P* for this initial email). Given the time constraints on the research timeline and the fact that teachers were very soon to enter the summer break it was felt necessary to select these two teachers and put in place some organisation for September of the same year where *Phase II* and *III* of the research could continue. The other teacher (who I have called Mary) was introduced to me much earlier in the lifetime of the research by a senior contact at the governing LEA concerned as an experienced teacher who would consider being involved in research into mathematics. Consequently, the three teachers involved in Phase II and III were largely self-selected (See the brief teacher biographies below).

It was clear very early on that two of the three primary teachers who were subsequently chosen were keen to be involved in the research: the teachers I have called Lisa and John (these are not their real names). The third teacher (Mary), although cooperative at the very start of the research, was less enthusiastic about some aspects of the research (particularly the audio-tape recording of interviews) but I felt that her very different background, in terms of her age and experience, made her participation in the research all the more important (in the interests of balance/representativeness). I endeavoured therefore to keep Mary involved in the research despite the problems I knew I would encounter in the future in transcribing interviews.

Teacher observations were conducted concurrently over a six-month period between October 2005 and March 2006. Approximately four to five observations (and interviews) were conducted with each teacher (Wragg, 1991) during this period but the exact number of observations required varied from teacher to teacher dependent on how quickly I felt I was gathering the type of information I thought pertinent. Observations were scheduled around teachers' other responsibilities and I typically tried to lessen any additional burden the observations may otherwise have caused for teachers. This meant that on occasions observations were postponed by teachers at very short notice and rearranged for more convenient times.

Teacher 1 (Lisa)

Lisa (not her real name) was twenty-nine years of age when she completed the questionnaire in Phase I of the research and had gained all her six years teaching experience in the same school; a Roman Catholic voluntary aided primary school.

Lisa's school was described in the most recent Office for Standards in Education (Ofsted) report as a smaller than average primary school, serving mainly Roman Catholic families. There is considerable deprivation in its catchment area and the school has a higher than average number of pupils who have learning difficulties and/or disabilities or who are eligible for free school meals. Pupil mobility is higher than average but the school has comparatively few pupils who are from minority ethnic backgrounds or who speak English as an additional language. Children enter the school with attainments which are considerably below what would be expected for their age but by the time they leave in Year 6, standards are above the national average (Ofsted, 2006).

Lisa was nearly thirty years of age when the observations began in mid-October 2005. She had gained a degree in Pure Mathematics in the summer of 1998 and after working in banking for one year she studied for a one-year Post Graduate Certificate in Education (PGCE) specialising in mathematics at Key Stage 2 and 3. She applied for and gained a post in her current and only school in the summer of 1999 and was immediately given the responsibility of mathematics coordinator. At the time of observations she had responsibility for teaching Key Stage 2 (KS2) mathematics to Year 6 pupils (pupils aged approximately 10 years).

An informal discussion with Lisa in late September 2005 and before observations and interviews began suggested to me that she held a relativist epistemological world view (which I have linked with a constructivist philosophy) more than a realist epistemological world view concerning the teaching and learning of mathematics. She said that she had 'always loved mathematics at school' but disliked the way in which her teachers taught the subject. She expanded on this by explaining that typically her teacher would first explain the 'correct way' to solve the problem and then go on to set them numerous problems of the same type to attempt. Lisa said that she could never understand why her teachers would make her attempt question after question of the same type (e.g. division) and march out to the teacher's desk to have each one checked before starting the next. The implication in her words was that she found this way of teaching very boring and had promised herself that she would always try 'not to teach my pupils like that'.

My informal discussion with Lisa in early October 2005 was interesting because I had no set view about what I had expected to find given her responses to the questionnaire items she had completed seven months earlier. That is, the responses she gave to the questionnaire were not immediately characteristic of either epistemological world view but, if anything, suggested a teacher with a hybrid or mixture of the realist and relativist world views. For example, Lisa scored higher than the sample mean on the certain knowledge sub-scale (indicative of a realist epistemological world view) but lower than the sample mean on the omniscient knowledge sub-scale (indicative of a relativist epistemological world view). She showed no preference for either of the two fictional world views described in the vignettes.

A summary of Lisa's responses to the relevant questionnaire items compared with the corresponding sample means can be seen in Table 4.2.1 below.

Aspect of Questionnaire	*Sample Mean*	*Lisa's Score*	*Out Of:*
Simple Knowledge sub-scale	20.43	20	35
Certain Knowledge sub-scale	14.59	16	30
Omniscient Knowledge sub-scale	12.41	11	20
Fictional View 1 (Behaviouristic)	2.91	2	5
Fictional View 2 (Constructivist)	3.59	2	5

Table 4.2 1 A summary of Lisa's responses to relevant questionnaire items compared to sample means.

(See *Appendix L* for Lisa's questionnaire from Phase I of the research)

Teacher 2 (John)

John was thirty-two years old when he completed the questionnaire in Phase I of the research and nearly thirty-three years of age when the observations began in Phase II in early October 2005. He had been a teacher for nearly eleven years at the time of the observations and was working in only his second school, both of which were within the same LEA. His current school was described by its most recent Ofsted report as an average sized primary school where the vast majority of pupils come from the local area, which is a mixture of rented and private housing. Most pupils were of White-British origin and no pupils had English as an additional language. The socio-economic indicators for the area were said to be broadly average but the percentage of children eligible for free school meals was described as well below the national average. The attainment on entry is broadly average but at the end of Year 6 the standards are very high (Ofsted, 2006).

John had studied for and gained a four-year theology degree with Qualified Teacher Status specialising in Religious Education (RE) and had joined his first primary school (a Roman Catholic voluntary aided primary school) shortly after he had graduated. He had joined his current school (another Catholic school) eight years previously and during the intervening period had had responsibility for RE, Physical Education (PE), Information and Communication Technology (ICT), and Initial Teacher Training (ITT).

John was nearing the final stages of a Master of Philosophy (M.Phil) degree investigating children's use of ICT but had never been the Lead Mathematics teacher in his current or previous school. John was responsible for teaching KS2 mathematics to predominantly Year 5 and Year 6 pupils (pupils aged approximately 10 years) but had taught solely Year 4 and solely Year 5 pupils in the past.

John's responses to the survey in Phase I of the research suggested he held a relativist epistemological world view. For instance, he scored lower than the sample mean on both the simple knowledge sub-scale and the omniscient knowledge sub-scale and a greater preference for vignette 2 describing the constructivist view of teaching and learning (all of which are indicative of a relativist epistemological world view).

A summary of John's responses to the relevant questionnaire items compared with the corresponding sample means can be seen in Table 4.2.2 below.

Aspect of Questionnaire	***Sample Mean***	***John's Scores***	***Out Of:***
Simple Knowledge sub-scale	20.43	17	35
Certain Knowledge sub-scale	14.59	15	30
Omniscient Knowledge sub-scale	12.41	10	20
Fictional View 1 (Behaviouristic)	2.91	2	5
Fictional View 2 (Constructivist)	3.59	4	5

Table 4.2.2 A summary of John's responses to relevant questionnaire items compared to sample means.

(See *Appendix M* for John's questionnaire from Phase I of the research)

During an informal discussion with John at his school in mid-September 2005 he talked of his preference for teaching mathematics to his pupils in a practical way, 'with stuff' as he put it, rather than with just paper and pencil. He also put forward his view that children learned mathematics best 'through doing'. He showed me his interactive white board, which he said he used much more than the traditional white board that was also present in the classroom and described it as invaluable in accessing interesting materials and ideas for his teaching. As a Year 5/6 teacher he described his ultimate goal as helping his pupils to pass their SAT tests (Standard Assessment Task) at the end of Key Stage 2 of their education in the same year. When probed on this further he stated that if he failed to achieve this goal he would be failing both the school and the pupils themselves and that ultimately 'the head teacher would be in here asking 'why?''. However, he disliked the publication of the results of such tests in the local press.

The real confirmation that John held a relativist view of the teaching and learning of mathematics came when I asked his views on whether he thought that children learned mathematics most effectively via the teacher passing on his or her expert knowledge (implying a transmission of information approach). His response was an emphatic 'no' and he went on to mention how he would like the opportunity to teach mathematics and his other different subjects in a more 'joined up way to show the relationships between them more' but that the National Curriculum and its requirements meant there was little time for this.

Teacher 3 (Mary)

Mary had been a teacher for thirty-one years when she expressed an interest in participating very early on in the lifetime of the research (approximately March 2004) and nearly thirty-two years when the observations began in October 2005. She had no qualifications in mathematics and indeed did not possess a degree of any kind, having entered teaching at a time when such qualifications were not a prerequisite for entering the profession. She did, however, hold a teaching certificate. She was highly respected within her school by the other staff and indeed within the LEA. Mary was responsible for teaching KS2 mathematics to Year 5 pupils (pupils aged approximately 9 years) but had taught Year 4 pupils (pupils aged approximately 8 years).

Mary's school was described by its most recent Ofsted report as a small primary school standing in an area of social and economic disadvantage. The proportion of children eligible for free school meals was broadly average but none of its pupils have English as an additional language. When children start at the school their attainment is just below average but by the end of Year 6 children are achieving results well above the national average in all subjects (Ofsted, 2006).

In an informal discussion with Mary early on in the lifetime of the research she had shared with me snippets of what she viewed as her philosophy of the teaching and learning of mathematics. This discussion was unexpected and I was unprepared to audio-tape the conversation. However, I did make brief field notes during our conversation and the quotes below are reproduced from those.

Mary said that she had 'grown up liking mathematics', that she viewed it as 'logical and structured' and believed there to be a 'mathematical truth' where there was 'only one correct answer'. This implied that she viewed mathematics as universal, objective, and unchanging across time and cultures. She described how she had always been 'quite good at it' and had learned mathematics at school largely through what she called 'chalk and talk' but it was apparent that she did not view this as a negative way to learn and, indeed, admitted that she used this approach with her own pupils. She also said she viewed herself as the 'expert in the class' and described how she stuck largely to the guidelines in the National Numeracy Strategy (NNS) documents for the content of her teaching. Although she did not like the Standard Assessment Tasks (SATs) that all children in England were expected to take at age 11 years (in Year 6) she did express the opinion that if they were expected to take these tests then it was important that the tests be 'objective' and 'standard', i.e. she was expressing a preference for norm-referenced and externally produced, standardised tests as a way of assessing the extent of students' learning.

These first early insights into Mary's philosophy of mathematics implied she viewed the subject of mathematics as having an absolutist epistemology and that she adopted a teacher–centred approach to her teaching; an approach that emphasised the 'transmission' of facts from the expert teacher to the passive learner. In short, she appeared to be espousing a realist world view of mathematics; a world view that I have linked closely with a Behaviouristic model of teaching and learning (Burton, 1994). See *Chapter 1: Teachers' Beliefs About Teaching and Learning.*

However, she also expressed views during this short conversation (and subsequent conversations we were to have together) that made it equally apparent that Mary was not to be so easily categorised as a primary teacher with a realist world view of mathematics. That is, she interspersed the above comments with others that could not be attributed to a teacher that held a purely realist world view of the teaching and learning of mathematics. For instance, she also described how she viewed her pupils as 'talking partners' in class and that 'discussion' and 'the flow of ideas' were also important aspects of her way of teaching mathematics. She also said that she viewed not just the children's understanding as important but the 'journey to that understanding' as important and that at times she acted as a 'facilitator' in the classroom as well as an 'expert'.

I asked Mary on a number of occasions to complete the EPI questionnaire but she refused stating that she found some of the questions rather puzzling. Despite this, I felt it important that I kept Mary as a participant in the research partly because she was so different to the other two teachers in terms of her age and experience and partly because I felt I had developed a good working relationship with her since we had first met in March 2004.

Data Collection

Twelve teachers volunteered their time for Phase II and III of the research by adding their names to *Phase I* questionnaires. The three teachers described in the previous section were selected on the basis of a number of criteria. Firstly and most importantly, the teachers selected were quick to reply to my initial attempt to contact them in June 2005 in their respective schools very soon after *Phase I* had been completed. All twelve teachers that offered their time were contacted to request their continued participation in the research but only two replied to this initial attempt at making contact (I had been introduced to Mary much earlier in March 2004 and had already developed a good working relationship with her). Given the time constraints on the research timeline and the fact that teachers were very soon to enter the summer break it was felt necessary to select these two teachers (and Mary) and put in place some organisation for September of the same year where *Phase II* and *III* of the research could continue without too much delay.

Two of the three teachers requested, via email, some further information concerning what their continued participation would involve. Consequently, further details were sent to all three teachers, via email, outlining the likely methods involved, their involvement in those methods, the likely timescale, and the need for them to gain the permission of their head teacher (See *Appendix P* for a copy of the email). The primary concern was to obtain the agreement of the three teachers and their respective head teachers for the participation in approximately five observations of their teaching of mathematics lessons between September/October 2005 and March 2006.

The teachers were requested to give their voluntary informed consent for Phase II and Phase III of the research. Consequently, before the first observation began each teacher was reminded of the aims of the research and asked to read and sign a voluntary informed consent form. This set out a reminder concerning the aims of the research overall and what was involved in the current phases. The document also outlined in some detail how teachers' identities would be protected (See *Appendix Q* for the voluntary informed consent form used in Phase II and III of the research).

In line with my commitment to ethically responsible research the need to obtain the informed consent of parents of the school children involved in the classroom observations was discussed with all three teachers very early on in the research and before any observations had begun. However, after teachers had discussed with their respective head teachers, it was felt not to be necessary. There were several reasons for this decision. Firstly, in the current climate of accountability it was felt that children, and therefore parents, were used to observers being present in classrooms. Secondly, the research did not involve direct discussions with children or the necessity to be alone with children. I also informed teachers and head teachers of participating schools that I had recently undergone the Criminal Record Bureau's (CRB) police checks into my background that is now a necessary requirement for all individuals (including teachers themselves) seeking to work with children (See *Appendix N* for a copy of letters from the CRB).

I initially intended to use a structured observation schedule to observe the teachers in their classrooms. My reasoning for this was that even with the most unstructured of observations it is desirable to have at least some sort of coding system which will allow some data to be captured as unambiguously as possible (Robson, 2002). In observations I envisaged I would take on the role of non-participant observer described by Cohen and Manion (1985):

> The best illustration of a non-participant observer role is perhaps the case of the researcher sitting at the back of a classroom coding up every three seconds the verbal exchanges between teacher and pupils by means of a structured set of observational categories (Cohen and Manion, 1985: 123)

Bickman, Rog and Hedrick (1998: 21) state that:

> Observational recording forms are guides to be used in the requesting and documenting of information. The subjects may be events, actions, or circumstances ... Observational recording forms are needed when there is substantial information to be collected through observational means or when there are multiple data collectors.

Consequently, I intended to use a semi-structured observation schedule and this was designed and piloted in May 2005 with the aim of identifying predetermined behaviour thought relevant to the study. The schedule was designed to identify behaviour across time samples of 3 minutes (See *Appendix R* for the first draft of the semi-structured observation schedule). My feeling at that time was that this would have the advantage of imposing some structure on the observations whilst still allowing the freedom to observe other pertinent aspects of teachers' classroom practice during the time samples.

The schedule underwent several cycles of improvement with an appropriate piloting group (the same group the piloted the questionnaire instrument in Phase I – See *Chapter 3: Phase I – The Survey*). A number of revisions were made to the schedule informed by the responses from members of the pilot group. Perhaps the most significant of these concerned the decision to omit the behavioural categories referring to Teaching (Behaviouristic) and Teaching (Constructivist). It was decided instead that this coding would be done after the observations had finished. However, I was still not entirely satisfied with draft two of the observation schedule (See *Appendix S*) and subsequently decided to use the first observation as a way of testing the efficacy of the structured observation schedule.

During this first observation, it quickly became apparent to me that the structured schedule was unworkable in that it failed to capture many of the complexities of the classroom behaviour on show. Looking back at my experiences with the schedule at that time, it seemed to me that I was spending too much time on ensuring that the schedule was filled with behavioural codes and not enough time on focussing on the detail of the behaviour I was there to observe. It very quickly became apparent that I would need to reconsider my approach to classroom observation.

I ultimately decided on a much less structured approach to observing classroom practice but one which could capture the complexity I was seeing. Typically, this involved making pages of notes during each observation session in the hope of subsequently identifying aspects of behaviour of interest in the analysis stage for discussion in the subsequent interview. Although I didn't realise it at the time my approach became more consistent with what Robson (2002) calls *informal observation.* Robson describes the advantages of a less structured, informal approach by comparing it with a more structured approach, like this:

> This kind of information [gathered] is relatively unstructured and complex, and requires the observer to perform difficult tasks of synthesis, abstraction and organisation of the data. Formal approaches impose a large amount of structure and direction on what is to be observed. High reliability and validity are easier to achieve ... but at the cost of a loss of complexity and completeness by comparison with the informal route. (Robson, 2002: 313)

During the observations I tried to take nothing for granted. However, I was aware that the instances of behaviour I deemed important to attend to and subsequently made notes about was a personal and subjective decision. That is, I was acutely aware of the fact that observational data can never be considered to be theory-neutral, but are always '... mediated through structures, paradigms and world views.' (Scott, 2000: 13). Wragg (1994) states that 'we often interpret events as we wish to see them, not as they are' and so I also attempted to be aware of the possible barriers to accurate perception.

I also gathered additional information I thought important to the contextualisation of the study. For example, I gathered information about the classes I observed and the classrooms in which I observed them. I also gathered information about the number of pupils in class and the gender mix. I also requested detailed information concerning the content of the lessons I observed in the form of lesson plans and the resources used. The teachers were always generous in supplying this additional information. (*Appendices T, V,* and *W* give details of all the lessons observed with Lisa, John, and Mary respectively).

Observations were scheduled with teachers, as far as was practicably possible, with sufficient time between each to enable the considerable amount of data gathered from the current observation to be studied and a tentative first analysis to be begun. This allowed insights that emerged from the analysis of current observations to feed into and inform my thinking in time for the next observation, consistent with the grounded theory approach adopted. The time between observations also allowed me to gain a degree of respondent validation from teachers concerning interview transcripts.

The observations I undertook of teachers typically followed the same pattern. In line with the non-participatory nature of my intended approach to observations I tried to take up a position at the rear of the classroom and behind the children so as to make myself as inconspicuous as possible. I was able to achieve this in all classes except Mary's. At the very first observation of Mary's teaching she had a seat prepared for me at the very front of the class and introduced me formally to the children before she started the lesson. This involved me in the class more than I had wanted but I still managed not to interact with the children or the teacher too much. During the lesson I made copious field notes concerning aspects of the teaching I thought may reveal something about that teacher's world view on the teaching and learning of mathematics and which I wanted to probe later in the interviews.

Data Analysis

Throughout the discussion of observations and of interviews with teachers I have changed the names of teachers and schools to protect their identity. In terms of the analysis of case study data, Yin (2002: 250) states that:

> … analysing case study evidence is especially difficult, compared with other methods, because the strategies and techniques have not been well developed. Therefore, a serious threat to your entire study is that you may get stalled at the analysis stage.

The analysis of the observations was initially intended to be a combination of quantitative and qualitative. For instance, the quantitative was to take the form of an analysis of the structured observation schedule. However, since the decision was made to abandon the semi-structured observation schedule in favour of field notes the analysis during Phases II and III of the research became purely qualitative. This qualitative analysis took the form of identifying emerging themes from field notes from different individual observations using the constant comparison method associated with grounded theory (Glaser and Strauss, 1967).

Grounded Theory was an approach developed by Glaser and Strauss (1967) to facilitate an inductive research process of generating theory that emerges out of qualitative data gained from concrete settings. It involves the detailed scrutiny of field notes or interview transcripts in an attempt to identify emerging categories or concepts. The approach is underpinned by two fundamental analytical commitments; the *constant comparison method*, and *theoretical sampling*. The constant comparison method leads to a 'fracturing' and rearranging of the data into categories that facilitate comparison between things in the same category or between categories (Maxwell, 1998). Pidgeon (1997) describes the method as:

> ... the principal analytical task ... of continually sifting and comparing elements (such as basic data instances, cases, emergent categories and theoretical propositions) throughout the lifetime of a research project. By making such comparisons the researcher is sensitised to similarities and differences as part of the exploration of the full range and complexities of a corpus of data, and these are used to promote conceptual and theoretical development (Pidgeon, 1997: 78).

The categories that emerge from the initial data then inform the decisions made in the next phase of the data gathering process. For example, my attempts at analysis of my field notes from early observations (and from transcripts of early interviews) suggested areas and aspects of teaching of further interest and which then informed what I looked for - and asked about - in subsequent observations). This represents an iterative process that blurs the traditional boundaries between data gathering and data analysis, i.e. a commitment to grounded theory involves continually moving between data gathering and data analysis, and back again, where the findings from each stage inform the decisions taken in the next stage, *ad infinitum*, or until the end of the research.

My approach to the data collection and analysis of both the observational data of Phase II and the interview data of Phase III followed closely that outlined by Pidgeon and Henwood (1997) and which can bee seen in diagrammatic form in Figure 4.2.1 below.

The process of actively sampling new cases of interest in subsequent phases of data gathering on the basis of what has been learned from early data analysis is what has become known as *theoretical sampling.* It is not driven by the requirement for representativeness like more traditional quantitative research because such an approach would not by resource-efficient in the sense of revealing or extending the emerging categories. Instead, this type of sampling selects cases for their potential for extending or developing the emerging understanding of the phenomenon under study (Pidgeon and Henwood, 1997).

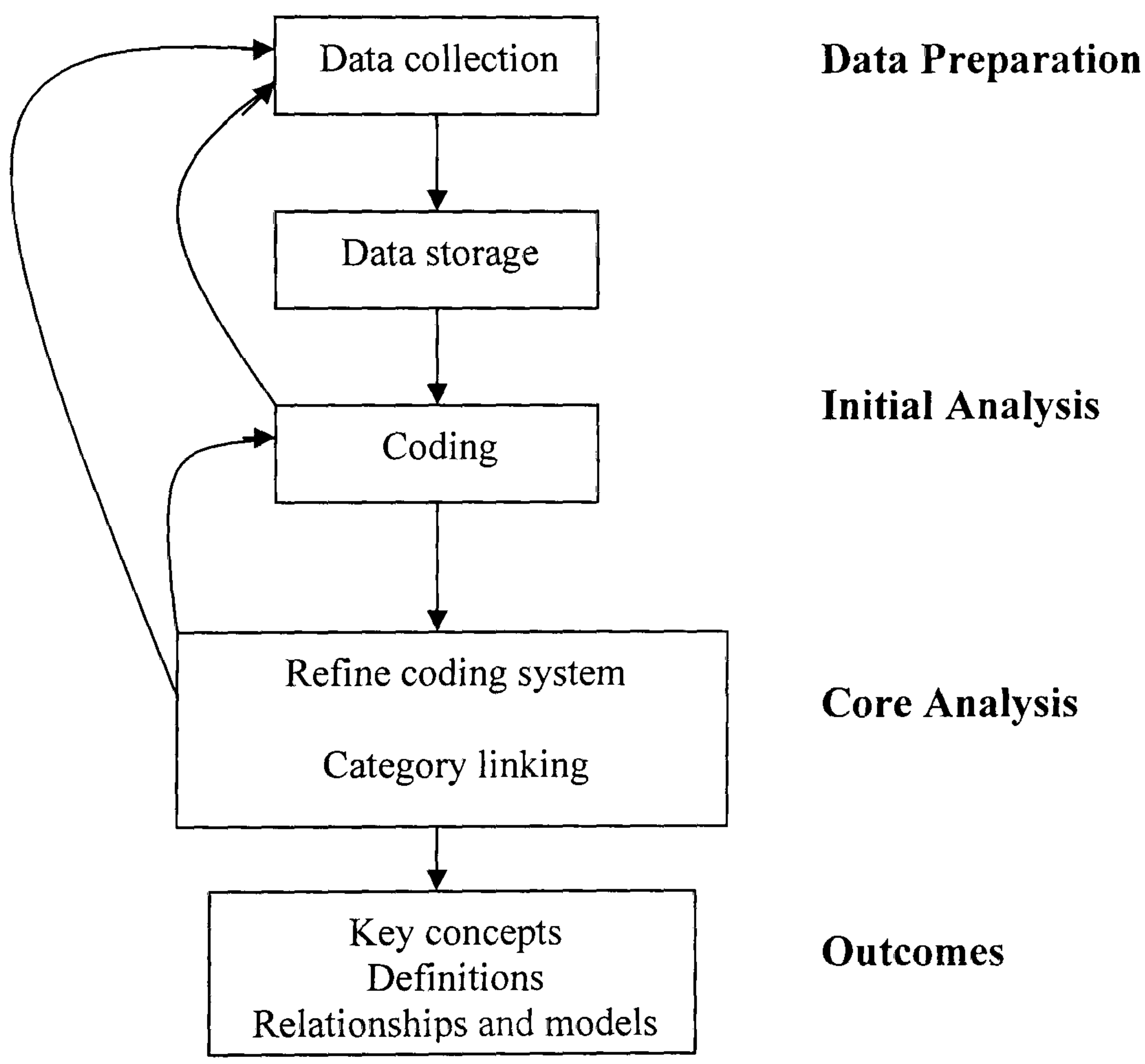

Fig 4.2.1 My approach to grounded theory (adapted from Pidgeon and Henwood, 1997:88)

Consequently, this is what I found myself doing early on and throughout Phases II and III of the research. Typically, in Phase II the coding process involved me identifying pieces of written text from my field notes and noting the potential theme (or code) in the margin. Field notes from other observations were then studied in line with the constant comparison method to ascertain whether similar pieces of text code could be assigned the same code. Codes that could be assigned to similar pieces of text in field notes from other observations, i.e. codes that repeated themselves, were applied until 'saturation' occurred. When codes were found not to repeat in the field notes from other observations they were discarded and other codes were sought. Sometimes codes initially identified did not exactly fit the various pieces of texts which I felt fell within that code. When this occurred the code was refined slightly so as to better fit the instances of text.

This process was often a difficult task in that there appeared to be much more data than I ever imagined there would be when I decided on this course of action. Although I never felt I became a victim of what Yin described in the above quote (p134) there were moments of fleeting anxiety where I felt lost in the large quantities of data. Ultimately though, I felt that the 'flip-flopping' process I undertook between data analysis and data gathering paid dividends in that it produced a conceptually rich and grounded account of teachers' practice and the role that their epistemological world views play in that practice.

4.3 Results

The field notes taken during classroom observations were typically messy but I looked for examples of what could be described as behaviouristic (transmission) teaching and constructivist teaching. I did not expect however that any teacher would use a transmission or constructivist approach exclusively but instead looked for the mix of such teaching methods in an attempt to cross-check this with their epistemological beliefs and epistemological world view. The results discussed below are based on classroom observations only. The reasons behind the teachers' decisions to teach in particular ways and the investigation of a possible link between the teachers' epistemological world views and their teaching practice are explored further in *Chapter Five - The Interviews.*

Aspects of a Constructivist Approach to Teaching

It became clear from the observations of teachers in this Phase of the research that all three teachers had aspects to their teaching that could be categorised as constructivist in nature. For instance, all three attempted to discover where their pupils were in their learning of a particular mathematical topic before proceeding to offer new insights into the same concept. Presenting new learning activities to a child after first taking into account previous knowledge and understanding allows pupils the opportunity to reorganise their own cognitive structures. That is, to acknowledge that children's understanding is determined both by what is experienced and by what is previously 'known' is an important implication of constructivist approach to teaching and learning.

However, I was aware that the teachers' tendency to access children's previous knowledge may have been more of a reflection of and an adherence to the requirements of the three-stage numeracy lesson suggested by the National Numeracy Strategy (DfEE, 1999) than the teacher's own belief about how mathematics should be taught. However, I also observed other instances of what could be called constructivist teaching from all three teachers that could not be attributed to external diktat.

For instance, I sometimes observed instances of teaching from all three teachers - to varying degrees – that allowed pupils' incorrect answers to develop until the pupils themselves realised their own error. If children's understanding of any concept is advanced by allowing them to construct their own meanings then allowing them also to reflect upon their own errors and misconceptions must also advance that understanding by allowing their faulty cognition to be personally recognised and reshaped. John did this in the very first session I observed. The lesson centred on the use of a graph to plot discrete data (See *Appendix V- Lesson One*) and John asked the class to suggest possible types of graphs that could possibly be used for such a purpose. However, the first suggestions he received from the class were not what he was looking for in terms of moving the lesson forward but he allowed the pupils concerned the time to explore further the answers they gave until the pupils themselves came to realise their own error. I observed this in the other teachers too but to a lesser extent. However, this technique was always more commonly used in the investigative lessons I observed all teachers deliver.

Teachers also commented (in interviews) on how they sometimes attempted to address their pupils' misconceptions of particular mathematical topics (See *Chapter Five – The Interviews*). Being aware that a child's incorrect answer may reveal important clues about their understanding of a particular topic is also an important underlying principle of a constructivist approach to teaching. However, although all teachers stated in interviews that they sometimes employed teaching strategies that were aimed at directly addressing pupil misconceptions I was not able to observe these in practice, other than the example discussed above. I have already outlined the potential disparity between what a teacher says and does and so without direct evidence we must be cautious in assuming that this was indeed the case.

Another aspect of the teaching I observed that I deemed to be largely constructivist in nature was the teachers' use of a variety of formative assessment techniques. Formative assessment can be described as assessment *for* learning as opposed to assessment *of* learning in that it is used not just to measure what a child has learned but also to inform the teacher's future teaching and the child's future learning (Harlen, Gipps, Broadfoot, and Nuttall, 1992). All three of the teachers made extensive use of the technique known as 'talking partners'. This technique allows children to discuss their potential answers to a question or problem with a partner before presenting it to the teacher. Teachers also used a variety of techniques to get the pupils to reflect on their own learning at the end of classes. John got his pupils to draw either a smiley, intermediate, or sad face in their books to indicate the extent to which they felt that they had successfully met the learning criteria set out at the beginning of the lesson. At the end of her lessons Lisa asked her pupils to close their eyes and indicate the extent to which they felt they had been successful by raising their hands in the air and giving either a thumb up, thumb in the middle, or a thumb down. Such techniques suggest that teachers were aware that individual learning can be advanced by discussion and negotiation in a social context and the importance of the children themselves being aware of the extent of their own learning and what they needed to do to improve that learning.

I also had the opportunity to observe all three teachers deliver what they described as 'investigative' lessons but what I came to see as largely constructivist in their approach. These lessons were all characterised by a number of features that were much more common in these lessons than in the 'non-investigative' lessons I observed the rest of the time. For instance, the lessons always involved a large degree of freedom in that the pupils were allowed much more time than would otherwise by the case in other lessons to explore and experiment with the task given by the teacher and their own approaches to it. It felt to me at the time that this freedom was a direct result of another common aspect of these lessons; the minimum amount of structure imposed on the lessons by the teachers concerned. For the most part teachers adopted a much more supervisory role only offering suggestions when children appeared to be stalling in their thinking on the task. These lessons were also characterised by what appeared to me to be the teachers' emphasis on the 'journey' of the lesson rather than the 'end destination'.

Overall, during these investigative lessons there appeared to be more of an emphasis by teachers on tasks that were differentiated by outcome rather than differentiated by task. This is much more consistent with a constructivist approach to teaching and learning. The former involves a more open activity where a degree of control is passed to the pupil and where the pupils can work at their own varying levels of attainment. The latter involves teacher set tasks set according to pupils perceived level of knowledge (Davis and Pettitt, 1994).

The lesson that typified this approach more than any other for me was the lesson delivered by Lisa which used the chessboard task and which required children to find the number of squares thereon (See *Appendix T – Lesson Three*). Lisa had explained to her pupils before the lesson got underway that '*this lesson is not about the result you get but about the process of getting there*' and later that '*it's about you trying things out and having a go and talking to others about your ideas*'.

Aspects of a Behaviourist (Transmission) Approach to Teaching

Almost inevitably I also observed instances of teaching that were more consistent with the traditional, didactic approach to teaching; one that I have linked with a realist (behaviouristic) world view and which relies on the transmission of information from the teacher to the pupil. For instance, I observed all teachers standing at the front of the class explaining mathematical strategies, followed by exercises requiring the strategy just explained. However, I was aware of the possibility that this approach may have had more to do with the requirements of the National Curriculum in terms of the considerable amount of content that needs to be covered, in what time frame, and the requirement that the pupils may be asked to 'reproduce' this knowledge at a later time when sitting their SATs than it did the teachers' preferred teaching style. I asked all teachers about this during interviews and this is discussed further in the next chapter (See *Chapter Five – The Interviews*).

In contrast to the 'investigative' lessons I observed, all the 'non-investigative' lessons employed a form of assessment that was characterised by differentiation by task rather than differentiated by outcome. That is, it was the teachers and not the pupils that decided on the appropriate level of mathematical learning for each pupil, or more to the point, each grouping of pupils.

Another aspect of the teaching I observed that could be described as more indicative of a transmission approach to teaching was the teachers' occasional use of closed questions that simply required the recall of facts (Selley, 1999). In a study of primary education, Her Majesty's Inspectorate (HMI) identified a link between good questioning skills of teachers and a high standard of pupil achievement (Ofsted, 1994). These closed questions were always more common during the oral/mental starters employed by all teachers to 'warm up' their pupils for the main part of the lesson. This was to be expected though since these parts of lessons seemed to be predominantly concerned with assessing children's mastery of number facts and methods of mental calculation. However, these types of closed questions were also sometimes used during the main sections of lessons when it seemed to me that the use of an open-ended question or even the offer of an opinion instead may have produced a greater degree of reflection in the pupil concerned. Again, I was aware of the possibility that the limited amount of time available to cover the content of the lesson may have played a role here.

Several of the many implications constructivism holds for teaching are that a child's thought processes are more important than outward behaviour in revealing their learning and that teachers can only use language to guide the learning of their pupils, not to directly transfer knowledge. This would further suggest that a teacher adopting a constructivist approach to teaching should be very interested in any instances when a pupil deviates from the expectations of the teacher because they could represent real opportunities for uncovering misconceptions (Harries and Spooner, 2000). As I have already indicated, teachers did sometimes allow pupils' errors to develop until they realised their own error but on occasion this did not occur. It seemed to me that when this did not occur it was because the teachers felt to do so would have been to interrupt the pace and flow of the lesson. That is, my feelings at the time were that this deviation from what I had previously observed teachers do was due to the pressure of time. Lisa's lessons in particular were characterised by sporadic periods of rapid delivery. However, this may have been due to her enthusiasm for the subject that I came to expect from Lisa.

A Tension?

I observed all teachers struggling with the problem of what Jaworski (1994) called the didactic tension, characterised by the phrase 'when to tell?' Jaworski, acknowledging the previous work of Edwards and Mercer (1987), described the didactic tension like this:

> To have to inculcate knowledge while apparently eliciting it [or] the problem of reconciling experiential, pupil-centred learning with the requirement that pupils rediscover what they are supposed to (Jaworski, 1994: 179)

Mason explained the dilemma like this:

> The more explicit I am about the behaviour I wish my pupils to display, the more likely it is that they will display the behaviour without recourse to the understanding which the behaviour is meant to indicate; that is the more they will take the form for the substance … The less explicit I am about my aims and expectations about the behaviour I wish my pupils to display, the less likely they are to notice what is (or might be) going on, the less likely they are to see the point, to encounter what was intended, or to realise what it was all about.
> (Mason, 1988 cited in Jaworski, 1994: 180)

I observed all the teachers involved in this research struggle in their attempts to achieve the requisite balance that results from this tension and which needs to be carefully managed in pursuit of a constructivist approach to teaching and learning of mathematics. It indicated to me that to attempt to adopt a more constructivist approach to teaching and learning is by no means the easy option and almost invariably will involve extra work for the teacher. I discussed this tension at length with all three teachers in interviews and the findings suggest that teachers were acutely aware of this tension. This is discussed in more detail in *Chapter Five – The Interviews*.

4.4 Discussion

This chapter set out to explore further teachers' epistemological beliefs and epistemological world views concerning the teaching and learning of mathematics. It did so by observing at close quarters the classroom practice of three primary teachers over a six-month period. This observational phase of the research was thought particularly important in investigating any potential link between these world views and teaching practice as much past research has shown that teacher behaviour is not always consistent with their previously stated beliefs and attitudes (Cohen, 1990; Schraw and Olafson, 2002; Schoenfeld, 2002). Observations were to be used to confirm or otherwise the extent to which the teacher's pedagogic practice was consistent with their stated epistemological beliefs about the teaching and learning of mathematics - given via questionnaires in Phase I of the research and to be given in interviews in Phase III of the research.

The chapter started with acknowledgement of the inherent difficulties in undertaking observations of teachers in the classroom. Consequently, a justification of the decision to use a multiple case study approach combined with semi-structured non-participant observations of classroom practice was given. The subsequent decision to discard the semi-structured observational technique in favour of a more unstructured non-participant observational approach was then discussed. Brief teacher biographies were given alongside brief details of each of the teacher's schools.

Findings from the observations suggested that teachers did show many aspects of their teaching practice that could be described as constructivist in nature.

This was expected of John given his clear stance as a relativist from his questionnaire responses. It was less expected of Lisa given her responses but I eventually came to view Lisa as having some of the most deeply held relativist (constructivist) beliefs about the teaching and learning of mathematics, although they were mostly unconscious. Mary refused to complete a questionnaire. All three teachers attempted to discover the extent of their pupils' existing knowledge on a given mathematical topic before beginning to offer new insights into the same concept. Presenting new learning activities to a child after first taking into account previous knowledge and understanding allows pupils to reorganise their own cognitive structures. It seemed to me that teachers acknowledged that children's understanding is determined both by what is experienced and by what is previously 'known'; an important implication of a constructivist approach to teaching and learning.

Observations also showed that all three teachers - to varying degrees - sometimes allowed their pupils' incorrect answers to develop until the pupils themselves realised their own error. Again, it seemed to me that teachers were acknowledging the importance of the child's own constructions of knowledge and their reflections on those constructions of knowledge in their learning. Teachers also used a variety of formative assessment techniques. That is, assessment *for* learning as opposed to assessment *of* learning. The 'investigative' lessons I observed also included a number of features that I characterised as constructivist. For instance, teachers employed tasks that were differentiated by outcome rather than by the task itself, where a degree of control was passed to the pupil

However, teachers also showed some aspects of their teaching that relied on the more traditional, didactic approach, i.e. an approach that uses the transmission of information from teacher to pupil. For instance, on occasions I observed all teachers standing at the front of the class explaining mathematical strategies, followed by exercises requiring the strategy just explained. I also observed the teachers use closed questions that simply required the recall of factual information when perhaps an open-ended question or a stated opinion may have proved more beneficial in inducing reflective thought in the pupil concerned. I was uncertain however to what degree these strategies were preferred teaching styles or a matter of contextual factors mediating their practice, e.g. the requirements of the national Curriculum.

Lastly, I also observed another interesting aspect of all teaching practice from all three teachers; what Jaworski (1994) called the didactic tension. This is the problem that teachers encounter when wanting pupils to construct their own understandings of concepts and allowing them the freedom to do that but also wanting to ensure that their pupils have enough information to grasp exactly what it is they want them to understand and the associated risk that the pupils may not construct their own meaning . It was very interesting watching teachers struggle with this problem of balancing the two pedagogical extremes of freedom *versus* structure.

Conclusions

All three teachers observed showed aspects to their teaching that could be categorised as constructivist; an approach I have linked with a relativist world view concerning the teaching and learning of mathematics. However, they also showed some aspects to their teaching that could be categorised as behaviouristic and which relied more on the traditional, didactic approach; an approach I have linked to the realist world view. I was unsure however whether these teaching styles reflected their own epistemological beliefs or epistemological world views about the teaching and learning of mathematics (and, if so, to what extent they did so) or whether they were simply the result of mediating contextual factors like the requirements of the National Curriculum. This issue was to be explored further in the next Phase of the research and which are discussed in the next chapter (*Chapter Five – The Interviews*).

Chapter 5: Phase III - The Interviews

The human mind is only capable of absorbing a few things at a time.
(Stanislaw Lem, 1970)

The overriding concern in this Phase of the research was how best to accurately elicit teachers' epistemological world views concerning the teaching and learning of mathematics. I decided to use two approaches within a semi-structured interview technique. One approach involved me asking teachers direct questions about specific teaching and learning issues that would reveal insights into their epistemological world views. The second involved me asking questions concerning specific instances of their teaching just observed. This latter approach took the form of the stimulated recall procedure to probe their thinking concerning the chosen aspects of their teaching (Calderhead, 1981).

The stimulated recall procedure involves attempting to elicit, at a later time, the thought processes teachers went through when delivering mathematics lessons to their pupils. This is methodologically very difficult because it has been shown that the human brain is limited in its capacity for storing memories in the short term (Miller, 1956) and that memories *can be* unreliable when subsequent recall takes place some time after the original event occurred (Bartlett, 1932; Loftus and Palmer, 1974). This meant that somehow teachers needed to be 'taken back' to the time of the lesson and 'reminded' of particular incidents that were deemed to be of interest in revealing their epistemological world view concerning the teaching and learning of mathematics.

Within the semi-structured interview method as a whole a triangulation process between researcher and participants was also employed when necessary in order to minimise the possibility that any discrepancy between a teacher's professed epistemological world view and their subsequent practice would be a result of a lack of shared understandings concerning the important descriptive terms employed (Speer, 2005).

This chapter then sets out the rationale for the method and some associated strategies chosen in order to accurately tap into teachers' epistemological world views concerning the teaching and learning of mathematics. This is followed by a critical discussion of the findings from this phase of the research.

5.1 The Interviews

Cannell and Kahn (1968) define the interview as:

> a two-person conversation initiated by the researcher for the specific purpose of obtaining research-relevant information, and focused by him on content specified by research objectives ... (Cannell and Kahn, 1968 cited in Cohen and Manion, 1985)

Although all interviews share the same aim of wanting to gather data via direct verbal interaction as a research tool they can be distinguished by the degree of structure they employ. The highly structured interview is characterised by the researcher asking a standardised set of questions in a set order and often with a limited number of response categories. There exists little or no opportunity for the interviewer to deviate from the questions asked or the order in which they are asked. The unstructured interview is characterised by opposite features, i.e. there are no set questions to be asked and the interviewee dictates the content and direction of the interview. In between these two extremes exists the semi-structured interview where the interviewer has a number of questions to ask or issues to touch upon during the interview but has a large degree of freedom in the way and order they are asked and where the interview itself is conducted in a conversational style (Fontana and Frey, 2000).

One of the advantages of using the semi-structured interview method here is that it allowed me to develop a close relationship with each of the three teachers involved. This in turn allowed me the opportunity to reveal what they viewed as their epistemological world view concerning the teaching and learning of mathematics rather than imposing my own view of what I thought their epistemological world view was or should be. I felt this approach to be ideally suited to the nature of this research and in particular this phase of the research where I was attempting to elicit teachers' beliefs. Tuckman (1972) touches on the very element of the approach that I felt made it ideal. He writes that:

> By providing access to what is 'inside a person's head', [it] makes it possible to measure what a person knows (knowledge or information), what a person likes or dislikes (values and preferences), and what a person thinks (attitudes and beliefs). (Tuckman, 1972, cited in Cohen and Manion, 1985)

Central to the aim of research on teachers' epistemological world views or personal epistemologies is to gain some insight into their cognitive processes during the teaching process, i.e. their thoughts and decision-making *in situ*. In an attempt to achieve this, some educational researchers in the past have typically relied upon classroom observations alone. However, the use in isolation of either systematic non-participant observation or participant observation as a means of gathering such difficult-to-access data has its limitations. However, the use of classroom observations in combination with some form of stimulated recall has proved beneficial for many studies (Delamont and Atkinson, 1980; Tabachnik and Zeichner, 1984; Leinhardt, 1988).

Stimulated recall is a term used to describe a number of techniques but it typically refers to a process that:

> ... involves the use of audiotapes or videotapes of skilled behaviour, which are used to aid a participant's recall of his thought processes at the time of that behaviour ... It is assumed that the cues provided ... will enable the participants to 'relive' the episode to the extent of being able to provide, in retrospect, an accurate verbalised account of his original thought processes. (Calderhead, 1981: 212)

The technique was thought to be first used by Bloom (1953) who used audio tapes of both lectures and discussions to check whether students' thought processes differed across the two learning situations.

Several aspects of the stimulated recall procedure have raised issues concerning the interpretation of any information gleaned through its use. Perhaps the most fundamental of these issues concerns the question of whether the teachers' responses to the stimulated recall procedure actually represent valid thoughts during the teaching process or whether they are simply explanations that place themselves or their teaching in the best possible light (Calderhead, 1996b). However, some research in the laboratory has suggested that the recall of problem-solving techniques used immediately after the event seemed to accurately reflect the strategies used (Ericsson and Simon, 1980).

Although I acknowledge that a great deal of trust needs to be exercised in this respect, the validity of teachers' reports of their thought processes in this Phase of the research were crudely benchmarked against the observations of their teaching in Phase II of the research.

Further criticisms of stimulated recall as a method of eliciting teacher's thought processes concerns several factors that may influence the extent to which teachers can accurately recall and discuss their thought processes. For instance, some research has suggested that viewing oneself teaching is a very stressful and anxiety-inducing experience for most teachers and that this level of discomfort influences the teacher's ability to recall the thought processes involved and/or the willingness to discuss them with the researcher (Fuller and Manning, 1973). Also, there is the idea that teachers associate with any action taken in the classroom a unique set of visual clues and that these cannot possibly be recorded by the researcher (Bloom, 1953).

Given these criticisms of researching teacher thinking and behaviour it is clear that a good deal of thought needed to be given to how data concerning their thought processes during teaching were elicited (Calderhead, 1996). These criticisms led partly to my decision not to include audiotapes or video recordings of teaching sessions in my version of stimulated recall but instead to use verbal descriptions of the different aspects of the observed lessons with instructions to teachers to imagine themselves back in the classroom. Consequently, it was hoped that this approach would avoid any teacher embarrassment and so increase the probability of gaining accurate and valid recollections concerning their teaching decisions. One other important reason why I decided not to opt for audio-tapes or video recordings of teachers' classroom activities was that I thought it would impact negatively on the recruitment of teachers in Phases II and III of the research. It is worth remembering at this point that one of the teachers selected for Phase II and III of the research, Mary, was very embarrassed by the thought of even an audio tape recorder being used in post-observation interviews.

It was also hoped that by asking teachers to imagine themselves back in the classroom this would also elicit for them their own unique set of visual cues leading up to each aspect of the observation discussed rather than imposing on the teacher the researcher's own visual or audio cues. Calderhead (1981) clearly had these issues in mind when he wrote:

> The questions of preparing teachers for stimulated recall interviews and of structuring the interview itself clearly have to be weighed against the possibilities of imposing, or encouraging the teachers to impose, unreal interpretations upon their behaviour. (Calderhead, 1981: 214)

5.2 Data Collection and Related Issues

This section includes some finer details concerning the data collection and analysis in Phase III of the research.

The Sample

The sample used in this Phase of the research was the same as that used in Phase II and details will not be repeated here. Instead, the reader is referred to *Chapter 4: Phase II – The Case Study Observations* for further details of the sample.

Data Collection

My approach to data collection and analysis followed closely that outlined by Pidgeon and Henwood and which can be seen in diagrammatic form in Figure 4.2.1 in the previous Chapter.

Interviews were scheduled with teachers, as far as was practicably possible, with sufficient time between each to enable the considerable amount of data from the current to be transcribed, studied and a tentative first analysis to be begun. I attempted in all cases to arrange interviews immediately following the observations but this was not always possible given the teachers' busy schedules. All the interviews I conducted with John and Mary followed immediately on from the observations of their classroom practice. However, Lisa's teaching timetable and other commitments meant I was only able to interview her on two occasions (although I observed her teaching on four different occasions). Transcriptions of interviews with Lisa, John, and Mary can be seen in *Appendices X, Y,* and *Z* respectively.

In line with the grounded theory approach discussed in detail in the previous chapter (See *Chapter 4: Phase II - The Case Study Observations*) this allowed insights that emerged from the analysis of current interviews to feed into my thinking in time for the next. It also allowed time for interviews to be transcribed and sent back to the relevant teacher for respondent validation before any analysis was confirmed and further developed.

I tried hard not to 'push' my own agenda or preconceived ideas onto teachers but to listen to what they had to say about their own world view. For instance, in early interviews I did not explicitly refer to *behaviourist* or *constructivist* teaching but allowed teachers to use their own descriptive terms for their teaching and the subsequent learning that occurred. Later in the interview process with teachers I began to introduce the terms 'behaviourist' and 'constructivist' as descriptors for teaching and learning in an attempt to more explicitly capture teachers' thoughts on these ideas. This necessitated a shared understanding of the terms 'behaviourism' or 'the transmission approach' and 'constructivism'. However, interviews did sometimes produce instances where teachers were unable to articulate their beliefs or to clearly explain why they had taught the way they had. In these instances I was conscious that I was stimulating teachers' thinking by introducing to the discussion words or phrases previously unheard by teachers.

On occasion I also asked teachers to expand on their interpretation of certain terms used within the interviews in an attempt to elicit a shared understanding of the terms used. Several researchers in the field have highlighted this as an important way to avoid misinterpreting teachers' responses (Schoenfeld, 2002; Speer, 2005). For instance, Schoenfeld (2002) has called this process a type of triangulation. This type of triangulation was also employed in an attempt to avoid the criticism raised by some researchers in the field that some reported discrepancies between teachers' world views and their teaching practice is due more to this lack of shared understanding and less to the accurate measurement of the phenomenon under study. For instance, on this matter Speer (2005) states:

> I assert that in some cases, reported discrepancies between professed and attributed beliefs may in fact be the result of methodological artefacts and not an accurate reflection of the phenomena researchers seek to understand. In particular, reported inconsistencies may be the result of a lack of shared understanding among researchers and teachers about what descriptive terms mean ... (Speer, 2005: 262)

Two of the three teachers involved in Phases II and III of the research were happy to be audio-taped during the interviews I held with them after every observation (although sometimes it was not possible to conduct interviews immediately after observations). However, one of the teachers, Mary, had stated from the very outset that she did not like tape recorders and refused to allow me to audio-tape the conversations we had together. This caused me several problems. Firstly, I had to take copious notes during out interviews together which meant that I could not give my full attention to the conversation. I also had to write up these notes very soon after the interviews had taken place to minimise the amount of forgotten or misremembered data. Consequently, the reader should be aware that the quotes used in this chapter from the conversations I had with Mary are based on my memory of what was said via my field notes. I do not see them as inaccurate but I am aware that they are not verbatim accounts.

Data Analysis

Transcripts of interviews were analysed using the principles of grounded theory described in *Chapter 4*, i.e. the constant comparison method and theoretical sampling (Glaser and Strauss, 1967). Much of the critical discussion of the grounded theory approach has been discussed previously and will not be repeated here. However, the reader is referred to the discussion of the approach in *Chapter 4: Phase II – The Case Study Observations.*

Typically, the data analysis involved a close examination of the interview transcripts and a subsequent identification of relevant incidents that were then coded into as many different categories as emerged from the data (Glaser and Strauss, 1967). In the context of interview transcripts, this meant that pieces of text that were thought to reveal interesting insights into teachers' beliefs and/or world views were highlighted and labelled with a code, i.e. an identifier that appropriately labelled or categorised that particular instance of text. For example, *evidence of a relativist world view* was initially used as a code or identifier for a number of pieces of text in interview transcripts. These identifiers were written in the margin until it became clear that there would be more than one incident comprising that particular code (See *Appendix AA* for an example of how codes were assigned to pieces of text). If no further incidents were identified from future transcripts the code was deemed inappropriate and discarded and different codes were sought from the data (ibid). The analysis of subsequent interview transcripts attempted to identify incidents that would 'fit' into the previously identified codes. The data was scrutinised like this until 'saturation' occurred, i.e. no further incidents were identified that could 'fit' into previously identified codes and no further codes emerged[1]. On occasion codes were refined or were found to reveal sub-codes. For instance, the code *evidence of a relativist world view* was found to include the sub-codes *discover previous learning, allow children's errors to develop,* and *use of assessment for learning.* Other main codes (and sub-codes) that emerged from the data were *evidence of a realist world view* (this revealed the sub-codes *expert role in the classroom, agreement with SATs.* and *exposition and practice*), *the didactic tension, restrictive aspects of the National Curriculum* (this revealed the sub-codes *content to be covered, time available, assessment by SATs,* and *some current working practices*), and *tacit beliefs/epistemological world views.* These main codes are presented as themes under main headings in the *Results Section* that follows and the sub-codes are discussed under their appropriate main code headings.

Tentative analysis of the interview transcripts started as soon as possible after the interviews had been transcribed but only after receiving transcripts back from the teachers concerned with their respondent validation did the analysis begin in earnest. This allowed the early identification and coding of potential categories whilst the interviews were still 'fresh' in the memory. These categories subsequently provided a working conceptual framework for the identification of new incidents. Pidgeon (1997) is in favour of the early analysis of qualitative data. He argues that:

[1] It is interesting to note that this process of 'fitting' incidents into previously identified categories or disregarding them as inappropriate is consistent with von Glasersfeld's (1984; 1987) theory of 'fit' in radical constructivism.

> Taken together, the commitments of constant comparison [and theoretical sampling] involve the researcher in a highly interactive and iterative process in which the traditional distinction between the data collection phase and the data analysis phase often breaks down. Data analysis can (and ideally should) proceed as soon as sufficient material is collected to work on (rather than waiting until a predefined dataset has been obtained), and this in turn feeds back into the sampling of new data. (Pidgeon, 1997: 79) [my parentheses]

5.3 Results

Throughout this section it was necessary to refer to teachers' views of teaching and learning in interviews and so, for expediency, those words are reproduced here. However, so the reader can place those quotes in their fuller context and within the chronology of the numerous interviews conducted with each teacher, each extract will be followed by an identifier that will cite the relevant appendix, the teacher's fictional name, the interview number, and the line numbers assigned to them in the appropriate appendix, e.g. Appendix Y: John: Interview 2: L145-156. One caveat is necessary at this point, already partially alluded to earlier in this chapter. That is, that one of the teachers (Mary) would not allow our conversations to be audio-taped. Consequently, the transcriptions of these conversations were produced as accurately as my memory of the events would allow and as such the reader's attention is drawn to the potential of bias in this aspect of the work.

Evidence of Relativist World Views

All three of the teachers involved in this research expressed beliefs during interviews about the teaching and learning of mathematics that suggested they held a predominantly relativist world view of the teaching and learning of mathematics. A view I have argued is associated with a constructivist conception of mathematics. For instance, very early on in the interview process with Lisa she hinted at her view of how pupils learn new mathematical ideas most effectively:

> **L:** It's different for different children. There needs to be a lot of different ways. It is no good just standing up and telling them it, they've actually got to do things themselves, they've got to investigate it, they've got to try things, use anything, apparatus, anything to help them. Because I think if you are just going to stand and tell them '*this is how you do this, this is how you do that*', they just don't take anything in. So it's to do with them having a go really. (Appendix X: Lisa: Interview 1: L10 -15)

John's philosophy too was partially revealed early in our first discussion. He said:

> **J**: Another thing that I try and do is to get away from the answer and get more towards what the children are thinking because the answer is only a part of maths and it is more the thought process that gets towards the answer and we need to formalise this thinking process and talk more about it because if we don't talk about it they may think the answer is the right thing. (Appendix Y: John: Interview 1: L111-115)

It became clear from the observations of teachers in Phase II of the research that all three teachers had aspects to their teaching that could be categorised as constructivist in nature. As I discussed in Chapter Four all three teachers attempted to discover where their pupils were in their learning of a particular mathematical topic before proceeding to discuss new mathematical concepts. However, it is possible that this may have been more to do with the teachers' adherence to the requirements of the three-stage numeracy lesson suggested by the National Numeracy Strategy (DfEE, 1999) than the teacher's own belief about how mathematics should be taught. However, I also observed other instances of what could be called constructivist teaching from all three teachers that could not be attributed to external diktat. For instance, I observed instances of teaching from all three teachers - to varying degrees - that allowed pupils' incorrect answers to develop until the pupils themselves realised their own error. I asked one teacher, John, about this:

> **DB:** I also found it interesting at the beginning when you asking the class '*what type of graph might we use here?*' but the suggestions you got weren't what you were looking for but you allowed those suggestions and followed them through.
> **J:** Well because you can't say '*no*' because '*why no?*' but when we see that we can't use a line graph because they involve time and we don't have the element of time there, we could use pie charts but we haven't actually learnt how to use pie charts, and we can't use a Venn diagram, where Venn diagram came from I don't know, but. What I thought about then though was that perhaps the lesson should have been guided by a question, something that would actually guide them towards having a final answer. It might have helped.
> **DB:** When you say '*you can't say no*' I think you there probably are teachers who would say 'no' in a certain way. Perhaps not in a forceful way but …
> **J:** But then the child doesn't understand why. There has to be a reason why. Another thing that I try and do is to get away from the answer and get more towards what the children are thinking because the answer is only a part of maths and it is more the thought process that gets towards the answer and we need to formalise this thinking process and talk more about it because if we

don't talk about it they may think the answer is the right thing and sometimes they can go completely on the wrong tangent and get the wrong answer or on the wrong tangent and get the right answer but it is how. So if they don't know the answer '*tell me what you think the answer might be*' or get them to talk with their partner and give the answer your partner thought not what you thought because often they are happier giving somebody else's answer. (Appendix Y: John: Interview 1: L99-121)

The other teachers too sometimes used this approach in their classes. Mary had this to say when I asked her about why she used the technique:

M: I just wanted him to see where he was going wrong rather than just saying '*no, that's wrong*'. (Appendix Z: Mary: Interview 2: L15-16)

All three teachers stated in interviews that they sometimes employed teaching strategies that attempted to bring their pupils' awareness to possible misconceptions. This approach could be described as constructivist in that it would allow pupils to reorganise their own cognitive structures. I had this conversation with Lisa about how she approached this aspect of her teaching:

L: I don't think ... you're always aware of possible misconceptions and you highlight them to the children.

DB: And where does that come from, that awareness?

L: Just from previous children and teaching in previous years, yeah, because you do pick up ... this class, the class you observed today, for some reason they all do carry methods and subtraction and I know that if was to give a subtraction problem they would just take the smallest number away from the biggest number no matter where it was and you just know that children do that so when you come to look at the work in their book you know that's why we try to show them different methods, to avoid that

DB: Do you prejudge that?

L: You don't prejudge it. Generally, at the beginning of a topic or whatever, I just put a question up and ask them to have a go and see how they do it and I look at that and then from there. I don't think '*Ah, they are going to make this mistake*' and get in there before they do it because nobody might do it.

DB: But you find that they do?

L: Generally, yeah. (Appendix X: Lisa: Interview 2: L358-379)

And later she revealed one approach she used to address these misconceptions:

L: And another good way of doing that is that if you are doing subtraction or addition when you demonstrate it is for you to make mistakes and get the children to pick them out because they are really following and understanding the methods rather than just applying it, they've actually got an understanding of it and I love doing that because the children are so keen to tell you you've made a mistake. (Appendix X: Lisa: Interview 2: L402-406)

Being aware that a child's incorrect answer may reveal important clues about their understanding of a particular topic is also an important underlying principle of a constructivist approach to teaching. However, as I stated in Chapter Four, I was not able to observe evidence of this in any of the classroom observations I undertook.

All three teachers also made extensive use of a variety of formative assessment techniques. For instance, as I discussed in Chapter Four, all teachers used the 'talking partner's' technique. They also used a variety of techniques to get the pupils to reflect on their own learning at the end of classes. John got his pupils to draw a smiley/intermediate/sad face in their books to indicate the extent to which they felt that they had successfully met the learning criteria set out at the beginning of the lesson. At the end of her lessons Lisa asked her pupils to close their eyes and indicate the extent to which they felt they had been successful by raising their hands in the air and giving either a thumb up, thumb in the middle, or a thumb down.

Such techniques suggest that teachers were aware that individual learning can be advanced by discussion and negotiation in a social context. It also suggests that teachers were aware of the importance of the children themselves being aware of and taking part responsibility for their own learning and what they needed to do to improve that learning. I asked all teachers about why they used these techniques. Their replies suggested they all held a relativist (constructivist) view of mathematics but the responses were all surprisingly similar and I was aware of the possibility that their answers were more a reflection of what they had heard and read in government policy documents and LEA training sessions than it was a reflection of their own beliefs or world view. When I asked Mary why she used the 'talking partners' technique she replied:

> **M:** Several reasons really. First of all it gives the children a chance to think rather than just jumping in with a rushed answer. It also gives them a chance to verbalise their thought with the other child before answering. It also shares out the responsibility for the answer so if they get it wrong no one person feels it is their fault alone. (Appendix Z: Mary: Interview 1: L16-19)

I asked John the same question about 'talking partners' and he replied:

J: It's formative assessment. It's the idea that sometimes children can't verbalise what they want to me so therefore they verbalise with their partner and often it supports the weaker ones and gets them to think about what they are going to say before they say it and gets them to think around things but it is also linked to extending the wait time. (Appendix Y: John: Interview 1: L78-82)

I had the following conversation with Lisa about how she discovered what her pupils had learned in class:

DB: How do you find out what your children have learned in class?

L: Quite a lot of it is formative assessment as you go along, by questioning and just by looking at them and then a lot of it is through questioning. Of course, through the marking of their work and at the end of term there is summative assessment but we are just starting something new, we are training in assessment for learning and it's to do with the smiley faces and for the children to assess their work and to know what they've done and whether they need more help with it. We've just started that actually and it is all to do with formative assessment, asking them, talking to them and finding out what they don't know and where that's come from and finding out where they are really as opposed to just assuming that everybody's at the same place. Just finding out where each child is. (Appendix X: Lisa: Interview 1: L194-204)

Despite the similarity of the answers, it seemed to me that Lisa had some of the most deeply held relativist beliefs about the teaching and learning of mathematics, although these were for the most part unconsciously held.

Teachers' own views of their role in their classrooms varied. Again, Lisa's view of her role in the classroom suggested she held a predominantly relativist (constructivist) world view of mathematics. When I asked Lisa whether she saw herself as the expert in the class she replied:

> **L:** Erm, no. I think I can help them improve their knowledge but I wouldn't say '*what I say goes*' or '*this is how we do it'* because I don't think maths is like that. I can offer ideas and I can tell them how I would do things and what methods I would use but I wouldn't say that was the best method to do them. Quite often I'm totally shocked when they come up with an even quicker method than I could ever have thought of. (Appendix X: Lisa: Interview 1: L59-64)

However, Mary's view on her role in the classroom hinted at a realist view (see below).

Evidence of Realist Epistemological Beliefs

All three teachers also expressed beliefs that could be interpreted as being indicative of a realist world view. A view I have argued is associated with a behaviouristic conception of mathematics. In particular, Mary's view of her role in the classroom suggested a belief that was more consistent with a realist (behaviouristic) world view. However, I was aware that this may simply have reflected the confusion she was having understanding the idea of constructivism as it related to the teaching and learning of mathematics. In one of our later discussions I tried to explain to Mary the main assumptions of constructivism:

> **DB:** What I've been trying to get at over the last couple of times we have met is your philosophy of the teaching and learning of mathematics, what you think is the nature of mathematical knowledge, how it should be best taught, how it is best learned, what teaching styles or techniques you feel produce the best results. There is this idea that teachers can't teach children anything but that the child must construct their own learning, it's called constructivism.
>
> **M:** I'm not sure I agree with that. I think teachers can and do teach children. I do teach children otherwise I'd be out of a job, wouldn't I?
>
> **DB:** Well, let's try and agree on what we mean by this idea of constructivism. I don't think it means that teachers should be made redundant because they have no role to play in the classroom. I think constructivism still acknowledges that teachers are important in the classroom but that they can only be facilitators of the children's learning. They can't transmit knowledge directly from themselves to the children.
>
> **M:** Mm. I know what you mean but I'm not sure about that. (Appendix Z: Mary: Interview 2: L32-45)

John too sometimes expressed beliefs that appeared inconsistent with his predominantly relativist (constructivist) world view, as measured by his questionnaire responses and his other statements during interviews. For instance, he said that he disliked the publication of league tables as they were reported in the local and national press. However, he agreed with the use of Standard Assessment Task (SATs) tests at the end of the Key Stage 2 education in Year 6 and the optional tests that almost all primary schools use in the years preceding it (James, 2000). He said he liked the SATs because of the data they provided him concerning the learning of his pupils. Early on in our discussions I asked John about his thoughts on the current use of SATs:

> **DB**: Tell me about your thoughts on SATs.
>
> **J**: I agree with SAT testing within class because I think it does give us an idea of where the children are at and it gives us an awful lot of data to look at where we are going wrong as teachers or where we are going right. But it tells us which area of our curriculum is weak and which area we need to strengthen. But in terms of the publication of SATs, that's where I disagree because we then have a problem that all schools aim high or aim to achieve, but when they don't achieve the teachers feel bad, the kids feel bad, the schools drop in the league tables and when they drop in the league tables, parents don't want to send their children there. I've been in two schools that have been high in the league table and you have parents phoning when they come out to try and register their children in that school because it is seen as a good school. So there is too much emphasis placed on SATs.
>
> **DB**: But you also said that they give you a lot of valuable information about where the children are at?
>
> **J**: Yes, they do. The optional testing we do gives us a lot of information. (Appendix Y: John: Interview 1: L130-144)

John's agreement with and acceptance of standardised testing in class interested me because he had previously espoused a largely relativist world view concerning the teaching and learning of mathematics, i.e. a constructivist philosophy. However, John did not seem to see the inconsistencies in his words here. That is, on the one hand he argued that he tried his very best to adopt a constructivist approach to his teaching of mathematics, and I observed evidence of that at first hand, but on the other hand he seemed to place great store in the information gleaned about his pupils' learning from the assessment of knowledge via standardised tests that require standardised answers. This latter view sits more easily with the absolutist epistemology of the realist world view and with the associated transmission approach to teaching and learning than it does with the fallibilist epistemology of the relativist world view and its associated view of teaching and learning as one of active construction.

As I stated in Chapter Four, almost inevitably I did observe instances of teaching that were more consistent with the traditional, didactic approach to teaching; one that I have linked with a realist (behaviouristic) world view and which relies on the transmission of information from the teacher to the pupil. For instance, I observed all teachers standing at the front of the class explaining mathematical strategies, followed by exercises requiring the strategy just explained. Mary explained her use of this 'exposition and practice' approach in her lessons:

> **DB:** I also noticed that the main part of your lesson involved a number of exercises for the children to attempt. What were your reasons behind giving them out?
>
> **M:** Well, the children need to practise on questions of the type I've just explained. Otherwise, they wouldn't get the chance to consolidate what I had just taught. The tasks were differentiated according to ability though. (Appendix Z: Mary: Interview 1: L20-25)

The Didactic Tension

In Chapter Four I referred to the didactic tension (Jaworski, 1994) I observed in classroom observations. The didactic tension can be summed up by the phrase 'when to tell?' and is the problem that teachers can encounter when wanting pupils to construct their own understandings of concepts and allowing them the freedom to do that but also wanting to ensure that their pupils have enough information to grasp exactly what it is they want them to understand but in doing so risking that the pupils may then not construct their own meaning. In the observational phase of the research, discussed in Chapter Four, I observed all three teachers struggling with the balancing act that is inherent in this tension. It seemed to me at the time that the fact that this struggle was going on in the classrooms I observed was indicative of the teachers' attempts to adopt a constructivist approach to their teaching of mathematics. I asked all three teachers about this tension during interviews and all three seemed to immediately understand the phenomenon I was explaining and its inherent difficulties. I had the following conversation with John:

> **DB:** There was something I wanted to talk about that you raised last time we spoke. When we talked about managing the Numeracy Hour you talked about the need for it to be '*flexed*' and if you'll allow me I'll quote what you said. You said '*Year 6 need more time to work and less time for me to talk*'
>
> **J:** I know and I did the exact opposite today.
>
> **DB:** But it seems to me that it is about trying to get the balance between. [You said] '*Have I talked enough to get them to do the task or have I just thrown the task at them?*' Now when I read that I thought that was very interesting. How do you manage that balance?

J: You can't. [laughs]. It's as simple as ... so today there was more talk because the concept didn't 'click' as quickly as I'd hoped. I'd hoped that it would 'click' so almost ... the way in saying '*there is a method, there is a method, there is a method*' is possibly not the best way. It is possibly better in this instance to say '*this IS the method*'. So we are almost going away from what we've said about constructivism to a more didactic approach and saying '*this IS how you do it*'. I think another example would be fractions because fractions and particularly addition and subtraction of fractions and things like that, they just need a method. (Appendix Y: John: Interview 2: L38-54)

The conversation with Lisa on the same subject went like this:

DB: That's an interesting problem there that you've hit on, isn't it? Guiding the children to discovering ideas. If you've got something you want to 'get across' to children but you want them to discover it for themselves, how far do you let them discover it for themselves and risk them not getting it before you say...
L: Major problem. I think it is different for different children but I can think of a group of children where I can just say '*there you go, try this, maybe start here and investigate this*' and they would go off and just spend ages doing all these different things. But I can also see a lot of children within the two classes that would just have no concept of where to start and they would give up before they had even finished listening to what the task was because they know they would have to investigate themselves. So I think with some children they would be quite happy and I was one of those children, I would be quite happy just to get on investigating things and if it didn't work I would do something else. (Appendix X: Lisa: Interview 1: L19-31)

The above conversations quite clearly show the importance the teachers attached to allowing their pupils the opportunities, when they could, to construct their own understandings of mathematical concepts. The conversations also suggest that the link between a teacher's epistemological world view and their teaching practice is very unlikely to be a direct one. I discuss this later in this chapter.

Restrictive Aspects of the National Curriculum

I was aware that the tendency to sometimes employ an 'exposition and practice' approach may have had more to do with the requirements of the National Curriculum in terms of what they children are expected to know, the amount of content that needs to be covered, and the time allowed to cover it, than the wishes of the teachers concerned. However, it is possible that this is also linked with some current working practices, which I discuss later. I asked John about his technique of allowing children's incorrect responses to develop until they had realised their own mistake and whether he always had time to do this:

> **DB**: Do you always have time to allow incorrect answers to be developed, almost up a dead-end, do you know what I mean?
>
> **J:** Yes, you've got to because again they are then saying …
>
> **DB**: But do you always have time to do that?
>
> **J**: Not always. I would try as far as possible to allow them to get themselves into a dead-end. (Appendix Y: John: Interview 1: L122-126)

In a later interview with John he expressed the view that his desire to adopt a more constructivist approach to the teaching and learning of mathematics was restricted by the requirements of the National Curriculum. I decided to ask the question directly:

> **DB:** So what you're saying is that truly constructivist teaching and learning is inconsistent with the National Curriculum?
>
> **J:** With our prescribed National Curriculum, yes. The National Curriculum that is as prescriptive as we have, yes. If it was slimmed down or if it was mixed … I have this vision in my mind of all these objectives and if you could sort of wash over them to make a general mash of what they need to know roughly, not specific objectives, then yes you could engineer learning for the children within that sphere, say electricity, you know there are so many prescriptive things, you couldn't direct it towards that but as a general overview then you could directly aim them towards that. So I think it needs to become less prescriptive for it to become truly constructivist. (Appendix Y: John: Interview 3: L155-163)

The interviews with Mary and Lisa too revealed suggestions that they sometimes felt constrained by some of the requirements of the National Curriculum in how they could realistically teach mathematics. I had the following discussion with Mary:

> **DB:** Does the National Curriculum restrict you in any way? For instance, does it restrict you in the way you would like to teach or not?
>
> **M:** Well, yes and no. The National Curriculum is prescriptive and it does impose constraints on teaching to a certain extent because we have to cover a lot of material in a set amount of time and sometimes it would be nice to have more time to cover topics with the children, especially the less able ones. So it's restrictive in that sense. Having said that though the National Curriculum only sets out what has to be covered, the key objectives, but the way you cover that

material is up to each teacher and so that can be adapted to a degree. (Appendix Z: Mary: Interview 1: L60-68)

Two of the three teachers (John and Mary) also expressed a definite wish to be able to teach in a constructivist way more often than they currently did but felt that the time available did not allow it. In our last discussion together John had told me about how much he had enjoyed teaching in a Year 5 class earlier in his career because he had more freedom to adopt a more constructivist approach to his teaching. He had this to say on the subject:

J: My favourite year in teaching, which was a while ago now, when I look back that was a wonderful year, there was lots and lots of practical stuff and I didn't care about whether it was recorded or ..., and the kids learned a massive amount, not just in terms of singular subjects but in terms of the inter-connectedness of subjects as well because it could be truly cross-curricular. You know, we would look at one thing in Science that would then reflect in their English, which would then reflect in their History, which would then reflect in their Maths. I they really got the inter-connectedness, now because it is so compartmentalised, we are losing that inter-connectedness. (Appendix Y: John: Interview 4: L48-56)

And later in the same interview I asked him:

DB: Would you like to teach more like that? From what you said earlier about your really good teaching year ....

J: Yes, I would prefer to have more .... Given that we had more space, more time, given that there wasn't an expectation every day to have something in the

> book which resembled work and which was monitorable, an actual answer, something to tick or something to mark wrong, something that that child has achieved or that child hasn't achieved, yes I would love to but all that would have to disappear first. (Appendix Y: John: Interview 4: L69-75)

Lisa said that she enjoyed teaching in a constructivist way but she also enjoyed the more traditional way of teaching mathematics. This was typical of Lisa's enthusiasm for all aspects of the subject of mathematics.

I pursued this notion that some of the requirements of the National Curriculum were restricting how teachers could teach mathematics. I asked Mary how many times in the academic year she was able to teach in an investigative way, and we had the following conversation:

> **M:** About five but I would like to do more but time does not allow it.
>
> **DB:** Is that because of the requirements of the National Curriculum?
>
> **M:** Yes, it means we have to get through the material in a given amount of time. I was thinking about this idea [constructivism] and I would say that I always try to get the children to work things out for themselves, to reason things out but it depends on what I am teaching them. I know we need to get things covered in a set time but I always try to get them to think for themselves first. (Appendix Z: Mary: Interview 3: L8-14)

And later in the same interview:

> **DB:** Would you like to teach that way more often? If all the constraints were taken away, would you?
>
> **M:** Yes, I would. It's a wonderful thought that, taking all the constraints away and teaching the way you think teaching should be done. (Appendix Z: Mary: Interview 3: L33-36)

One hint at another possible reason why teachers like Lisa, John, and Mary are unable to adopt a more constructivist approach to the teaching and learning of mathematics in their classrooms, sometimes despite their clear desire to do so, was offered to me by John very early in the interviews I had with him. We were discussing the requirements of the National Curriculum:

> **DB**: Do you feel under pressure as a teacher?
>
> **J**: Horrendously under pressure. We are the top school in [name of LEA] so the pressure is on me, not just to get level 4s, but now to get level 5s. Because our children come in with a good baseline the authority say that they should be at 'X' by the time they get to Year 6 and we have to meet that as far as possible but sometimes it's unachievable.
>
> **DB**: And what happens when it isn't achieved?
>
> **J**: Well, ultimately, if it were such a big gap we could have Ofsted back in or we could have HMI in, or we could have the authority in saying 'well, why not?' It's not in terms of getting sacked but there is pressure.
>
> **DB**: That must impact on your teaching?
>
> **J**: It does but it's not a bad thing because you are aware of levels, so you are aware that what you are teaching is what the children need to move them on. (Appendix Y: John: Interview 1: L159-171)

Interestingly, John's last sentence here perhaps hints again at a realist epistemological belief and therefore a rather confused overarching world view.

I followed this up with Lisa in the subsequent interview I held with her. I asked Lisa how many times each academic year she was able to teach in what she called an investigative way but what we agreed could also be described as constructivist:

> **DB:** How many times per year are you able to do that type of constructivist teaching?
>
> **L:** I tend to do a lot more in the Summer because then SATs are finished. We do transition units to go to secondary school and a lot of the work we do for them is investigative work. (Appendix X: Lisa: Interview 2: L171-174)

There was an implication in Lisa's words here that she did not have the freedom to teach in a constructivist way more often before the SATs because the pressure of time was too great. This led to the following exchange:

> **DB:** There is an implication in there somewhere, isn't there? You said you do a lot more in the Summer because then the SATs are out of the way.
>
> **L:** Yeah, and you can take up more of the timetable with investigations.
>
> **DB:** So, before the SATs there is less time to do that type of constructivist teaching? That open-ended type of teaching?
>
> **L:** Yeah, and especially because it is open-ended and from one lesson to the next you have to see which way the children are going before you do the next and it could go on for a while. (Appendix X: Lisa: Interview 2: L175-186)

John criticised the requirements of the National Curriculum in later interviews too:

DB: But it seems to me that it is about trying to get the balance between '*Have I talked enough to get them to do the task or have just thrown the task at them?*' Now when I read that I thought that was very interesting. How do you manage that balance?

J: You can't. [laughs]. It's as simple as ... so today there was more talk because the concept didn't 'click' as quickly as I'd hoped. I'd hoped that it would 'click' so almost ... the way in saying '*there is a method, there is a method, there is a method*' is possibly not the best way. It is possibly better in this instance to say '*this IS the method*'. So we are almost going away from what we've said about constructivism to a more didactic approach and saying '*this IS how you do it*'. I think another example would be fractions because fractions and particularly addition and subtraction of fractions and things like that, they just need a method.

DB: So you are saying that there are some instances where you have to forget about teaching in a constructivist way altogether?

J: I'm saying from a class teacher's perspective and ease of teaching, ... yes. And others lend themselves beautifully to discovering methods. Having said that, it's possibly more a criticism of the Numeracy Hour and the time that we have to do it in because according to the National Numeracy Strategy I have a day to teach that and yes I could bring it up in other subjects but in the Numeracy Hour I have a day to teach it. Even if I took it to two or three days I would have missed out the other bits and pieces that I need to teach them that week so I would then have a difficulty in fitting in the next. But we are looking at that as a school. We are talking about doing away with this time for teaching separate units and actually chunking all the Numeracy together so all of your

> fractions would be taught in one block and apparently, although I haven't looked at it, there is research that says that the children retain more focussing on fractions for, say, a month than they would focussing on it for a week, four times in the year. (Appendix Y: John: Interview 2: L44-69)

I was coming to the conclusion that some of the requirements of the National Curriculum were incompatible with a more constructivist approach to the teaching and learning of mathematics. This seemed to extend to include a constructivist approach to assessment also:

> **DB:** If we agree that children learn best by discovering things for themselves then doesn't it follow that assessment needs to be tailored to each individual child to see what they have learned?
>
> **L:** Yes but you can't do that for every single topic or for every single …
>
> **DB:** Why not?
>
> **L:** Because you would spend your entire time assessing each child and you would never be able to move anybody else on.
>
> **DB:** So you haven't got time to do that?
>
> **L:** Not on every single topic … (Appendix X: Lisa: Interview 1: L222-230)

John too suggested to me that assessment by SATs was inconsistent with a constructivist conception of the teaching and learning of mathematics. This surprised me because he had previously said he liked the SATs for the information they provided him concerning his pupils' learning. We were discussing SATs and whether he thought it important that the tests should be standard, in the sense that each child receives the same test:

DB: Because the SATs give you the ability to compare children, is that important? I'm just trying to figure out how SATs as a way of assessment fits in with this idea of constructivist teaching and learning given that ...

J: I don't think it does [laughs].

DB: Why?

J: Why do SATs not fit in with constructivism? Because children aren't really guiding their own learning, we are guiding their learning for them. If, once they had done the SATs test, the children could identify the areas for improvement themselves .....(Appendix Y: John: Interview 3: L99-106)

This led to the following exchange:

DB: What type of assessment would be consistent with it then? What could we do? If we agree that children learn best by constructing their own conceptions of things ....

J: Well ideally, it would be like a portfolio-based assessment, that's the standard answer. (Appendix Y: John: Interview 3: L118-120)

There was also a view expressed by at least one of the teachers that the current emphasis placed on teacher accountability by the government and the resulting way in which teachers' work is monitored by their local education authority is also incompatible with a constructivist approach to the teaching and learning of mathematics. Lisa explained the way in which this current way of monitoring teachers' work was carried out:

L: Yeah, because you have work scrutinies and things where they get books and say '*Has this topic been taught? Has this topic been taught? Has this topic been*

> *taught?*' And then they can come and say '*This topic hasn't been taught*' and you say '*Well, it has*' but as long as you can justify that it has but that it is just not in their books and we have done this and we have done that. But the books don't bother me. (Appendix X: Lisa: Interview 2: L199-204)

John too alluded to this problem when I asked him if he had enjoyed delivering a particular lesson using a constructivist approach (See *Appendix V - Lesson Four*). My question led to the following conversation:

> **J:** Erm, through them, yes. In terms of what they have actually produced, no. Because, ideally, don't do the first bit and just launch into it, less talk but then … I am trying to sort of free up time because if we had had time at the end, which we didn't have, then we could've got them to write down something, something they had discovered from today and that would've then been sufficient for me to be happy with what they produced. At the moment what we've got is a collection of sheets that, some of them have got a rule written on it which is accurate, others are still in the midst of things.
>
> **DB:** Why is it important that they write something down? Is it so they can go back and look at it?
>
> **J:** No, to satisfy the 'powers that be'.
>
> **DB:** Because they come and look at the books?
>
> **J:** Yes, they would be asking questions like '*what did the children do on this day?*', '*why have you got a day missing*?' If I say '*we did a practical activity that day*' they ask '*where's the evidence for that practical activity?*' It's wrong. It is wrong. (Appendix Y: John: Interview 4: L33-46)

However, Lisa and Mary seemed less worried by the need to have records of all their teaching in the children's books:

> **DB:** And of course, you don't have a lot of material in the children's books.
>
> **L:** No but it's not a big thing, getting things in books.
>
> **DB:** You're not worried about that?
>
> **L:** No. (Appendix X: Lisa: Interview 2: L187-190)

Mary attributed her laissez-faire attitude to strict record keeping to her many years of experience as a teacher:

> **DB:** Does the fact that there is nothing much in their books at the end of it all make you anxious or uncomfortable?
>
> **M:** No, because I am capable of justifying my reasons for doing it this way. It might have done in the past when I was younger and less experienced but I'm now experienced enough to not to let that bother me. I could justify it and set out my objectives for the lesson, etc. (Appendix Z: Mary: Interview 3: L44-49)

As stated above, I was coming to the conclusion that some of the requirements of the National Curriculum were incompatible with a more constructivist approach to the teaching and learning of mathematics. This meant I was also increasingly becoming aware that any link that may exist between a teacher's epistemological world view and their teaching practice was very unlikely to be a direct one. Instead, it was much more likely that any relationship would be mediated by these types of contextual factors.

Tacit Beliefs/Epistemological World Views

Of course, this inconsistency may simply be the result of the teachers not having reflected on their world view in the past or the possibility that they had never had the need to communicate these philosophies to anyone else. The findings from teacher interviews strongly suggest that although teachers can often verbalise and communicate *individual* epistemological beliefs they are often not aware of their overarching world view of mathematics or whether indeed they have one. Even when they are explicitly asked the question they are very unlikely to be able to easily communicate that philosophy. It is possible that this is the reason why teachers sometimes hold individual epistemological beliefs that are inconsistent with the underlying world views that they are meant to represent. All three teachers stated in interviews that they felt they did not hold well-rounded or well thought-out philosophies of mathematics. When I asked Lisa about whether she believed there to be a mathematical truth, she replied:

> **L:** I think there has to .... Well, I don't know. You see I get myself all confused about this now because.....I think all you can do is guide the children for where they want to take maths because some will want to go to University and others will just want enough mathematical skills to be able to work out bills and things and I think that's fine for them. (Appendix X: Lisa: Interview 1: L75-79)

And later, when I explicitly asked whether she felt she had a well-rounded philosophy of mathematics she replied:

> **L:** No, I haven't really. As far as teaching mathematics goes I just want the children to do the best they can and to achieve and to have an enjoyment of it, more than anything. (Appendix X: Lisa: Interview 1: L87-89)

In relation to this same aspect of the research, I had this conversation with Mary:

> **DB:** Do you feel that before we started talking together that you had a well-rounded philosophy of mathematics, thought out views on the nature of mathematical knowledge, on how maths is best taught and how maths is best learned?
>
> **M:** I don't think I had any philosophy of maths at all before we started talking. Actually, that's not right. I don't think I had no philosophy, I think I probably had a philosophy somewhere but that I probably had not thought about it too much. It's all in there in a bit of a mess but it's there somewhere. I've gone through my career taking things on board, from other teachers, from courses I've attended and my teaching style has changed dramatically from when I first started.
>
> **DB:** Would it be fair to say that you had a philosophy but not a well-rounded philosophy and not one that could be easily communicated to others?
>
> **M:** Yes, that's a good way of putting it. I could never have told someone my philosophy of maths if they had asked me before. Actually, I'm not sure I could now but I'm a little clearer on certain things. (Appendix Z: Mary: Interview 4: L47-60)

A similar conversation with John went like this:

DB: I wondered before I entered this Phase of observing and interviewing teachers whether they would hold a well rounded philosophy, one which could be easily communicated to others. You all seem to have a philosophy but how well rounded that is, how well developed that is, and how easily communicated that is to others, is another matter. I wonder, do you feel that you had a well-rounded philosophy of mathematics before we met?

J: Possibly not. I always think about my practice and always try and make it so that the things that we are doing, not all the time but as far as possible, will be what the children like to do. So, probably not, is the short answer. (Appendix Y: John: Interview 4: L122-130)

The data analysis of teachers' interview transcripts involved assigning codes to pieces of text that were thought to reveal insights into their beliefs and/or world views. These codes were allowed to emerge from interview transcripts and presented as themes with supporting text. This data analysis informs the conceptual conclusions set out in the final two chapters, including the conceptual model offered in *Chapter Seven – Conclusions and Suggestions for Further Research.*

5.4 Discussion

This chapter has outlined the rationale for employing semi-structured interviews with teachers in an attempt to shed some light on both their individual epistemological beliefs and their epistemological world views. A two-pronged approach within the semi-structured method was eventually adopted. I decided to use two approaches within a semi-structured interview technique. One approach involved asking teachers direct questions about specific teaching and learning issues that would reveal insights into their epistemological world views. The second involved asking questions concerning specific instances of their teaching just observed. This latter approach took the form of the stimulated recall procedure to probe their thinking concerning the chosen aspects of their teaching (Calderhead, 1981). The results from the teacher interviews were analysed using the constant comparative method associated with Grounded Theory approach and presented as themes. These themes emerged out of the transcripts from the teacher interviews conducted during this phase of the research and were supported throughout by quotes.

The interviews with teachers showed that all three of the teachers expressed beliefs about the teaching and learning of mathematics that suggested they held a predominantly relativist world view of the teaching and learning of mathematics. This is a view I have argued is associated with a constructivist conception of mathematics. However, all three teachers also sometimes expressed beliefs that could be interpreted as being indicative of a realist world view. A view I have argued is associated with a behaviouristic conception of mathematics.

Findings from teacher interviews also strongly suggested that the requirements of the National Curriculum in terms of what the children are expected to know, the amount of content that needs to be covered, the time allowed to cover it, and the assessment by SATs serve to restrict teachers in their attempts to adopt a more constructivist approach to their teaching. The current emphasis on school and teacher accountability by the government and how this translates into working practices in LEAs was also identified as restrictive in this sense. This, of course, had implications for any possible link between teachers' epistemological world views and their teaching practice. Such contextual factors are almost inevitably to mediate between the two.

Conclusions

The findings discussed above reinforce those from previous phases of the research in suggesting that the picture of teachers' epistemological beliefs about the teaching and learning of mathematics and the potential link with their practice is a complex one. Amongst these findings is the notion that teachers can have deeply held epistemological beliefs about the teaching and learning of mathematics but that they are very often unconsciously held. Moreover, these epistemological beliefs can very often be contradictory in the sense that they are associated with opposing world views. This means that teachers in this research did not hold neat epistemological world views as defined in this and previous research.

A key finding from teacher interviews was the strong suggestion that some of the requirements of the National Curriculum were restricting teachers from adopting a more constructivist approach to the teaching and learning of mathematics. Chief amongst these was the amount of time allowed to teach the required content, some current working practices, and the assessment of pupils by SATs. This last finding has led to the conclusion that any link that may exist between a teacher's epistemological world view and their teaching practice was very unlikely to be a direct one. Instead, it was much more likely that any relationship would be mediated by these types of contextual factors. These issues will be discussed in more fully in the following chapter.

Chapter 6: Discussion of Findings

I don't give a damn what happened, what I want to know is why it happened.
(Henry Adams, 1890)

The research described throughout the previous five chapters was designed to shed some light on primary teachers' epistemological beliefs and epistemological world views concerning the teaching and learning of mathematics. Chapters three, four, and five have outlined the findings from each phase of the research; the postal questionnaire in Phase I, the classroom observations in Phase II, and the interviews in Phase III. This chapter attempts to draw together and review these findings in the context of the stated research questions set out at the end of Chapter One and relate the findings to previous research in the field.

The findings from the survey results set out in Chapter Three shed some light on the phenomena related to the first two research questions set out at the end of Chapter One. That is, what epistemological beliefs do primary teachers' hold about the teaching and learning of mathematics and do these epistemological beliefs constitute distinct and mutually exclusive epistemological world views as defined by previous research or are hybrid positions possible? Findings from the observations and interviews conducted with the three teachers involved in Phase II and III of the research can shed further light on these issues but also go some way to addressing the other three research questions.

The findings are discussed under the headings of the five individual research questions set out at the end of Chapter One. However, the findings discussed under the heading of one research question often have relevance to other research questions so a degree of overlap is inevitable in the following discussion.

6.1 Research Question One

Research Question One asked: what epistemological beliefs do primary teachers' hold about the teaching and learning of mathematics?

The survey findings from Phase I of the research provided some support for the idea that the realist (behaviouristic) world view is associated with or constituted by a particular set of individual, less sophisticated beliefs about knowledge. For instance, Prawat and Floden (1994), Hofer (2000), Schommer-Atkins (2002) and Schraw and Olafson, (2002) have all reported evidence to suggest that the realist world view is associated with less sophisticated beliefs about knowledge, i.e. a belief in simple rather than complex knowledge, certain rather than changing knowledge, and authoritative rather than self-emanating knowledge. The findings from the survey in Phase I of the research partly supported this view in that it suggested that the belief in omniscient knowledge, i.e. that knowledge emanates from authoritative sources, was significantly positively correlated with the realist world view. Beliefs in simple knowledge, i.e. the belief that knowledge is comprised of discrete facts, and *certain* knowledge, i.e. the belief that absolute knowledge exists independently of the knower and will eventually be known, were also positively correlated with the realist world view but the correlations were neither significant nor strong.

Teachers' length of service was also found to be positively linked to a more realist (behaviouristic) world view. This is inconsistent with some previous research (Schraw and Olafson, 2002). However, age was not found to have the same positive association with this less sophisticated world view. This suggests that something else must mediate between teachers' age and length of service in the profession. There are two alternative possibilities that come to mind here. The first is that it is teachers' exposure to the demanding nature of teaching as they progress through their teaching careers that results in the adoption of a realist (behaviouristic) world view of the teaching and learning of mathematics. The second is that current programmes of teacher education in this country are inculcating in trainee teachers a relativist (constructivist) world view concerning teaching and learning generally or mathematics in particular. However, this research did not set out to investigate the process of change in teacher epistemologies and this finding may suggest an avenue for further research using the appropriate longitudinal research methods.

The findings from the survey also showed that primary teachers overall were significantly more likely to agree with the relativist world view, a view I have argued is associated with a constructivist conception of the teaching and learning of mathematics. The findings from the survey also showed that primary teachers hold different, sometimes polarised, world views concerning the teaching and learning of mathematics. That is, some hold a predominantly realist (behaviouristic) world view whilst others hold a predominantly relativist (constructivist) world view. However, the word 'predominantly' is used here because this finding hid some extreme individual differences. That is, some primary teachers held beliefs that could not be neatly categorised as belonging to only one epistemological world view as defined in previous research. It seems unlikely that any teacher will fit neatly into any one of the epistemological world views discussed here. The data from observations and interviews with teachers in subsequent phases of the research only reinforced this finding (See Research Question Two below).

6.2 Research Question Two

Research Question Two asked: do these epistemological beliefs constitute distinct and mutually exclusive epistemological world views as defined in this research, or are hybrid positions possible?

Previous research has suggested that teachers can only hold one of the epistemological world views at a time and that hybrid positions are impossible or rare (Schraw and Olafson, 2002; Prawat and Floden, 1994). Findings from the survey in Phase I of the research did not seem to support this notion but the data was inconclusive. The findings from the survey did show that the two world views were negatively correlated with each other, which one would expect if they represent separate constructs, but this correlation was not significant. Moreover, findings from subsequent phases of the research, particularly the interviews with teachers in Phase III, suggested more strongly that this was not the case but that teachers can hold epistemological beliefs that are contradictory or inconsistent with any one epistemological world view as defined by past research.

In fact, teacher interviews suggest that teachers can sometimes hold epistemological beliefs that are characteristic of diametrically opposed world views and therefore contradictory. For instance, John had espoused during interviews a largely relativist world view concerning the teaching and learning of mathematics, i.e. a constructivist philosophy but also expressed agreement with and acceptance of standardised testing. That is, on the one hand he argued that he tried his very best to adopt a constructivist approach to his teaching of mathematics whilst on the other hand he seemed to place great store in the information gleaned about his pupils' learning from the assessment of knowledge via standardised tests that require standardised answers. This latter view sits more easily with the absolutist epistemology of the realist world view and with the associated transmission approach to teaching and learning than it does with the fallibilist epistemology of the relativist world view and its associated view of teaching and learning as one of active construction. Consequently, it must be concluded that the epistemological beliefs held by teachers do not always constitute distinct and mutually exclusive world views as defined in previous research alluded to above.

There is some recent research to support this finding. For instance, McCoombs (2002) argues against the existence of such neat teacher epistemological world views. She argues that:

> My own research over the past nearly ten years in the area of teacher beliefs about teaching, learning, and learners has shown me that teachers often hold what may appear to be mixed or contradictory belief systems. (McCoombs, 2002: 183)

Prawat (2002), in a paper that contrasts with his earlier views of knowledge, argues that the difficulty researchers have in drawing clean lines between the seemingly different epistemological world views is that they represent overlapping views of knowledge, teaching and learning, i.e. both the realist and relativist world views are outgrowths of nominalism.

6.3 Research Question Three

Research Question Three asked: are primary teachers' epistemological world views held in such a way that enables them to be easily communicated to others?

Much past research has suggested that teacher's epistemological world views are tacit and therefore not easily communicated to others (Kagan, 1992a; Schraw and Moshman, 1995; Calderhead, 1996b; Patrick and Pintrich, 2001). Kagan (1992a), in light of this, defined teacher beliefs as '... broadly tacit, often unconsciously held assumptions about students, classrooms, and the academic material to be taught' (Kagan, 1992a: 65). This assumption is based upon quite a large degree of consensus in the research investigating the epistemological beliefs of teachers. For instance, research conducted by Schraw and Moshman (1995), Calderhead (1996b), and Patrick and Pintrich (2001) all suggest that teacher beliefs may not always be held in a form that can be readily communicated to others or even verbalised to themselves.

Schraw and Olafson (2002) suggest that although teachers may be able to vocalise individual epistemological beliefs about teaching and learning they are often unaware of their own overarching philosophy or epistemological world view. This also means that teachers are very often unable to communicate this world view to others. There was strong evidence from all three teachers during teacher interviews to strongly support this assumption. None of the teachers felt able to communicate their overarching philosophy of the teaching and learning of mathematics, either when asked indirectly or directly. Sometimes, they were unable to communicate even individual epistemological beliefs about mathematics. Lisa's confusion concerning her belief about the existence or not of a mathematical truth is one example of this.

However, the evidence from interviews also strongly suggests that talking around and about these issues with a critical friend often allows teachers to consider, sometimes for the first time, their individual epistemological beliefs and the overarching world view concerning the teaching and learning of mathematics. All three teachers expressed the view that our discussions together had made them think more about their philosophy of mathematics. This finding represents perhaps the most pleasing outcome of the research. Some research, conducted in the United States, has illustrated the importance of teachers being able to reflect on their own beliefs about teaching and learning if they are to have any chance of developing as teachers. For instance, research by Schifter (1998), Vacc and Bright (1999), and Borasi, Fonzi, Smith, and Rose (1999) has shown that when teachers have the opportunity to reflect on their beliefs about teaching and learning it also allows them to connect thought with action. In doing so it also allows them to develop and change their teaching styles.

6.4 Research Question Four

Research Question Four asked: what is the relationship, if any, between primary teachers' epistemological beliefs about the teaching and learning of mathematics and their classroom pedagogy?

Past research on the relationship between teachers' epistemological world views and their teaching practice is divided. Some studies have produced evidence to support such a link, in the field of mathematics (Lerman, 1983; Thompson, 1984; Marks, 1987; Dougherty, 1990; Askew *et al*, 1997), wider subject areas like science (Brickhouse, 1989, 1991; Hasweh, 1996; Hofer and Pintrich, 1997; Newton and Newton, 2000; Patrick and Pintrich, 2001; Johnston, Woodside-Jiron, and Day, 2001; Lunn, 2002), science and history (Newton and Newton, 1997; Newton, Newton, and Oberski, 1998), and sectors of education other than primary, e.g. tertiary (Biggs, 1990; Dall'Alba, 1990; Martin and Balla, 1990; Samuelowicz and Bain, 1992). Other studies however have reported no relationship or at the very best inconsistencies between teacher's epistemological world views and their teaching practice (White, 2000; Levitt, 2001; Wilcox-Herzog, 2002).

The evidence from this research suggests that any relationship between teachers' epistemological world views and their teaching is complex and therefore very difficult to describe, for several reasons. Firstly, the findings suggest that teachers may not hold a neat epistemological world view that is amenable to a parsimonious explanation or description as argued by other researchers in the field and which I described in previous chapters (see above about hybrid positions). That is, my research suggests that it is possible that teachers hold quite complex epistemological world views, ones that include individual epistemological beliefs that are characteristic of diametrically opposed world views, i.e. what I have described in previous chapters as the realist epistemological world view and the relativist epistemological world view. Other researchers have claimed that individual categories or several broad categories of beliefs fail to hold explanatory power for teachers' practices and that what is needed instead are particular, context-specific collections of beliefs (Speer, 2005).

If this finding is a valid reflection of teachers' epistemological world views generally then the possibility of finding any one-to-one relationship between the world views as described and teaching practices was always going to be problematic from the outset (Martinez, 2002).

Secondly, and even if teachers can be legitimately categorised by the epistemological world views as previously described, the findings also suggest that teaching practice is determined by much more than just the teacher's epistemological world view. That is, the impact that epistemological world views have on teaching practice is likely to be indirect and subtle because teaching practice is highly likely to be mediated by other contextual factors deemed important by the teacher at the time. For instance, contextual factors like what content teachers are required to teach and within what length of time, other beliefs, the response of pupils, school ethos, current working practices, etc. will almost certainly mediate the impact of a teacher's world view on their teaching practice. Schoenfeld (2002) argues that:

> ...one can honestly profess a constructivist set of principles but have them undermined in practice by other beliefs, such as "students' need to have neat, clean models of what they are supposed to be doing written up on the blackboard". (Schoenfeld, 2002: 218)

Jaworski's (1994) research, conducted before the introduction of the National Curriculum, found that although teachers often identified in themselves a constructivist approach to the teaching and learning of mathematics things were never quite that straight forward in practice. She wrote at the time that:

> I recognised that even though one might espouse a constructivist philosophy ... it was nevertheless hard to break away from long encouraged beliefs in the objectivity of knowledge and the possibility of giving this knowledge to another person. (Jaworski, 1994: 85)

The findings from the observations of teaching in Phase II of my research both reinforce and contradict the findings of Jaworski (1994). For instance, in agreement with Jaworski, the teaching I observed did sometimes show that traditional, didactic, transmission approach to teaching still occurs in classrooms despite teachers holding a predominantly relativist (constructivist) world view. However, it also showed that teachers were attempting to teach in a more constructivist way. Moreover, my findings suggested that teachers wanted to teach in a constructivist way more often but felt constrained by the requirements of the National Curriculum. That is, in contrast to Jaworski's findings, any inconsistency found between teachers' epistemological world views and teaching practice was thought to be due to the teachers concerned not having the freedom to explore in the classroom their largely constructivist philosophy rather than their belief in the objectivity of knowledge. That is, the demanding requirements of the national curriculum in terms of the sheer volume of what is to be taught in a single year and the increasing importance placed on the results of its assessment procedures at the end of Key Stage 2 leaves little time for teachers to fulfil their wish to adopt a more constructivist approach to their teaching. As such, these requirements acted as contextual mediators between the teachers' world view and their subsequent teaching practice.

All of the teachers involved in this research (some with greater clarity and insistence than others) commented on how the demanding requirements of the National Curriculum sometimes prevented them from teaching in a constructivist way. Current working practices were alluded to by two of the three teachers and the time allowed to teach the required content was commented on by all three teachers. An evaluation of the early implementation of the National Curriculum in England and Wales identified this as a concern for teachers back in 1992/3 (Askew, Brown, Johnson, and Millett, 1993). They concluded from their evaluation at the time that:

> At all key stages and in each of the areas of mathematics, teachers indicated that there was 'too much to get through'. At least 28% of KS2 teachers felt that there was too much to get through in each of the areas of mathematics. Constraints of time were repeatedly mentioned in interviews [with teachers]. (Askew *et al*, 1993: 122)

Overall, my findings lend some support to the suggestion that there is a link between a teacher's epistemological world view and their teaching practice. However, at the very best this link is indirect and subtle (one might say insignificant) in that it is mediated by other, more, important contextual factors deemed important to the teacher at the time.

6.5 Research Question Five

Research Question Five asked: what are the theoretical and practical implications of any relationship (or non-relationship) that may be found to exist?

Findings from the teacher survey in Phase I of the research suggested that primary teachers preferred (statistically) a relativist (constructivist) approach to the teaching and learning of mathematics. Findings from subsequent teacher observations and interviews clearly showed also that all three teachers involved in this research sometimes attempted - to varying degrees – to teach in a constructivist way. They also expressed the opinion that they would like to teach in a constructivist way more often but that the requirements of the National curriculum were prohibitive in this sense. Time, the amount of content to be covered, and current working practices were cited as barriers to implementing a more constructivist approach to the teaching and learning of mathematics in their respective classrooms. There is some past research that suggests 'coverage' is taking precedence over 'understanding' (Pollard, Muschamp, and Sharpe, 1992; Dadds, 1994; Pollard and Triggs, 2000; Dadds, 2001). The evaluation of the early implementation of the National Curriculum in England and Wales referred to above also identified time and the amount of curriculum content to cover as issues causing concern for primary teachers back in 1992/3 (Askew, Brown, Johnson, and Millett, 1993). They concluded at the time that:

> Comments from some interviewees indicated that they were doing less practical and investigative work than they used to [before the introduction of the National Curriculum] because of the pressures of what had to be covered in the mathematics curriculum. (Askew *et al*, 1993: 127)

An interviewer (Q) involved in that evaluation had this conversation with a Year 5 teacher (T):

> **T:** Nowadays you have to do that number of topics, because you have to tick that number of boxes, or you have to ... and ... the first thing that goes by the board is practical work, because it takes a long time. I mean you've got the time of taking the stuff out of the box and setting it up ... and organising groups and stuff, and ...
>
> **Q:** Do you regret that?
>
> **T:** I do, very much, yes. I think it's terrible. I mean really maths is a hands-on activity. (Askew *et al*, 1993: 127)

It seems that little has changed in the intervening period between 1992 and 2005. Primary teachers still feel their desire to teach more in a constructivist way is restricted by some of the requirements of the National Curriculum.

Selley (1999) argues that a constructivist approach to teaching is achievable by teachers. He argues that a teacher attempting to adopt such a constructivist approach would adopt the following strategies. Firstly, the teacher would consider what the child already knows, by perhaps using a test task that requires the children to use that knowledge. Secondly, the teacher would be aware of and take account of previously published research findings that reveal the alternative conceptions or misconceptions shown by children of that age. Finally, the teacher would bring a child's awareness to any misconception diagnosed by the previous two steps (Selley, 1999). Although my research strongly suggests that teachers feel they are fulfilling the first and final steps described by Selley above, not one of the teachers felt that they were reading previously published research findings in an attempt to reveal alternative conceptions or misconceptions. The issue of time was identified again as a possible barrier to this.

Current methods of assessment by testing could legitimately be added to that list of barriers to the adoption of a more constructivist approach to teaching. I argued in an earlier chapter that current assessment by tests in the National Curriculum is based on a behaviouristic view of teaching and learning. (See the section *Implications for Assessment* in *Chapter One*). Several teachers stated during the interview phase of the research that they felt that the current assessment of children by SATs tests is incompatible with a more constructivist approach to teaching mathematics. This means that some of the current assessment procedures in the UK's National Curriculum may be in need of revision. As long ago as 1990, Lerman (1990) was putting forward the same argument. He argued that:

> Clearly, new ways of learning call on new ways of assessment and interpretation of 'ability'. Such very different directions as those ... focusing on the child's constructions, which of necessity originate in the understanding that children bring into the classroom, cannot be assessed by the usual traditional methods which, in general, examine children's grasp of things taught by the teacher rather than the children's understanding ... Yet we adhere to this mode of assessment of children's mathematical ability. (Lerman, 1990: 60)

Although we have seen the implementation of the National Curriculum during the intervening period between then and now it could be argued that the assessment has little changed and that it is still predicated on a behaviouristic view of teaching and learning.

Summary

This chapter has discussed the findings from this research in the context of both the stated research questions and previous research in the field. The next chapter sets out the overall conclusions of the research but also draws the reader's attention to some of its limitations. It then goes on to suggest avenues for further research.

Chapter 7: Conclusions and Suggestions for Further Research

> **The tension between making it better and getting it done appears wherever people have work to finish or a product to get out: a computer, a dinner, ... a book. We want to get it done and out to the people who will use it, eat it, read it. But no object ever fully embodies its makers' conception of what it could have been.**
> *(Howard Becker, 1986)*

This research has attempted to investigate the nature of primary teachers' epistemological beliefs and epistemological world views concerning the teaching and learning of mathematics and the potential relationship these may have with their teaching practice. The research has taken as its central concept the idea of an epistemological world view as coined by Schraw and Olafson (2002). The term *epistemological world view* refers to a personal construct that is constituted by a wider set of individual epistemological beliefs held by one individual concerning the nature and acquisition of knowledge and image of social reality. Consequently, they define an epistemological world view as '... a broad intellectual perspective that serves as a lens to see the world that transcends individual beliefs about knowledge' Schraw and Olafson (2002: 104). Much other research that has been conducted in the field of teacher epistemological beliefs over the past ten to fifteen years has given support to the existence of different epistemological world views (Kuhn, 1991; Prawat and Floden, 1994; Cunningham and Fitzgerald, 1996; Fielstein and Phelps, 2001; Kincheloe, Slattery, and Sterberg, 2001; Hofer, 2002; Schraw and Olafson, 2002).

At the very outset of this research I attempted to justify its importance and I feel it timely to review those arguments here. Firstly, the research was deemed important for the development of teachers and their teaching practice. That is, teachers whose conception of the teaching and learning of mathematics and their subsequent classroom practice do not correspond are very unlikely to be able to reflect accurately on their practice in an attempt to improve it. Some research, largely conducted in the United States, has illustrated the importance of teachers being able to reflect on their own beliefs about teaching and learning if they are to have any chance of developing as teachers. For instance, research by Schifter (1998), Vacc and Bright (1999), and Borasi, Fonzi, Smith, and Rose (1999) has shown that when teachers have the opportunity to reflect on their beliefs about teaching and learning it also allows them to connect thought with action. In doing so it also allows them to develop and change their teaching styles.

Secondly, the research has an importance for the development of trainee teachers and the teacher training they undertake. That is, if teachers do hold implicit beliefs that fit into an epistemological world view about the teaching and learning of mathematics and these implicit beliefs are found to guide their practice in the classroom and they are largely unconscious, then it seems vitally important that student teachers are made aware of this relationship when undertaking a programme of initial teacher training.

Thirdly, the research was also deemed to have an importance for the development of pupils and their learning of mathematics and serving teachers and their teaching of mathematics. That is, it is possible that pupils who learn best by constructing their own understandings of mathematics will have their learning potential impaired by teachers who actually teach in a more traditional, behaviouristic way that relies on the transmission of facts. Consequently, it would seem equally important not only that student teachers are made aware of this but that serving teachers are given the time and support required to either bring their teaching more in line with the world view or develop a more sophisticated world view of mathematics.

Black argued in 1996, seven years after the introduction of the National Curriculum in England, that classroom practices were where:

> All too often dull formulaic methods have produced students lacking interest or understanding ... [and that teachers should] ... question their traditional practices and routines. They call for a change in their roles from being authorities in the transmission of knowledge of subject matter to being guides who support and challenge their students to be more effective and more ambitious as learners. (Black, 1996: 5)

Lerman's (1990) work too emphasised the importance of confronting and addressing this apparently deep-rooted absolutist view of the teaching and learning of mathematics. He argued persuasively that:

Recent research has brought many of these [absolutist] assumptions into question, but only a thorough examination of the philosophical, as well as psychological, underpinnings of this position can lead to fundamental changes. (Lerman, 1990: 57)

7.1 Conclusions

The survey findings from Phase I of the research provided some support for the idea that the realist (behaviouristic) world view is associated with or constituted by a particular set of individual, less sophisticated beliefs about knowledge. The findings also showed that primary teachers overall were significantly more likely to agree with the relativist world view, a view I have argued is associated with a constructivist conception of the teaching and learning of mathematics. However, this finding did hide some extreme individual differences. That is, some teachers did appear to hold contradictory epistemological beliefs suggesting that hybrid positions are not as rare as suggested by other researchers in the field. The data from observations and interviews with teachers in subsequent phases of the research only reinforced this finding. That is, although the three teachers involved in this research all held *predominantly* relativist world views concerning the teaching and learning of mathematics it is my belief, reinforced from the findings discussed throughout this research, that teachers do not hold neat epistemological world views as described in this and previous research. There is strong evidence to suggest that there are no neat epistemological world views that we could describe as purely realist or purely relativist. In fact, the evidence suggests that teachers are able to hold epistemological beliefs that are characteristic of different overarching world views.

There was also strong evidence from the research, particularly from all three teachers during teacher interviews, to strongly support the assumption that teachers' epistemological beliefs and epistemological world views are tacit and often unconsciously held. None of the teachers felt able to communicate their overarching philosophy of the teaching and learning of mathematics, either when asked indirectly or directly. Sometimes, they were unable to communicate even individual epistemological beliefs about mathematics. Despite the tacit nature of their beliefs it seemed to me that all three teachers - to varying degrees - held some strong epistemological beliefs about the teaching and learning of mathematics.

The research described throughout this work also suggests that the link between teachers' epistemological world views and their teaching practice is complex. Although there was some evidence to support the suggestion that there is a link between a teacher's epistemological world view and their teaching practice, at the very best this link could only be described as indirect and subtle in that it is mediated by other, more important, contextual factors deemed important to the teacher at the time. This mediated relationship also suggests some practical implications for the teaching and learning of primary mathematics in this country. The key finding here was that a desire to implement a more constructivist approach to teaching in the classroom appeared incompatible with some of the requirements of the National Curriculum. For instance, teachers sometimes felt restricted in the way they could teach mathematics by some aspects of the National Curriculum. Teachers identified the limited time available to them to cover the required content, the amount of content to be covered, and some current working practices brought about by the current government's emphasis on teacher and school accountability as barriers to implementing a more constructivist approach to the teaching and learning of mathematics in their respective classrooms.

These findings become even more significant in light of evidence that suggests an inquiry stance in classrooms by teachers can help their students gain a deeper understanding of mathematics (Wood and Sellers, 1996; Wood, 1996; 1999; and Wilson and Cooney, 2002). Wilson and Cooney (2002) suggest that this research provides:

> ...evidence that understanding by students, defined as the ability to construct rational, meaningful solutions to meaningful problems, is enhanced by such an inquiry approach by mathematics teachers. (Wilson and Cooney, 2002: 134)

The finding that contextual factors mediate between teachers' epistemological beliefs and epistemological world views and their teaching practice is consistent with some past research (Lerman, 1990; Putnam and Borko, 2000; McCoombs, 2002). Lerman (1990) identified the school context generally as an important factor mediating teachers' epistemological world views and their teaching practice. More recently, Putnam and Borko (2000) have also emphasised the importance of the school context as places where teachers work and learn in determining what goes on inside classrooms. They call these school contexts 'discourse communities' and state that:

> These discourse communities play central roles in shaping the way teachers view their world and go about their work. Indeed, patterns of classroom teaching and learning have historically been resistant to fundamental change, in part because schools have served as powerful discourse communities that enculturate participants (students, teachers, administrators) into traditional school activities and ways of thinking. (Putnam and Borko, 2000: 8)

My findings suggest a model of the relationship between teachers' epistemological beliefs and epistemological world views and classroom practice that is slightly different to the one proposed by Askew *et al* (1997) and which was set out in *Chapter One*. Their model was based on research that did not investigate the types of contextual factors alluded to above. My findings suggest the following conceptual model:

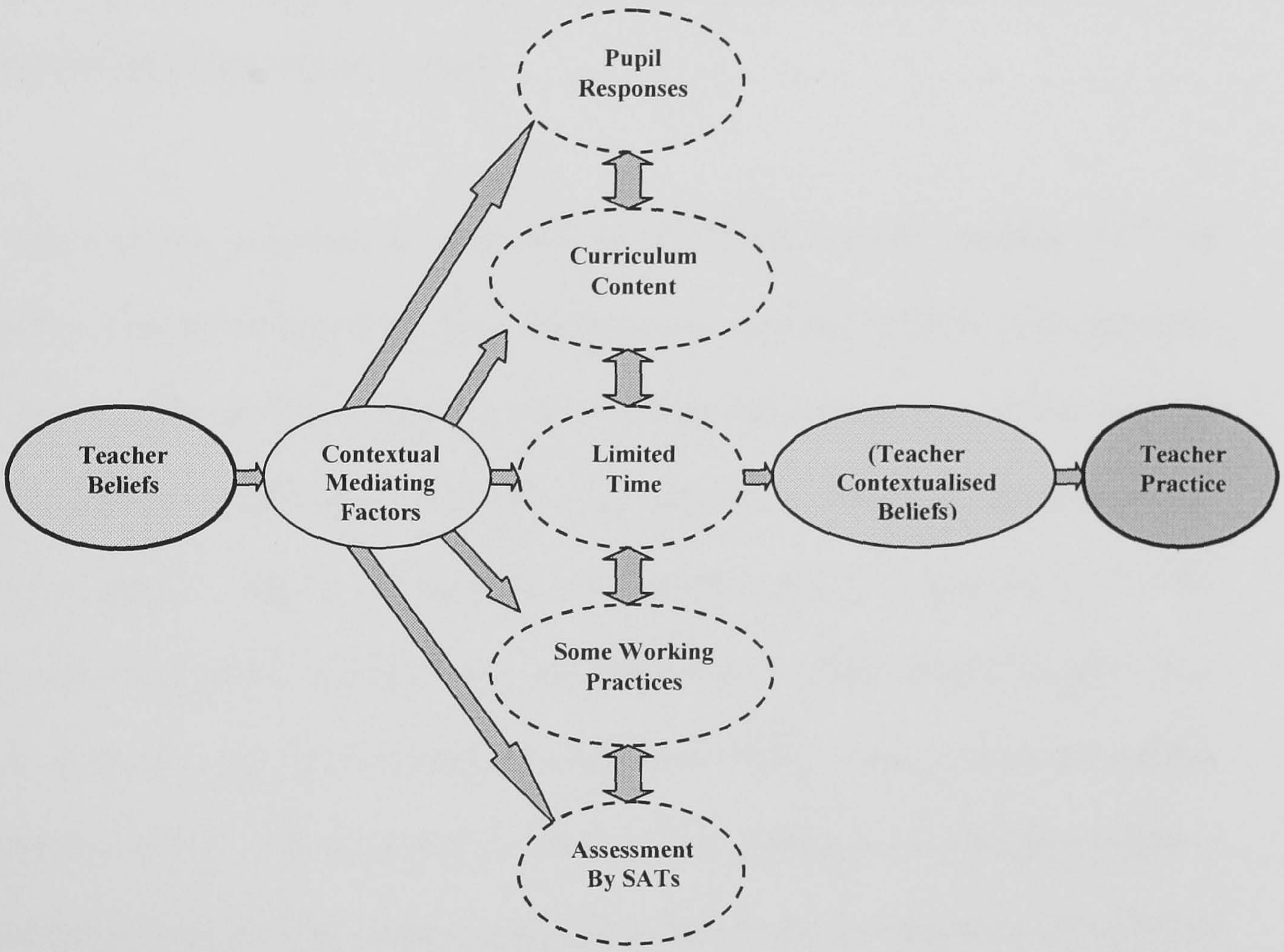

Fig 7.1.1 A model of the relationship between teachers' beliefs/world views and their classroom practice.

The model suggests that teachers' epistemological beliefs or world views can impact on teaching practice to a degree but only indirectly and that the relationship is mediated by contextual factors deemed important to the teacher. The mediating contextual factors included in the model are mostly those that my research identified as important to the three teachers involved but the model is not meant to suggest that the list of contextual factors is exhaustive. The use of the two-way arrows between the mediating contextual factors also suggests that these factors are interrelated and can therefore impact on each other. For instance, some working practices, assessment by SATs, and the amount of curriculum content to be covered will inevitably impact on the amount of time perceived to be available by the teacher and this, in turn, will have implications for teaching practice. It is also possible that these mediating contextual factors may feed back into teacher beliefs and world views although this was beyond the scope of this research.

The current emphasis in programmes of initial teacher training (ITT) in England is on the development of competencies in teaching in those that undertake such courses. Those who undertake such courses are known as trainees and not students. This in itself almost suggests a behaviouristic view of what it means to become a teacher. That is, it suggests that teaching can be characterised by the accumulation of certain skills. There also appears to be little emphasis given to a reflection of one's own epistemological world view. Without this it seems impossible that a teacher can accurately reflect upon his or her teaching in an attempt to improve it. Of course, if learning is socially constructed then it also implies that an important part of learning to teach will involve this enculturation into the discourse community of the school.

The view that constructivism is now the most dominant view of teaching and learning (Gadanidis, 1994; Fox, 2001) has not been conclusively answered by this research. The three teachers involved in this research did hold a predominantly relativist (constructivist) approach to their teaching but it is uncertain to what extent the rest of the primary teaching population matches their own stance.

7.2 Limitations of the Research

There are a number of issues that I feel need to be brought to the reader's attention that might be termed limitations of the research.

I would have liked to have spent more time in schools observing a more diverse range of teachers delivering mathematics lessons. It is possible that teachers that teach in primary years other than the ones covered by this research (Years 5 and 6) differ in important ways. Years 5 and 6 in this key stage of children's primary education are widely viewed by teachers to be those carrying the 'high stakes', both for pupils and the schools themselves, and it is plausible to suggest that teachers teaching these years feel more pressure than teachers teaching in other primary years. However, constraints on time and other resources meant I was unable to either extend this period any longer than the six month period it subsequently took up or recruit any more primary teachers.

A related point to that above concerns the potential bias inherent in the self-selecting nature of the samples used in both the questionnaire and the interview stages of the research. It is entirely possible that teachers that volunteer for such research will be atypically different in important ways than those that do not volunteer. For instance, it is plausible to suggest that teachers that volunteer to participate in research that includes classroom observations of their teaching practice will be very confident in their own teaching ability and perhaps have a more sophisticated world view of their subject, however tacit that might be. Research by Woods and Sellers (1997) in the United States using teachers that volunteered to participate in a problem-centred programme of teaching found that those teachers held a more sophisticated philosophy of the teaching and learning of mathematics, i.e. constructivist consistent with a relativist epistemological world view. However, a high degree of external validity was never the primary aim of the research although the sample of primary teachers used in Phase I was shown to be broadly similar to the general population of primary teachers nationally. Instead, the research was always viewed as exploratory in nature and I hoped to produce a close account of the phenomenon under study by developing close relationships with three primary teachers and observing and interviewing them at close quarters.

On a more personal note, I would also have liked to have devoted more of my time to the teachers' own personal development. For instance, I would have liked to help the three teachers involved in the latter phases of the research to find ways, within the prescriptions of the National Curriculum, in which they could implement a more constructivist approach to their teaching. It was clear from observations that teachers did attempt to adopt a constructivist approach to their teaching but it was equally clear from interviews that they found that the requirements of the National Curriculum prevented them from doing this more often. Unfortunately, I was unable to offer the teachers involved in this research any real time in which we could explore ways in which they could pursue this approach.

Lastly, I would also like to draw the reader's attention to the limitations of the exploratory research that has been described throughout the previous chapters. If we adopt a constructivist viewpoint for one moment then we must acknowledge that the interpretations given of these phases of the research are the result of my constructions alone. As such I am acutely aware that another researcher conducting the same research may have interpreted the same data in a different way and perhaps come to very different conclusions. Perhaps this is what Ball refers to when he writes:

> There is much that researchers do not know about the lives of those they study, but too often accounts fail to alert the readers to the limits within which the portrayal and analysis should be read ... Implicitly or explicitly, ethnographers claim too often to have produced definitive accounts of the settings they have studied. (Ball, 1990: 160)

What has gone before is not a definitive account of the teachers' epistemology but I hope it does add something to the body of evidence of this phenomenon.

7.3 Suggestions for Further Research

Many of the suggestions for further research identified here arise out of the limitations discussed above.

My feeling is that there are two possible directions for future research: both of which I see as building on the exploratory nature of the research described here. If we assume that epistemological world views are valid constructs with which to categorise teachers then this suggests a number of possible avenues. For instance, in terms of the research described here there needs to be more observational research conducted with a wider variety of Key Stage 2 teachers from a wider variety of KS2 years to ascertain whether it is the case that these attempts by teachers to teacher in a more constructivist way is representative of primary teaching as a whole or whether my teachers were exceptional in this sense and that traditional teaching still predominates in primary mathematics. Teachers involved in this research were all Year 5 and/or Year 6 teachers. Years 5 and 6 are widely considered to be the important years during the primary phase of education in terms of assessment and it may be possible that the constraints these teachers feel makes them less able to adopt a fully constructivist teaching style and that teachers of other years in Key Stage 2 are more able to explore their constructivist philosophies of teaching and learning of mathematics. Conversely, the self-selecting nature of the teaching sample observed and interviewed may suggest that they are teachers at ease with their teaching and therefore more likely to adopt a constructivist approach to their teaching.

There are also the questions of whether epistemological world views are consistent across subject domains and across time or whether they are subject-specific and time-specific. The development of teachers' epistemological beliefs and epistemological world views were beyond the scope of my research but from my experience and discussions with teachers I feel it likely that both are changeable across both subjects and time. An investigation of the latter would necessitate appropriate longitudinal research but it would be interesting and insightful to discover if teachers' world views change and, if so, what brings about that change and with what impact on their teaching practice.

There also needs to be more research on teachers' epistemological beliefs and their world views conducted in English schools. The body of extant literature in the field suggests that too little is currently being done in this country in comparison with the United States. Teachers globally are all likely to have to teach under certain constraints and research conducted say, in the United States, may well help to shed light on the work of teachers in this country, but each country's specific circumstances means specific research in each may also be necessary.

The question of whether tacit and explicit epistemological world views differ in the ways they impact on teaching practice may also be seen as a potential avenue for further research. However, given my research findings I feel that relatively few teachers will hold explicit epistemological world views if they have not first had the opportunity to discuss them with a critical friend. The three teachers involved in this research were not young and inexperienced and my feeling is that their relative ignorance of their own overarching world view of the teaching and learning of mathematics is likely to be largely representative of primary teachers generally. However, given my finding concerning teachers' favourable views of our discussions about their epistemological world views and the findings of previous research in this area (Schifter, 1998; Vacc and Bright, 1999; Borasi, Fonzi, Smith, and Rose, 1999) it seems plausible to suggest that teachers that can be made to externalise (i.e. make more explicit) their epistemological world views will be better able to reflect on those views in an attempt to change them, especially if they have first had the opportunity to discuss them with a critical friend.

The discussion in Chapter One gave details of a number of different systems devised by researchers in the field. Some of these are two tier systems whereas others employ a three tier system. If epistemological world views are seen to be valid constructs then I suggest that in terms of teacher epistemologies there needs to be more research into identifying a more exhaustive taxonomy. However, some argue that the constructs of epistemological world views as described in this research are not useful concepts with which to categorise teachers (Martinez, 2002). This suggests alternative avenues for future research. My findings suggest that there appear to be no neat epistemological world views but that teachers could be broadly categorised as realist or relativist. However, there needs to be more research into the validity of epistemological world views as constructs that can be usefully used to categorise teachers. If they are found not to be valid constructs then that would beg the question of whether the epistemological world views as described in this and past research cease to be useful categories with which to classify teachers.

However, if we accept that relatively few teachers will hold explicit epistemological world views and remember that one of the key findings from the research described here was that teachers' epistemological world views played a rather indirect role in determining teaching practice then it is perhaps time to shift the research emphasis to investigations into what does significantly impact teaching practice in a pursuit of best practice. My research provides some evidence to implicate the mediating contextual factors I have described in at least partly determining teacher's classroom practice. More time needs to be spent on research that attempts to verify or refute these findings and if replicated then there also needs to be more research into how teachers may best transcend the barriers identified here in pursuit of best teaching practice.

7.4 Concluding Remarks

This chapter has outlined the overall conclusions of the research but also drawn the reader's attention to some of its limitations. It has also suggested possible avenues for further research that could lead to further insights into primary teachers' epistemological beliefs and their epistemological world views concerning the teaching and learning of mathematics.

If this research on teacher' epistemologies has achieved nothing else it has provided the three teachers involved in Phases II and III with opportunities to reflect upon both their individual epistemological beliefs and their overarching epistemological world view concerning the teaching and learning of mathematics. It has also allowed them the opportunity to reflect on their teaching practice. One of the subsidiary aims whilst conducting the research was to help the teachers involved develop their own philosophy or world view concerning the teaching and learning of mathematics. Gratifyingly, all three teachers stated that their involvement in the research process had made them think more about their own philosophy and their own teaching practice. For example, in response to this type of question from me, Lisa said:

> **L:** It has because I went away after the last time thinking '*I actually know very little about what I think about things*' and then I read this transcript [pointing to copy of transcript from previous interview] and I was thinking '*Mm, what do I know and what don't I know?*' So it has, yeah. I've actually thought about it a lot and I've actually looked at what I've been doing more as well.
>
> **DB:** Yeah?

L: Yeah and thinking '*why did I do that and what have I done that for and how would I do that if I had a different class?*' so I have actually thought about the way I teach maths a lot. (Appendix X: Lisa: Interview 2: L444-452)

John and I had this conversation on the same topic:

DB: Do you think your philosophy of mathematics, because that's what I've been trying to tap into over the last five or six months, I wonder if that's developed over that time that we've had together?
J: Ah definitely, definitely. If only to reflect on my practice and to say '*where would I like it to go?*' which is what we've discussed. I would like it to be more of a constructivist way of teaching and looking within the bounds of what we've got I certainly think that once we have more time within the curriculum to teach a particular subject then there is no reason why it can't be more investigative, more constructivist. (Appendix Y: John: Interview 4: L113-121)

And later on the same subject:

J: Ah definitely. Ah yes, yeah, yeah, because any reflection upon practice and any professional discussion with a critical friend, which is effectively what you've been, challenging what I think, makes you think further. It would be interesting to see whether in six months time or this time next year whether things have changed sufficiently to allow me to do that or whether, I can manipulate sufficiently to make sure that that happens. (Appendix Y: John: Interview 4: L132-137)

Mary too said she had found our discussion useful:

M: Yes, it has definitely made me think more about what I think but it hasn't changed the way I teach at all. (Appendix Z: Mary: Interview 4: L63-64)

At the very outset of this study I had only what I thought to be modest hopes for the outcomes of the research. I hoped merely that the findings would in some small way add something to the extant body of knowledge on teacher epistemologies and their possible relationship with teaching practice. I also hoped that the teachers involved in the research would eventually come to view their participation as worthwhile. The fact that the teachers valued our time together is a source of great personal satisfaction to me and I feel this alone represents a major strength of the research. I will leave it to others in the field to determine the extent to which the other aim has been achieved.

Appendices

Appendix A: Final Draft of Questionnaire

Teaching and Learning KS2 Mathematics

David Bolden
Research Associate
Northumbria University
Education Research Unit
Allendale House
Newcastle upon Tyne
NE7 7XA

Tel: 0191 215 6107
[Date]

Dear Colleague

I am a researcher at Northumbria University and [name] from the LEA has given me permission to approach you to ask whether you would be willing to participate in some research.

As part of a study into primary teachers' views of teaching and learning of KS2 mathematics I would like to ask your views. I know how busy you are but I would be very grateful if you would take time to complete the enclosed questionnaire and return it to me in the prepaid envelope attached. It is relatively short and should only take you about five minutes to complete.

The questionnaire itself is anonymous and so everything you write will be absolutely confidential. Neither individual teachers nor the LEA will be identified in the writing up of the research findings. Even if you give your name your confidentiality is assured. If you have any queries or concerns about the questionnaire or the research in general please do not hesitate to ring me on the above number.

Many thanks in advance of your help.

Best wishes

David Bolden

Enc

northumbria
UNIVERSITY

Teaching and Learning in Mathematics at KS2

The first section comprises questions asking for details about you. The answers you give will be anonymous and confidential. This type of information is important in that it allows me to draw comparisons between different subgroups of teachers.

I About You

1. How long have you been a KS2 primary teacher? [ ] years

2. What is the highest mathematics qualification you hold?

GCSE/O Level ☐ A Level ☐ Degree ☐

Masters ☐ None ☐ Other ☐
[specify: ____________________]

3. What is the age range of the pupils in the school in which you teach?

[_____ *to* _____] years

4. Have you ever been the Lead Mathematics teacher in this or any other school?

Yes ☐ No ☐

5. Which KS2 year group do you teach? You may tick more than one box.

Year 3 ☐ Year 4 ☐ Year 5 ☐ Year 6 ☐ Other ☐
[specify: _______________]

6. Please tell us your age. [ ] years of age

7. Please tell us your sex. Male ☐ Female ☐

PTO

II About Teaching and Learning

The section below sets out thirty-two statements. Think about how you view the teaching and learning of mathematics in your classrooms and for each statement, indicate the extent to which you agree or disagree by circling the appropriate number (1 is *strongly disagree*, through 3 *neutral*, to 5 *strongly agree*). There are no 'right' or 'wrong' answers.

	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
1. It bothers me when teachers don't tell students the answers to complicated problems.	1	2	3	4	5
2. Truth means different things to different people.	1	2	3	4	5
3. Students who learn things quickly are the most successful.	1	2	3	4	5
4. People should always obey the law.	1	2	3	4	5
5. Some people will never be clever no matter how hard they work.	1	2	3	4	5
6. Absolute moral truth does not exist.	1	2	3	4	5
7. Parents should teach their children all there is to know about life.	1	2	3	4	5
8. Really clever students don't need to work as hard to do well in school.	1	2	3	4	5
9. If a person tries too hard to understand a problem, they will most likely be confused.	1	2	3	4	5
10. Too many theories just complicate things.	1	2	3	4	5
11. The best ideas are often the most simple.	1	2	3	4	5
12. People can't do much about how clever they are.	1	2	3	4	5
13. Teachers should focus on facts instead of theories.	1	2	3	4	5
14. I prefer to present several competing theories and let students decide which is best.	1	2	3	4	5
15. How well you do in school depends on how clever you are.	1	2	3	4	5
16. If you don't learn something quickly, you won't ever learn it.	1	2	3	4	5
17. Some people just have a knack for learning and others don't.	1	2	3	4	5
18. Things are much simpler than they appear.	1	2	3	4	5
19. If two people are arguing about something, at least one of them must be wrong.	1	2	3	4	5
20. Children should be allowed to question their parents' authority.	1	2	3	4	5
21. If you haven't understood a chapter of a book the first time, going back won't help.	1	2	3	4	5
22. Mathematics is easy to understand because it contains so many facts.	1	2	3	4	5
23. The moral rules I live by apply to everyone.	1	2	3	4	5
24. The more you know about a topic the more there is to know.	1	2	3	4	5
25. What is true today will be true tomorrow.	1	2	3	4	5
26. Clever people are born that way.	1	2	3	4	5
27. When someone in authority tells me what to do, I usually do it.	1	2	3	4	5
28. People who question authority are trouble-makers.	1	2	3	4	5
29. Working on a problem with no quick solution is a waste of time.	1	2	3	4	5
30. You can study something for years and still not really understand it.	1	2	3	4	5
31. Sometimes there are no right answers to life's big problems.	1	2	3	4	5
32. Some people are born with special gifts and talents.	1	2	3	4	5

PTO

Below are two fictional descriptions of how a teacher may see the teaching and learning of mathematics. For each one, indicate the extent to which you think it reflects your teaching approach by circling the appropriate number. There are no right and wrong answers.

Fictional View 1

There is a core body of knowledge in my classroom that each student must learn. Some of it is factual, but some of it is based on broad concepts and principles that everyone agrees on. This knowledge doesn't change much over time and represents the accumulation of important truths and understanding in my discipline. It is important for students to acquire this knowledge exactly as it is. The best way to acquire this knowledge is through an expert like me because I have a much better sense than they do of what is important to learn. It's unlikely that students could really create this knowledge on their own, so learning it from me will be quicker and more efficient. For this reason, it is important to me to assume a take-charge attitude so students can learn as much as possible. It is important to me that everyone comes away from my class with the big picture. It is my job to present the big picture clearly.

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

Fictional View 2

Students in my class need to understand that there are a variety of different ways to understand things. Knowledge comes and goes and what the so-called experts consider the truth today will be viewed with suspicion tomorrow. Even people who spend years studying a topic disagree about what things mean, and in the long run, one opinion is as good as another. This means that students have to learn to think for themselves, question the knowledge and authority of others, and evaluate how what they know affects their life. Knowledge has to be used widely so no one is left out or exploited by society. For these reasons, I don't believe that I can really teach my students what is important, since they all need to know different things. They have to figure it out in their own, taking into account the events that shape their lives, even if the uncertainty of living in a world with conflicting views of truth bothers them. What I know and believe really shouldn't influence my students. My job is to create an environment where students learn to think independently and take nothing for granted.

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

I would like to follow up this questionnaire by contacting some teachers in schools. If you feel you would be willing to take part further in this research please supply your name and contact details below:

Name:	
Name of School:	
School Tel No:	
Your Mobile No:	
Contact Email:	

Please post the completed questionnaire in the prepaid envelope provided. **Many thanks for taking the time out to participate in this research.**

David Bolden

Appendix B: Three Examples of Pilot Groups' Responses

Example 1

Teaching and Learning KS2 Mathematics

northumbria
UNIVERSITY

David Bolden
Research Associate
Northumbria University
Education Research Unit
Allendale House
Newcastle upon Tyne
NE7 7XA

Tel: 0191 215 6107
[Date]

Dear Colleague

I am conducting research for my doctoral thesis and [name of contact] from the LEA has given me permission to approach you to ask whether you would be willing to participate.

I am interested in primary teachers' views of teaching and learning in mathematics at KS2. The attached questionnaire is relatively short and should only take you about five minutes to complete. I know how busy you are but I would be very grateful if you would take time to complete the questionnaire and return to me in the prepaid envelope attached. The questionnaire itself is anonymous and so everything you write will be absolutely confidential. Neither individual teachers nor the LEA will be identified in writing the thesis. Even if you give your name your confidentiality is assured.

If you have any queries or concerns about the questionnaire or the research in general please do not hesitate to ring me on the above number.

Many thanks in advance of your help.

Best wishes

David Bolden
Enc

northumbria
UNIVERSITY

Teaching and Learning in Mathematics at KS2

The first section comprises questions asking for details about you. The answers you give will be anonymous and confidential. This type of information is important in that it allows me to draw comparisons between different ~~sub~~groups of teachers.

I About You

1. How long have you been a teacher? [ ] years

2. What is the highest mathematics qualification you hold?

GCSE/O Level ☐ A Level ☐ Degree ☐

Masters ☐ None ☐ Other ☐ [specify: ________________]

3. In what type of school do you teach?

Primary ☐ Junior ☐ Other ☐

4. Are you a Lead Mathematics teacher in this or a generalist?

Lead Maths Teacher ☐ Generalist ☐

5. Which KS2 year group do you teach? You may tick more than one box.

Year 3 ☐ Year 4 ☐ Year 5 ☐ Year 6 ☐ Other ☐ [specify: ____________]

What is your age?
6. ~~Please tell us your age.~~ [ ] years of age

Are you
7. ~~Please tell us your sex.~~ Male ☐ Female ☐

PTO

II About Teaching and Learning

The section below sets out thirty-two statements. Think about how you view the teaching and learning of mathematics in your classrooms and for each statement, indicate the extent to which you agree or disagree by circling the appropriate number (1 is *strongly disagree*, through 3 *neutral*, to 5 *strongly agree*). There are no 'right' or 'wrong' answers.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. It bothers me when teachers don't tell students the answers to complicated problems.	1	2	3	4	5
2. Truth means different things to different people.	1	2	3	4	5
3. Students who learn things quickly are the most successful.	1	2	3	4	5
4. People should always obey the law.	1	2	3	4	5
5. Some people will never be clever no matter how hard they work.	1	2	3	4	5
6. Absolute moral truth does not exist.	1	2	3	4	5
7. Parents should teach their children all there is to know about life.	1	2	3	4	5
8. Really clever students don't need to work as hard to do well in school.	1	2	3	4	5
9. If a person tries too hard to understand a problem, they will most likely end up being confused.	1	2	3	4	5
10. Too many theories just complicate things.	1	2	3	4	5
11. The best ideas are often the most simple.	1	2	3	4	5
12. People can't do much about how clever they are.	1	2	3	4	5
13. Teachers should focus on facts instead of theories.	1	2	3	4	5
14. I prefer to present several competing theories and let students decide which is best.	1	2	3	4	5
15. How well you do in school depends on how clever you are.	1	2	3	4	5
16. If you don't learn something quickly, you won't ever learn it.	1	2	3	4	5
17. Some people just have a knack for learning and others don't.	1	2	3	4	5
18. Things are much simpler than they appear.	1	2	3	4	5
19. If two people are arguing about something, at least one of them must be wrong.	1	2	3	4	5
20. Children should be allowed to question their parents' authority.	1	2	3	4	5
21. If you haven't understood a chapter of a book the first time, going back over it won't help.	1	2	3	4	5
22. Mathematics is easy to understand because it contains so many facts.	1	2	3	4	5
23. The moral rules I live by apply to everyone.	1	2	3	4	5
24. The more you know about a topic, the more there is to know.	1	2	3	4	5
25. What is true today will be true tomorrow.	1	2	3	4	5
26. Clever people are born that way.	1	2	3	4	5
27. When someone in authority tells me what to do, I usually do it.	1	2	3	4	5
28. People who question authority are trouble makers.	1	2	3	4	5
29. Working on a problem with no quick solution is a waste of time.	1	2	3	4	5
30. You can study something for years and still not really understand it.	1	2	3	4	5
31. Sometimes there are no right answers to life's big problems.	1	2	3	4	5
32. Some people are born with special gifts and talents.	1	2	3	4	5

hard to read for elderly eyes / short-sighted people

PTO

Below are two fictional descriptions of how a teacher may see the teaching and learning of mathematics. For each one, indicate the extent to which you think it reflects your teaching approach by circling the appropriate number. There are no right ~~and~~ or wrong answers.

Fictional View 1

There is a core body of knowledge in my classroom that each student must learn. Some of it is factual, but some of it is based on broad concepts and principles that everyone agrees on. This knowledge doesn't change much over time and represents the accumulation of important truths and understanding in my discipline. It is important for students to acquire this knowledge exactly as it is. The best way to acquire this knowledge is through an expert like me because I have a much better sense than they do of what is important to learn. It's unlikely that students could really create this knowledge on their own, so learning it from me will be quicker and more efficient. For this reason, it is important to me to assume a take-charge attitude so students can learn as much as possible. It is important to me that everyone comes away from my class with the big picture. It is my job to present the big picture clearly.

Arial text may be easier to read here

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

The change is that if offered a mid-point they'll always go for it hence a 4 point scale

Fictional View 2

Students in my class need to understand that there are a variety of different ways to understand things. Knowledge comes and goes and what the so-called experts consider the truth today will be viewed with suspicion tomorrow. Even people who spend years studying a topic disagree about what things mean, and in the long run, one opinion is as good as another. This means that students have to learn to think for themselves, question the knowledge and authority of others, and evaluate how what they know affects their life. Knowledge has to be used widely so no one is left out or exploited by society. For these reasons, I don't believe that I can really teach my students what is important, since they all need to know different things. They have to figure it out in their own, taking into account the events that shape their lives, even if the uncertainty of living in a world with conflicting views of truth bothers them. What I know and believe really shouldn't influence my students. My job is to create an environment where students learn to think independently and take nothing for granted.

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

Change text to italic

I would like to follow up this questionnaire by contacting some teachers in schools. If you feel you would be willing to take part further in this research please supply your name and contact details below:

Name:	
Name of School:	
Contact Tel No:	
Contact Email:	

Please post the completed questionnaire in the prepaid envelope provided. Many thanks for taking the time ~~out~~ to participate in this research.

David Bolden

Example 2

Teaching and Learning KS2 Mathematics

northumbria
UNIVERSITY

David Bolden
Research Associate
Northumbria University
Education Research Unit
Allendale House
Newcastle upon Tyne
NE7 7XA

Tel: 0191 215 6107
[Date]

Dear Colleague

I am a researcher at UNN

I am ~~conducting research for my doctoral thesis~~ and [name of contact] from the LEA has given me permission to approach you to ask whether you would be willing to participate.

I am interested in primary teachers' views of teaching and learning in mathematics at KS2. The attached questionnaire is relatively short and should only take you about five minutes to complete. I know how busy you are but I would be very grateful if you would take time to complete the questionnaire and return to me in the prepaid envelope attached. The questionnaire itself is anonymous and so everything you write will be absolutely confidential. Neither individual teachers nor the LEA will be identified in writing the thesis. Even if you give your name your confidentiality is assured.

If you have any queries or concerns about the questionnaire or the research in general please do not hesitate to ring me on the above number.

Many thanks in advance of your help.

Best wishes

David Bolden

Enc

As part of a study on mathematics learning & teaching @ KS2

northumbria UNIVERSITY

Teaching and Learning in Mathematics at KS2

The first section comprises questions asking for details about you. The answers you give will be anonymous and confidential. This type of information is important in that it allows me to draw comparisons between different subgroups of teachers.

I About You KS2 primary

1. How long have you been a teacher? [ ] years

2. What is the highest mathematics qualification you hold?

GCSE/O Level ☐ A Level ☐ Degree ☐

Masters ☐ None ☐ Other ☐ [specify: ________________]

3. In what type of school do you teach? What is the age range of pupils in the school in which you teach

Primary ☐ Junior ☐ Other ☐

4. Are you a Lead Mathematics teacher in this or a generalist?
Have you ever been the Lead Mathematics teacher

Lead Maths Teacher ☐ Generalist ☐

5. Which KS2 year group do you teach? You may tick more than one box.

Year 3 ☐ Year 4 ☐ Year 5 ☐ Year 6 ☐ Other ☐ [specify: ______________]

6. Please tell us your age. [ ] years of age

7. Please tell us your sex. Male ☐ Female ☐

PTO

II About Teaching and Learning

The section below sets out thirty-two statements. Think about how you view the teaching and learning of mathematics in your classrooms and for each statement, indicate the extent to which you agree or disagree by circling the appropriate number (1 is *strongly disagree*, through 3 *neutral*, to 5 *strongly agree*). There are no 'right' or 'wrong' answers.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. It bothers me when teachers don't tell students the answers to complicated problems.	1	2	3	4	5
2. Truth means different things to different people.	1	2	3	4	5
3. Students who learn things quickly are the most successful.	1	2	3	4	5
4. People should always obey the law.	1	2	3	4	5
5. Some people will never be clever no matter how hard they work.	1	2	3	4	5
6. Absolute moral truth does not exist.	1	2	3	4	5
7. Parents should teach their children all there is to know about life.	1	2	3	4	5
8. Really clever students don't need to work as hard to do well in school.	1	2	3	4	5
9. If a person tries too hard to understand a problem, they will most likely end up being confused.	1	2	3	4	5
10. Too many theories just complicate things.	1	2	3	4	5
11. The best ideas are often the most simple.	1	2	3	4	5
12. People can't do much about how clever they are.	1	2	3	4	5
13. Teachers should focus on facts instead of theories.	1	2	3	4	5
14. I prefer to present several competing theories and let students decide which is best.	1	2	3	4	5
15. How well you do in school depends on how clever you are.	1	2	3	4	5
16. If you don't learn something quickly, you won't ever learn it.	1	2	3	4	5
17. Some people just have a knack for learning and others don't.	1	2	3	4	5
18. Things are much simpler than they appear.	1	2	3	4	5
19. If two people are arguing about something, at least one of them must be wrong.	1	2	3	4	5
20. Children should be allowed to question their parents' authority.	1	2	3	4	5
21. If you haven't understood a chapter of a book the first time, going back over it won't help.	1	2	3	4	5
22. Mathematics is easy to understand because it contains so many facts.	1	2	3	4	5
23. The moral rules I live by apply to everyone.	1	2	3	4	5
24. The more you know about a topic, the more there is to know.	1	2	3	4	5
25. What is true today will be true tomorrow.	1	2	3	4	5
26. Clever people are born that way.	1	2	3	4	5
27. When someone in authority tells me what to do, I usually do it.	1	2	3	4	5
28. People who question authority are trouble makers.	1	2	3	4	5
29. Working on a problem with no quick solution is a waste of time.	1	2	3	4	5
30. You can study something for years and still not really understand it.	1	2	3	4	5
31. Sometimes there are no right answers to life's big problems.	1	2	3	4	5
32. Some people are born with special gifts and talents.	1	2	3	4	5

bigger if possible

PTO

Below are two fictional descriptions of how a teacher may see the teaching and learning of mathematics. For each one, indicate the extent to which you think it reflects your teaching approach by circling the appropriate number. There are no right and wrong answers.

Fictional View 1

There is a core body of knowledge in my classroom that each student must learn. Some of it is factual, but some of it is based on broad concepts and principles that everyone agrees on. This knowledge doesn't change much over time and represents the accumulation of important truths and understanding in my discipline. It is important for students to acquire this knowledge exactly as it is. The best way to acquire this knowledge is through an expert like me because I have a much better sense than they do of what is important to learn. It's unlikely that students could really create this knowledge on their own, so learning it from me will be quicker and more efficient. For this reason, it is important to me to assume a take-charge attitude so students can learn as much as possible. It is important to me that everyone comes away from my class with the big picture. It is my job to present the big picture clearly.

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

Fictional View 2

Students in my class need to understand that there are a variety of different ways to understand things. Knowledge comes and goes and what the so-called experts consider the truth today will be viewed with suspicion tomorrow. Even people who spend years studying a topic disagree about what things mean, and in the long run, one opinion is as good as another. This means that students have to learn to think for themselves, question the knowledge and authority of others, and evaluate how what they know affects their life. Knowledge has to be used widely so no one is left out or exploited by society. For these reasons, I don't believe that I can really teach my students what is important, since they all need to know different things. They have to figure it out in their own, taking into account the events that shape their lives, even if the uncertainty of living in a world with conflicting views of truth bothers them. What I know and believe really shouldn't influence my students. My job is to create an environment where students learn to think independently and take nothing for granted.

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

I would like to follow up this questionnaire by contacting some teachers in schools. If you feel you would be willing to take part further in this research please supply your name and contact details below:

Name:	
Name of School:	
Contact Tel No:	
Contact Email:	

Try to get middle school name [illegible]

Please post the completed questionnaire in the prepaid envelope provided. Many thanks for taking the time out to participate in this research.

bigger

David Bolden

Example 3

Teaching and Learning KS2 Mathematics

northumbria
UNIVERSITY

David Bolden
Research Associate
Northumbria University
Education Research Unit
Allendale House
Newcastle upon Tyne
NE7 7XA

Tel: 0191 215 6107
[Date]

Dear Colleague

I am a researcher at Northumbria University and [name of contact] from the LEA has given me permission to approach you to ask whether you would be willing to participate in some research.

As part of a study into primary teachers' views of teaching and learning in mathematics at KS2 I would like to ask you views to complete the enclosed questionnaire. I know how busy you are but I would be very grateful if you would take time to complete the enclosed questionnaire and return to me in the prepaid envelope attached. It is relatively short and should only take you about five minutes to complete.

The questionnaire itself is anonymous and so everything you write will be absolutely confidential. Neither individual teachers nor the LEA will be identified in the writing ~~the thesis~~. Even if you give your name your confidentiality is assured. If you have any queries or concerns about the questionnaire or the research in general please do not hesitate to ring me on the above number. (of the research findings)

Many thanks in advance of your help.

Best wishes

David Bolden

Enc

northumbria
UNIVERSITY

Teaching and Learning in Mathematics at KS2

The first section comprises questions asking for details about you. The answers you give will be anonymous and confidential. This type of information is important in that it allows me to draw comparisons between different groups of teachers.

I About You

1. How long have you been a KS2 primary teacher? [ ] years

2. What is the highest mathematics qualification you hold?

GCSE/O Level ☐ A Level ☐ Degree ☐

Masters ☐ None ☐ Other ☐
[specify: ______________]

3. What is the age range of the pupils in the school in which you teach?

[____ *to* ____] years

4. Have you ever been the Lead Mathematics teacher in this or any other school?

Yes ☐ No ☐

5. Which KS2 year group do you teach? You may tick more than one box.

Year 3 ☐ Year 4 ☐ Year 5 ☐ Year 6 ☐ Other ☐
[specify: ______________]

6. Please give your age. [ ] years of age

7. Are you: Male ☐ Female ☐

PTO

II About Teaching and Learning

The section below sets out thirty-two statements. Think about how you view the teaching and learning of mathematics in your classrooms and for each statement, indicate the extent to which you agree or disagree by circling the appropriate number (1 is *strongly disagree*, through 3 *neutral*, to 5 *strongly agree*). There are no 'right' or 'wrong' answers.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. It bothers me when teachers don't tell students the answers to complicated problems.	1	2	3	4	5
2. Truth means different things to different people.	1	2	3	4	5
3. Students who learn things quickly are the most successful.	1	2	3	4	5
4. People should always obey the law.	1	2	3	4	5
5. Some people will never be clever no matter how hard they work.	1	2	3	4	5
6. Absolute moral truth does not exist.	1	2	3	4	5
7. Parents should teach their children all there is to know about life.	1	2	3	4	5
8. Really clever students don't need to work as hard to do well in school.	1	2	3	4	5
9. If a person tries too hard to understand a problem, they will most likely end up being confused.	1	2	3	4	5
10. Too many theories just complicate things.	1	2	3	4	5
11. The best ideas are often the most simple.	1	2	3	4	5
12. People can't do much about how clever they are.	1	2	3	4	5
13. Teachers should focus on facts instead of theories.	1	2	3	4	5
14. I prefer to present several competing theories and let students decide which is best.	1	2	3	4	5
15. How well you do in school depends on how clever you are.	1	2	3	4	5
16. If you don't learn something quickly, you won't ever learn it.	1	2	3	4	5
17. Some people just have a knack for learning and others don't.	1	2	3	4	5
18. Things are much simpler than they appear.	1	2	3	4	5
19. If two people are arguing about something, at least one of them must be wrong.	1	2	3	4	5
20. Children should be allowed to question their parents' authority.	1	2	3	4	5
21. If you haven't understood a chapter of a book the first time, going back over it won't help.	1	2	3	4	5
22. Mathematics is easy to understand because it contains so many facts.	1	2	3	4	5
23. The moral rules I live by apply to everyone.	1	2	3	4	5
24. The more you know about a topic, the more there is to know.	1	2	3	4	5
25. What is true today will be true tomorrow.	1	2	3	4	5
26. Clever people are born that way.	1	2	3	4	5
27. When someone in authority tells me what to do, I usually do it.	1	2	3	4	5
28. People who question authority are trouble makers.	1	2	3	4	5
29. Working on a problem with no quick solution is a waste of time.	1	2	3	4	5
30. You can study something for years and still not really understand it.	1	2	3	4	5
31. Sometimes there are no right answers to life's big problems.	1	2	3	4	5
32. Some people are born with special gifts and talents.	1	2	3	4	5

PTO

Below are two fictional descriptions of how a teacher may see the teaching and learning of mathematics. For each one, indicate the extent to which you think it reflects your teaching approach by circling the appropriate number. There are no right and wrong answers.

Fictional View 1

There is a core body of knowledge in my classroom that each student must learn. Some of it is factual, but some of it is based on broad concepts and principles that everyone agrees on. This knowledge doesn't change much over time and represents the accumulation of important truths and understanding in my discipline. It is important for students to acquire this knowledge exactly as it is. The best way to acquire this knowledge is through an expert like me because I have a much better sense than they do of what is important to learn. It's unlikely that students could really create this knowledge on their own, so learning it from me will be quicker and more efficient. For this reason, it is important to me to assume a take-charge attitude so students can learn as much as possible. It is important to me that everyone comes away from my class with the big picture. It is my job to present the big picture clearly.

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

Fictional View 2

Students in my class need to understand that there are a variety of different ways to understand things. Knowledge comes and goes and what the so-called experts consider the truth today will be viewed with suspicion tomorrow. Even people who spend years studying a topic disagree about what things mean, and in the long run, one opinion is as good as another. This means that students have to learn to think for themselves, question the knowledge and authority of others, and evaluate how what they know affects their life. Knowledge has to be used widely so no one is left out or exploited by society. For these reasons, I don't believe that I can really teach my students what is important, since they all need to know different things. They have to figure it out in their own, taking into account the events that shape their lives, even if the uncertainty of living in a world with conflicting views of truth bothers them. What I know and believe really shouldn't influence my students. My job is to create an environment where students learn to think independently and take nothing for granted.

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

I would like to follow up this questionnaire by contacting some teachers in schools. If you feel you would be willing to take part further in this research please supply your name and contact details below:

Name:	
Name of School:	
Contact Tel No:	
Contact Email:	

Please post the completed questionnaire in the prepaid envelope provided. Many thanks for taking the time out to participate in this research.

David Bolden

Appendix C: First Draft of Questionnaire

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. It bothers me when teachers don't tell students the answers to complicated problems.	1	2	3	4	5
2. Truth means different things to different people.	1	2	3	4	5
3. Students who learn things quickly are the most successful.	1	2	3	4	5
4. People should always obey the law.	1	2	3	4	5
5. Some people will never be clever no matter how hard they work.	1	2	3	4	5
6. Absolute moral truth does not exist.	1	2	3	4	5
7. Parents should teach their children all there is to know about life.	1	2	3	4	5
8. Really clever students don't need to work as hard to do well in school.	1	2	3	4	5
9. If a person tries too hard to understand a problem, they will most likely end up being confused.	1	2	3	4	5
10. Too many theories just complicate things.	1	2	3	4	5
11. The best ideas are often the most simple.	1	2	3	4	5
12. People can't do much about how clever they are.	1	2	3	4	5
13. Teachers should focus on facts instead of theories.	1	2	3	4	5
14. I prefer to present several competing theories and let students decide which is best.	1	2	3	4	5
15. How well you do in school depends on how clever you are.	1	2	3	4	5
16. If you don't learn something quickly, you won't ever learn it.	1	2	3	4	5
17. Some people just have a knack for learning and others don't.	1	2	3	4	5
18. Things are much simpler than they appear.	1	2	3	4	5
19. If two people are arguing about something, at least one of them must be wrong.	1	2	3	4	5
20. Children should be allowed to question their parents' authority.	1	2	3	4	5
21. If you haven't understood a chapter of a book the first time, going back over it won't help.	1	2	3	4	5
22. Mathematics is easy to understand because it contains so many facts.	1	2	3	4	5
23. The moral rules I live by apply to everyone.	1	2	3	4	5
24. The more you know about a topic, the more there is to know.	1	2	3	4	5
25. What is true today will be true tomorrow.	1	2	3	4	5
26. Clever people are born that way.	1	2	3	4	5
27. When someone in authority tells me what to do, I usually do it.	1	2	3	4	5
28. People who question authority are trouble makers.	1	2	3	4	5
29. Working on a problem with no quick solution is a waste of time.	1	2	3	4	5
30. You can study something for years and still not really understand it.	1	2	3	4	5
31. Sometimes there are no right answers to life's big problems.	1	2	3	4	5
32. Some people are born with special gifts and talents.	1	2	3	4	5

Appendix D: Second Draft of Questionnaire

Teaching and Learning in Mathematics at KS2

The first section comprises questions asking for details about you. The answers you give will be anonymous and confidential. This type of information is important in that it allows me to draw comparisons between different subgroups of teachers.

I About You

1. How long have you been a teacher? [ ] years

2. What is the highest mathematics qualification you hold?

GCSE/O Level ☐ A Level ☐ Degree ☐

Masters ☐ None ☐ Other ☐
[specify: ________________]

3. In what type of school do you teach?

Primary ☐ Junior ☐ Other ☐
[specify: ________________]

4. Are you a Lead Mathematics teacher or a generalist?

Lead Maths Teacher ☐ Generalist ☐

5. Which KS2 year group do you teach? You may tick more than one box.

Year 3 ☐ Year 4 ☐ Year 5 ☐ Year 6 ☐ Other ☐
[specify: ____________]

6. Please tell us your age. [ ] years of age

7. Please tell us your sex. Male ☐ Female ☐

PTO

II About Teaching and Learning

The section below sets out thirty-two statements. Think about how you view the teaching and learning of mathematics in your classrooms and for each statement, indicate the extent to which you agree or disagree by circling the appropriate number (1 is *strongly disagree*, through 3 *neutral*, to 5 *strongly agree*). There are no 'right' or 'wrong' answers.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. It bothers me when teachers don't tell students the answers to complicated problems.	1	2	3	4	5
2. Truth means different things to different people.	1	2	3	4	5
3. Students who learn things quickly are the most successful.	1	2	3	4	5
4. People should always obey the law.	1	2	3	4	5
5. Some people will never be clever no matter how hard they work.	1	2	3	4	5
6. Absolute moral truth does not exist.	1	2	3	4	5
7. Parents should teach their children all there is to know about life.	1	2	3	4	5
8. Really clever students don't need to work as hard to do well in school.	1	2	3	4	5
9. If a person tries too hard to understand a problem, they will most likely end up being confused.	1	2	3	4	5
10. Too many theories just complicate things.	1	2	3	4	5
11. The best ideas are often the most simple.	1	2	3	4	5
12. People can't do much about how clever they are.	1	2	3	4	5
13. Teachers should focus on facts instead of theories.	1	2	3	4	5
14. I prefer to present several competing theories and let students decide which is best.	1	2	3	4	5
15. How well you do in school depends on how clever you are.	1	2	3	4	5
16. If you don't learn something quickly, you won't ever learn it.	1	2	3	4	5
17. Some people just have a knack for learning and others don't.	1	2	3	4	5
18. Things are much simpler than they appear.	1	2	3	4	5
19. If two people are arguing about something, at least one of them must be wrong.	1	2	3	4	5
20. Children should be allowed to question their parents' authority.	1	2	3	4	5
21. If you haven't understood a chapter of a book the first time, going back over it won't help.	1	2	3	4	5
22. Mathematics is easy to understand because it contains so many facts.	1	2	3	4	5
23. The moral rules I live by apply to everyone.	1	2	3	4	5
24. The more you know about a topic, the more there is to know.	1	2	3	4	5
25. What is true today will be true tomorrow.	1	2	3	4	5
26. Clever people are born that way.	1	2	3	4	5
27. When someone in authority tells me what to do, I usually do it.	1	2	3	4	5
28. People who question authority are trouble makers.	1	2	3	4	5
29. Working on a problem with no quick solution is a waste of time.	1	2	3	4	5
30. You can study something for years and still not really understand it.	1	2	3	4	5
31. Sometimes there are no right answers to life's big problems.	1	2	3	4	5
32. Some people are born with special gifts and talents.	1	2	3	4	5

PTO

Below are two fictional descriptions of how a teacher may see the teaching and learning of mathematics. For each one, indicate the extent to which you agree with that view by circling the appropriate number. There are no right and wrong answers.

Fictional View 1

There is a core body of knowledge in my classroom that each student must learn. Some of it is factual, but some of it is based on broad concepts and principles that everyone agrees on. This knowledge doesn't change much over time and represents the accumulation of important truths and understanding in my discipline. It is important for students to acquire this knowledge exactly as it is. The best way to acquire this knowledge is through an expert like me because I have a much better sense than they do of what is important to learn. It's unlikely that students could really create this knowledge on their own, so learning it from me will be quicker and more efficient. For this reason, it is important to me to assume a take-charge attitude so students can learn as much as possible. It is important to me that everyone comes away from my class with the big picture. It is my job to present the big picture clearly.

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

Fictional View 2

Students in my class need to understand that there are a variety of different ways to understand things. Knowledge comes and goes and what the so-called experts consider the truth today will be viewed with suspicion tomorrow. Even people who spend years studying a topic disagree about what things mean, and in the long run, one opinion is as good as another. This means that students have to learn to think for themselves, question the knowledge and authority of others, and evaluate how what they know affects their life. Knowledge has to be used widely so no one is left out or exploited by society. For these reasons, I don't believe that I can really teach my students what is important, since they all need to know different things. They have to figure it out in their own, taking into account the events that shape their lives, even if the uncertainty of living in a world with conflicting views of truth bothers them. What I know and believe really shouldn't influence my students. My job is to create an environment where students learn to think independently and take nothing for granted.

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

I would like to follow up this questionnaire by contacting some teachers in schools. If you feel you would be willing to take part further in this research please supply your name and contact details below:

Name:	
Name of School:	
Contact Tel No:	
Contact Email:	

Please post the completed questionnaire in the prepaid envelope provided. Many thanks for taking the time out to participate in this research.

David Bolden

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Appendix F: Covering Letter to Head Teachers

Teaching and Learning KS2 Mathematics

northumbria UNIVERSITY

David Bolden
Research Associate
Northumbria University
Education Research Unit
Allendale House
Newcastle upon Tyne
NE7 7XA

Tel: 0191 215 6107
[Date]

Dear [Name of Head Teacher]

I am a researcher at Northumbria University and [name] from the LEA has given me permission to approach you to ask whether several of your teaching staff would be willing to participate in some research.

As part of a study into primary teachers' views of the teaching and learning of KS2 mathematics I would like to ask some of your teachers to complete the enclosed questionnaire. I know how busy you are but I would be very grateful if you would take time to distribute the four enclosed questionnaires to a cross-section of your KS2 mathematics teaching staff, e.g. age, experience, sex, year group taught, etc. It is relatively short and should only take about five minutes to complete. There is also a prepaid envelope attached to each questionnaire so there is no cost involved.

The questionnaire itself is anonymous so any information given will be absolutely confidential. Neither individual teachers nor the LEA will be identified in the writing up of the research findings. If you have any queries or concerns about the questionnaire or the research in general please do not hesitate to ring me on the above number.

Many thanks in advance of your help.

Best wishes

David Bolden

Enc

Appendix G: Coding Frame for Variables in SPSS

Section I: About You

Question	Variable Name	Variable Type	Coding Used
Q1: How long have you been a KS2 teacher?	service*	Interval	No coding used
Q2:What is the highest mathematics qualification you hold?	qual	Ordinal	0 = none, 1 = GCSE/O Level, 2 = A Level, 3 = Degree, 4 = Masters, 5 = Other, 9 = no response
Q3:What is the age range of the pupils you teach?	range	Nominal	No coding used
Q4: Have you ever been a Lead Mathematics teacher in this or any other school?	lead	Nominal	1 = yes, 2 = no, 9 = no response
Q5: Which KS2 year group(s) do you teach?			
Year 3	year3	Nominal	1 = yes, 2 = no, 9 = no response
Year 4	year4	Nominal	1 = yes, 2 = no, 9 = no response
Year 5	year5	Nominal	1 = yes, 2 = no, 9 = no response
Year 6	year6	Nominal	1 = yes, 2 = no, 9 = no response
Other	yearo	Nominal	1 = yes, 2 = no, 9 = no response
Q6: Please give your age.	age*	Interval	No coding used
Q7: Sex of respondent?	sex	Nominal	1 = male, 2 = female, 9 = no response

NB: Items marked * were subsequently recoded (See *Appendix H: Recoded Variables in SPSS* for details).

Section II: About Teaching and Learning

Question	Variable Name	Variable Type	Coding Used
1: It bothers me when teachers don't tell students the answers to complicated problems.	answers	Ordinal	1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree, 9 = no response
2: Truth means different things to different people.	truth*	Ordinal	As above
3: Students who learn things quickly are the most successful.	quickly	Ordinal	As above
4: People should always obey the law.	obey	Ordinal	As above
5: Some people will never be clever no matter how hard they work.	clever	Ordinal	As above
6: Absolute moral truth does not exist.	moral	Ordinal	As above
7: Parents should teach their children all there is to know about life.	parents	Ordinal	As above
8: Really clever students don't need to work as hard to do well in school.	students	Ordinal	As above
9: If a person tries too hard to understand a problem, they will most likely end up being confused.	hard	Ordinal	As above
10: Too many theories just complicate things.	theories	Ordinal	As above
11: The best ideas are often the most simple.	simple	Ordinal	As above
12: People can't do much about how clever they are.	people	Ordinal	As above
13: Teachers should focus on facts instead of theories.	facts	Ordinal	As above
14: I prefer to present several competing theories and let students decide which is best.	compete*	Ordinal	As above
15: How well you do in school depends on how clever you are.	school	Ordinal	As above
16: If you don't learn something quickly, you won't ever learn it.	learn	Ordinal	As above
17: Some people just have a knack for learning and others don't.	knack	Ordinal	As above
18: Things are much simpler than they appear.	simpler	Ordinal	As above
19: If two people are arguing about something, at least one of them must be wrong.	arguing	Ordinal	As above
20: Children should be allowed to question their parents' authority.	question	Ordinal	As above
21: If you haven't understood a chapter of a book the first time, going back over it won't help.	chapter	Ordinal	As above
22: Mathematics is easy to understand because it contains so many facts.	maths	Ordinal	As above
23: The moral rules I live by apply to everyone.	rules	Ordinal	As above
24: The more you know about a topic the more there is to know.	topic*	Ordinal	As above
25: What is true today will be true tomorrow.	true*	Ordinal	As above

26: Clever people are born that way.	born	Ordinal	As above
27: When someone in authority tells me what to do, I usually do it.	authorit	Ordinal	As above
28: People who question authority are trouble-makers.	trouble	Ordinal	As above
29: Working on a problem with no quick solution is a waste of time.	waste	Ordinal	As above
30: You can study something for years and still not really understand it.	years	Ordinal	As above
31: Sometimes there are no right answers to life's big problems.	problems*	Ordinal	As above
32: Some people are born with special gifts and talents.	special	Ordinal	As above

NB: Variables marked * were subsequently reverse-scored.

Section III: Fictional Views of Teaching and Learning

Question	Variable Name	Variable Type	Coding Used
Q1: Fictional View 1	view1	Ordinal	1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree, 9 = no response
Q2: Fictional View 2	view2	Ordinal	1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree, 9 = no response

Appendix H: Recoded Variables in SPSS

Original Variable:	Recoded Into:
Length of service	Length of service recoded
Name: [service]	Name: [serv_rec]
Description: interval level variable	Description: ordinal level variable, e.g.
	0 to 4 years
	5 to 9 years
	10 to 14 years
	15 to 19 years
	20+ years

Original Variable:	Recoded Into:
Age of teacher	Age of teacher recoded
Name: [age]	Name: [age_rec]
Description: interval level variable	Description: ordinal level variable, e.g.
	Under 25 years
	25 to 29 years
	30 to 34 years
	35 to 39 years
	40 to 44 years
	45 to 49 years
	50 to 54 years
	55 to 59 years
	60+ years

Appendix J: The Survey Raw Data

Sex of Respondent	*N*	Percent	Valid Percent[1]
Male	12	16.0	16.0
Female	63	84.0	84.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.1 Percentage responses for variable *gender*, with corresponding *N*.

Age (Recoded)	*N*	Percent	Valid Percent
Under 25 years	7	9.3	9.3
25-29 years	14	18.7	18.7
30-34 years	19	25.3	25.3
35-39 years	6	8.0	8.0
40-44 years	10	13.3	13.3
45-49 years	9	12.0	12.0
50-54 years	7	9.3	9.3
55-59 years	3	4.0	4.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.2 Percentage responses for variable *age recoded*, with corresponding *N*.

Length of Service (Recoded)	*N*	Percent	Valid Percent
0-4 years	26	34.7	34.7
5-9 years	26	34.7	34.7
10-14 years	10	13.3	13.3
15-19 years	7	9.3	9.3
20+ years	6	8.0	8.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.3 Percentage responses for variable *length of service recoded*, with corresponding *N*.

Highest Mathematics Qualification Held	*N*	Percent	Valid Percent
GCSE/O Level	46	61.3	63.9
A Level	10	13.3	13.9
Degree	14	18.7	19.4
Masters	2	2.7	2.8
Other	0	0.0	0.0
Total	**72**	**96.0**	**100.0**
No response	3	0.0	---
Total	**75**	**100.0**	---

Table J.4 Percentage responses for variable variable *highest mathematics qualification held*, with corresponding *N*.

[1] *Valid percent* represents a measure of proportion when non-responses are eliminated (see Table J.4).

Lead Mathematics Teacher	*N*	**Percent**	**Valid Percent**
Yes	12	16.0	16.0
No	63	84.0	84.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.5 Percentage responses for variable *lead mathematics teacher*, with corresponding *N*.

Teach Year 3	*N*	**Percent**	**Valid Percent**
Yes	19	25.3	25.3
No	56	74.7	74.7
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.6 Percentage responses for variable *teachers teaching Year 3*, with corresponding *N*.

Teach Year 4	*N*	**Percent**	**Valid Percent**
Yes	18	24.0	24.0
No	57	76.0	76.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.7 Percentage responses for variable *teachers teaching Year 4*, with corresponding *N*.

Teach Year 5	*N*	**Percent**	**Valid Percent**
Yes	29	38.7	38.7
No	46	61.3	61.3
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.8 Percentage responses for variable *teachers teaching Year 5*, with corresponding *N*.

Teach Year 6	*N*	**Percent**	**Valid Percent**
Yes	30	40.0	40.0
No	45	60.0	60.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.9 Percentage responses for variable *teachers teaching Year 6*, with corresponding *N*.

It bothers me when teachers don't tell students the answers to complicated problems	*N*	Percent	Valid Percent
Strongly Disagree	0	0.0	0.0
Disagree	6	8.0	8.0
Neutral	23	30.7	30.7
Agree	33	44.0	44.0
Strongly Agree	13	17.3	17.3
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.10 Percentage responses for *main questionnaire Q1*, with corresponding *N*.

Truth means different things to different people.	*N*	Percent	Valid Percent
Strongly Disagree	11	14.7	14.7
Disagree	43	57.3	57.3
Neutral	12	16.0	16.0
Agree	7	9.3	9.3
Strongly Agree	2	2.7	2.7
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.11 Percentage responses for *main questionnaire Q2,* with corresponding *N*.

Students who learn things quickly are the most successful.	*N*	Percent	Valid Percent
Strongly Disagree	7	9.3	9.3
Disagree	47	62.7	62.7
Neutral	12	16.0	16.0
Agree	7	9.3	9.3
Strongly Agree	2	2.7	2.7
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.12 Percentage responses for *main questionnaire Q3*, with corresponding *N*.

People should always obey the law.	*N*	Percent	Valid Percent
Strongly Disagree	1	1.3	1.3
Disagree	10	13.3	13.3
Neutral	13	17.3	17.3
Agree	34	45.3	45.3
Strongly Agree	17	22.7	22.7
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.13 Percentage responses for *main questionnaire Q4*, with corresponding *N*.

Some people will never be clever no matter how hard they work.	*N*	Percent	Valid Percent
Strongly Disagree	9	12.0	12.0
Disagree	24	32.0	32.0
Neutral	17	22.7	22.7
Agree	21	28.0	28.0
Strongly Agree	4	5.3	5.3
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.14 Percentage responses for *main questionnaire Q5*, with corresponding *N*.

Absolute moral truth does not exist.	*N*	Percent	Valid Percent
Strongly Disagree	3	4.0	4.0
Disagree	12	16.0	16.0
Neutral	31	41.3	41.3
Agree	24	32.0	32.0
Strongly Agree	5	6.7	6.7
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.15 Percentage responses for *main questionnaire Q6*, with corresponding *N*.

Parents should teach their children all there is to know about life.	*N*	Percent	Valid Percent
Strongly Disagree	1	1.3	1.3
Disagree	31	41.3	41.3
Neutral	17	22.7	22.7
Agree	23	30.7	30.7
Strongly Agree	3	4.0	4.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.16 Percentage responses for *main questionnaire Q7*, with corresponding *N*.

Really clever students don't need to work as hard to do well in school.	*N*	Percent	Valid Percent
Strongly Disagree	8	10.7	10.7
Disagree	34	45.3	45.3
Neutral	11	14.7	14.7
Agree	21	28.0	28.0
Strongly Agree	1	1.3	1.3
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.17 Percentage responses for *main questionnaire Q8*, with corresponding *N*.

If a person tries too hard to understand a problem, they will most likely end up being confused.	*N*	Percent	Valid Percent
Strongly Disagree	3	4.0	4.0
Disagree	34	45.3	45.3
Neutral	25	33.3	33.3
Agree	13	17.3	17.3
Strongly Agree	0	0.0	0.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	75	**100.0**	---

Table J.18 Percentage responses for *main questionnaire Q9*, with corresponding *N*.

Too many theories just complicate things.	*N*	Percent	Valid Percent
Strongly Disagree	1	1.3	1.3
Disagree	22	29.3	29.3
Neutral	16	21.3	21.3
Agree	33	44.0	44.0
Strongly Agree	3	4.0	4.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	75	**100.0**	---

Table J.19 Percentage responses for *main questionnaire Q10*, with corresponding *N*.

The best ideas are often the most simple.	*N*	Percent	Valid Percent
Strongly Disagree	3	4.0	4.0
Disagree	3	4.0	4.0
Neutral	16	21.3	21.3
Agree	43	57.3	57.3
Strongly Agree	10	13.3	13.3
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	75	**100.0**	---

Table J.20 Percentage responses for *main questionnaire Q11*, with corresponding *N*.

People can't do much about how clever they are.	*N*	Percent	Valid Percent
Strongly Disagree	11	14.7	14.7
Disagree	52	69.3	69.3
Neutral	8	10.7	10.7
Agree	4	5.3	5.3
Strongly Agree	0	0.0	0.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.21 Percentage responses for *main questionnaire Q12*, with corresponding *N*.

Teachers should focus on facts instead of theories.	*N*	Percent	Valid Percent
Strongly Disagree	3	4.0	4.0
Disagree	43	57.3	57.3
Neutral	22	29.3	29.3
Agree	7	9.3	9.3
Strongly Agree	0	0.0	0.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.22 Percentage responses for *main questionnaire Q13*, with corresponding *N*.

I prefer to present several competing theories and let students decide which is best.	*N*	Percent	Valid Percent
Strongly Disagree	2	2.7	2.7
Disagree	38	50.7	50.7
Neutral	20	26.7	26.7
Agree	13	17.3	17.3
Strongly Agree	2	2.7	2.7
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.23 Percentage responses for *main questionnaire Q14*, with corresponding *N*.

How well you do in school depends on how clever you are.	*N*	Percent	Valid Percent
Strongly Disagree	15	20.0	20.0
Disagree	47	62.7	62.7
Neutral	5	6.7	6.7
Agree	7	9.3	9.3
Strongly Agree	1	1.3	1.3
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.24 Percentage responses for *main questionnaire Q15*, with corresponding *N*.

If you don't learn something quickly, you won't ever learn it.	*N*	Percent	Valid Percent
Strongly Disagree	24	32.0	32.0
Disagree	45	60.0	60.0
Neutral	4	5.3	5.3
Agree	1	1.3	1.3
Strongly Agree	1	1.3	1.3
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.25 Percentage responses for *main questionnaire Q16*, with corresponding *N*.

Some people just have a knack for learning and others don't.	*N*	Percent	Valid Percent
Strongly Disagree	3	4.0	4.0
Disagree	30	40.0	40.0
Neutral	22	29.3	29.3
Agree	18	24.0	24.0
Strongly Agree	2	2.7	2.7
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.26 Percentage responses for *main questionnaire Q17*, with corresponding *N*.

Things are much simpler than they appear.	*N*	Percent	Valid Percent
Strongly Disagree	2	2.7	2.7
Disagree	19	25.3	25.3
Neutral	42	56.0	56.0
Agree	10	13.3	13.3
Strongly Agree	2	2.7	2.7
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.27 Percentage responses for *main questionnaire Q18*, with corresponding *N*.

If two people are arguing about something, at least one of them must be wrong.	*N*	Percent	Valid Percent
Strongly Disagree	16	21.3	21.3
Disagree	51	68.0	68.0
Neutral	6	8.0	8.0
Agree	2	2.7	2.7
Strongly Agree	0	0	0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.28 Percentage responses for *main questionnaire Q19*, with corresponding *N*.

Children should be allowed to question their parents' authority.	*N*	Percent	Valid Percent
Strongly Disagree	4	5.3	5.3
Disagree	30	40.0	40.0
Neutral	28	37.3	37.3
Agree	12	16.0	16.0
Strongly Agree	1	1.3	1.3
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.29 Percentage responses for *main questionnaire Q20*, with corresponding *N*.

If you haven't understood a chapter of a book the first time, going back over it won't help.	*N*	Percent	Valid Percent
Strongly Disagree	22	29.3	29.3
Disagree	51	68.0	68.0
Neutral	2	2.7	2.7
Agree	0	0.0	0.0
Strongly Agree	0	0.0	0.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.30 Percentage responses for *main questionnaire Q21*, with corresponding *N*.

Mathematics is easy to understand because it contains so many facts.	*N*	Percent	Valid Percent
Strongly Disagree	12	16.0	16.0
Disagree	44	58.7	58.7
Neutral	15	20.0	20.0
Agree	4	5.3	5.3
Strongly Agree	0	0.0	0.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.31 Percentage responses for *main questionnaire Q22*, with corresponding *N*.

The moral rules I live by apply to everyone.	*N*	Percent	Valid Percent
Strongly Disagree	17	22.7	22.7
Disagree	41	54.7	54.7
Neutral	11	14.7	14.7
Agree	5	6.7	6.7
Strongly Agree	1	1.3	1.3
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.32 Percentage responses for *main questionnaire Q23*, with corresponding *N*.

The more you know about a topic the more there is to know.	*N*	Percent	Valid Percent
Strongly Disagree	5	6.7	6.7
Disagree	44	58.7	58.7
Neutral	22	29.3	29.3
Agree	4	5.3	5.3
Strongly Agree	0	0.0	0.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.33 Percentage responses for *main questionnaire Q24*, with corresponding *N*.

What is true today will be true tomorrow.	*N*	Percent	Valid Percent
Strongly Disagree	1	1.3	1.3
Disagree	4	5.3	5.3
Neutral	17	22.7	22.7
Agree	47	62.7	62.7
Strongly Agree	6	8.0	8.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.34 Percentage responses for *main questionnaire Q25*, with corresponding *N*.

Clever people are born that way.	*N*	Percent	Valid Percent
Strongly Disagree	3	4.0	4.0
Disagree	31	41.3	41.3
Neutral	29	38.7	38.7
Agree	11	14.7	14.7
Strongly Agree	1	1.3	1.3
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.35 Percentage responses for *main questionnaire Q26*, with corresponding *N*.

When someone in authority tells me what to do, I usually do it.	*N*	Percent	Valid Percent
Strongly Disagree	0	0.0	0.0
Disagree	14	18.7	18.7
Neutral	13	17.3	17.3
Agree	42	56.0	56.0
Strongly Agree	6	8.0	8.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.36 Percentage responses for *main questionnaire Q27*, with corresponding *N*.

People who question authority are trouble-makers.	*N*	Percent	Valid Percent
Strongly Disagree	8	10.7	10.7
Disagree	47	62.7	62.7
Neutral	18	24.0	24.0
Agree	2	2.7	2.7
Strongly Agree	0	0.0	0.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.37 Percentage responses for *main questionnaire Q28*, with corresponding *N*.

Working on a problem with no quick solution is a waste of time.	***N***	**Percent**	**Valid Percent**
Strongly Disagree	17	22.7	22.7
Disagree	51	68.0	68.0
Neutral	4	5.3	5.3
Agree	2	2.7	2.7
Strongly Agree	1	1.3	1.3
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.38 Percentage responses for *main questionnaire Q29*, with corresponding *N*.

You can study something for years and still not really understand it.	***N***	**Percent**	**Valid Percent**
Strongly Disagree	0	0.0	0.0
Disagree	8	10.7	10.7
Neutral	10	13.3	13.3
Agree	52	69.3	69.3
Strongly Agree	5	6.7	6.7
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.39 Percentage responses for *main questionnaire Q30*, with corresponding *N*.

Sometimes there are no right answers to life's big problems.	***N***	**Percent**	**Valid Percent**
Strongly Disagree	16	21.3	21.3
Disagree	50	66.7	66.7
Neutral	8	10.7	10.7
Agree	1	1.3	1.3
Strongly Agree	0	0.0	0.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.40 Percentage responses for *main questionnaire Q31*, with corresponding *N*.

Some people are born with special gifts and talents.	***N***	**Percent**	**Valid Percent**
Strongly Disagree	1	1.3	1.3
Disagree	0	0.0	0.0
Neutral	4	5.3	5.3
Agree	50	66.7	66.7
Strongly Agree	20	26.7	26.7
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.41 Percentage responses for *main questionnaire Q32*, with corresponding *N*.

Fictional View 1 (Behaviourist)	*N*	Percent	Valid Percent
Strongly Disagree	4	5.3	5.3
Disagree	27	36.0	36.0
Neutral	19	25.3	25.3
Agree	22	29.3	29.3
Strongly Agree	3	4.0	4.0
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.42 Percentage responses for *Fictional View 1 (Behaviourist)*, with corresponding *N*.

Fictional View 2 (Constructivist)	*N*	Percent	Valid Percent
Strongly Disagree	2	2.7	2.7
Disagree	12	16.0	16.0
Neutral	11	14.7	14.7
Agree	40	53.3	53.3
Strongly Agree	10	13.3	13.3
Total	**75**	**100.0**	**100.0**
No response	0	0.0	---
Total	**75**	**100.0**	---

Table J.43 Percentage responses for *Fictional View 2 (Constructivist)*, with corresponding *N*.

Appendix K: The Sub-Scales

The Simple Knowledge Sub-Scale

The Simple Knowledge Sub-Scale Items	Mean	St Dev
1. It bothers me when teachers don't tell students the answers to complicated problems.	3.74	.86
10. Too many theories just complicate things.	3.20	.96
11. The best ideas are often the most simple.	2.72	.89
13. Teachers should focus on facts instead of theories.	2.44	.72
18. Things are much simpler than they appear.	2.88	.77
22. Mathematics is easy to understand because it contains so many facts.	2.15	.75
24*. The more you know about a topic the more there is to know.	2.33	.68

NB: Reverse-scored items are marked *.

The Certain Knowledge Sub-Scale

The Certain Knowledge Sub-Scale Items	Mean	St Dev
2*. Truth means different things to different people.	2.28	.92
14*. I prefer to present several competing theories and let students decide which is best.	2.67	.89
19. If two people are arguing about something, at least one of them must be wrong.	1.92	.63
23. The moral rules I live by apply to everyone.	2.09	.87
25*. What is true today will be true tomorrow.	3.71	.75
31*. Sometimes there are no right answers to life's big problems.	1.92	.61

NB: Reverse-scored items are marked *.

The Omniscient Knowledge Sub-Scale

The Omniscient Knowledge Sub-Scale Items	Mean	St Dev
4. People should always obey the law.	3.75	1.00
7. Parents should teach their children all there is to know about life.	2.95	.97
27. When someone in authority tells me what to do, I usually do it.	3.54	.89
28. People who question authority are trouble-makers.	2.19	.65

NB: Reverse-scored items are marked *.

Appendix L: Lisa's Questionnaire

northumbria
UNIVERSITY

Teaching and Learning in Mathematics at KS2

The first section comprises questions asking for details about you. The answers you give will be anonymous and confidential. This type of information is important in that it allows me to draw comparisons between different subgroups of teachers.

I About You

1. How long have you been a KS2 primary teacher? [6] years

2. What is the highest mathematics qualification you hold?

GCSE/O Level ☐ A Level ☐ Degree ☑
Masters ☐ None ☐ Other ☐
[specify: ____________]

3. What is the age range of the pupils in the school in which you teach?

[10 to 11] years

4. Have you ever been the Lead Mathematics teacher in this or any other school?

Yes ☐ No ☑

5. Which KS2 year group do you teach? You may tick more than one box.

Year 3 ☐ Year 4 ☐ Year 5 ☐ Year 6 ☑ Other ☐
[specify: ____________]

6. Please tell us your age. [29] years of age

7. Please tell us your sex. Male ☐ Female ☑

PTO

II About Teaching and Learning

The section below sets out thirty-two statements. Think about how you view the teaching and learning of mathematics in your classrooms and for each statement, indicate the extent to which you agree or disagree by circling the appropriate number (1 is *strongly disagree*, through 3 *neutral*, to 5 *strongly agree*). There are no 'right' or 'wrong' answers.

	Strongly Disagree	**Disagree**	**Neutral**	Agree	Strongly Agree
1. It bothers me when teachers don't tell students the answers to complicated problems.	1	2	3	4	5
2. Truth means different things to different people.	1	2	3	4	5
3. Students who learn things quickly are the most successful.	1	2	3	4	5
4. People should always obey the law.	1	2	3	4	5
5. Some people will never be clever no matter how hard they work.	1	2	3	4	5
6. Absolute moral truth does not exist.	1	2	3	4	5
7. Parents should teach their children all there is to know about life.	1	2	3	4	5
8. Really clever students don't need to work as hard to do well in school.	1	2	3	4	5
9. If a person tries too hard to understand a problem, they will end up being confused.	1	2	3	4	5
10. Too many theories just complicate things.	1	2	3	4	5
11. The best ideas are often the most simple.	1	2	3	4	5
12. People can't do much about how clever they are.	1	2	3	4	5
13. Teachers should focus on facts instead of theories.	1	2	3	4	5
14. I prefer to present several competing theories and let students decide which is best.	1	2	3	4	5
15. How well you do in school depends on how clever you are.	1	2	3	4	5
16. If you don't learn something quickly, you won't ever learn it.	1	2	3	4	5
17. Some people just have a knack for learning and others don't.	1	2	3	4	5
18. Things are much simpler than they appear.	1	2	3	4	5
19. If two people are arguing about something, at least one of them must be wrong.	1	2	3	4	5
20. Children should be allowed to question their parents' authority.	1	2	3	4	5
21. If you haven't understood a chapter of a book the first time, going over it won't help.	1	2	3	4	5
22. Mathematics is easy to understand because it contains so many facts.	1	2	3	4	5
23. The moral rules I live by apply to everyone.	1	2	3	4	5
24. The more you know about a topic the more there is to know.	1	2	3	4	5
25. What is true today will be true tomorrow.	1	2	3	4	5
26. Clever people are born that way.	1	2	3	4	5
27. When someone in authority tells me what to do, I usually do it.	1	2	3	4	5
28. People who question authority are trouble-makers.	1	2	3	4	5
29. Working on a problem with no quick solution is a waste of time.	1	2	3	4	5
30. You can study something for years and still not really understand it.	1	2	3	4	5
31. Sometimes there are no right answers to life's big problems.	1	2	3	4	5
32. Some people are born with special gifts and talents.	1	2	3	4	5

PTO

Below are two fictional descriptions of how a teacher may see the teaching and learning of mathematics. For each one, indicate the extent to which you think it reflects your teaching approach by circling the appropriate number. There are no right and wrong answers.

Fictional View 1

There is a core body of knowledge in my classroom that each student must learn. Some of it is factual, but some of it is based on broad concepts and principles that everyone agrees on. This knowledge doesn't change much over time and represents the accumulation of important truths and understanding in my discipline. It is important for students to acquire this knowledge exactly as it is. The best way to acquire this knowledge is through an expert like me because I have a much better sense than they do of what is important to learn. It's unlikely that students could really create this knowledge on their own, so learning it from me will be quicker and more efficient. For this reason, it is important to me to assume a take-charge attitude so students can learn as much as possible. It is important to me that everyone comes away from my class with the big picture. It is my job to present the big picture clearly.

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

Fictional View 2

Students in my class need to understand that there are a variety of different ways to understand things. Knowledge comes and goes and what the so-called experts consider the truth today will be viewed with suspicion tomorrow. Even people who spend years studying a topic disagree about what things mean, and in the long run, one opinion is as good as another. This means that students have to learn to think for themselves, question the knowledge and authority of others, and evaluate how what they know affects their life. Knowledge has to be used widely so no one is left out or exploited by society. For these reasons, I don't believe that I can really teach my students what is important, since they all need to know different things. They have to figure it out in their own, taking into account the events that shape their lives, even if the uncertainty of living in a world with conflicting views of truth bothers them. What I know and believe really shouldn't influence my students. My job is to create an environment where students learn to think independently and take nothing for granted.

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

I would like to follow up this questionnaire by contacting some teachers in schools. If you feel you would be willing to take part further in this research please supply your name and contact details below:

Name:	**Participant's details withheld to protect identity**
Name of School:	
School Tel No:	
Your Mobile No:	
Contact Email:	

Please post the completed questionnaire in the prepaid envelope provided. **Many thanks for taking the time out to participate in this research.**

David Bolden

Appendix M: John's Questionnaire

northumbria UNIVERSITY

Teaching and Learning in Mathematics at KS2

The first section comprises questions asking for details about you. The answers you give will be anonymous and confidential. This type of information is important in that it allows me to draw comparisons between different subgroups of teachers.

I About You

1. How long have you been a KS2 primary teacher? [10] years

2. What is the highest mathematics qualification you hold?

GCSE/O Level ☐ A Level ☐ Degree ☑
Masters ☑ None ☐ Other ☐
(Nearly!) [specify: ____________]

3. What is the age range of the pupils in the school in which you teach?

[4 to 11] years

4. Have you ever been the Lead Mathematics teacher in this or any other school?

Yes ☐ No ☑

5. Which KS2 year group do you teach? You may tick more than one box.

Year 3 ☐ Year 4 ☐ Year 5 ☐ Year 6 ☑ Other ☐
[specify: ____________]

6. Please tell us your age. [32] years of age

7. Please tell us your sex. Male ☑ Female ☐

PTO

II About Teaching and Learning

The section below sets out thirty-two statements. Think about how you view the teaching and learning of mathematics in your classrooms and for each statement, indicate the extent to which you agree or disagree by circling the appropriate number (1 is *strongly disagree*, through 3 *neutral*, to 5 *strongly agree*). There are no 'right' or 'wrong' answers.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. It bothers me when teachers don't tell students the answers to complicated problems.	1	2	3	4	5
2. Truth means different things to different people.	1	2	3	4	5
3. Students who learn things quickly are the most successful.	1	2	3	4	5
4. People should always obey the law.	1	2	3	4	5
5. Some people will never be clever no matter how hard they work.	1	2	3	4	5
6. Absolute moral truth does not exist.	1	2	3	4	5
7. Parents should teach their children all there is to know about life.	1	2	3	4	5
8. Really clever students don't need to work as hard to do well in school.	1	2	3	4	5
9. If a person tries too hard to understand a problem, they will end up being confused.	1	2	3	4	5
10. Too many theories just complicate things.	1	2	3	4	5
11. The best ideas are often the most simple.	1	2	3	4	5
12. People can't do much about how clever they are.	1	2	3	4	5
13. Teachers should focus on facts instead of theories.	1	2	3	4	5
14. I prefer to present several competing theories and let students decide which is best.	1	2	3	4	5
15. How well you do in school depends on how clever you are.	1	2	3	4	5
16. If you don't learn something quickly, you won't ever learn it.	1	2	3	4	5
17. Some people just have a knack for learning and others don't.	1	2	3	4	5
18. Things are much simpler than they appear.	1	2	3	4	5
19. If two people are arguing about something, at least one of them must be wrong.	1	2	3	4	5
20. Children should be allowed to question their parents' authority.	1	2	3	4	5
21. If you haven't understood a chapter of a book the first time, going over it won't help.	1	2	3	4	5
22. Mathematics is easy to understand because it contains so many facts.	1	2	3	4	5
23. The moral rules I live by apply to everyone.	1	2	3	4	5
24. The more you know about a topic the more there is to know.	1	2	3	4	5
25. What is true today will be true tomorrow.	1	2	3	4	5
26. Clever people are born that way.	1	2	3	4	5
27. When someone in authority tells me what to do, I usually do it.	1	2	3	4	5
28. People who question authority are trouble-makers.	1	2	3	4	5
29. Working on a problem with no quick solution is a waste of time.	1	2	3	4	5
30. You can study something for years and still not really understand it.	1	2	3	4	5
31. Sometimes there are no right answers to life's big problems.	1	2	3	4	5
32. Some people are born with special gifts and talents.	1	2	3	4	5

PTO

Below are two fictional descriptions of how a teacher may see the teaching and learning of mathematics. For each one, indicate the extent to which you think it reflects your teaching approach by circling the appropriate number. There are no right and wrong answers.

Fictional View 1

There is a core body of knowledge in my classroom that each student must learn. Some of it is factual, but some of it is based on broad concepts and principles that everyone agrees on. This knowledge doesn't change much over time and represents the accumulation of important truths and understanding in my discipline. It is important for students to acquire this knowledge exactly as it is. The best way to acquire this knowledge is through an expert like me because I have a much better sense than they do of what is important to learn. It's unlikely that students could really create this knowledge on their own, so learning it from me will be quicker and more efficient. For this reason, it is important to me to assume a take-charge attitude so students can learn as much as possible. It is important to me that everyone comes away from my class with the big picture. It is my job to present the big picture clearly.

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

Fictional View 2

Students in my class need to understand that there are a variety of different ways to understand things. Knowledge comes and goes and what the so-called experts consider the truth today will be viewed with suspicion tomorrow. Even people who spend years studying a topic disagree about what things mean, and in the long run, one opinion is as good as another. This means that students have to learn to think for themselves, question the knowledge and authority of others, and evaluate how what they know affects their life. Knowledge has to be used widely so no one is left out or exploited by society. For these reasons, I don't believe that I can really teach my students what is important, since they all need to know different things. They have to figure it out in their own, taking into account the events that shape their lives, even if the uncertainty of living in a world with conflicting views of truth bothers them. What I know and believe really shouldn't influence my students. My job is to create an environment where students learn to think independently and take nothing for granted.

Strongly Disagree		Neutral		Strongly Agree
1	2	3	4	5

I would like to follow up this questionnaire by contacting some teachers in schools. If you feel you would be willing to take part further in this research please supply your name and contact details below:

Name:	**Participant's details withheld to protect identity**
Name of School:	
School Tel No:	
Your Mobile No:	
Contact Email:	

Please post the completed questionnaire in the prepaid envelope provided. **Many thanks for taking the time out to participate in this research.**

David Bolden

Appendix N: Letter from Criminal Records Bureau

Enhanced Disclosure
Page 1 of 2

disclosure

Disclosure Number 001094383508

Date of Issue: 17 FEBRUARY 2005

Applicant Personal Details

Surname:	BOLDEN
Forename(s):	DAVID SCOTT
Other Names:	NONE DECLARED
Date of Birth:	21 DECEMBER 1965
Place of Birth:	SUNDERLAND TYNE AND WEAR
Gender:	MALE

Employment Details

Position applied for:
RESEARCH ASSOCIATE

Name of Employer:
UNIVERSITY OF NORTHUMBRIA AT N

Countersignatory Details

Registered Person/Body:
UNIVERSITY OF NORTHUMBRIA AT NEWCASTLE

Countersignatory:
JULIET SARAH AMOS

Police Records of Convictions, Cautions, Reprimands and Final Warnings

NONE RECORDED

Information from the list held under Section 142 of the Education Act 2002.

NONE RECORDED

Protection of Children Act List information

NONE RECORDED

Protection of Vulnerable Adults List information

NOT REQUESTED

Other relevant information disclosed at the Chief Police Officer(s) discretion

NONE RECORDED

Appendix O: Interview Transcript Consent Form

Teaching and Learning KS2 Mathematics

northumbria
UNIVERSITY

Date:
T: 0191 215 6107
E: d.bolden@unn.ac.uk

Dear [Name of Teacher]

Find attached two copies of the transcription of the interview conducted the last time we met. Could I ask you to check that it represents a fair account of the interview as you remember it and, on one copy, delete, if necessary, any sections you feel you would rather I did not use in the writing up of the research. Could you then sign and date the attached sheet to say you agree to the transcript and its future use and send it back to me with the relevant transcript in the envelope provided. The other copy is for your records. Many thanks.

Best wishes

David Bolden
Northumbria University

To protect your privacy, the following measures have been implemented to ensure that others do not learn your identity from what you tell me:

1. No real names will be used in writing up results from the classroom observations or in transcribing the interviews from the audiotape (if used).

2. All other potentially identifying characteristics will be deleted or changed, e.g. names of schools, colleagues, pupils, etc.

3. No-one but me will have access to these sources of data and these will be destroyed after the write-up of the results have been completed and any articles have been accepted for publication (estimated to be approximately June 2008).

4. What is discussed during our sessions together will be kept confidential.

I have read the attached transcription of my interview and I am happy that it is a fair account as I remember it. I agree to its use in future reports and articles (except for those deleted sections highlighted) although I reserve the right to change my mind at a later date.

Signed: ____________________________ Date:______________

Appendix P: Emails to Phase II and III Participants

David Bolden

From: David Bolden
Sent: 20 May 2005 11:13
To: [Name of Participant]
Subject: Your response to research survey.

Dear [Name of Participant]

Many thanks for recently returning the questionnaire *Teaching and Learning in Mathematics at KS2*. Your participation in the research is greatly appreciated. You gave your personal details at the end of the questionnaire because you were willing to consider taking part in the next stage of the research. This stage is due to start in September 2005 and I am in the process of recruiting suitable teachers and wondered whether you would still be willing to take part. As a reminder, I am looking at primary teachers' views of the teaching and learning of mathematics and how this might impact on their classroom practice. If you are willing to take part or would like to discuss it before committing I would love to hear from you. You can contact me by return email or by 'phone. Many thanks in advance.

Best wishes

David Bolden
Research Associate
Northumbria University
Tel: 0191 215 6107

David Bolden

From:	David Bolden
Sent:	09 June 2005 12:12
To:	[Name of Participant]
Subject:	Research Survey.
Importance:	High

Dear [Name of Participant]

Thanks again for taking the time to reply to my original email. Here is a brief overview of the research followed by what is involved in Stage 2 (i.e. beginning Sep/Oct 2005)

Overview
The research is concerned with how primary teachers view the teaching and learning of KS2 mathematics, i.e. how the feel it should be best taught, how children learn mathematics best, what constitutes mathematical knowledge, why they teach they way they do, etc. The questionnaire you kindly completed earlier in the year was sent out to all primary schools in [Name of LEA] (with the full permission of [Name of Contact at LEA] from the LEA) and constituted the first phase of the research. It attempted to access how a wide variety of primary teachers view the teaching and learning of KS2 mathematics.

The second phase involves a much smaller number of those primary teachers that completed the questionnaires and I hope that you will be one of them.

What Is Involved?
It would involve me, with your permission and the permission of your head teacher, observing you delivering several mathematics lessons to children. This would be followed by (either immediately afterwards or at the end of the day or at a time to suit you) a short discussion between the two of us where we could explore some of the things you did with the children during that lesson, e.g. why you taught a particular aspect in a particular way. I know that teachers often have people observing their lessons but I hope you won't feel threatened by that and, indeed, I hope you will forget I am even there. I envisage that I may perhaps need 4 or 5 opportunities to observe (and discuss with you) between Sep/Oct 2005 and Mar/Apr 2006 and, of course, I would fit in around you and the school.

I should also say that: no child, teacher, school, local authority will be identified in the writing up of any of the research findings so your complete anonymity is assured; any data gathered will be destroyed after the write up is finished (estimated to be around June 2008); and that I am also fully police checked (although the research does not require that I speak directly to or be left alone with any child). I do hope you will be able to be involved but if you have any worries or feel you would like to discuss further any aspect of the research please do not hesitate to ring me on the number below. Many thanks in advance and I hope to hear from you soon.

Best wishes

David Bolden
Northumbria University
0191 215 6107

Appendix Q: Voluntary Informed Consent Form

Teaching and Learning KS2 Mathematics

Date: Sept' 2005
T: 0191 215 6107
E: d.bolden@unn.ac.uk

Dear Colleague

As you already know this research investigates primary teachers' views of teaching and learning in mathematics at KS2. Phase II and Phase III of the research involves me (the researcher) observing you delivering approximately five mathematics lessons and interviewing you after each one to discuss relevant aspects of your teaching. With your permission I would like to make notes during the observations and use an audiotape recorder during the interviews. This will help me when I later come to analyse the data gathered. However, transcriptions from interviews will be sent to you for your agreement before any analysis is begun.

Please take a few minutes to read below the procedures put in place to protect your identity. If you are happy with the information set out on this form and are still willing to agree to participate in Phase II and Phase III please sign your name in the space provided below and date the form.

Best wishes

David Bolden
Northumbria University

To protect your privacy, the following measures have been implemented to ensure that others do not learn your identity from what you tell me:

1. No real names will be used in writing up results from the classroom observations or in transcribing the interviews from the audiotape (if used).

2. All other potentially identifying characteristics will be deleted or changed. e.g. names of schools, colleagues, pupils.

3. Transcriptions from interviews will be sent to you for your agreement before any analysis is begun. At this or any time in the future you may request that parts or all of the transcription are not to be used.

4. No-one but me will have access to these sources of data and these will be destroyed after the write-up of the results have been completed and any articles have been accepted for publication (estimated to be approximately June 2008).

5. What is discussed during our sessions together will be kept confidential.

I am happy with the information set out in this form and agree to participate in Phase II and Phase III of the research.

Signed: ______________________________ Date: ____________

Appendix R: Structured Observation Schedule (First Draft)

Teaching and Learning KS2 Mathematics

Teacher: ____________________ Date: __________

N pupils in class: ____________________ Time: __________

Lesson Topic: ______________________________

Additional Info: ______________________________

Position in programme

Time (Mins)	Behaviour	Other Comments
3		
6		
9		
12		
15		
18		
21		
24		
27		
30		
33		
36		

39		
42		
45		
48		
51		
54		
57		
60		

Behaviour Codes:

Code	Behaviour
0	Teaching (Behaviourist)
~~1~~	~~Teaching (Constructivist)~~
2	Teacher questioning pupil(s)
3	Teacher listening to pupil(s)
4	Teacher supervising pupils

Code	Behaviour
5	Pupils working alone
6	Pupils working in groups
7	Teacher doing other (specify)
8	Pupil doing other (specify)

Appendix S: Structured Observation Schedule (Second Draft)

Teaching and Learning KS2 Mathematics

Teacher: ____________ Date: ____________

N pupils in class: ____________ Time: ____________

Lesson Topic: ____________ Year: ____________

Position in Programme ____________

Additional Info: ____________

Time (Mins)	Behaviour	Other Comments
3		
6		
9		
12		
15		
18		
21		
24		
27		
30		
33		

36		
39		
42		
45		
48		
51		
54		
57		
60		

Behaviour Codes:

Code	Behaviour
0	
1	
2	Teacher questioning pupil(s)
3	Teacher listening to pupil(s)
4	Teacher supervising pupils

Code	Behaviour
5	Pupils working alone
6	Pupils working in groups
7	Teacher doing other (specify)
8	Pupil doing other (specify)

Appendix T: Details of Lisa's Lessons

Lesson One (Tuesday 22nd November 2005 from 9.30 to 10.30)

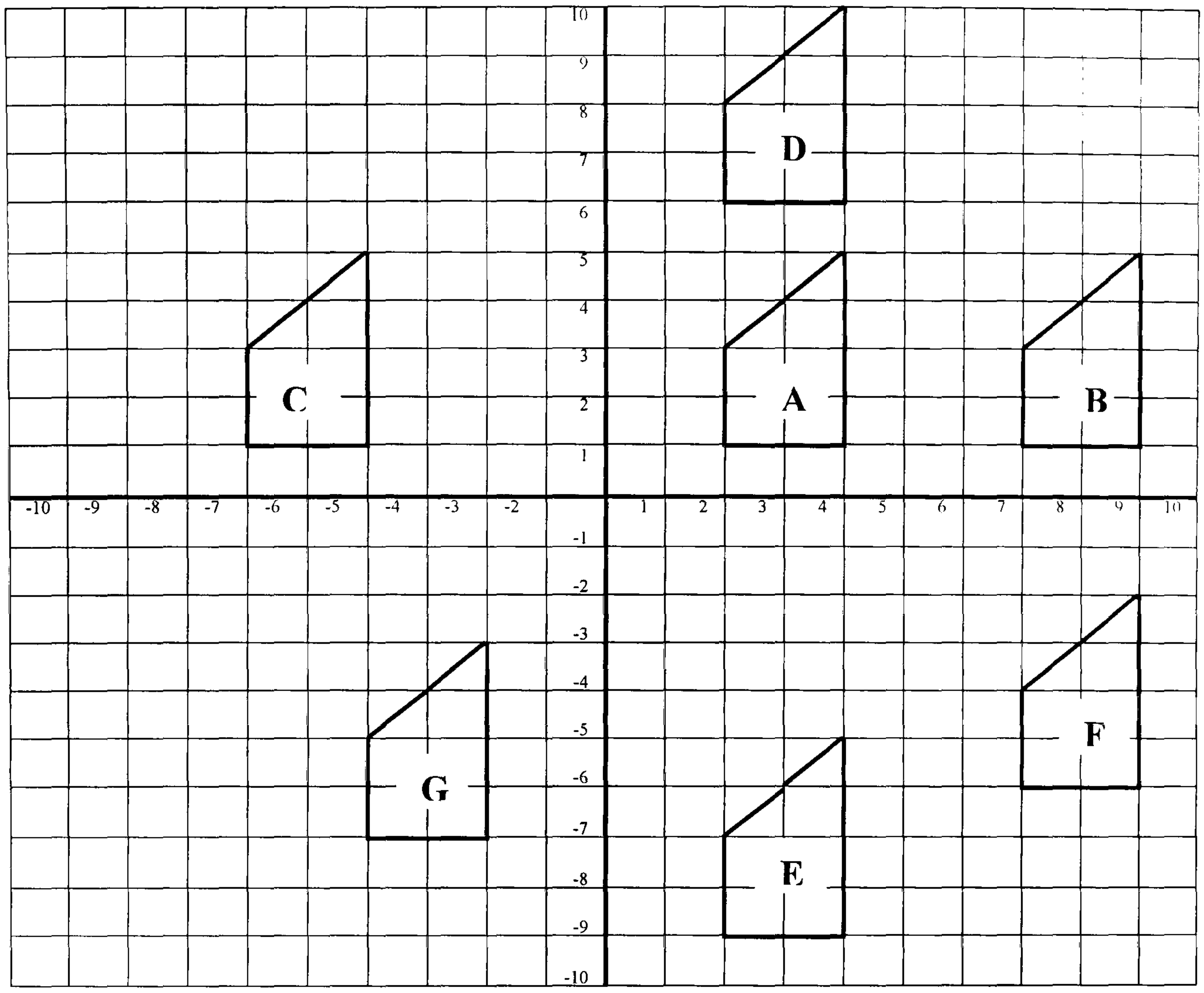
A mixture of Year 5 and Year 6 pupils totalling a class of twenty-four children (sixteen girls and eight boys).

1. Lisa's Lesson Plan for Lesson One

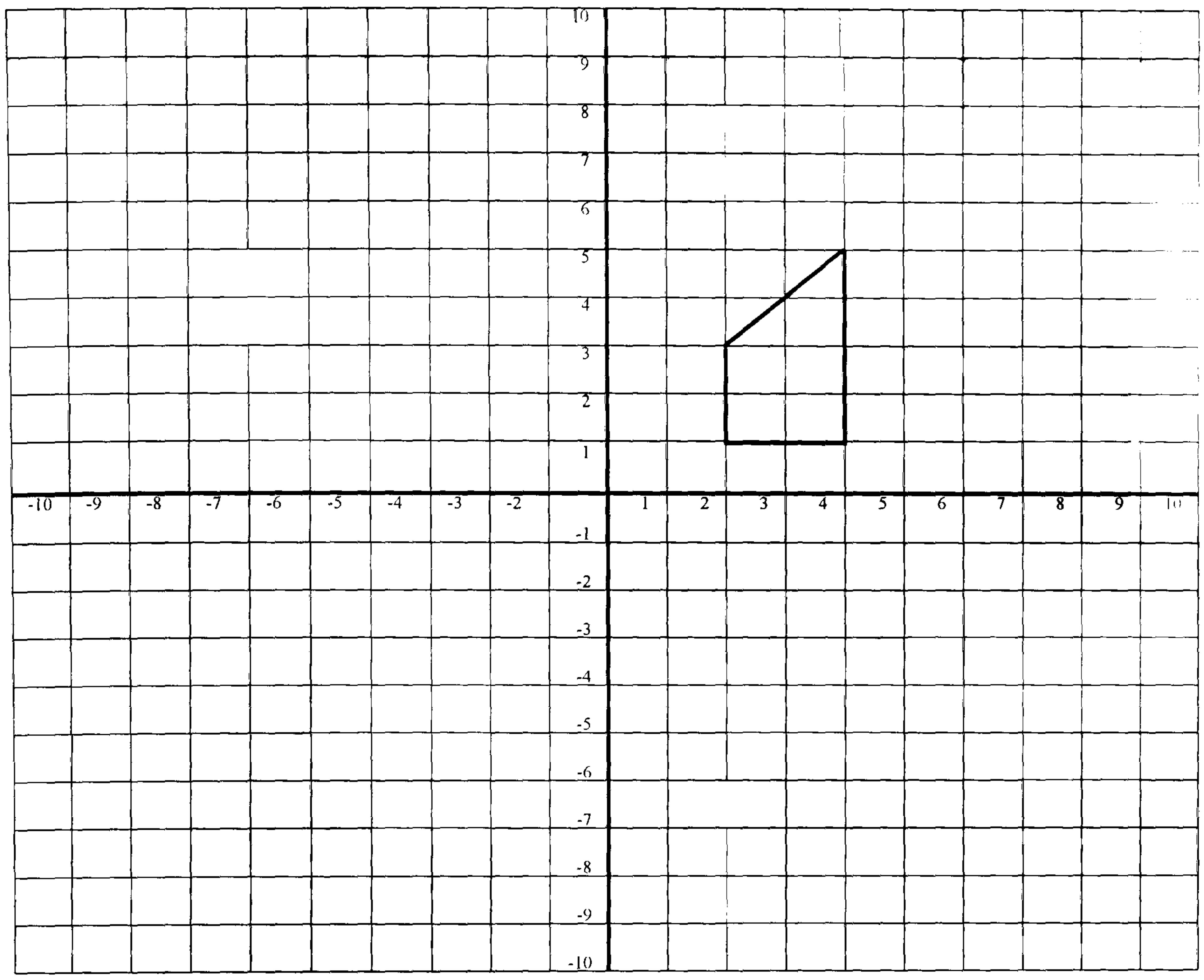
Mental Activity	Review times table facts up to 10x10. Review coordinates in four quadrants. Use DigiCards to test children's multiplication facts, i.e. children show card with correct answer to teacher's multiplication problem. Use IWB and 'Billy Bug' interactive game to get children to plot correct coordinates in four quadrants.
Key Vocabulary	Parallel, intercept, trapezium, translation, orientation.
Learning Intention	Recognise where a shape will be after 2 translations in 4 quadrants. ▪ Use OHT 10.2a with trapeziums A to G. Ask for coordinates of trapezium A. Using the overlay shape on OHT 10.2b move shape A to shape B. How has the shape moved? Remind children that they may have to describe the direction the shape has moved in as well as the distance the shape has moved and they should refer to the axis to do this. ▪ Explain that the orientation does not change because each vertex has moved the same distance and so the area has not changed. Explain that it is a translation and it has moved 5 forward in X direction and 5 if Y direction.
Success Criteria	▪ Ask children to describe the translations of shape A to all other shapes and also from B to C, B to F, D to E, and G to F. Discuss with the children how to describe the translation from C to D and emphasis the 2 translations C to A and A to D. ▪ Ask the children to draw axis -10 to +10 and draw the trapezium in the same orientation, position as shape A. Give children some 1 and 2 translations to perform.
Whole Class	▪ Ask children to describe the translations of shape A to all other shapes and also from B to C, B to F, D to E, and G to F. Discuss with the children how to describe the translation from C to D and emphasis the 2 translations C to A and A to D. ▪ Ask the children to draw axis -10 to +10 and draw the trapezium in the same orientation, position as shape A. Give children some 1 and 2 translations to perform.
Group/Paired/ Independent Work	▪ Ask children to describe the translations of shape A to all other shapes and also from B to C, B to F, D to E, and G to F. Discuss with the children how to describe the translation from C to D and emphasis the 2 translations C to A and A to D. ▪ Ask the children to draw axis -10 to +10 and draw the trapezium in the same orientation, position as shape A. Give children some 1 and 2 translations to perform. Teacher to support.
Plenary Session/Assessment	
Resources	OHT 10.2a, OHT 10.2b, list of translations for children to attempt.

2. Lisa's Resources for Lesson One

a) OHT 10.2a



b) OHT 10.2b



Lesson Two (Wednesday 18th January 2006 from 9.20 to 10.20)

A mixture of Year 5 and Year 6 pupils totalling a class of nineteen children (eleven girls and eight boys).

1. Lisa's Lesson Plan for Lesson Two

Mental Activity	Repeat activity with pendulum from yesterday but extend to include asking for related facts. Repeat counting with pendulum but backwards. What will the next number be? Extend into negative numbers. Count on and back including negative numbers.
Key Vocabulary	Positive, negative, difference, partition, factor.
Learning Intention	Children will use partitioning to complete mental multiplication.
Success Criteria	▪ Recognise the place value of figures within each number. ▪ Know how to partition numbers correctly. ▪ Recognise numbers it is easy to multiply by. ▪ Recall mental strategies for multiplication by 2, 4, 5, 8, etc. ▪ Use knowledge of tables to partition numbers to help them solve the calculation mentally.
Whole Class	▪ Write a 2 digit x 2 digit calculation on the board. ▪ Ask children to discuss in pairs how they would solve it. ▪ Remind children of place value of digits and how to partition numbers. ▪ Ask children which would be most suitable to partition and why? ▪ Demonstrate using partitioning how to solve the calculation. ▪ Remind children looking for factors 2 and 5 are very useful. ▪ Repeat using other numbers, e.g. 15, 14, 22, etc.
Group/Paired/ Independent Work	1) As Group 2 below but extend to include multiplications with multiples of 10, e.g. 17 x 22. TA to support. 2) Calculate 2 digit by 2 digit multiplications using partitioning and related facts to work out answer. Work in pairs to support each other. Generate questions by picking cards. 3) As Group 2 above but using place value cards to partition IWB number and with teacher support for 2 digit x 1 digit calculations.
Plenary Session/Assessment	Ask children out to front of class to demonstrate their examples using the IWB and explain their reasoning for doing it.
Resources	Pendulum, cards for Group 2 (includes x12, 15, 14), cards for Group 1 (includes x 12, 15, 22, 52).

Lesson Three (Thursday 16th February 2006 from 10.50 to 11.50)

Year 6 class of twenty-five children (thirteen girls and twelve boys).

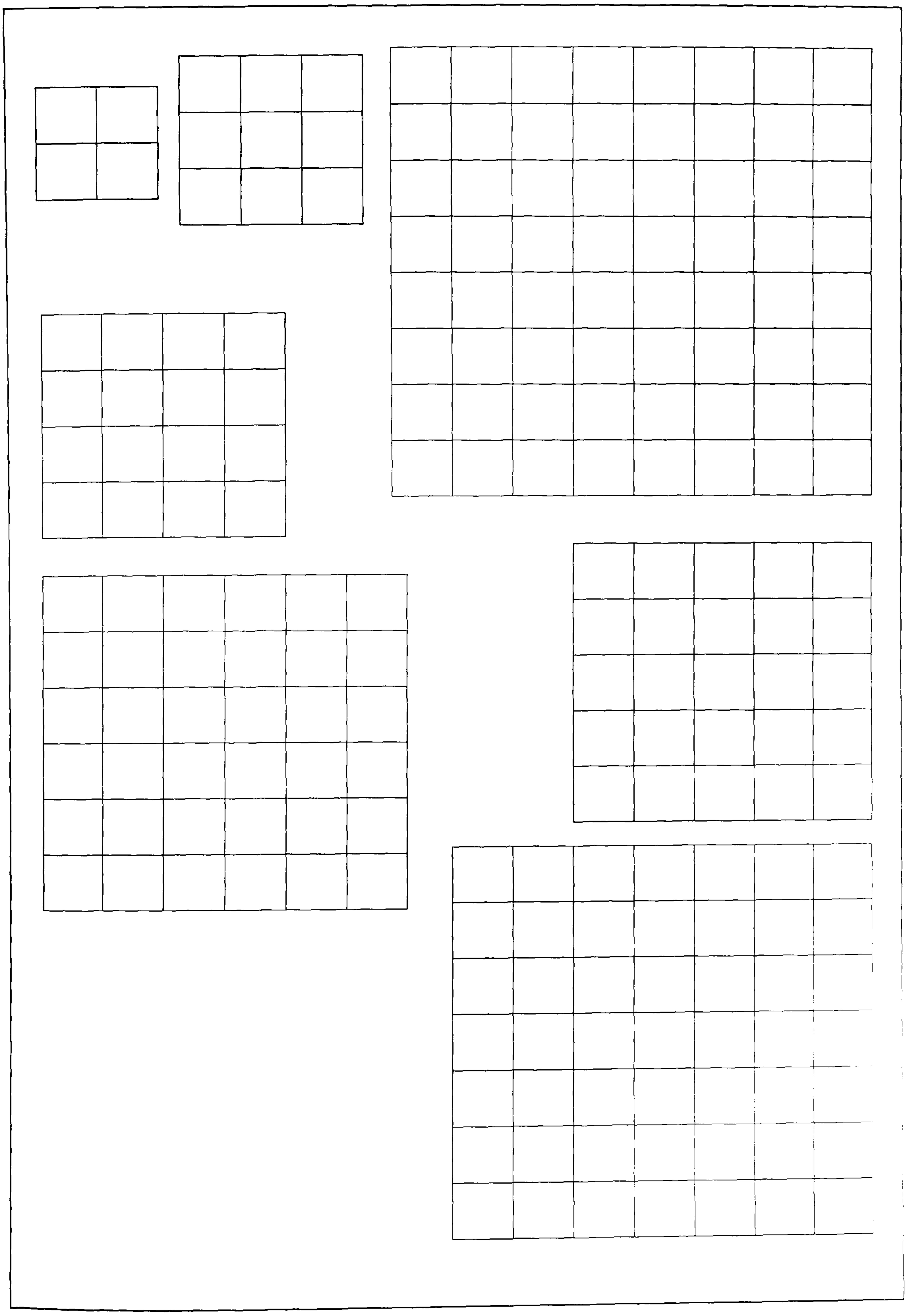
1. Lisa's Lesson Plan for Lesson Three

Mental Activity	Using the empty tin and cubes, drop differing amounts of cubes into the tin and ask the children to count in multiples of a) 6 and b) 7, in their heads. When finished dropping in the different number of cubes, ask the children: a) the multiple they have reached, b) the number of cubes they heard drop into the tin, and c) the related multiplication and division facts. Repeat this activity for different multiples and times tables. Extend to count in multiples of numbers bigger than 12. Ask the children how they can use these facts to derive other facts. Draw a clock on the board and write the multiples around it. Ask children to use this to work out the different facts.
Key Vocabulary	Multiple, multiplication fact, division fact, divisor, divide, product, times, lots of, investigate.
Learning Intention	Children will carry out an investigation to find the number of squares on a chessboard.
Success Criteria	▪ Understand the task they are investigating. ▪ Discuss the investigation, ideas and possible problems and solutions with talking partner(s). ▪ Decide on the best method to tackle it. ▪ Decide on the different resources and equipment they might need to tackle it. ▪ Have a go at investigating. ▪ Refine and change methods for tackling it. ▪ Decide on a logical order to go about the investigation. ▪ Think of a way of recording the information so that it is clear to read and follow. ▪ Think about mathematical symbols and formula they could use to express their ideas and findings.
Whole Class	▪ Ask the children to think of a chessboard and spend 2 minutes with the person next to them deciding how many squares there are on it. ▪ Ask the children to feed back to the rest of the children and discuss their ideas and thoughts. ▪ Ask the children what would make the problem easier to solve and encourage the idea that if one be present in front of them. ▪ Show the children the chessboard and ask them again to calculate the number of squares with their partner(s). ▪ Take feedback and discuss the answers. ▪ Ask the children what we mean by a square. ▪ Remind the children that a square has equal sides and that in this case we have been looking at squares that are 1 square length by 1 square length. ▪ Ask the children whether we can have a square that is 2 square by 2 square lengths. Establish that we can and ask for other ideas for squares. ▪ Remind the children that seeing the chessboard was a great help. ▪ Demonstrate how to use models of the different squares to count square son board. ▪ Encourage children to be clear about the recording of totals.

Group/Paired/ Independent Work	▪ All children work in pairs or groups to investigate the problem of how many squares on a chessboard. ▪ Encourage children to talk about the investigation and encourage them to question each others ideas and solutions. ▪ Teacher to support groups of children who are struggling by talking through different ideas and suggestions. Teacher also to help support and extend children's thinking by questioning children about their reasons and asking them to explain their methods. ▪ All through the lesson the teachers tops the children to ensure they are following the right track to succeed and encourage them to explain and justify their ideas. No specified time for group work.
Plenary Session	Ask the children to explain their ideas and thoughts about the different processes they went through. Ask children to explain to each other methods that did and did not work, ways of recording. Ask children whether they have found a formula for calculating the number of squares on a chessboard.
Resources	Chessboards, squared paper for templates, pencils and scissors

2. Lisa's Resources for Lesson Three

a) Templates



Lesson Four (Friday 10th March 2006 from 10.50 to 11.50)

Mixture of Year 5 and Year 6 pupils totalling a class of seventeen children (eleven girls and six boys). Two teaching assistants also present.

1. Lisa's Lesson Plan for Lesson Four

Mental Activity	Ask children to think of the different words associated with addition and subtraction. Ask the children to use the words in different questions to demonstrate they know the meaning of the words. Use Maths Pack 1 (IWB software package) to answer different questions on addition and subtraction. Go around the class asking children to answer the different questions.
Key Vocabulary	Subtract, minus, less than, more than, add, plus, addition, greater than.
Learning Intention	Children will be able to answer a range of addition and subtraction questions including interpreting and solving number stories.
Success Criteria	▪ Know what vocabulary is associated with addition. ▪ Know what vocabulary is associated with subtraction. ▪ Know and use an appropriate way of adding different numbers including decimals. ▪ Know and use an appropriate way of subtracting different numbers. ▪ Read number stories carefully and understand the value of the numbers involved. ▪ Decide on the operation of the question and highlight key vocabulary. ▪ Use the key questions to decide upon the most appropriate method to answer the number story. ▪ Relate the answer back to the question and ensure it makes sense.
Whole Class	▪ Remind the children we have been looking at different ways of adding and subtracting different numbers including decimals. ▪ Give the children different examples of addition and subtraction questions and then ask the children to describe what the different stages are in answering them. ▪ Teacher to play the role of not knowing what to do and ask the children for every next step. ▪ Teacher also to play the role of making different mistakes so the children correct the different stages and use this to see what the children have understood and what still needs further explanation. ▪ Give the children some different examples of addition and subtraction number stories and explain to them how to look for the type of operation required. Remind the children of the different key vocabulary that will help them to understand the different type of question. ▪ Remind the children of the different questions they ask themselves to answer the questions. ▪ Demonstrate different methods. ▪ Remind children to ensure they have to relate the answer to the maths problem to the real life questions.
Group/Paired/ Independent Work	1) As group 2 but with TA support to help understand the different vocabulary and type of question. 2) Teacher to work with these children to encourage them to work through different number story questions. Remind the children to look for the key vocabulary and to decide on the type of question and the most appropriate method to solve it. 3) Children use methods to answer different addition and subtraction questions.
Plenary Session/Assessment	Ask children to state different addition and subtraction vocabulary and decide which operation the different words mean. Give the children different addition and subtraction questions and ask the children in maths partners to think up the different types of number stories that could be associated with them.
Resources	IWB Maths Program 1, maths addition and subtraction number stories.

2. Lisa's Resources for Lesson Four

a) Number Stories (Examples)

1. Sarah spent £21 on a dress and another £36 on a pair of shoes. How much did Sarah spend altogether?

2. I picked 63 apples from an apple tree and then gave 32 to my next door neighbour. How many did I have left?

Appendix V: Details of John's Lessons

Lesson One (Monday 17th October 2005 from 11.25 to 12.15)

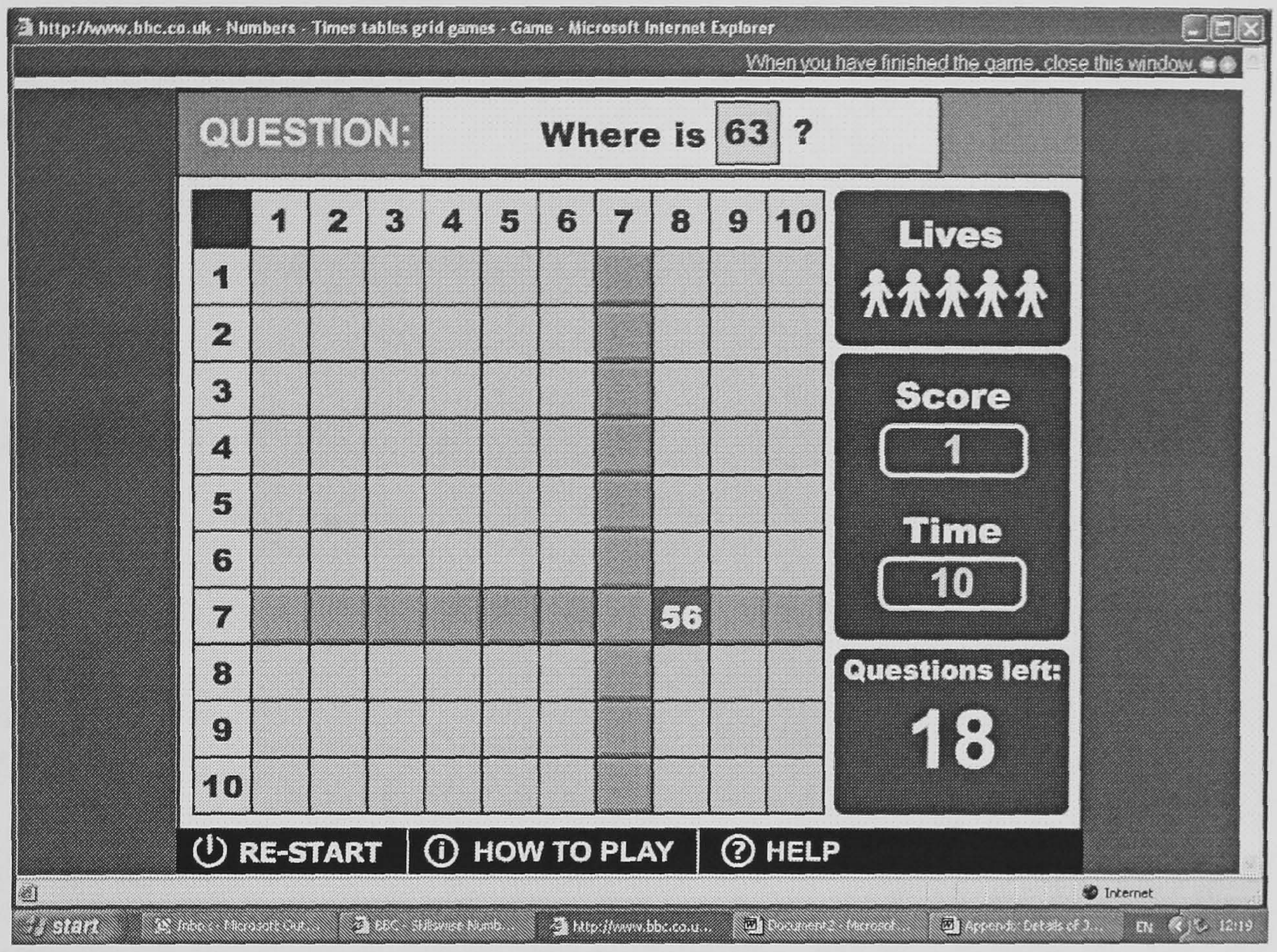
Year 6 group of eighteen pupils (five girls and thirteen boys). This represented only those children considered the 'more able' of John's usual class size. The less able children had been sent to another class to be taught by another teacher. Children were allowed to sit any where the wanted in the class.

1. John's Lesson Plan for Lesson One

Mental/Oral WALT & Activity	WALT- Review times tables facts to 10x10 (See Resource a) below) Use Skills Wise website to test children's knowledge on IWB http://www.bbc.co.uk/skillswise/numbers/wholenumbers/multiplication/timestables/
Main Activity	WALT - To use graph to plot discrete data. Show the children a set of data (See Resource b) below). What could this be? Review in pairs and discuss ideas. Show them what the data is and discuss my reason for giving the data that theme. How can this data be presented? Review ideas in pairs. Present and discuss ideas. Review how to group data using equal groupings. Share task with children.
Independent Task(s) (Differentiation: 1 above average, 2 average, 3 below average and SEN) **(Support T: Teacher, OA: Other Adult, I: Independent)**	**1) Group data using tally chart sheet then plot information in bar chart onto graph paper.** **2) Group data using tally chart sheet (OA to ensure groups are correctly spaced) then plot information in bar chart onto graph paper (OA to ensure axes are correct).**
Plenary Session/Assessment	WILF - data grouped accurately and bar chart created from data. Review their progress for grouping data and record it on the IWB.

2. John's Resources for Lesson One

a) Review Table Facts



b) The Data Set

25	38	17	28	32
9	28	27	36	37
13	25	14	8	26
30	31	32	19	25
27	16	9	32	36
35	31	30	15	21
30	29	24	20	10
12	32	34	27	36
15	19	31	11	33
30	32	18	25	26

What could this data represent?

The ages of a selection of people at a Kylie concert.

Lesson Two (Tuesday 8th November 2005 from 11.15 to 12.15)

Year 6 group of twenty-nine pupils (eighteen boys and eleven girls).

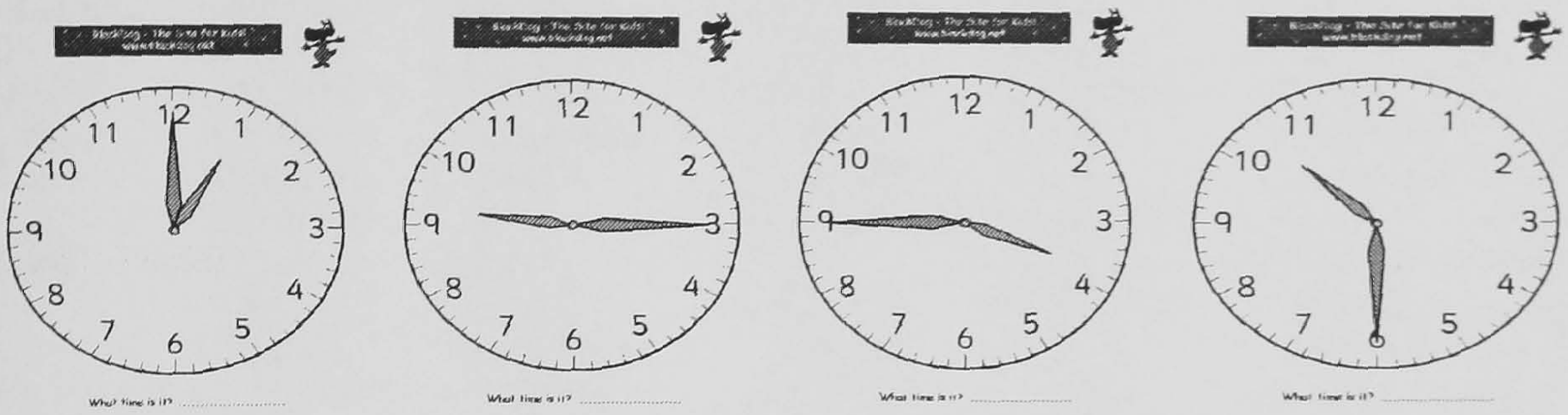
1. John's Lesson Plan for Lesson Two

Mental/Oral WALT & Activity	WALT- Review conversion of 24 hour clock times. Quickly review children's knowledge of 24 hour clock conversion. Play 'Stop the Clock' (teaching time game) and challenge children to come up to the board and match 24 hour clock to analogue on screen in fastest time (See Resource a) below).
Main Activity	WALT - Appreciate different times around the world. Show children sheet of times around the world ((See Resource b) below - Activity Sheet 9.2). Have a look at the sheet and tell me what is happening to the time East and then West of the UK. Can anybody think why that is?
Independent Task(s) (Differentiation: 1 above average, 2 average, 3 below average and SEN) **(Support T: Teacher, OA: Other Adult, I: Independent)**	**1) See Task One. Provide children with sheet of times with flights. Ask them to calculate flight times from the UK. Calculate arrival time and time delay for each. How long will it take? (See Task One below).**
	2) See Task Two. Provide children with questions. When it is X in Bombay what time is it in London? (See Task Two below).
Plenary Session/Assessment	WILF - Accurate use of time chart. Review finished activity with the children.

2. John's Resources for Lesson Two

a) Stop the Clock Game

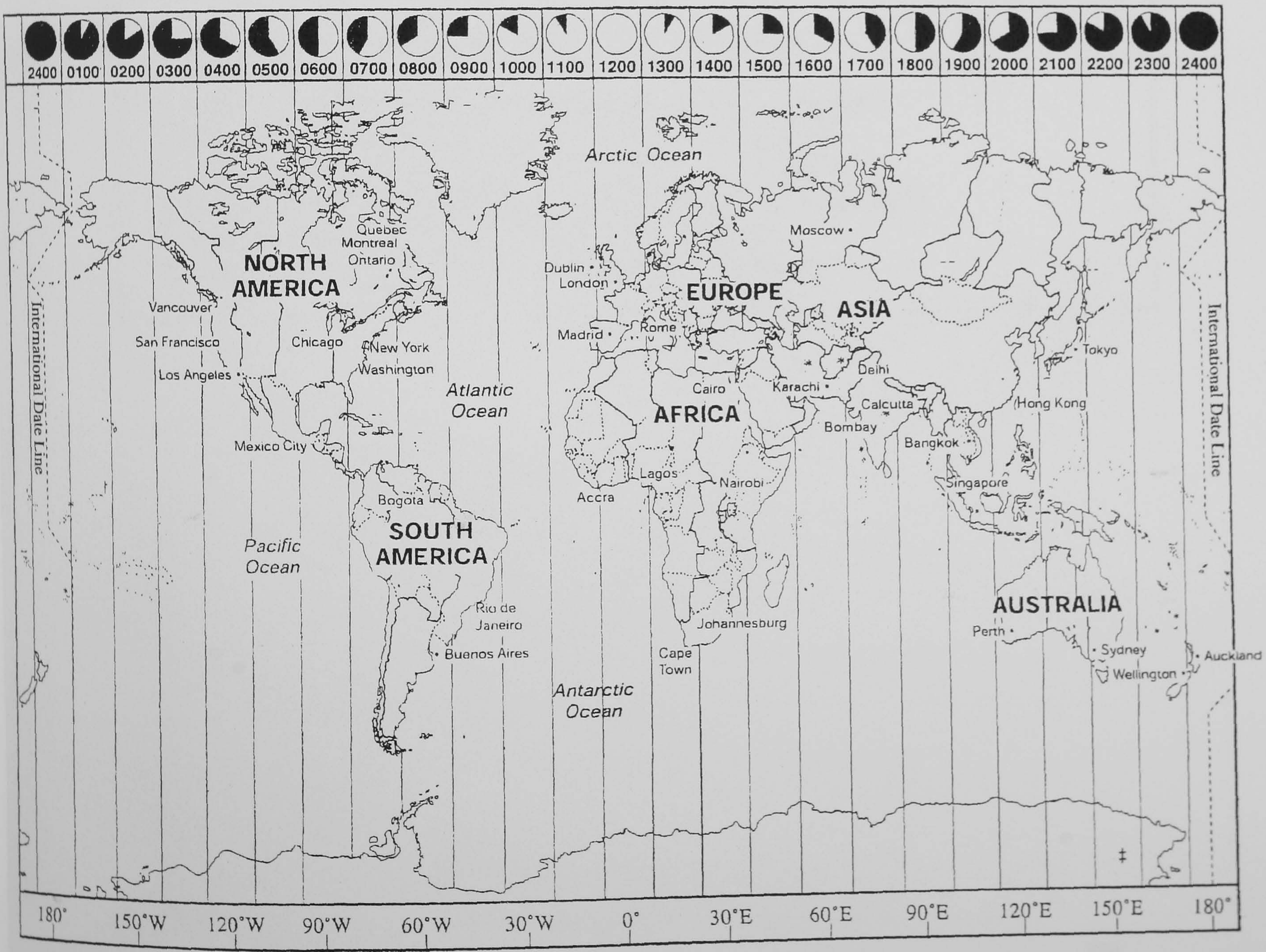
03:45	10:30	21:15	13:00	Time Taken 007 secs



b) Activity Sheet 9.2

World Time Differences (Hours plus or minus GMT in London)

Accra	GMT	Cairo	1400 (+2)	Kuwait	1500 (+3)	Perth WA	2000 (+8)
Adelaide	2130 (-9½)	Calcutta	1730 (+5½)	Lagos	1300 (+1)	Pretoria	1400 (+2)
Amsterdam	1300 (+1)	Calgary	0500 (-7)	Lisbon	GMT	Quebec	0700 (-5)
Athens	1400 (-2)	Cape Town	1400 (+2)	London	GMT	Rio de Jan	0900 (-3)
Auckland	2400 (-12)	Chicago	0600 (-6)	Los Angeles	0400 (-8)	Rome	1300 (+1)
Baghdad	1500 (+3)	Copenhagen	1300 (+1)	Madrid	1300 (+1)	San Fran	0400 (-8)
Bangkok	1900 (+7)	Darwin	2130 (+9½)	Malta	1300 (+1)	Seoul	2100 (+9)
Beijing	2000 (+8)	Delhi	1730 (+5½)	Mexico City	0600 (-6)	Singapore	2000 (+8)
Belgrade	1300 (+1)	Dublin	GMT	Montreal	0700 (-5)	Stockholm	1300 (+1)
Berlin	1300 (+1)	Helsinki	1400 (+2)	Montevideo	0900 (-3)	St Petersburg	1300 (+3)
Bogota	0700 (-5)	Hong Kong	2000 (+8)	Moscow	1500 (+3)	Sydney	2200 (+10)
Bombay	1730 (+5½)	Honolulu	0200 (-10)	Nairobi	1500 (+3)	Tokyo	2100 (+9)
Brasilia	0900 (-3)	Jerusalem	1400 (+2)	New York	0700 (-5)	Vancouver	0400 (-8)
Brussels	1300 (+1)	Johannesburg	1400 (+2)	Oslo	1300 (+1)	Vienna	1300 (+1)
Bucharest	1400 (+2)	Karachi	1700 (+5)	Ottawa	0700 (-5)	Warsaw	1300 (+1)
Buenos Aires	0900 (-3)	Kuala Lumpur	2000 (+8)	Panama	0600 (-6)	Washington	0700 (-5)



Task One

Calculate the Arrival Times

Destination	Flight Time	Departure Time	Arrival Time?
Washington DC	8 hrs 25 mins	12.00	
Vancouver	9 hrs 40 mins	08.25	
Tokyo	11 hrs 35 mins	07.30	
Soeul	11 hrs 00 mins	13.47	
Cairo	4 hrs 50mins	11.45	
Mexico City	11 hrs 50 mins	00.30	
Honolulu	20 hrs 00 mins	03.50	
Cape Town	21 hrs 15 mins	14.45	
Chicago	11 hrs 50 mins	10.30	
Bombay	12 hrs 15 mins	02.50	

c) Task Two

Calculate the Times:

1. When it is 09.00 in Bombay what time is it in London?
2. When it is 14.00 in Cairo what time is it in Vancouver?
3. When it is 21.00 in Mexico City what time is it in Los Angeles?
4. When it is 01.00 in Hong Kong what time is it in Karachi?
5. When it is 23.00 in San Francisco what time is it in Madrid?
6. When it is 08.30 in Rio de Janeiro what time is it in Johannesburg?
7. When it is 04.00 in Moscow what time is it in Rome?
8. When it is 10.15 in Chicago what time is it in Singapore?

Lesson Three (Wed 1st February 2006 from 11.15 to 12.15)

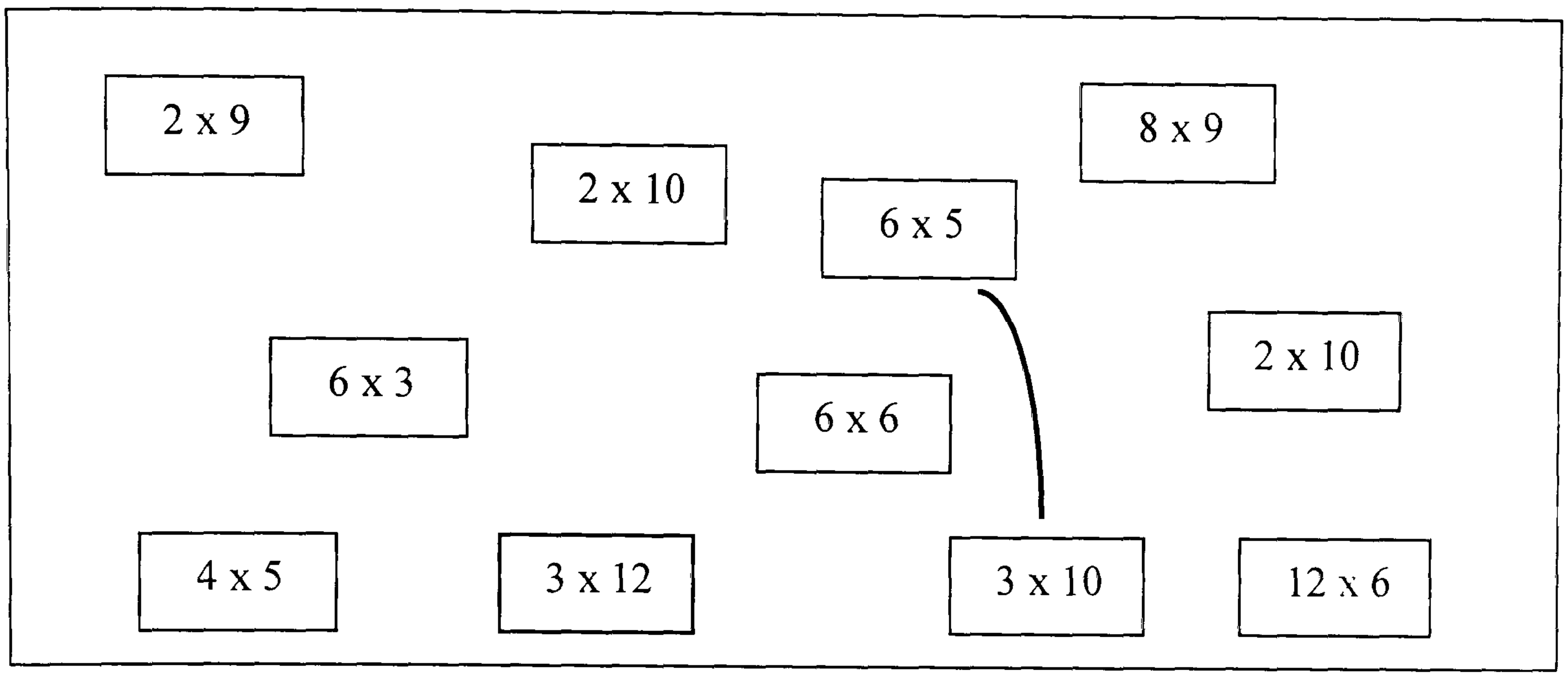
Year 6 group of twenty-six pupils (sixteen boys and ten girls).

1. John's Lesson Plan for Lesson Three

Mental/Oral WALT & Activity	WALT- Improve recall of table facts. - Use IWB slide one to challenge children to compare the like values of the statements. Ask children to come out to front of class to link like answers (See Resource a) below). - Use IWB slide two to link two number grids. What do we multiply X by to get Y? (See Resource b) below). Ask children to come out to front of class and fill boxes with correct answers using paint pot tool.
Main Activity	WALT - Choose and use appropriate number operations. - Use all four operations to solve problems involving 'real life'. Look at the 'Eating Out' slide and discuss what it represents (See Resource c) below). ▪ How much would it cost to pay for these three meals? ▪ Work out the answer in pairs with white boards. ▪ Share the answer and method on board. Look at the 'Fun Fair' slide (See Resource d) below). ▪ Discuss questions. ▪ Work out the answer in pairs with white boards. ▪ Share the answer and method on the board. Through each slide reinforce method of solving problems: underline essential information, think through method, carry out method, review answer and check it is appropriate. Share day's work with children.
Independent Task(s) (Differentiation: 1 above average, 2 average, 3 below average and SEN) **(Support T: Teacher, OA: Other Adult, I: Independent)**	**1) Money Problems – Teacher Sheet 1 (T, OA, I)** **2) Money Problems – Teacher Sheet 2 (T, OA, I)** **3) Money Problems – Teacher Sheet 3 (T, OA, I)**
Plenary Session/Assessment	WILF - Accurate solving problem choosing and using appropriate method. Look at the 'School Trip' slide (See Resource e) below). ▪ Discuss what it represents. ▪ How much would each child have to pay? ▪ What elements are involved? ▪ Work out the answers in pairs with white boards. ▪ Share the answer and method on the board.

2. John's Resources for Lesson Three

a) Example of IWB Slide One



b) Example of IWB Slide Two

3	6	8
4	2	5
3	7	9
5	7	3
8	6	4
9	2	7

12	36	73
48	20	40
18	56	27
15	28	24
48	42	36
45	22	63

c) Example of Eating Out Slide

A starter salad costs £2.25, a main course of steak and chips costs £5.20, and a dessert of ice cream costs £2.50. How much does the meal cost in total?

d) Example of Fun Fair Slide

All the Fun of the Fair

Dodgems	**£1.75**
Ghost Train	**£2.75**
Twizzler	**£1.75**
Rifle Range	**£1.30**
Headspinner	**£2.25**

1. Johnny goes to the fun fair with £10 and comes home with less than £5 left. What different rides could he have gone on?

2. What is the maximum number of different rides Johnny could have gone on with his £10?

e) Example of School Trip Slide

Sorting out the School Trip

There are 50 children going on the school trip.

1. Coach costs £100 and seats up to 52 children.
2. Museum ticket costs £2 per child.
3. Pocket money = £1.50
4. Lunch = £1.25

1. How much will it cost each child for the day?
2. The cost of the coach has increased to £150. How much will it cost each child for the day now?
3. None of the children have brought any pocket money. How much will it cost each child for the day now?
4. The school decides to donate half of the overall cost of the trip. How much will it cost each child for the day now?

Lesson Four (Tuesday 28th February 2006 from 11.20 to 12.20)

Year 6 class of 22 pupils (14 boys and 8 girls. Seven other less able children were removed from the class at the outset to receive focussed support from another teacher in another class.

1. John's Lesson Plan for Lesson Four

Mental/Oral WALT & Activity	WALT- Review co-0rdinates in four quadrants. - Provide the children with a set of co-ordinates to make a message. Work in 'talking partners' to come up with/translate word or phrase (See Resource a) below).
Main Activity	WALT - ▪ Recognise what happens to co-ordinates when a shape is reflected and rotated in four quadrants. ▪ Consolidate with the children what is meant by rotation and reflection. Link this to a demonstration on the IWB. ▪ Discuss the differences between the co-ordinates in the four quadrants. Link to the effect of rotating/reflecting shape on co-ordinates. ▪ Provide children with task of finding out effect rotating/reflecting shape on co-ordinates. ▪ Discuss in pairs what they are going to do. ▪ Review ideas after five minutes
Independent Task(s) (Differentiation: 1 above average, 2 average, 3 below average and SEN) **(Support T: Teacher, OA: Other Adult, I: Independent)**	**1) Complete task of finding out the effect of rotating a shape on co-ordinates (T, OA, I).**
	2) Complete task of finding out the effect of reflecting a shape on co-ordinates (T, OA, I).
	3) Booster (T, OA, I).
Plenary Session/Assessment	WILF - Accurate rotation and reflection of shapes with identification of co-ordinates. Review findings of each group. Collate together to create a consensus. If time allows review SAT questions related to topic.

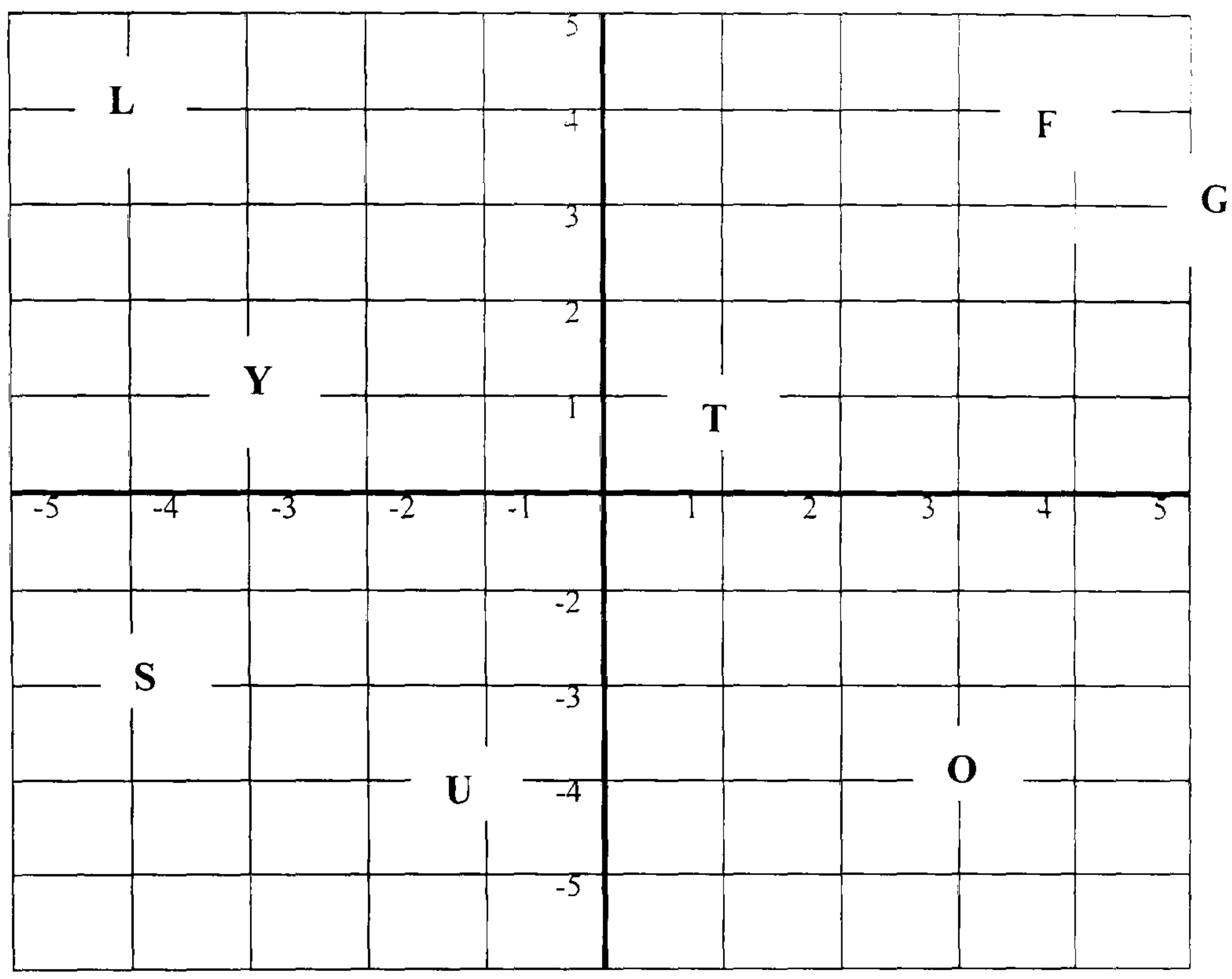
2. John's Resources for Lesson Four

a) Four Quadrant Task

(3, -3)
(4, 4)
(4, 4)

(-3, 1)
(3, -3)
(-1, -4)

(5, 3)
(3, -3)



Appendix W: Details of Mary's Lessons

Lesson One (Wednesday 9th November 2005 from 10.20 to 11.20)

Year 5 class of 27 pupils (15 boys and 12 girls) grouped according to ability with each group given a name (colours of the rainbow).

1. Mary's Lesson Plan for Lesson One

Shape and Space	
Objectives:	Oral/Mental Starter: Recognise properties of 2D and 3D shapes. Main Part of Lesson: Recognise positions, read and plot co-ordinates in the first quadrant.
Success Criteria:	▪ The children will be able to: ▪ Recognise and name 2D and 3D shapes from given properties. ▪ Plot co-ordinates in the first quadrant. ▪ Read co-ordinates. ▪ Know the associated mathematical vocabulary.
Key Words:	Axis, plot, co-ordinates, quadrant, point of origin, vertical, horizontal.
Oral/Mental Starter:	
Using shape cards, read one property at once for either 2D or 3D shapes; pupils to listen to the given properties and name the shape. When shape has been identified, pupils to give some of the other properties.	
Main Part of Lesson:	
▪ Recap on how to read co-ordinates and on the correct mathematical language. ▪ Co-ordinates to read and plot on large grid – pupils to demonstrate. ▪ Plot (1,1), (2,9), (3,1) – name the shape. ▪ Plot (1,5), (1,7), (3,7) – what would be the forth co-ordinate to make a square? ▪ Explain tasks – 2 main groups: 1. Red, Orange and Yellow: Two worksheets – a) read co-ordinates and name the shape (rectangle, isosceles triangle, octagon); b) read co-ordinates and plot the remaining ones to make a given shape (rectangle, pentagon, hexagon). 2. Green and Blue: Two worksheets – a) read co-ordinates and name the shape (square, rectangle, triangle); b) read co-ordinates and name the remaining ones to make a given shape (isosceles triangle, pentagon).	
Extension Activities:	
▪ Plot co-ordinates – two separate tasks; one for the more able; one for the middle/lower ability. ▪ Plot co-ordinates – more demanding task.	
Plenary	
Reading and plotting co-ordinates in all four quadrants: (3,-2), (5,-2), (3,-5) – right angled scalene triangle. (-2,-2), (-5,-2), (-4,-3), (-1,-3) – parallelogram.	
Resources	
Shape cards, large 10 x 10 grid, worksheets, extension task sheets, rulers.	

Lesson Two (Wednesday 7th December 2005 from 9.20 to 10.20)

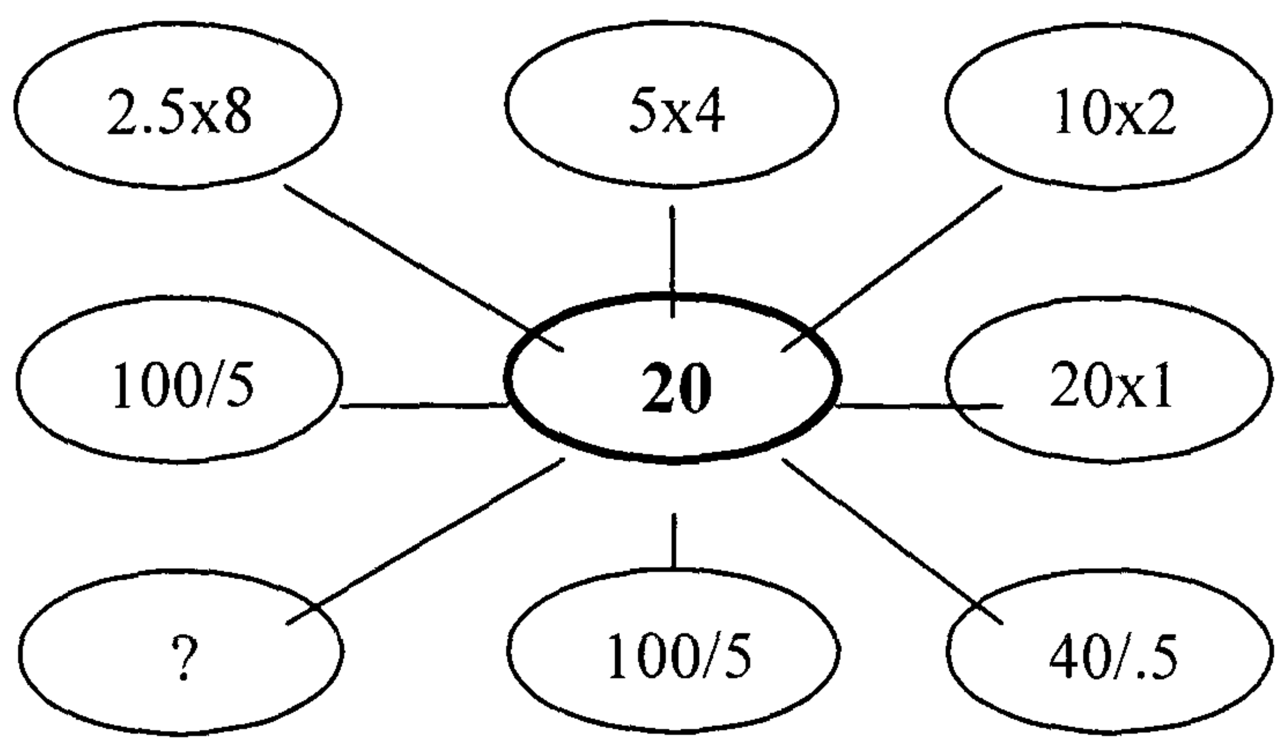
Year 5 class of 28 pupils (16 boys and 12 girls) grouped according to ability with each group given a name (colours of the rainbow).

1. Mary's Lesson Plan for Lesson Two

Probability

Oral/Mental Starter:

Use doubling/halving; use known facts to create new facts; use 'talking partners' and number webs, e.g.



Pupils to create the answers and explain 'new' facts.

Main Part of Lesson:

Success Criteria:

- State the probability of events happening.
- Use the language of probability.
- Mathematically reason the probability of given events.
- Use a probability line and place events.

Vocabulary

No chance, poor chance, even chance, good chance, certain, probability, tally.

Activities (Talking Partners)

- Questions relating to: lucky numbers, rolling die and getting that number.
- Place the probability of getting a 6 on probability line (several pupils to make prediction and give reasons). See Resource A below.
- If roll a die 30 times, how many 6s will you get (give reasons).
- Roll die 30 times and record on tally sheet (See Resource B below).
- On completion record 4-5 pupils' results and discuss.
- Mathematically, what should the probability be? Discuss.
- Place the mathematical probability of getting a 6 on probability line and compare with initial prediction.

Additional Questions

What is the probability on a 1-6 die of throwing:

- An odd number? An even number? A factor of 12? A factor of 10?

Extension Activities:

- Plot co-ordinates – two separate tasks; one for the more able; one for the middle/lower ability.
- Plot co-ordinates – more demanding task.

Plenary

Placing events on a probability line and recap success criteria.

Resources

Dice, spinners.

2. Mary's Resources for Lesson Two

a) The Probability Line

0 0.25 0.5 0.75 1

no chance evens certain

b) The Tally Sheet

Children to predict number of times each die face would appear during 30 throws, record actual number and cumulative total.

Dice Number	**Number of Times Number Predicted**	**Actual number**	**Cumulative Total**
6			
5			
4			
3			
2			
1			30

Lesson Three (Wednesday 25th January 2006 from 9.20 to 10.20)

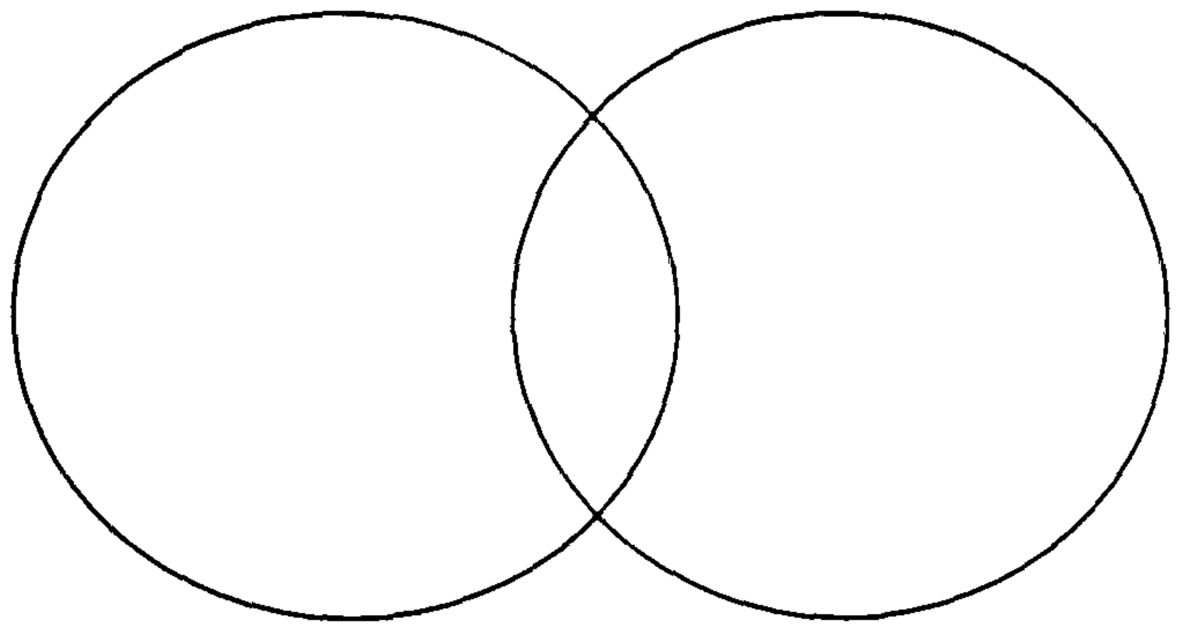
Year 5 class of 29 pupils (17 boys and 12 girls) grouped according to mixed ability pairs.

1. Mary's Lesson Plan for Lesson Three

<table>
<tr><td colspan="2">Investigative Lesson: Reasoning with Numbers</td></tr>
<tr><td>Objectives:</td><td>Improve recall of table facts
Use Venn diagrams
Develop reasoning skills</td></tr>
<tr><td>Success Criteria:</td><td>▪ Increase speed of recall of 6 times table and know associated facts
▪ Use a Venn diagram to group multiples
▪ Use knowledge of number table facts and reasoning skills to solve puzzles</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Oral/Mental Starter:</td></tr>
<tr><td colspan="2">Recall of 6 times table using counting stick, Tigger and Malcolm the Mathematical bear. (Tigger bounces along the multiples on the counting stick and Malcolm is used as a quick response pointer for table facts)</td></tr>
<tr><td colspan="2">Main Part of Lesson:</td></tr>
<tr><td colspan="2">Activity One
▪ Using 'talking partners' and writing answers in jotters. Children to sort numbers 1 to 20 into Venn diagram using multiples of 2 and 3 and explain reasoning (See Venn diagram under resources).
Activity Two
▪ Using coded multiplication facts to work out what each letter represents and explain reasoning. Children to discuss in pairs for a few minutes then report back to class with ideas (See OHT 12.6 under resources).
▪ If necessary, establish it can't be 2s, 3s, or 4s and reason why. Continue discussion.
▪ If necessary, establish it is 5s and where to start working out what each letter represents (D=5, K=0, J=1, etc.). Children continue.</td></tr>
<tr><td colspan="2">Extension Activities:
▪ Sheet OHT 12.7 for similar task but 6 times table (See under resources)</td></tr>
<tr><td colspan="2">Plenary
Answers and children to give reasoning. Discuss</td></tr>
<tr><td colspan="2">Resources
Sheets 12.6 and 12.7 and table sheets (12 x 12 grid).</td></tr>
</table>

2. Mary's Resources for Lesson Three

Venn Diagram



Multiples of 2 Multiples of 3

OHT 12.6

E	x	D	=	HK
J	x	D	=	D
F	x	D	=	AD
B	x	D	=	AK
H	x	D	=	JK
G	x	D	=	ED
C	x	D	=	EK
A	x	D	=	JD
D	x	D	=	HD

OHT 12.7

W	x	N	=	PV
S	x	N	=	QS
U	x	N	=	VU
T	x	N	=	QU
Q	x	N	=	N
P	x	N	=	TM
R	x	N	=	VS
N	x	N	=	TN
V	x	N	=	SV

Lesson Four (Wednesday 8th March 2006 from 9.20 to 10.20)

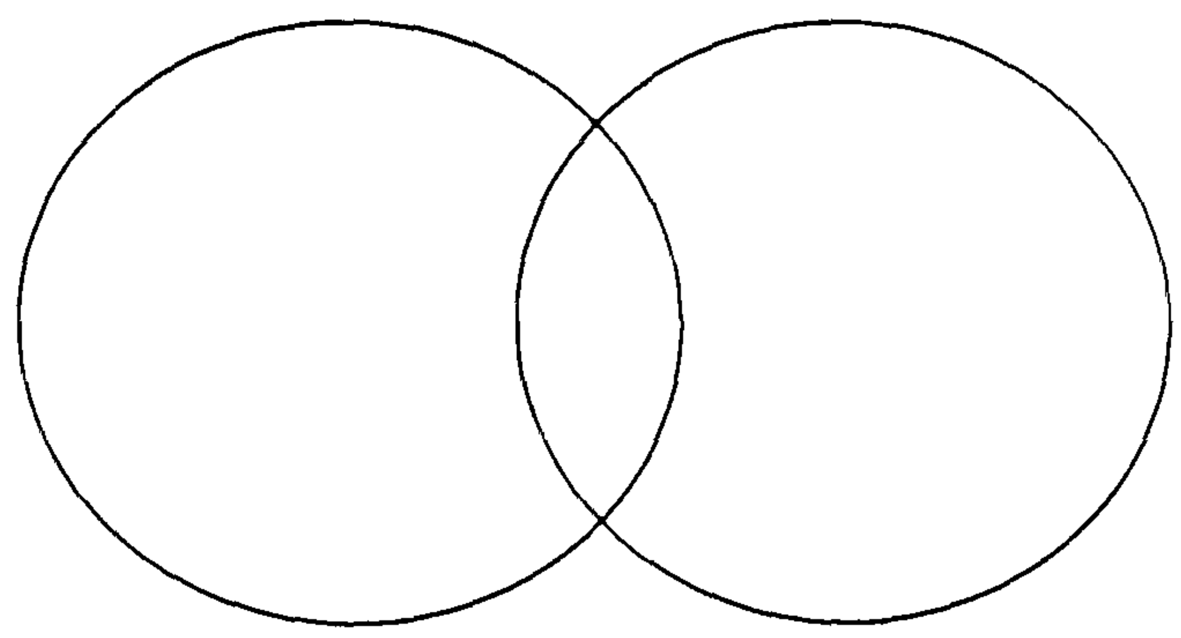
Year 5 class of 25 pupils (13 boys and 12 girls) grouped according to ability with each group given a name (colours of the rainbow).

1. Mary's Lesson Plan for Lesson Four

Investigative Lesson: Solving word problems using multiplication and division facts, multiples, remainders and inverse operations.	
Objectives:	Oral/Mental Starter: Use Venn diagram to review children's multiples. Main Part of Lesson: To solve word problems using multiplication and division facts, multiples, remainders and inverse operations.
Oral/Mental Starter	
	Use Venn diagram to review children's multiples: ▪ Place the numbers 19-41 (in multiples of 4 and 5) in the correct positions in the Venn diagram (See Resource a) below). ▪ Place the numbers 20-50 (in multiples of 6 and 7) in the correct positions in the Venn diagram (See Resource b) below).
Main Part of Lesson:	
▪ To solve word problems using multiplication and division facts, multiples, remainders and inverse operations. **Task:** Guess my number. I have a number in my head that is less than 50. If I divide the number by 6 I have a remainder of 3. If I divide the number by 7 I get a remainder of 6. What is my number? **Strategy**: What do I have to work out? (The unknown number). What facts do I know? In pairs give the children time to see if they can develop a systematic strategy (if not, suggest 'starting points'). Which numbers under 50 give a remainder of 3 when divided by 6? (9, 15, 21, 27, 33, 39, 45) Which numbers under 50 give a remainder of 6 when divided by 7? (13, 20,27,34,41,48) Which number is common to both lists? (27). Check (27/6 = 4 r 3 and 27/7 = 3 r 6) **NB**: May need to simplify further for some pupils.	
Extension Activities: 1. There are between 25 and 55 footballs. When Ryan counted them he first counted them in 4s and there were 3 left over. When he counted them again he counted them in 5s and there were 3 left over again. How many footballs were there?	
Plenary Jack had between 15 and 40 Smarties. He sorted them into groups of 3 and had 2 left over. Next, he sorted them into groups of 5 and he had 1 left over. How many Smarties did he have?	
Resources Extension task sheets, rulers.	

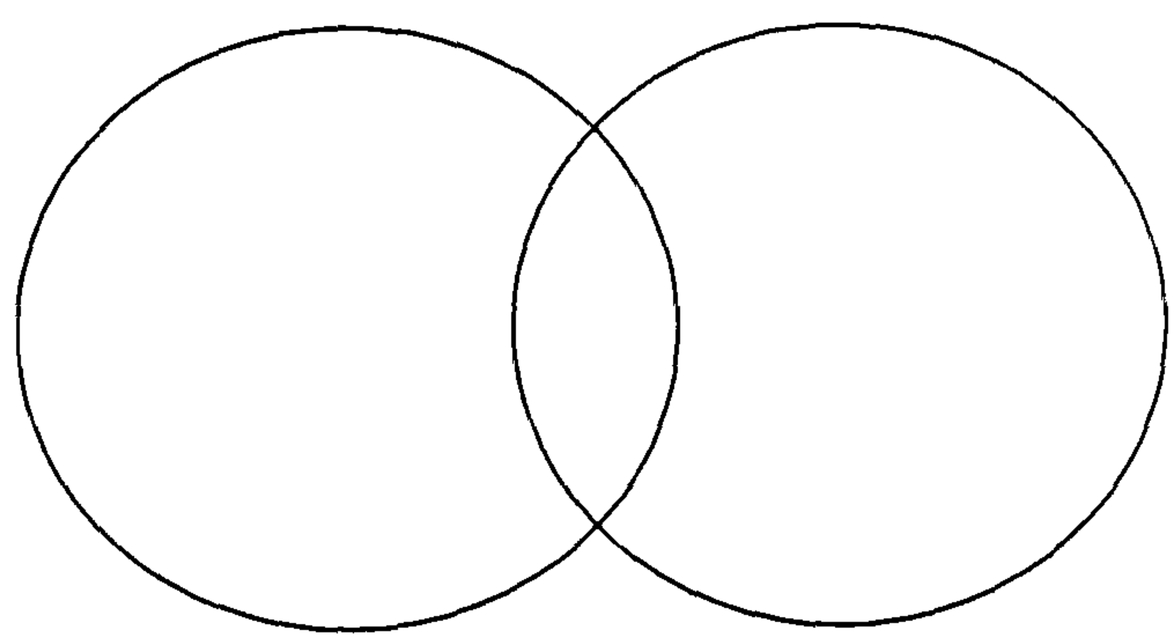
2. Mary's Resources for Lesson Four

a) Venn Diagram One



Multiples of 4 Multiples of 5

b) Venn Diagram Two



Multiples of 6 Multiples of 7

Appendix X: Interviews with Lisa

Interview One (Tuesday 22nd November 2005)

This interview followed a lesson that dealt with the Recognition of a shape after two translations in 4 quadrants and relates to Lesson One set out in *Appendix T*.

DB Tell me how you became interested in mathematics.

L It started when I was at school. I don't know what it was. I remember being in primary school and just loving doing maths, I just loved the challenge of it and I just loved how you could do so many things to write it out. And then I went to secondary school and one of the maths teachers was so enthusiastic about it that it just made me even more determined that I wanted to do maths so I went off to University to do it, A bit of a shell-shock [laughs] but I still enjoyed it and it's been from there really, I've always had it, the love of maths, always.

DB How do you think children learn new mathematical ideas best?

L It's different for different children. There needs to be a lot of different ways. It is no good just standing up and telling them it they've actually got to do things themselves, they've got to investigate it, they've got to try things, use anything, apparatus, anything to help them. Because I think if you are just going to stand and tell them '*this is how you do this, this is how you do that*', they just don't take anything in. So it's to do with them having a go really.

DB Discovering things for themselves?

L Yeah, discovering things for themselves or even just guiding them to discovering things and asking questions and just completely changing their view of something.

DB That's an interesting problem there that you've hit on, isn't it? Guiding the children to discovering ideas. If you've got something you want to 'get across' to children but you want them to discover it for themselves, how far do you let them discover it for themselves and risk them not getting it before you say…

L Major problem. I think it is different for different children but I can think of a group of children where I can just say '*there you go, try this, maybe start here and investigate this*' and they would go off and just spend ages doing all these different things. But I can also see a lot of children within the two classes that would just have no concept of where to start and they would give up before they had even finished listening to what the task was because they know they would have to investigate themselves. So I think with some children they would be quite happy and I was one of those children, I would be quite happy just to get on investigating things and if it didn't work I would do something else.

DB But it would be a fruitful use of your time but for some children it wouldn't?

L Ah yes. For some it would be a turn-off for them because they've got nothing concrete of where to start from and I can also see children where if I was working with them and maybe just saying '*have you noticed that?*' or '*what do you think that is?*' and I think that would keep them going. I think for some of them it's just not getting something quick and easy at the end of it, like 2 x 4 is 8, having it done. I think investigations and new concepts for some children are really difficult if you just let them go with it, let them get on with it. But I do agree it's really difficult.

DB Do you have time to do that type of investigative teaching then?

L Yeah, actually I'm doing one next week. It's a bit difficult sometimes with the two classes being split, extending the time but I do have this class for maths, just this whole class, and I tend to do investigation type work then. I can extend that into other sessions because I've got them over time.

DB When do you do that type of work?

L I do that on a Thursday because I have them all together on a Thursday.

DB Could I come and observe that, would that be OK?

L Of course you can, yeah.

DB How do you see your role in the classroom with the children?

L Lots of different things really. Helping them progress. Helping them improve their mathematical knowledge and giving them the confidence to actually attempt new things and not to be put off and I hope anyway, to raise their idea of what maths is because I think a lot of children think *'Ah maths. I can't do it.'* And I try really, really hard to get rid of that because I think if they are starting from that then they've got no chance because they are always going to have it because my sister had that and she is still like that now. So I think my role is to support them whilst they are learning, to guide them.

DB Do you see yourself as the expert in the class?

L Erm, no. I think I can help them improve their knowledge but I wouldn't say '*what I say goes*' or '*this is how we do it'* because I don't think maths is like that. I can offer ideas and I can tell them how I would do things and what methods I would use but I wouldn't say that was the best method to do them. Quite often I'm totally shocked when they come up with an even quicker method than I could ever have thought of.

DB So you actually learn something sometimes.

L Yes, sometimes I do and I think '*I would never have done it like that*' and I can see why they've done it because I think you can see questions and problems in totally different ways. I can see them sometimes when I say '*this is how I do it*' they are looking at me thinking '*what on earth has she done it that way for when it is much easier to do it like this*' and for them it is easier but for other children it helps them and they remember that and so that. You can't stand up and say '*this is the way you do it. I know everything, this is what you've got to do, this is what you've got to do*' because maths isn't like that, there are so many different ways of doing so many different things.

DB That's interesting. Do you think there is a mathematical truth or not?

L I think there has to .... Well, I don't know. You see I get myself all confused about this now because.....I think all you can do is guide the children for where they want to take maths because some will want to go to University and others will just want enough mathematical skills to be able to work out bills and things and I think that's fine for them. Maths is quite personal for everyone, whatever you want to do with it so if you are always trying to push to people and try to get to one thing you are going to lose the majority and you are just going to be left with the ones who really want to do maths and you are just going to totally lose everybody else. So it's more just a case of guiding them really.

DB What I'm trying to get at is your philosophy of teaching and learning of mathematics and how that impacts on your teaching, if it does. So would you say that you, perhaps, you don't have a well thought out philosophy?

L No, I haven't really. As far as teaching mathematics goes I just want the children to do the best they can and to achieve and to have an enjoyment of it, more than anything. To not be scared of maths, not to think that maths is something to hide away from because the children at this school have got children whose parents say '*oh no, I can't help you with your maths homework. I was never any good at it at school*' so if that's the type of philosophy they are getting at home, they are coming into school with that and I think the first thing we have to do is to get rid of that. So I think as far as teaching maths goes I just want them to enjoy it and have lots of different strategies to do lots of different things. Not to think that '*that doesn't work so I can't do it*' but '*I can do it another way. I'll try this*'.

DB OK, Let me change tack a little bit. Do you think the National Curriculum has been a good idea and in particular do you think the National Numeracy Strategy has been a good idea?

L Definitley. I've only been teaching since the Numeracy Strategy has been in place, I started the first year it came into place and when I first saw it I was so pleased it was all based around mental arithmetic because I think what the numeracy strategy does it that it starts from being able to do things in your head and being able to explain them and understand them before you can pick up a pencil to try and do any sort of calculation because if you haven't got that understanding you are following a procedure you don't know any thing about whereas the numeracy strategy bases everything on mental first and being able to work it out, place value, all of those kind of things because then the children are understanding it and they've got that as their base for moving on to other things. Again, with parents at home we are teaching the children all these different ways of doing multiplication and division and they are taking them home and they are using place value and they are really understanding it but parents say '*no, you don't do it like that, you do it like this, you cross this number out and you put a little one there and then you get your doorstep*' and things like that and the kids are just totally confused and they are coming in and now this is the first year they are coming in and saying '*my Mam is trying to show me this and doing doorsteps and I told her we don't do it like that*' and I say '*don't say that*' because at least the Mam is trying to help. So the children explain to their parents now because they've got that understanding now because they've come through with the mental bit and actually describing it and explaining it and questioning things as well.

DB Are there any other aspects you like about it?

L I like how children can have lots of different ways to do multiplication or division. You don't have to have everybody doing the same method.

DB What about the structure of the Numeracy Hour?

L I think we've kind of got away from the Numeracy Hour now. I think when it first came in I stuck to 10 minutes mental arithmetic, 15 minutes introduction, 20 minutes activity, 10 minutes plenary. I think that's gone now, well, I don't do that. That doesn't fit in with investigations, you can't do an investigation in 20 minutes. That kind of structured lesson is fine for certain topics or for certain objectives but sometimes I talk more or get children to do examples or quite often I don't get the children write down much. Sometimes I find it is more interaction or coming out. Sometimes in the lesson I do more mental if I think I need that bit for the next lesson. I won't say '*right, sorry, ten minutes is up, we are going to go on to the next bit*'. I don't think anybody does that now. I think everybody used to stick to the time but I think that's gone now but it is good that you've got a place for daily mental arithmetic. I know when I was at school it was just a ten minute test at school on a Friday afternoon, that was all the mental arithmetic you did.

DB So there is nothing in the National Curriculum or the National Numeracy Strategy or the Numeracy Hour that stops you from teaching the way you want to teach or do you think there is something stopping you from teaching in a more investigative approach?

L No, I think you can teach like that if you want to. Although you do have to fit in an awful lot into the Numeracy Strategy and some of them you just kind of touch on.

DB I wonder, does that limit the way you can teach given that an investigative approach would take longer, wouldn't it?

L Yes, an investigative approach would take longer but I think a lot of things in the Numeracy Strategy are not really investigative, they have got bits, they have got a section where it is investigative and I know [name of local education authority] are producing loads of things to do with investigations and SATs are slightly changing as well and I think it's more to do with using and applying all the different skills you develop more in investigative work so I think it's going to change a lot more towards investigative but I don't think the Numeracy Strategy limits you on what investigations you can do because I think it's quite flexible really. You've got to be realistic, you can't cover everything in a year and as long as you know throughout the school which bits are being covered and which year groups are doing which things so that when it comes to a certain class and you expect them to do something and they haven't got all the prerequisites to get there, as long as you know that I think you can choose to do.

DB And what happens if you miss out something that is then covered in the SATs?

L Well, you don't really [laughs]. You just don't.

DB But if you say you can't cover everything in a year but ..

L No, what I meant was you can't cover all the different strategies but you can cover all the different themes of it ... nightmare.

DB Is it a nightmare? Do you feel under pressure?

L No, not at all. Well I don't because I do English, Maths, well I do all the SATs really. I don't feel under any pressure, I might as it gets nearer the time decide to go over some topic but with Maths I don't and I don't know why, I don't know. I think I am more confident with Maths. I think '*ah well, I've done that*' and I'm not going to get flummoxed by a question that they might ask '*can I do it this way?*'. I just think as long as I've shown them different ways of doing things.

DB Not so much in the children's eyes but do you feel you've got to perform to produce results.

L No, because in our school when children come in they are below what they are expected to be so just seeing them have the confidence to tackle things and to see that they have made progress and know that they feel they have made progress, that's enough. I don't feel pressured by anybody in the school to say '*you must get this*'. Of course, they get targets that they have to reach but as long as the children know they are making progress and feel more confident I think that's it really. With every thing that goes on as well with parents, a level 4 is no longer good enough, they all want their children to get level 5 and I think '*well, do you know how hard it is to get a level 4? Have you seen what they've got to do?*' and I think sometimes parents that might say things to their children like '*you must get a level 5*' and sometimes it is totally unrealistic and I would be happy if they got level 3 and we've just got to make the child aware that they know.

DB Are the government pushing that as well?

L Yeah.

DB What do you feel about SATs? Are they a good idea?

L No. No, because I see their little faces when they come in to do them.

DB So it impacts on the children?

L It can do. We kind of don't make a big deal of it and we say '*OK, we are going to do this and you know you've got to try and do your best*' but that's it, once it's finished, it's finished, it's forgotten and that's it. We don't say '*Ah, come on, come on*' there's no pressure put on them at all and we have a nice party at the end.

DB How do you find out what your children have learned in class?

L Quite a lot of it is formative assessment as you go along, by questioning and just by looking at them and then a lot of it is through questioning. Of course, through the marking of their work and at the end of term there is summative assessment but we are just starting something new, we are training in assessment for learning and it's to do with the smiley faces and for the children to assess their work and to know what they've done and whether they need more help with it. We've just started that actually and it is all to do with formative assessment, asking them, talking to them and finding out what they don't know and where that's come from and finding out where they are really as opposed to just assuming that everybody's at the same place. Just finding out where each child is.

DB Do you do that anyway at the beginning of a new topic?

L Yeah, finding out where they are. Finding out what they know.

DB Can you only do that in a general sense?

L I think you can do it in a general sense but I think you get to know the children and you know what their mathematical knowledge is and where you think '*I'm just going to check this*' and especially if you know from other topics they've had there are a bit hazy with place value you can sometimes focus on that. So you can do it in a general sense but you also know the children and you can sit down with books as well at the beginning of a topic and work with a group and do different types of activities and tasks and use questions and find out where they are.

DB You differentiated the tasks today, didn't you?

L Yeah

DB But you differentiated by group not individually but you are saying that you can assess children individually because you know them so well?

L Yeah, you can. Within that group there is a mixture of 5 and 6 and there is one girl who will just giggle and I know that if I don't keep coming back to her she's just going to go ... and not get the actual task let alone the answers.

DB If we agree that children learn best by discovering things for themselves then doesn't it follow that assessment needs to be tailored to each individual child to see what they have learned?

L Yes but you can't do that for every single topic or for every single ...

DB Why not?

L Because you would spend your entire time assessing each child and you would never be able to move anybody else on.

DB So you haven't got time to do that?

L Not on every single topic but with the numeracy check you have the key objectives and we assess against the key objectives all the time. For this class I know that three quarters don't know their four times table, don't know any thing bigger than their four times table, they know odd bits but I know a major thing with this class is to get them multiplying and doing their tables. That doesn't have to be an individual, you can do that in oral/mental starters, follow-me cards and you can tailor a lot of your oral/mental starters to multiplying by two, multiplying by four.

DB And that's because you know your children so well?

L Yeah, and because of work that they've done and things you've done in other topics. I think you've got to focus on things which, not basic things but they need to know their tables to be able to do so many different things with maths and I think half the time they are struggling not because they don't know how to find a fraction of a number but because they can't divide by four, because they don't know that four sevens make twenty-eight and they can't divide twenty-eight by four. I think they have to go right back and you assess from there.

DB OK [name] let's leave it there for today. Thanks.

Interview Two (Friday 10th March 2006)

This interview followed a lesson that dealt with the use of addition and subtraction in number stories and relates to Lesson Four set out in *Appendix T*. However, two other observations took place during the period between Interview One and Interview Two. The first involved a lesson that dealt with the use of partitioning to complete mental multiplication and relates to Lesson Two set out in *Appendix T*, and the second involved an investigative lesson to find the number of squares on a chessboard and relates to Lesson Three set out in *Appendix T*.

DB Tell me why the class is split?
L Erm, we started it a few years ago and we split them five and six and we do it ability-wise
DB What do you mean, five and six?
L Year five and Year six. It's a mixture of Year 5 and Year 6 and we've done it ability-wise so that we can tailor the lesson more to their ability rather than having the two extremes.
DB So you've got a mixture of Year 5 and Year 6 pupils but with the same ability you think?
L And we've found that works really well because we to have three groups with another teacher that came in but with the present Year 5 only being a small class we've just made them into two and it gives the not so confident ones a chance to answer without ... because sometimes I think they feel as if people who know the answer will shout out all the time and then they'll feel inferior to them and it just gives them the confidence to have a go, and it works really well.
DB And the ones this morning, would I be right in thinking they were the less able ones?
L Yeah, you would be definitely [laughs].
DB Generally, how are they grouped in the class?
L The ones over there are [points to area of classroom], at the far end over by the window that I moved over to this table that I worked with, they are grouped by ability. The other two are grouped slightly by ability but they are roughly the same but I kind of kept a Year 5, Year 6 split because there is not that many Year 6s, I've kept the Year 6s together so if I want to then focus on something specific with them, I can do and I can do with Year 5 for the different frameworks.
DB What happens to the Year 5s next year? Do the do the same stuff again?
L No, they don't do the same thing. Right from Year 1 they are doing addition, they are doing subtraction so within maths you can just change it, it is never the same thing.
DB Tell me why you sometimes use digicards? I think I know but tell me anyway.
L It's just so that the children can actually see something, they can visualise it. They often move them about if its addition. Some children actually put the addition in front of them because that's how they see it, some just pick up the answer, it just depends on the different way children learn really and also the less able ones, you know who they are anyway, but they can just have a little look [laughs] at somebody else's answer and they can hold up the cards. It is something to do, it keeps them active.
DB And this close you eyes, thumbs up, thumbs middle, thumbs down thing. What's that about?
L That's to help me as well. I mean I can look at their books and see what they are doing but how do they feel about it and it is often different from what's in their book. Because sometimes they've done it but they haven't actually understood what they have done and that's a case of '*how do you think you have done?*', and '*do you need more help with it?*'

DB And the close your eyes bit?

L It's because, we always do that for what score did you get?, how many out of ten did you get? It's just so some of them that are getting low scores don't feel embarrassed about other people's scores. It doesn't always work because you can see people with their thumbs up saying 'yeah, I did that really well' and you just think 'no, you didn't really, did you?' [laughs]. Again it gets them involved and makes them think about their learning.

DB OK, let's move on. You said last time that if you gave some of the children an investigation then they would give up before they had got started. Do you think generally that children like to be told the answers?

L No, not generally. I think with investigations some children just don't have those skills that you need to be able to do an investigation. They just don't have those skills and they have to be taught those skills to do it, to take part in an investigation and they haven't developed those skills as well as others.

DB We are using the term investigation but I think it involves a lot of what I would call constructivist.

L Yes.

DB We've mentioned this before, haven't we?

L Yes, I know. Yes.

DB So, just to agree on what we mean by constructivism. It's acknowledging that the children construct their own understandings of things and when we say investigation we are talking about the same thing, aren't we?

L Yes, I think so, yes.

DB It's just so we have a common understanding of what it is we are talking about. So, are you saying that for some of the children, and I guess it would be the less able ones, constructivist teaching doesn't really work?

L Erm, no, it doesn't. Well, it does to a certain extent but I think with the less able children they need really basic skills before they can even get on to anything else and you've got to teach all those basic skills and that takes up a long time as well and once they've got those skills they need to be able to apply them and you just have to give them practice doing them and especially if they are less able they often think, ... they are often worried about the subject or they don't want to do it and you've just got to build their confidence really. When I did that lesson I had them all mixed up ability-wise because I think the less able children just benefit a lot from working with more able children and it just kind of rubs off, their enthusiasm, whatever, and they feel as if they are being involved and they feel as if they are achieving something whereas if I just gave them something, gave each child an investigation and said '*that is your investigation, that is your investigation*', they just couldn't do it.

DB But you also said ... can I just quote you something you said.

L Yes, of course you can.

DB We were talking about that problem of getting across something but also wanting the children to discover it for themselves, we were talking about that tension, weren't we and you said '*Major problem. I think it is different for different children but I can think of a group of children where I can just say 'there you go, try this, maybe start here and investigate this' and they would go off and just spend ages doing all these different things*'. And you said that you were one of those children when you were growing up, but you also said there were others that it wouldn't work with.

L No, it wouldn't work with them, they need somebody there reassuring them, they need somebody there telling them which way to go because if they get lost or if they get stuck, that's it, they've given up because they don't know how to get back to go somewhere else.

DB But it's the more able where you would be able to give them it and they would be off?

L Yes ... well I wouldn't say just the more able. I would say the ones that have a got a real interest in it because I think there are some more able children in maths but for some reason, they may not like the subject, so they will only do as much as they have to and if I give them an investigation they would do it to a certain extent but there would be others who would want to take it further and take it home and do things.

DB So, it's not just linked to ability then?

L No, it's not.

DB It's motivation …

L And interest.

DB Interesting. Do you think that constructivist teaching brings greater gains in children than other types of teaching?

L In what way do you mean, greater gains?

DB Well, for example, does it increase children's ability to think independently?

L No, I think there are lots of areas where children can do that.

DB OK. Why do investigations then?

L Because it enables children to apply skills that they have learned to different situations and then just have a go at things basically and know that if this is wrong, they can try another way or it can be different to how somebody else has done it. Just to really think about the problem and have a go themselves, use what skills they've got to do it.

DB So it's not a type of teaching that produces something in the children, something that another type of teaching doesn't?

L Well, it can do. Again, it's different for … when you are teaching investigations and you're helping them with the investigation I think that sometimes they do get a lot that they will remember later on and it's just basically knowing that maths isn't just sitting down, opening a textbook and doing some sums and going out the door. It just widens it for them and after that investigation I did I did have some children who went home and did all sorts of things and created all different sizes of chess boards themselves and came back …

DB Did you ask them to do that?

L No.

DB Do they go away and do extra things after normal lessons?

L Sometimes they do, different children again because I've got less able ones who would be so pleased that they've succeeded in adding and go home and bring me a page of addition that they've done at home. And I think that if they feel they have achieved something, whether it is written on paper or added up two numbers, if they feel a sense of achievement they'll go off and do it.

DB Do you enjoy teaching like that? In a constructivist way?

L Yes.

DB Do you like it better than …

L No … when I do that type of teaching I like seeing their faces when they realise the next step or … like in that chess board one when they said 64 but then someone said 'well, hang on but that's a square' I just like seeing when that little light comes on and then they go off and do something else, it doesn't put them off but I like teaching the other way as well and just seeing children grasp the different concepts or not as today has proved.

DB So you enjoy because the children enjoy it.

L But I just enjoy doing maths anyway so ….

DB What about the children? Do they enjoy that type of teaching better than the other type of teaching or is it not as simple as that?

L Erm, no. I'm just thinking of that class and some would say '*Are we going to continue? Can we do a different chess board?*' and some would say '*Ah no, not again*' and they don't like it. I don't know what it is and why they don't like it but some children don't. I can think of one girl in particular who doesn't like that open-ended approach and she is an able pupil at maths.

DB Does she like the structure that comes with the other type of teaching?

L I think so and I think it's a case of she knows that when she does something she is going to get an answer at the end, whether it's right or it's wrong and she's got that type of closure whereas in investigations she hasn't got that at all.

DB You said earlier that you like it when that little light comes on …

L Yeah, I do.

DB Does that suggest then that there is a Eureka moment where they suddenly think *'I've got it. I've got it'*.

L Yeah, they do.

DB But can they get that in other lessons as well?

L Yeah, it could be just as simple as finding the rule for a sequence of numbers and they can do. And they say *'Ah, I've got it. I can work out the next number'*. We were doing maths today in a different lesson and it was find three prime numbers which give this product and they were sitting trying it and this girl said 'I've got it. I've got it' and she is middle ability and there were other ones that hadn't got it and the more able were desperately trying to get the answer because she had done it. And she was just really pleased because she had done it.

DB How many times per year are you able to do that type of constructivist teaching?

L I tend to do a lot more in the Summer because then SATs are finished. We do transition units to go to secondary school and a lot of the work we do for them is investigative work.

DB There is an implication in there somewhere, isn't there? You said you do a lot more in the Summer because then the SATs are out of the way.

L Yeah, and you can take up more of the timetable with investigations.

DB Why can't you do more before the SATs?

L You can, … and I think more and more SATs are becoming more investigative, they are becoming more 'Using and Applying' but you still have to do all the addition, the subtraction, the fractions, the decimals.

DB So, before the SATs there is less time to do that type of constructivist teaching? That open-ended type of teaching?

L Yeah, and especially because it is open-ended and from one lesson to the next you have to see which way the children are going before you do the next and it could go on for a while.

DB And of course, you don't have a lot of material in the children's books.

L No but it's not a big thing, getting things in books.

DB You're not worried about that?

L No.

DB Some of the other teachers I've spoken to have been…

L Yeah, and I think it has been for a while in loads of subjects. We got the call for OfSTED and everyone was *'Ah, let's have a look at the books'* and we sat down and thought about it and I thought *'well, a lot of it won't go in the books'* and I think that that is recognised now that a lot of it isn't in books. It doesn't bother me.

DB One teacher I spoke to said he would like to teach more like that but it was in the back of his mind that there is often nothing in the books at the end of that type of teaching and if someone comes in and says *'what did you do on that day?'*

L Yeah, because you have work scrutinies and things where they get books and say *'Has this topic been taught? Has this topic been taught? Has this topic been taught?'* And then they can come and say *'This topic hasn't been taught'* and you say *'Well, it has'* but as long as you can justify that it has but that it is just not in their books and we have done this and we have done that. But the books don't bother me.

DB I'd like to quote you something else that you said last time, if I can.

L Right.

DB We were talking about the structure of the Numeracy Hour and you said *'I think we've kind of got away from the Numeracy Hour now. I think when it first came in I* *stuck to 10 minutes mental arithmetic, 15 minutes introduction, 20 minutes activity, 10 minutes plenary. I think that's gone now, well, I don't do that. That doesn't fit in with investigations, you can't do an investigation in 20 minutes'*. There seemed to be an implication in there that some of the requirements of the National Curriculum restrict you in the way you can teach.

L No, I think becuase when the Numeracy Hour came out it was specified that you did 10 minutes mental, 15 introduction and that children worked 20 minutes independently when you worked with one group and then you bring them back together for your 10 minutes plenary and I think it was because it was new everyone just did it and it was like on a Friday when you did an investigation it was outside the maths timetabled time. I don't think the National Numeracy Hour was a requirement, I think it's just kinda there to help, I think most people follow it and if you are not following it you probably need to have good reasons why you're not

DB I'm just wondering why they would suggest you do it that way if ....?

L I think it was because they wanted more mental calculation strategies in a lesson rather than just a mental arithmetic test or ... I think it was just daily practice of mental calculation strategies they wanted but I don't know.

DB When you were doing your chessboard activity, was there a particular objective you were trying to get them to achieve or ...

L No, not in the sense of '*By the end of the lesson I want you to have done this*'. No, there wasn't any specific one I just wanted them to see if they could work out how many squares there were on a chess board.

DB Just to go with it and see where it ended up?

L Yeah, and then ... and some children did actually come back with the answer and had even drawn other chess boards and worked out the answers to that and were asking '*Does it always work?*' They were just really interested in it but there wasn't one particular thing I wanted them to get out of it. When they are all working in groups as well I think it's a big thing getting them to tell somebody what they think and just to talk about their ideas and explain it to people on their table if they didn't understand and just to chat really and make sure they were all involved in it.

DB So, it was the process rather that the end result?

L Yeah.

DB Moving on then. Can I quote you something else? I was reading a book on constructivism and the man that wrote it was arguing that constructivist teaching is quite possible in schools and wondered whether you would agree with this. He says that a constructivist approach to teaching would be one that: '*First considers what the child already knows, by perhaps using a test task that requires the children to use this knowledge. Secondly, takes account of previously published research findings that reveal the alternative conceptions or misconceptions shown by children of that age, thereby alerting the teacher to the possibility that some of his or her pupils may hold the same misconceptions. And thirdly, brings a child's awareness to any misconceptions diagnosed by the previous two steps*'. (Selley, 1999: 16). Do you currently do all that now?

L Erm, finding out where the children are at or what they know, yes. What was the next bit?

DB The second bit was '*takes account of previously published research findings that reveal the alternative conceptions or misconceptions shown by children of that age*'.

L So, know what misconception children have?

DB Yes.

L I don't think ... you're always aware of possible misconceptions and you highlight them to the children.

DB And where does that come from, that awareness?

L Just from previous children and teaching in previous years, yeah, because you do pick up ... this class, the class you observed today, for some reason they all do carry methods and subtraction and I know that if was to give a subtraction problem they would just take the smallest number away from the biggest number no matter where it was and you just know that children do that so when you come to look at the work in their book you know that's why we try to show them different methods, to avoid that

DB Do you prejudge that?

L You don't prejudge it. Generally, at the beginning of a topic or whatever, I just put a question up and ask them to have a go and see how they do it and I look at that and then from there. I don't think *'Ah, they are going to make this mistake'* and get in there before they do it because nobody might do it.

DB But you find that they do?

L Generally, yeah.

DB Are there any other common ones? Do they always draw triangles in a certain way?

L Yeah, they do. A square like that [makes the shape of a square standing on one corner] is a diamond and they won't accept that it's just a square. Turning fractions to decimals, the numerator always comes before the decimal point, the denominator always comes after the decimal point, always.

DB I suppose if we take that loosely, that *takes account of previously published research findings that reveal the alternative conceptions or misconceptions shown by children of that age'* I mean it wouldn't be previously published research but it is based on your experience of past cohorts of pupils. Do you also get the QCA feedback on the previous year's SATs papers?

L Well, I do it. When we get the SATs papers back, I analyst them.

DB Well, QCA do that also for a national perspective.

L Ah yes, we get those things as well.

DB I suppose you could class that as research, couldn't you?

L Yeah.

DB And '*...thirdly, brings a child's awareness to any misconceptions diagnosed by the previous two steps*'? You do that as well?

L Yes.

DB So you are a constructivist teacher then?

L Yeah.

DB Although you may not have put that label on yourself when we first met?

L No. Definitely not, no [laughs].

DB When I first read that I thought 'teachers haven't got time to do all that' but you are doing it?

L Ah yes, you have to otherwise nobody is ever going to move forward. If you don't know where they are at.

DB I knew you did the first part of that, I always knew that ....

L And another good way of doing that is that if you are doing subtraction or addition when you demonstrate it is for you to make mistakes and get the children to pick them out because they are really following and understanding the methods rather than just applying it, they've actually got an understanding of it and I love doing that because the children are so keen to tell you you've made a mistake.

DB Let me move on. You've thrown me a little bit here because I thought you were going to answer in a certain way because other teachers have said to me that children seem to make greater gains when they've used an investigative approach, but you think not.

L No, ... I can specifically say for which one because I can definitely think of some children who would not get anywhere using an investigative approach, they just wouldn't.

DB What about if you had just the more able ones in the class. Would you see then bigger jumps in their understanding or in their ability to think independently?

L Only if they are interested in it. Only if they have got the motivation and interest in it.

DB Then a constructivist approach to teaching mathematics is only any good for a certain type of child?

L Erm, at this stage, for some, yeah but that's not to say that later on it wouldn't be. They all develop in different ways. This Year group, Year 6 I think you have to do more of the investigative type teaching because they enjoy it more, they've built up skills and generally they do love and that lesson I did, they did love it and I think you've got to do it.

DB Did you say before when I asked you how many times you would take an investigative approach before the SATs?

L Well, it depends on what topic it is and what topic we are doing that week or that two weeks. I think if we are doing skills, like calculations then not very much but if we are doing Shape and Space you can do a lot more, within Measures you are kind of just converting between them really but Using and Applying is coming into a lot more. They are actually changing the framework for numeracy.

DB Is the AT1 that's becoming more prominent?

L Yeah, well AT1 has had a big focus for the past two years but they are actually changing the numeracy strategy completey.

DB When does that come in?

L June? I think it is going to be implemented by December 2006 or January 2007. I think there is a big emphasis on AT1, using and applying, and reasoning.

DB Do you ever use the 'critical incident' technique?

L I don't know if I know what that is.

DB Don't worry about it.

L No, I don't know what that is.

DB Do you think that our conversations have helped you think about your thinking more?

L It has because I went away after the last time thinking '*I actually know very little about what I think about things*' and then I read this transcript [pointing to copy of transcript from previous interview] and I was thinking '*Mm, what do I know and what don't I know?*' So it has, yeah. I've actually thought it about it a lot and I've actually looked at what I've been doing more as well.

DB Yeah?

L Yeah and thinking '*why did I do that and what have I done that for and how would I do that if I had a different class?*' so I have actually thought about the way I teach maths a lot.

DB You said last time that you didn't think you had a very well-rounded philosophy of mathematics.

L No.

DB And do you think that has improved?

L I think it has, well, I don't know

DB You seemed to spend a lot of time and energy this morning on behaviour management?

L This morning I did, yeah.

DB Do you get tired of that?

L No, it's always the same when it's indoor play.

DB I thought I could feel your frustration that it wasn't going the way you wanted it to go?

L No, I don't think I was frustrated that it wasn't going the way I wanted it to go it was just that I had done it the day before, and the day before that and I'm still doing what do add to nine to make ten. What does frustrate me with that class is that they come in and out all the time, their attention is not there for one second to the next and I think that is a problem with them but at other times they are not that bad, they are still not very bright but today, it just wasn't there at all. I don't get frustrated in that fact that I'm telling them to 'stop it' or whatever because I know which children are going to do that it's this nine and one make ten and I can't get past that and I know it's really bad, but I can't [laughs] and they are still saying three, three and three makes ten and it's frustrating in that I don't know how to get round that, I don't know how to teach that any more.

DB You mean you can't simplify it any more, where do you go from there?

L Yeah, and that frustrates me and it frustrates me that there are other children who are having to be held back just a little bit, in the whole class situation not the group situation, because I am having to do that bit again, and again. The group I moved today could add 4 to 6 to make 10 but couldn't see what you had to add to 26 to get to 30 and so I had to go right back to number bonds and it frustrates that I've been doing that since September and I'm running out of ideas of where to go. And I give them sheets and cards to practice at home and I know they go out with the best will in the world but as soon as they walk through that door.

DB You've answered all my questions [name]. Have you got any questions for me?

L No, I haven't actually. You've just made me think a lot.

DB Thanks. I've really enjoyed our time together.

Appendix Y: Interviews with John

Interview One (Monday 17th October 2005)

This interview followed a lesson that dealt with the use of a graph to display discrete data and relates to Lesson One set out in *Appendix V.*

DB [Name]. Tell me about the format of the class. Is there any reason for the way they are split?

J No. Obviously you've got the lower ability out of the class so we've only got the able.

DB And they're all Year 6?

J Yes. And you could see that by the pitch of the lesson because it made certain assumptions about what they could do

DB Have they done any of that before?

J No grouping of data, no, but obviously they will have done bar charts before. I did some work with them on bar charts last year but where they sit within the class is really by accident and they just spread themselves out naturally. Some of them sit by themselves because they want to sit by themselves, some because I've told them to sit by themselves. It depends who they are. There is one particular child who talks too much to his friends so he was moved to get on and he'll be back in time, sitting with his friends.

DB So there are no hard and fast rules, they just want they want to do?

J They just do exactly what they want to do

DB And I saw a boy get up and walk around, and that's alright?

J He'll be doing something related to the lesson. In s small class like this it's fine, it's when you have 30 in the class they have to sit down and although they would class me as a strict teacher I wouldn't tell them off for coming out, in that instance but he would probably know that in a whole class situation you couldn't have children wandering around.

DB Tell me about when you first come into a class, what is your primary objective when you are starting a topic?

J At the start of a topic or at the start of a lesson?

DB Both

J At the start of a topic I would need to think about where the children were at and what they've had before. Well I suppose it is the same at the start of a lesson, you would need to know what they'd had before but at the start of a topic I see it as far more general because the topic is general.

DB How do you do that then? How do you find out what they've had before? Is that in terms of the group or in terms of the individuals?

J In terms of both, through data. Obviously, with the core subjects we have testing information. So take science, we have assessments at the end of each science unit so I'll know how well the children have done in that unit and it will give me a numerical, it won't really tell me what they know but it will give me a rough idea at the end of that unit how well they learnt. Obviously you can't take into account their level of English within that, as well. So that'll give me an idea but what I usually do at the beginning of a topic is to discuss with them what they know so I'll actually do some sort of mind map or some way of generating discussion with them at the beginning of the topic. In history we did a mind map on the Tudors, we wrote down every thing they knew about the Tudors and then I said we are going to carry on with some of these things. It is more difficult in maths because we are starting new topics all the time so I'm partly making assumptions as to what they should know and partly making assumptions about the testing information as to what they do know, so it's a mixture of both.

DB So, if you are starting new topics in maths on a regular basis then you are having to do a lot of work outside the classroom checking data to find out where the children are at?

J Yes, but with maths we have more general levels. So I know the children I had today are working at Level 4 towards Level 5 so I am making an assumption because of that they know certain things, so they know how to do a bar chart and that they would know their tables up to 12 times. It's an assumption so I can pitch the lesson at the correct level so if you came in and saw them drawing pictographs, that is way below what they should be doing, it would fit the objective but it wouldn't be at their level.

DB How do you handle the Numeracy hour? Do you stick rigidly to it or .....

J No, I don't. It has to be flexed but often, with this class, they need that something at the beginning to wake them up. They some sort of short, sharp something to get them awake because they do not respond particularly well to discussion within lessons so to get them awake we have something. It's effectively, the warm-up but it's the teacher input bit that becomes a bit more disjointed and they are spending time discussing and doing. If I were to think about the lesson again I may have actually given them the data sheet and got them to think about the groupings and to actually got them to write down the groupings together in pairs. I like to flex the hour but the hour is very restrictive I that we only have a hour. Year 6 need more time to work and less time for me to talk but it's trying to get the balance between have I talked enough to get them to do the task or have I just thrown the task at them.

DB And is it important to finish on time? I saw you looking at your watch more as the lesson came to the end

J It is important to finish on time.

DB To get that particular day's message across?

J Yes, but if it goes over it goes over but then we have problems with lunches and the kids only get three quarters of an hour break as it is so if I'm going 5 minutes over then fair enough but if I go ten minutes over it's not fair on them.

DB It was interesting that about five or six times you said '*turn to the person next to you*'. Tell me why you do that?

J It's formative assessment. It's the idea that sometimes children can't verbalise what they want to me so therefore they verbalise with their partner and often it supports the weaker ones and gets them to think about what they are going to say before they say it and gets them to think around things but it is also linked to extending the wait time. So, what's the answer to this, I want it now. We try to get rid of that and move more towards time to think about something to come up with a proper answer. We had an instance this morning, not related to this lesson where we had a child this morning when a child was giving information that didn't link to anything that we were talking about, it was a very tenuous link. If he had spent more time discussing it with his partner he may have realised that that was inappropriate. It's extending the wait time and getting them to talk around something. And it works really well. I didn't use talking partners but in a whole class setting we would use this, where an able child is linked with a less able or the way put it is you are working with someone you don't normally work with, because effectively they work within their groups so they are working with somebody else who will, more than likely, be on a different level to them and it supports the less able child through the more able child's ability but it also supports the more able child because often they have to explain things more carefully and they have t think about what they are saying. The answer can't be '*just because I know*' because the other person might say '*well how do you know?*' So they have to verbalise it more carefully for the other person so it helps both ways.

DB I also found it interesting at the beginning when you asking the class '*what type of* *graph might we use here?*' but the suggestions you got weren't what you were looking for but you allowed those suggestions and followed them through.

J Well because you can't say '*no*' because '*why no?*' but when we see that we can't use a line graph because they involve time and we don't have the element of time there, we could use pie charts but we haven't actually learnt how to use pie charts, and we can't use a Venn diagram, where Venn diagram cam from I don't know, but. What I thought about then though was that perhaps the lesson should have been guided by a question, something that would actually guide them towards having a final answer. It might have helped.

DB When you say '*you can't say no*' I think you there probably are teachers who would say 'no' in a certain way. Perhaps not in a forceful way but ...

J But then the child doesn't understand why. There has to be a reason why. Another thing that I try and do is t get away from the answer and get more towards what the children are thinking because the answer is only a part of maths and it is more the thought process that gets towards the answer and we need to formalise this thinking process and talk more about it because if we don't talk about it they may think the answer is the right thing and sometimes they can go completely on the wrong tangent and get the wrong answer or on the wrong tangent and get the right answer but it is how. So if they don't know the answer '*tell me what you think the answer might be*' or get them to talk with their partner and give the answer your partner thought not what you thought because often they are happier giving somebody else's answer.

DB Do you always have time to allow incorrect answers to be developed, almost up a dead-end, do you know what I mean?

J Yes, you've got to because again they are then saying '*why?*'

DB But do you always have time to do that?

J Not always. I would try as far as possible to allow them to get themselves into a dead-end.

DB Let me link something back to what we were talking about when we had that chat when we first met. We were talking about SATs, do you remember that?

J Yes.

DB Tell me about your thoughts on SATs.

J A necessary evil. I agree with SAT testing within class because I think it does give us an idea of where the children are at and it gives us an awful lot of data to look at where we are going wrong as teachers or where we are going right. But it tells us which area of our curriculum is weak and which area we need to strengthen but in terms of the publication of SATs, That's where I disagree because we then have a problem that all schools aim high or aim to achieve, but when they don't achieve the teachers feel bad, the kids feel bad, the schools drop in the league tables and when they drop in the league tables, parents don't want to send their children there. I've been in two schools that have been high in the league table and you have parents phoning when they come out to try and register their children in that school because it is seen as a good school. So there is too much emphasis placed on SATs.

DB But you also said that they give you a lot of valuable information about where the children are at.

J Yes, they do. The optional testing we do gives us a lot of information. But there is also a discrepancy because the way that the SATs work there isn't a common thread of levelling from baseline up to Year 6 so what you would class a Level 3 at Year 2 will not necessarily be a Level 3 at Year 3 because there is a discrepancy between what they need for a Key Sate 1 level and a key stage 2 level and there is also a discrepancy between maths and science that how do you know that that child is working at a particular level across the board? Because there are so many areas in maths and so many areas in science that you can't say for definite that that child is a level 4. You can say that on that day with that piece of work they are a level 4. And the other problem with SAT testing is that it is comprehension based and we have children who can't read, their maths is super but can't read. One have one child here whose maths is super but whose comprehension skills are absolutely appalling, although we can help him by giving him a reader because his reading skills are sufficiently low that we can do that.

DB Do you feel under pressure as a teacher?

J Horrendously under pressure. We are the top school in [name of LEA] so the pressure is on me, not just to get level 4s, but now to get level 5s. Because our children come I with a good baseline the authority say that they should be at X by the time they get to Year 6 and we have to meet that as far as possible but sometimes it's unachievable.

DB And what happens when it isn't achieved?

J Well, ultimately, if it were such a big gap we could have Ofsted back in or we could have HMI in, or we could have the authority in saying *'well, why not?'* It's not in terms of getting sacked but there is pressure.

DB That must impact on your teaching?

J It does but it's not a bad thing because you are aware of levels, so you are aware that what you are teaching is what the children need to move them on.

DB And do you feel under pressure to get through the topic, whatever it is, quicker than you would like?

J Well in terms of the Numeracy strategy, you only have a certain number of days to do that any way. It would either be 3 or 5 days to teach whatever. The thing we are teaching at the moment is data handling and probability, in a week. So, in terms of finding out where the kids are and working with them to improve them I that area, you are limited in the amount of time you've got to do that. So, if on the Friday, so and so still doesn't understand probability, you going to have to try and find time somewhere in your oral/mental starter or at the beginning of the lesson to bring that out or use another strategy because you can't say I won't start addition and subtraction on Monday because they didn't understand on Friday. Otherwise, you would fall so far behind. You would need to pick it up elsewhere or try to use the cross-curricular type of teaching so you can engineer it.

DB When marking your pupils' work, do you give them marks out of ten or do you sit them down and talk to them?

J Well, the marks out of 10 or 20, no. That would be reserved for SATs or things you need numerical data for, spelling, where they actually enjoy getting a mark and that strives them on but in terms of marking within the books I use more of a formative assessment strategy so the work is marked, obviously, but there will be some form of positive comment and then some form of what they need to do to improve. So, it's like a good comment and a wish or a target, so it's not just so many marks out of ten.

DB Do you ever use the 'critical incident' technique? Have you ever heard of that?

J No

DB Thanks [name], I've really enjoyed this morning.

Interview Two (Tuesday 8th November 2005)

This interview followed a lesson that dealt with the twenty-four hour clock and appreciating different times around the world and relates to Lesson Two set out in *Appendix V.*

DB Well [name], how did that go?

J That was frantic. I think they all got it in the end, from the evidence of work that I saw they all understood the concepts but there was too much of the twenty-four hour clock and not enough of discussion around the map and the time differences.

DB And where did that come from, that problem?

J Me. I was the main problem because I just spent too much time with the games at the beginning assuming that they wouldn't have had as much knowledge of the twenty-four hour clock as they had.

DB So you were surprised by how much knowledge they had?

J I was.

DB I think they enjoyed that though, didn't they?

J They did, yes. So it's a balance as well. Too many concepts and perhaps...well, I would argue that they do need to know why the time difference is there, so when I was planning the lesson I thought I've got to put a bit in a bit in about the reasons why, because you can't just say '*there are time differences*', end of story, there's got to be an explanation and I think sometimes they look for the harder solution to something than the easier solution. So when we were talking about how would you calculate the time we had four different ways of calculating the time, the last one was the easiest which was simply to count the bars across the map, but having said that some of the ones that did do that miscounted the bars. Now that is possibly an inaccuracy in the sheet.

DB When they are assessed, on that, what type of question would they be asked? For instance, would it be a subtraction question or a ....?

J I don't know, to be honest, whether they would be assessed on that. If you are thinking about assessment as in SATs I've never seen a question on time differences in that context. The time difference might be simply that '*It is this time in the UK if X is five hours ahead. What time would it be?*' It would be as simple as that. But that would be too easy for the able ones so that's why I chucked in the flight times and that would be about right for the poorer ones, or the lower ability ones.

DB And you had them both together this time?

J Yes.

DB Why was that?

J Only because now I am an AST I am released on a Thursday so we have a shared class Mondays, Wednesdays, and Fridays because we identified that there are quite a few children who need extra support. So the easiest way for us, because there was such a percentage, was to split the class. And then you could guarantee that they would be getting focussed support.

DB There was something I wanted to talk about that you raised last time we spoke. When we talked about managing the Numeracy Hour you talked about the need for it to be '*flexed*' and if you'll allow me I'll quote what you said. You said '*Year 6 need more time to work and less time for me to talk*'.

J I know and I did the exact opposite today.

DB But it seems to me that it is about trying to get the balance between '*Have I talked enough to get them to do the task or have I just thrown the task at them?*' Now when I read that I thought that was very interesting. How do you manage that balance?

J You can't. [laughs]. It's as simple as ... so today there was more talk because the concept didn't 'click' as quickly as I'd hoped. I'd hoped that it would 'click' so almost … the way in saying '*there is a method, there is a method, there is a method*' is possibly not the best way. It is possibly better in this instance to say '*this IS the method*'. So we are almost going away from what we've said about constructivism to a more didactic approach and saying '*this IS how you do it*'. I think another example would be fractions because fractions and particularly addition and subtraction of fractions and things like that, they just need a method.

DB So you are saying that there are some instances where you have to forget about teaching in a constructivist way altogether?

J I'm saying from a class teacher's perspective and ease of teaching, … yes. And others lend themselves beautifully to discovering methods. Having said that, it's possibly more a criticism of the Numeracy Hour and the time that we have to do it in because according to the National Numeracy Strategy I have a day to teach that and yes I could bring it up in other subjects but in the Numeracy Hour I have a day to teach it. Even if I took it to two or three days I would have missed out the other bits and pieces that I need to teach them that week so I would then have a difficulty in fitting in the next. But we are looking at that as a school. We are talking about doing away with this time for teaching separate units and actually chunking all the Numeracy together so all of your fractions would be taught in one block and apparently, although I haven't looked at it, there is research that says that the children retain more focussing on fractions for, say, a month than they would focussing on it for a week, four times in the year.

DB And doing that would allow more time to ….?

J Well, it would consolidate and it would give you more idea of how the children were doing because you would test at the beginning and you would test at the end, formally or informally, whatever way you want to do it and then you would have a definite picture of how they had improved whereas at the moment we are just throwing things at them almost and hoping that it sticks. If it sticks, great. If it doesn't stick, we are frantically trying to find time to fit it in. Last week, as an example, we did some work on triangles and my kids didn't have a clue, not a clue in the differences between triangles and that is an assumption from me because they should have done it last year. So I then had to try and find time which I did the following day in an oral/mental starter, looking at properties of triangles but it is that 'eating in' of things that isn't ideal. So if we had more time to concentrate on something we would then have more time to build up and really assess how they were doing on that particular subject.

DB You said earlier that there are some aspects of the curriculum that lend themselves beautifully to this constructivist idea, can you give some examples?

J Erm, certainly Shape and Space. Anything like that. So, if you're talking about properties of shapes, tessellation, that sort of thing, great.

DB But do you still find you still have that tension between allowing the children to discover what it is you want them to discover without actually giving them the answer and making sure that they actually get the point in the end?

J Yes. Yes. But having said that, the session we had last week on quadrilaterals they were just given the shapes and asked to find the properties of the shapes from the shapes and they just spent the time doing that and so they were then just discovering it for themselves.

DB And did they?

J Oh yeah. Very much so. But again, the able ones did, the less able ones didn't because the less able ones didn't have the understanding that '*those angles are equal*' or didn't have the skill to measure them accurately enough to find that they were equal or know that there were parallel lines, etc.

DB Is that frustrating for you then? As a teacher who wants to teach like that.

J No. It would be nice to …. No, because they are learning at their level. We could almost be saying that the more able would take to constructivism more easily than the less able or we could have two separate … not curriculums but two separate objectives so they are actually learning at their level. We've got another tension here in that we are teaching kids things when they don't have the basics so if we were properly constructivist then they would be learning at their level and the more able ones would be learning at their level. At the moment, they are learning at their level but we've got to support them to make sure they can learn at that level. So, I'm putting the scaffolds in, but I'm not really developing the underlying skills as much as I would like to.

DB Do you think the National Curriculum has been a good idea?

J Yes, I do think it's been a good idea because pre-National Curriculum people were teaching whatever they wanted whenever they wanted and they were just forgetting about ... but what I do think is the problem is unit plans, the QCA schemes. We've gone more down that route so the National Curriculum states the set of objectives and then teachers can put any theme to those objectives that they want, they didn't, that was the problem, or they didn't do it quickly enough, they moaned, they complained, whatever. The QCA said '*there are some schemes, follow those*', and everybody took them as gospel and followed them to the letter. Some of them are absolute rubbish and some of the themes don't fit with what you're doing. They don't make cross-curricular links, they are not interesting for the kids. So what we are doing is we are going right back to the National Curriculum and looking at the key skills within the National Curriculum and taking those key skills and saying '*right, it doesn't matter whether you teach through a QCA scheme or whether you've got a visiting artist in or whether you fancy doing something on* [name of local place] *because you are going to be doing work with your international school, as long you are teaching those key skills, that's it, that's great*'. Your fall back would be QCA but if you want to be more adventurous or if you want to make the links between the subjects, use the key skills. This guy called [name] has developed these key skills and when you look at them and match them to the National Curriculum they are virtually identical but what they also do is they focus on, not just the skills for that subject, so if you take Geography, not just geographical skills but there will be mathematical skills, speaking and listening skills and ICT skills, and social skills and group management skills within the key skills for Geography. So really, if you just teach the key skills for Geography you also hitting literacy, speaking, listening.

DB Is this a nationwide initiative?

J No. It's something new that's just come out. The Head went to a conference on it. So we decided that this was definitely the way forward because a forward-thinking school can't be stuck with these QCA schemes. They have to be thinking '*what can be exciting for the kids to do?*' Because the schemes aren't ...they can be made exciting but it's probably going to take more work to make those exciting than it is to say '*right, let's move to the key skills*'.

DB Is it an 'off the shelf programme'?

J No, you just get the key skills and you have to do a lot if work around them. An example being, next year it is the Church's 250th anniversary. Where does that come in the curriculum? It is really important for the kids of this parish to know about the church. Yes, you could fit it in with your literacy but if it was history and it does fit in with the key skills, why not just teach that instead. Why not take two weeks out and as long as at the end of the term you've finished those key skills and you can say that the children have had experience of all those key skills.

DB What about the assessment that might come after? Do you worry about that or not?

J No, because if we link this with the chunking of the curriculum you can then have more idea of where they going from and to. But also, these key skills are levelled so it takes the worry away from '*Am I teaching the right level?*' because if you are teaching the correct skill you know that that child has learned a Level 4 skill and if they can do that you can say '*that child, Level 4*' or again match up the number of skills that they've got and say that they are roughly working towards the end of Level 4 or the beginning of Level 5.

DB So where did he get the Levels from?
J The National Curriculum. But it begs the question '*who put the levels in?*'
DB Because the levels imply a sort of average pupil.
J Yes, well nationally, that is what they say. The expectation for Year 6 is Level 4 or it was, it is now Level 5.
DB Is that Level 5 nationally or Level 5 for you?
J It's tongue in cheek because it IS Level 4 but Level 4 has sort of passed by now. There was a time when the schools were happy that they all got Level 4s – schools nationally.
DB Well, that was the requirement, wasn't it?
J That's still the requirement but they are now considering publishing Level 5 results as well as Level 4 results so that would indicate to me straight away that the government are saying Level 4 isn't good enough, it's Level 5 that we now want.
DB It's strange that at the outset of the National Curriculum, it was implied that Level 4 was the level that an average pupil of that age would get but it's changed somewhat, hasn't it? It's now not what the average gets, it's not 50% above and 50% below, it's what's required.
J Yes, definitely
DB Thanks again [name].

Interview Three (Wednesday 1st February 2006)

This interview followed a lesson that dealt with the use of all four mathematical operations in solving problems in 'real life' and relates to Lesson Three set out in *Appendix V.*

Line

DB [Referring to an aspect of the lesson just observed] I got the answers to the task completely wrong. I'd written down the answers, what I thought were the answers, but they were totally different from the answers you gave at the end.

J So which bit ...

DB I'll tell you why I got them wrong. I misunderstood the question. I thought the pocket money was the pocket money they had got from their parents and that they would donate to the cost of the trip.

J Yeah, I understand that....

DB So in effect I deducted the pocket money from the cost of the trip instead of adding.

J Yeah, I suppose it was me just thinking that the pocket money would be something they would submit to the cost.

DB If it had been identified as 'spending money' rather than 'pocket money' I think I would've interpreted it correctly. I wondered if, as you walked around the class, did any of the children struggle with that or is it just me?

J The ones that you would call the middles to the bottom struggled but I don't think that was the actual concept, it wasn't because of that. I don't know, it might be a local thing. Obviously the way that problem was built up was to make a multi-stage problem to reinforce to them that they must have accuracy all the way through, there were very few that actually got through the multi-stage problem that they had on the sheet because they brought an error into it straight away. Strangely enough the biggest error was when they did 90 times 30 pence, a load of them, they did it as 9 times 30 pence

DB 9 times 30 pence, what was that for?

J Not the one that was on the board it was the multi-stage problem that I gave them, I'll give you the sheet. They did 9 times 30 pence instead of 90 times 30 pence and most of them put £2.70 as the answer and that threw their sum completely.

DB Let's talk about the 'School Trip' problem then. Did any of the children work out the problem both cumulatively and as separate problems? For instance, the second part said that the cost of the coach had just gone up by £50 so how much would it cost each child now? They could've just added a pound onto the previous answer.

J Which is what we did but what I was battling with was my middles and my less ables not seeing the link or questioning themselves that it can't be as easy as £50 and 50 people, therefore it's a pound and this is where we come back to the 'talking partners' and the security of the 'talking partners' and them worrying they are going to give the wrong answer so just not saying anything but when they talk with their 'talking partner' they suddenly think '*well hold on a minute, she's saying the same as me, therefore it must be right*'. So after 'talking partners' I have a lot more people putting their hands up.

DB How are the 'talking partners' paired?

J Well they are paired by ability just as they are but for some sessions we would pair them able with less able.

DB But that wasn't the case today?

J No. Because the question on the board was really aimed more at the middle, it was far too easy for the more able.

DB And the more able are seated at the back of the classroom here?

J Yeah, you have a large band of about 15 children that are towards the more able side and that are working towards the level 5 bracket whereas you have your middle ones that are in the middle of your level 4s and your poorer ones that are low level 4s if not level 3s.

DB So how did you think the task went then?

J It is very enlightening for me, do you mean the task on the board?

DB Yes.

J I think it was more confusing for them than it was any thing else.

DB Why was that then?

J I think it was just the way it was presented. I think putting that number of questions together, they were thrown. One girl at the end said '*Is that SATs? Are we going to get more of those in SATs?*' And '*No*' is the answer so I think they are getting used to sort of SATs questions where you really only have a two stage problem.

DB Were they thrown by the fact that it was a multi-stage problem or was it the wording of the task?

J Possibly.

DB As I was looking around I saw some puzzled faces and actually when I put my answers down, I put several answers down according to whether you included the pocket money or not, and I was perhaps thinking about things too much and I wondered if the children did the same.

J They didn't seem to. Certainly when we had the answers coming back they were fine.

DB Because there is a history of badly worded SATs questions.

J Yeah, it's comprehension

DB And children are penalised because they have misinterpreted the question.

J From the answer I was getting back it seemed fine.

DB Let's move on then. I wanted to pick up on something you said on a previous occasion. You said you disliked league tables but that SATs gave you a lot of valuable information about the children.

J Yes.

DB If we've got to have SATs, do you think that they should be standard, or standardised?

J In what sense?

DB Well, each child gets the same SAT paper.

J Yes, unless somebody that's very, very clever can sit down and can create levels within papers. So that if you knew that a child was a level 3 you could give them a level 3 paper and then it would give them a proper level within that level 3. If you knew the child was a 4 you could do the same. Now they tried this in lower Key Stage 2 but it didn't work. If the child gets to a certain level, it gets a certain score on the first paper and they are then allowed to go on to the second paper, so effectively it's a level 3 paper and a level 4 paper. It doesn't work because the questions on the second paper sometimes are easier than on the first paper, you are not taking into account the broad spectrum of maths so a child may not be able to do the addition and subtraction of the first paper but could do shapes, space and measures questions on the second paper no problem at all. I think the way the SATs are is fine because I think in n terms of the question papers, yes, you need to teach to the test and yes if you just gave it to them cold they would do really, really badly. The reason I like them is because the majority of the children, whether they are good or not so good, can attempt most of the questions so I think they've levelled the questions quite well, they've sort of hit them for the middle. I mean one girl today, who is a middle level 4, answered an algebraic question for her homework because we had done a little bit in class and she'd had a bit of support from Mum so she'll remember that. So there needs to be a balance there.

DB Because the SATs give you the ability to compare children, is that important? I'm just trying to figure out how SATs as a way of assessment fits in with this idea of constructivist teaching and learning given that …

J I don't think it does [laughs].

DB Why?

J Why do SATs not fit in with constructivism? Because children aren't really guiding their own learning, we are guiding their learning for them. If, once they had done the SATs test, the children could identify the areas for improvement themselves .....

DB Let me say that I absolutely agree with you, I think SATs don't fit in with the idea of constructivism.

J No but having said that a lot of the emphasis that I put on SATs now is for the children to identify their own areas for improvement, to look through the question papers, to say to themselves '*right, I struggled on .... coordinates. So what I'm going to do is I am going to do find out how to do that, I am going to do some revision on that area, I am going to come and talk to my teach, I am going to come and talk to my Mum and I am going to improve that area because I know that that is a weakness*'. So in a sense they are guiding their own learning and those ones that are self-motivated are doing wonderfully because they are picking up areas that they need to improve on. So in that sense, yes it is, but in the true sense of the word, no, it can't be because the children aren't really guiding their own learning far enough.

DB What type of assessment would be consistent with it then? What could we do? If we agree that children learn best by constructing their own conceptions of things ....

J Well ideally, it would be like a portfolio-based assessment, that's the standard answer.

DB Do you think that would be possible?

J No. In schools, no, definitely not ... unless ... that was what my [name of qualification] was on producing a portfolio-based assessment for [name of subject], that worked to a certain degree but it was very, very messy, lots of kids, lots of bits of paper, and it becomes very unwieldy. However, if we took and broke down the standards for Year 6 maths, the objectives effectively, but now your then saying 'objectives' and you're then going away from the children constructing their own learning because you are imposing on them a set of objectives, but if we forget about that, if we took the objectives and if we then had children needing to produce pieces of evidence to match those chunks of objectives or whatever, that would work in a sense but then arguably how would you guide their learning towards those objectives?

DB Alright, maybe it wouldn't be perfect but would it be more consistent with the idea of constructivist teaching and learning than SATs?

J But SATs are not the only form of assessment that we have although they are the ultimate form of assessment for Key Stage 2. Yes it would be much better because then we'd have more chance to really reflect the child's level and really for the child to be saying '*this is what I need to improve throughout the year*'. Whilst we have targets and whilst most schools have targets for the children to achieve because the teacher is guiding their learning all of the time the children struggle to really meet their targets that are set. You either have the scenario that they are so incremental targets that it's unmanageable because the teacher needs to be on at the child all the time or you have them so broad that they don't work at all. It would be better.

DB And achievable? Workable?

J Some schools are using that sort of thing anyway but not in a true constructivist sense but then no schools really are following true constructivist teaching, they are doing some elements of it but the fact that we have a National Curriculum that specifies in such detail what the children need to learn means you can't set the child off on an open-ended task and then reign them back because they are going in the wrong direction.

DB So what you're saying is that truly constructivist teaching and learning is inconsistent with the National Curriculum?

J With our prescribed National Curriculum, yes. The National Curriculum that is as prescriptive as we have, yes. If it was slimmed down or if it was mixed ... I have this vision in my mind of all these objectives and if you could sort of wash over them to make a general mash of what they need to know roughly, not specific objectives, then yes you could engineer learning for the children within that sphere, say electricity, you know there are so many prescriptive things, you couldn't direct it towards that but as a general overview then you could directly aim them towards that. So I think it needs to become less prescriptive for it to become truly constructivist.

DB Let me quote to you a writer who thinks that constructivist teaching is possible in schools and see what you think. He argues that a constructivist approach to teaching would be one that: '*First considers what the child already knows, by perhaps using a test task that requires the children to use this knowledge. Secondly, takes account of previously published research findings that reveal the alternative conceptions or misconceptions shown by children of that age, thereby alerting the teacher to the possibility that some of his or her pupils may hold the same misconceptions. And thirdly, brings a child's awareness to any misconceptions diagnosed by the previous two steps*'. (Selley, 1999: 16).
I have several questions. I'll come on to the others later but the first is, is that possible?

J Within constructivism?

DB No. Is that possible for you as a teacher now?

J Yes, we are doing it?

DB All of those things?

J What we are doing, not with the numeracy but with the literacy, or what we are playing with at the minute, I wouldn't say we are doing it across the school, is at the beginning of a unit of work we are getting the children to write a cold piece of whatever, a narrative piece of report writing, we are then aware because of the broken down levels that the children are working at and because we have frameworks, we are aware what the increments are between those levels, so that's effectively the misconceptions, you know the children at that certain level will not be including speech marks for instance or they won't be including commas in lists, that is how I see the misconceptions.

DB And where have those misconceptions been identified from? Because he talks about '*...previously published research findings that reveal children's misconceptions...*'.

J Well, I am assuming that it would be ... I don't know if anyone has done any specific research on the level of children's understanding within literacy and breaking it down, it's something that comes to us, probably from SATs, well in fact, it is from SATs. From SAT testing they break down and they know levels and increments between those levels.

DB So the misconceptions are identified by previous attempts at SATs questions?

J I am only seeing misconceptions in terms of where that child would be at, so a child at that level would be writing in this particular way, it's all best fit and all a bit airy fairy at times but if you are writing in that particular way you then know what the next stage is for them to improve, it's incremental.

DB Literacy is not my thing so let's leave that to one side. So you saying you are playing with that in literacy but not in numeracy?

J Yes, but we are looking to, and I mentioned this last time, to chunk the curriculum. If we chunked the curriculum and taught addition and subtraction for a block of time that would work but it is unmanageable to do a cold piece of work on the Monday, set targets with the child and expect them to reach those targets by the Friday or in some cases by the Wednesday, because we teach five day blocks or three day block of numeracy and the next week we could be onto shapes, and the following week we could be onto coordinates and then we could be back to subtraction, so it's all over the place. We do have targets but the targets because they are so specific to numeracy areas, they don't work. Your target could be addition and subtraction bonds to 100 and they may not come across that for 3 or 4 weeks so in a term you might only meet it once, so if they only meet it once it's difficult to get that target met.

DB As it currently stands do you do the things set out in that quote.

J Am I doing what they are saying there? No.

DB Selley thinks that constitutes constructivist teaching and it involves those three steps. Is that what you are currently doing?

J No. But I would argue against his view of constructivist teaching because I don't think … how can you be truly constructivist if you are *telling* a child what to put right, because he is saying to the child '*look, this is what you are doing wrong*', before, as I see it, before they've even had a go. My vision of constructivism would be that the children start with something and through discussion with the teacher and with their peers, find their own errors.

DB Well, just to support Selley here, I'm not sure he means that. First he says '*consider what the child already knows*', you are already doing that, I know you're doing that, I've seen you do it.

J Yes.

DB Secondly, and this is the problem I had with his viewpoint of what's possible, he says the teacher also '*…takes account of previously published research findings that reveal the alternative conceptions or misconception shown by children of that age, thereby alerting the teacher to the possibility that some of his or her pupils may hold the same misconception*'. He is still giving them the opportunity to try things out and develop their own strategies ….

J But he then says '*… and sharing those misconceptions with the children?*'

DB And thirdly '*…brings a child's awareness to any misconception diagnosed…*'

J Right. '*brings*'. Different to '*tells*'. Right, fair enough.

DB I'm not disagreeing with you I just want us to agree on what he is saying here.

J I know.

DB It's not the first step I have trouble with.

J I know, it's the second step.

DB Yes, its the second step I have trouble with. It's this '*…takes account of previously published research finding…*'. I wonder whether teachers do that?

J No.

DB Not because they don't want to do it but because they haven't got the time to do it?

J No, definitely not. It's only when it filters down from academia, down to either local authority level or whatever. An example being the grid method for division but thinking back 4 or 5 years that wasn't in primary schools. Chunking, division, that wasn't in primary schools. Now somebody has obviously researched this or somebody has obviously researched the calendar starting at the left hand side as opposed to the right hand side, that's a popular misconception. It's those sorts of things but unless it's delivered to the teacher through a course or unless the head teacher is sufficiently forward thinking to jump on bandwagons like we're doing with these key skills, they will never know.

DB There are analyses of SATs that come out the year after that identify the problems children have had with particular questions. Do you ever pick up on that sort of stuff?

J No, if I'm honest. I read it but that tells me how badly the children last year did on last year's test. It doesn't tell me how where the areas are for improvement in my teaching. What tells me the areas are for improvement in my teaching are testing my kids now and me doing similar analyses of those tests.

DB Would they not alert you to the possibility that those misconceptions might occur again in your next cohort of pupils and you could then perhaps adapt your teaching accordingly?

J Yes, but it is the '*might*'. Do I do things twice? Do I plan a set of lessons which target those misconceptions and then plan a separate set of lessons that target the misconceptions that I find from my own SATs analysis? Or do I just target these kids. Now I think these kids are far more important and it would save me the time of doing it twice.

DB Do you think he is being a little optimistic there in what he thinks teachers have the time to do?

J It gives you heart that that is constructivism because you can be constructivist in lots of different ways. So by doing some of those things a lot of teachers have elements of constructivism but it's the actual children exploring their own and finding their own meaning in the classroom that is the difficult bit and he doesn't really come across that, he doesn't really acknowledge that.

DB There are lots of elements of your teaching that I would class as constructivist. Even today you were allowing children to try out the own strategies and methods before coming around and maybe guided them to the one that you though may be least problematic for them.

J But then the Numeracy Stratgey as it stands is constructivist because that's where that comes from. There is no enforced method, there isn't one method that is right. If you look at our school calculation booklet you can do division umpteen different ways, you can do multiplication umpteen different ways. It is whatever the child has got at their stage of development. Yes, we teach different methods and yes we would encourage children if they were still adding by partitioning, that would be one. If they were still doing that I would be encouraging them to move forward to the compound method but only because I am aware of SATs, if we didn't have SATs in then really it is what method is best for the child..... But we can't set effective targets and work towards effective targets in 5 days, give us 3 weeks and that's a different matter.

DB But you don't have 3 weeks?

J Well, that's what we are looking at, chunking the maths curriculum but you have the problem that you might only visit fractions once in a year. Now in terms of retention, that's a problem. Really we need to come back to the revision of the numeracy strategy, which is coming in mid 2006 and see whether that makes it easier but I don't think it will.

DB I think that's it [name] for today. Do you have any questions for me?

J No.

DB I did want to ask you whether you feel our discussions are being useful in helping to develop your thinking?

J Ah yes, definitely. That quote has got me thinking.

DB That's good because one of the aims of this process was to help develop your thinking about your teaching.

Interview Four (Tuesday 28th February 2006)

This interview followed a lesson that dealt with the reflection and rotation of shapes in four quadrants and relates to Lesson Four set out in *Appendix V.*

DB Well how do you feel that went?
J They enjoyed it. They were far more enthusiastic doing that than they were doing the sort of paper-based exercise. The test will be whether they have actually learned what they would have learned with the paper-based exercise.
DB From what you saw in the end what's your feeling about that? Do you think they got it?
J Some of them, not of all, not of all by any means but going round in the independent bit some were still struggling to see almost why we were doing it, not in terms of they knew what they were doing but in terms of '*I don't understand why I am rotating this shape*' and I was trying to get across to them that we just need to see what we can find out.
DB And is that why you said to me during the class that you would usually have employed a lot more structure ....
J Yeah. So, in a sense, although that wasn't wholly constructivist, if we want to move children forward quickly we can't allow them to go off on their own tangents, we need to give them structure to make sure they focus. The likes of the ones across here [points to part of classroom where the more able pupils sat], the likes of [name of pupil] and [name of pupil], not a problem.
DB Did you see them have their 'Eureka' moment?
J No.
DB It was fantastic, they got so excited. You were over here and one of them suddenly said 'I've got, I've got it' and they all started arguing to see who could be the first to write the rule down.
J That's the bit you want to keep and that's the bit you want to give to all of them but it is just unfortunate that some of them, I mean even one of the brightest ones over there [points to part of classroom where the more able pupils sat] fell foul a couple of times. Her first shape was too big to rotate, her second shape she rotated incorrectly, she didn't rotate it around the origin. She got it in the end but she was almost last to get it, it wasn't the actual understanding of it, it was just the mechanics of the rotation of the shape. They are all more confident at rotating and reflecting shapes.
DB You said that they enjoyed the lesson, did you enjoy it?
J Erm, through them, yes. In terms of what they have actually produced, no. Because, ideally, don't do the first bit and just launch into it, less talk but then ... I am trying to sort of free up time because if we had had time at the end, which we didn't have, then we could've got them to write down something, something they had discovered from today and that would've then been sufficient for me to be happy with what they produced. At the moment what we've got is a collection of sheets that, some of them have got a rule written on it which is accurate, others are still in the midst of things.
DB Why is it important that they write something down? Is it so they can go back and look at it?
J No, to satisfy the 'powers that be'.
DB Because they come and look at the books?
J Yes, they would be asking questions like '*what did the children do on this day?*', '*why have you got a day missing?*' If I say '*we did a practical activity that day*' they ask '*where's the evidence for that practical activity?*' It's wrong. It is wrong.
DB So would you say you are torn?
J Horrendously torn, horrendously. My favourite year in teaching, which was a while

ago now, when I look back that was a wonderful year, there was lots and lots of practical stuff and I didn't care about whether it was recorded or .... and the kids learned a massive amount, not just in terms of singular subjects but in terms of the inter-connectedness of subjects as well because it could be truly cross-curricular. You know, we would look at one thing in Science that would then reflect in their English, which would then reflect in their History, which would then reflect in their Maths. I they really got the inter-connectedness, now because it is so compartmentalised, we are losing that inter-connectedness.

DB Do you think the children sometimes prefer to have it more structured, in effect, to be told what do and how to do it?

J Certain children, yes, but [name of pupil] there, who was probably one of the first to get an answer, that 'Eureka' moment, give him a sheet [structured] and he doesn't function as well. He is very spatially aware is [name of pupil] as well which obviously is a help but if you'd asked me at the beginning of the lesson '*who's going to get this first?*' he wouldn't have been top of my list, he would've been way down the list. I would have thought somebody like [name of another pupil] who was still messing around with the method of it, would have got it first.

DB So you're saying that that type of teaching is more suited to particular types of children?

J Yes.

DB Would you like to teach more like that? From what you said earlier about your really good teaching year ....

J Yes, I would prefer to have more .... Given that we had more space, more time, given that there wasn't an expectation every day to have something in the book which resembled work and which was monitorable, an actual answer, something to tick or something to mark wrong, something that that child has achieved or that child hasn't achieved, yes I would love to but all that would have to disappear first.

DB Are we back to the requirements of the National Curriculum?

J Not so much the requirements of the National Curriculum because I think that could be taught in a more sort of open way. It certainly couldn't be taught in the amount of time, you know you couldn't have three days on rotation and reflection and say to little Johnny '*sorry, I know you haven't understood it but we are now going onto multiplication*'. If we could stretch that as well but this is coming because the new revision of the Literacy and Numeracy documents is advocating more of an open approach and more of a chunked approach that we talked about, when they come out in March, April, May time. They are actually saying '*you should be teaching a few weeks of addition and subtraction so that you can actually see progression in the children*' as opposed to teaching it for a week and not seeing that much progression and ten having to play catch up because they didn't understand.

DB But as it stands currently, the need for the children to have something in their books prevents you from teaching that way?

J Yes. Well, I wouldn't say it prevents me, it hinders me. It wouldn't stop me. Given a restructure of today's lesson we could've come up with something that was super that they could put in their books that I could tick, that I could comment on, that I could give them a target for improvement on but they would still have done something that they had investigated themselves. It is going more towards investigative maths but there is then that conflict against you can investigate but when do you actually tighten up on the mathematical skills as such, the basic mathematical skills.

DB Was that the first lesson of the year that used an investigative approach?

J Erm no but I would erred more towards Shape and Space type of thing not, although that was partly Shape and Space, because it was co-ordinates I wouldn't normally have said '*say what you see*'.

DB So you would normally choose something that was more amenable to that type of investigative approach?

J Yes. And I would very rarely go with the addition and subtraction or multiplication and division type, or fractions, although the more you think about it the more the more the possibilities appear in your mind and the less opportunities you can see for saying you can't do it.

DB I think you were surprised by what you got from the children today.

J Ah yeah. Yeah, very surprised. Like I say, disappointed with some that I thought might have got it. It would've been interesting to have got them to work individually and see how that went. I certainly don't think it would've worked as a big group because they then start arguing with each other about who is right and who is wrong.

DB We're coming to the end. Do you think your philosophy of mathematics, because that's what I've been trying to tap into over the last five or six months, I wonder if that's developed over that time that we've had together?

J Ah definitely, definitely. If only to reflect on my practice and to say '*where would I like it to go?*' which is what we've discussed. I would like it to be more of a constructivist way of teaching and looking within the bounds of what we've got I certainly think that once we have more time within the curriculum to teach a particular subject then there is no reason why it can't be more investigative, more constructivist.

DB I wondered before I entered this Phase of observing and interviewing teachers whether they would hold a well rounded philosophy, one which could be easily communicated to others. You all seem to have a philosophy but how well rounded that is, how well developed that is, and how easily communicated that is to others, is another matter. I wonder, do you feel that you had a well rounded philosophy of mathematics before we met?

J Possibly not. I always think about my practice and always try and make it so that the things that we are doing, not all the time but as far as possible, will be what the children like to do. So, probably not is the short answer.

DB But do you think it has developed?

J Ah definitely. Ah yes, yeah, yeah, because any reflection upon practice and any professional discussion with a critical friend, which is effectively what you've been, challenging what I think, makes you think further. It would be interesting to see whether in six months time or this time next year whether things have changed sufficiently to allow me to do that or whether, I can manipulate sufficiently to make sure that that happens. I would also have been interesting to have had the less able in [the classroom] and to see how that worked in the scenario of things because you had kids that were motivated to go towards the task and knew what they were doing and could achieve all the tings they needed to achieve within that, for starters they could all do co-ordinates, because it falls fouls when they can't. I suppose I could support them in that and work with them on that but that would then take me out of the equation for challenging the others like [name of pupil] to get his solution down to a readable sentence, which he did.

DB But isn't that the nature of the investigative approach that it just suddenly clicks and they get it and I wondered how close the others were to that moment.

J Yeah.

DB Well, thank you very much [name], that's all I've got to ask you.

Appendix Z: Interviews with Mary

Interview One (Wednesday 9th November 2005)

NB: Mary would not permit our conversations to be audio-taped. Consequently, this transcription was reproduced from field notes and memory.

This interview followed a lesson that dealt with the recognition of properties of 2D and 3D shapes and relates to Lesson One detailed in *Appendix W.*

Line

DB Remind me how you became interested in mathematics?

M At school. I was always interested in maths but I think that was partly because I was quite good at it. It was logical and structured and the answer you arrived at was either right or wrong.

DB How do you start the beginning of a new class or new topic?

M I try to give them a task to find out about their previous understanding of the subject. You need to find out where they are in their learning really before moving on to new things. The class you just saw needs waking up sometimes early in the morning so the oral/mental starter is a good way of doing that and reviewing what the children have done before.

DB Was that a typical lesson I just saw?

M Pretty typical yes, although it does depend somewhat on the lesson obviously, but pretty typical.

DB I noticed that you often said to the pupils '*talk to your partner before I ask you for an answer*'. Why did you do that?

M Several reasons really. First of all it gives the children a chance to think rather than just jumping in with a rushed answer. It also gives them a chance to verbalise their thought with the other child before answering. It also shares out the responsibility for the answer so if they get it wrong no one person feels it is their fault alone.

DB I also noticed that the main part of your lesson involved a number of exercises for the children to attempt. What were your reasons behind giving them out?

M Well, the children need to practise on questions of the type I've just explained. Otherwise, they wouldn't get the chance to consolidate what I had just taught. The tasks were differentiated according to ability though.

DB How were the children organised in the classroom? I noticed that there were children organised by tables and you were referring to the tables by colours. Explain that to me?

M The tables are organised by ability and then I gave them colours of the rainbow so they don't get any feeling of which group is of lesser ability and which is of higher ability, although I'm sure they know in themselves. The group on the corner table are the ones of higher ability and the boy at the front needs to be watched, that's why is at the front, so I can watch him. I'll put him back with his friends when his behaviour improves.

DB So, your differentiated tasks are differentiated by table, that is, a differentiated task is aimed at a group of children sharing the same ability?

Yes.

DB How do you see your role in the classroom? For instance, do you see yourself as the expert in the class?

M Well, I'm the expert in the sense that I know more than the children do.

DB And what about the children in the classroom, how do you see their role in the classroom? For instance, do you see children as the passive receivers of the knowledge you 'give out'?

M I think that teachers very much teach and that children learn from that teaching but I wouldn't say that children are 'passive'.

DB How do you think children learn new maths ideas most effectively?

M I think it depends on the child but I think generally that children learn through listening and doing practical things, getting involved in what it is they are supposed to be learning.

DB Do you feel the National Curriculum has been a good idea?

M Yes, I do. I think National Curriculum maths has been one of the better ideas because it is structured, thought out, sequenced. I would like more time sometimes to teach topics. It all feels a bit rushed sometimes and in that sense I think it is a bit prescriptive. I feel uncomfortable sometimes moving on to another topic when I know some children haven't got what I'm trying to get across, but you've got to because we only have a certain amount of time to cover certain topics. Having said that though I think the National Curriculum has done a lot for the teaching of maths and it has actually improved the teaching of maths. I think it's a good thing that we are all now batting from the same type of wicket, so it's been good in that respect.

DB Does the National Curriculum restrict you in any way? For instance, does it restrict you in the way you would like to teach or not?

M Well, yes and no. The National Curriculum is prescriptive and it does impose constraints on teaching to a certain extent because we have to cover a lot of material in a set amount of time and sometimes it would be nice to have more time to cover topics with the children, especially the less able ones. So it's restrictive in that sense. Having said that though the National Curriculum only sets out what has to be covered, the key objectives, but the way you cover that material is up to each teacher and so that can be adapted to a degree.

DB And what about SATs? Do you think they are a good idea?

M No. I don't like the idea of SATs at all. I think SATs have totally ruined primary education. They tell us nothing that we as teachers don't already know about the children. If you were to ask any teacher the vast majority would say the same thing. They simply confirm what we already knew about the children. You can make quite an accurate prediction about what the children will achieve way in advance of them achieving it. That's because I know the children so well. But the powers that be don't trust our professional judgement and they won't rely on teacher assessment, they have to have this data. I would kick SATs out of primary education altogether if it was up to me.

DB Do you think it is important that they are standard in the sense that each child gets the same paper?

M Well, I suppose if you are going to have them then it seems only fair that they all get the same paper.

DB Have you ever used the 'critical incident technique'?

M No, I don't even know what that is.

Interview Two (Wednesday 7th December 2005)

NB: Mary would not permit our conversations to be audio-taped. Consequently, this transcription was reproduced from field notes and memory.

This interview followed a lesson that dealt with probability and relates to Lesson Two set out in *Appendix W*.

DB How did you feel that went then?
M That was OK. It went pretty much as I expected it to go really. The more able ones got it much quicker than the others, as I expected.
DB I think they really enjoyed the practical aspect of that, rolling the dice and counting the number of times each number came up.
M Yes, I think they did but not all of them quite understood what they were doing, what they were moving towards, the probability of rolling a certain number.[Name of pupil] got it almost immediately, one in six so you would get 5 6s on a dice on average. Some of them didn't get it that the total of throws needed to add up to 30 though.
DB Where did that come from? That confusion?
M I don't know. It's just the nature of those particular children.
DB I noticed that once during the lesson that you allowed a child's wrong answer to develop until it reached a 'dead end'. Why did you do that?
M I just wanted him to see where he was going wrong rather than just saying '*no, that's wrong*'.
DB Let me take you back to something we discussed last time we met. We were talking about SATs and you said that you didn't like them at all. I wondered when I read that afterwards whether you feel under pressure as a teacher?
M Yes, I do. I am forever conscious of SATs. My whole school life is dominated by SATs. I mean we even teach the children test techniques [laughs]. For example, we actually tell them that when the first time the question is read out in the mental maths test that they should have their jotters open and ready because when it is read out for the second time that will actually save them 9 or 10 seconds. I know tests are an important part of life but that is just ridiculous. I just hope that nothing negative is transmitted to the children and we do try to be positive all the time with them about the SATs.
DB That seems crazy, doesn't it?
M Yes, it is but we have to do it.
DB Yes.
M You've got to think of the school and the pupils.
DB What I've been trying to get at over the last couple of times we have met is your philosophy of the teaching and learning of mathematics, what you think is the nature of mathematical knowledge, how it should be best taught, how it is best learned, what teaching styles or techniques you feel produce the best results. There is this idea that teachers can't teach children anything but that the child must construct their own learning, it's called constructivism.
M I'm not sure I agree with that. I think teachers can and do teach children. I do teach children otherwise I'd be out of a job, wouldn't I?
DB Well, let's try and agree on what we mean by this idea of constructivism. I don't think it means that teachers should be made redundant because they have no role to play in the classroom. I think constructivism still acknowledges that teachers are important in the classroom but that they can only be facilitators of the children's learning. They can't transmit knowledge directly from themselves to the children.
M Mm. I know what you mean but I'm not sure about that.

DB But they are still very important in determining how much a child will learn because they can guide the child to that learning.
M Yes. OK.
DB Have you ever noticed the tension that exists in a lot of your teaching? The tension between wanting the children to discover some concept for themselves and giving them the freedom to do that but not allowing them so much freedom that they simply have no idea what it is they are supposed to be doing but then on the other hand also not wanting to actually intervene too early and tell them what it is you want them to find out or discover for themselves.
M Yes, that's a difficult balance to get.

Interview Three (Wednesday 25th January)

NB: Mary would not permit our conversations to be audio-taped. Consequently, this transcription was reproduced from field notes and memory.

This interview followed a lesson that was describe by the teacher as an investigative lesson and involved reasoning with numbers and relates to Lesson Three set out in *Appendix W*.

DB Why an investigative lesson then?

M I was thinking about the idea you mentioned last time [constructivism] and I thought that this type of lesson might be classified as that type of teaching and it would be more relevant to your research.

DB Well, I'm interested in getting a representative picture of your teaching rather than just a specific aspect of it. How many lessons like this will you be able to do throughout the year?

M About five but I would like to do more but time does not allow it.

DB Is that because of the requirements of the National Curriculum?

M Yes, it means we have to get through the material in a given amount of time. I was thinking about this idea [constructivism] and I would say that I always try to get the children to work things out for themselves, to reason things out but it depends on what I am teaching them. I know we need to get things covered in a set time but I always try to get them to think for themselves first.

DB That tension we talked about before was more evident again today, wasn't it? You know, that wanting to give them enough information to get them on discovering the task and concepts but not enough that you actually tell them what it is you are trying to get them to discover for themselves.

M Yes, that tension was there but it is always there to some extent, it doesn't matter what lesson you are teaching.

DB Do you think the children generally enjoy that type of teaching or would they prefer to just have the answers given to them and not do too much work?

M The more able ones do enjoy it but the mid to less able ones tend not to enjoy it as much because they are lazy. I would say about a third enjoy whilst two thirds don't enjoy it. Again it's a balancing act, I am constantly gauging when I need to intervene to rekindle their enthusiasm for the task, you can see it waning in the less able children and then I act to re-boost their enthusiasm, and I do that by giving them a little more guidance. For most of the class today that was a very difficult task.

DB What about you? Do you enjoy that way of teaching?

M Yes, when they get it. When that happens I really feel that I am developing their thinking skills. If you jut stand up and say '*this is how you do this*' whatever it is then they are not going to remember that, the information will not be retained.

DB Would you like to teach that way more often? If all the constraints were taken away, would you?

M Yes, I would. It's a wonderful thought that, taking all the constraints away and teaching the way you think teaching should be done.

DB Do you feel that an investigative approach to lessons is worthwhile given that they take longer in that you need to give the children time to think and reflect?

M Yes. In my opinion it makes them more independent of thought in the end. I definitely think that this type of teaching produces greater gains as well but you couldn't do it this way all the time because there is no recording in their books. I think maths generally is like that, it's more of a 'drip, drip, drip' approach with the children.

DB Does the fact that there is nothing much in their books at the end of it all make you anxious or uncomfortable?

M No, because I am capable of justifying my reasons for doing it this way. It might have done in the past when I was younger and less experienced but I'm now experienced enough to not to let that bother me. I could justify it and set out my objectives for the lesson, etc.

Interview Four (Wednesday 8th March 2006)

NB: Mary would not permit our conversations to be audio-taped. Consequently, this transcription was reproduced from field notes and memory.

This interview followed a lesson that dealt with an investigative approach to solving word problems involving multiplication and division facts, multiples, remainders, and inverse operations and relates to Lesson Four set out in *Appendix W*.

Line

DB Another investigative lesson. Is this just for me?

M I thought you would be more interested in this but it is something I would do anyway.

DB How do you think it went this morning?

M It turned out roughly as I had expected it to turn out. Some got it straight away, the cleverer ones, the ones I thought would get it, and most of them didn't, the not so able ones. I expected to have to lead them to what I was trying to get at most of the way through the lesson. [Name of child] got it straight away but I knew he would get it quite quickly. [Name of another child] worked really hard for him but I knew he would need leading most of the way but I was pleasantly surprised by him.

DB Let me come back to this idea of constructivism. I'd like to read you something, it's a quote from a writer who thinks that constructivist teaching is possible in schools. He argues that a constructivist approach to teaching would be one that: '*First considers what the child already knows, by perhaps using a test task that requires the children to use this knowledge. Secondly, takes account of previously published research findings that reveal the alternative conceptions or misconceptions shown by children of that age, thereby alerting the teacher to the possibility that some of his or her pupils may hold the same misconceptions. And thirdly, brings a child's awareness to any misconceptions diagnosed by the previous two steps*'. (Selley, 1999: 16). What do you think of that? Are you doing all that now?

M I certainly do the first bit. I mean apart from the fact that I use the oral/mental starter I also know my children very well and I could tell you what they already know with some accuracy. We've also got their previous year's record. I'm not so sure about the second bit though, although I would say that my years of experience means that I am aware of what types of common misconceptions children have with particular maths topics. I wouldn't say that I sit down and read research books on the subject but the same misconceptions come up again and again, year after year. The third bit I do based on my knowledge of the misconceptions I've just talked about, but again they are not from research. Sometimes I actually put questions up on the board where there is an error and ask the children to spot the mistake.

DB Do you think that perhaps you are a constructivist teacher at times but you just didn't know it?

M Yes, I probably am.

DB You said the last time we met that it is usually the more able children that enjoy this constructivist type of teaching and that the mid to less able ones don't like it as much. Is that because the more able ones get more out of it?

M Probably.

DB If we follow that to its logical extension then we have to ask the question whether the National Curriculum is doing the cause of some children's learning a major disservice? Because you've said that more able children get more out of it but that the requirements of the National Curriculum doesn't allow you the time to teach in this constructivist way as much as you would like.

M I'd not really thought about it before but yes, I think the more able ones lose out a little because they really enjoy that type of teaching but I think it's OK for the mid to less able ones because they need that structure that the National Curriculum gives them.

DB Do you feel that before we started talking together that you had a well-rounded philosophy of mathematics, thought out views on the nature of mathematical knowledge, on how maths is best taught and how maths is best learned?

M I don't think I had any philosophy of maths at all before we started talking. Actually, that's not right. I don't think I had no philosophy, I think I probably had a philosophy somewhere but that I probably had not thought about it too much. It's all in there in a bit of a mess but it's there somewhere. I've gone through my career taking things on board, from other teachers, from courses I've attended and my teaching style has changed dramatically from when I first started.

DB Would it be fair to say that you had a philosophy but not a well-rounded philosophy and not one that could be easily communicated to others?

M Yes, that's a good way of putting it. I could never have told someone my philosophy of maths if they had asked me before. Actually, I'm not sure I could now but I'm a little clearer on certain things.

DB That's interesting for me because I was going to ask whether our discussions have helped you develop your thinking?

M Yes, it has definitely made me think more about what I think but it hasn't changed the way I teach at all.

DB No, I wasn't expecting our discussions to impact on your teaching but it is nice to hear that it has made you think more about your philosophy of mathematics.

Appendix AA: Example of Coding System

Interview One (Monday 17th October 2005)

This interview followed a lesson that dealt with the use of a graph to display discrete data and relates to Lesson One set out in *Appendix V.*

DB [Name]. Tell me about the format of the class. Is there any reason for the way they are split?

J No. Obviously you've got the lower ability out of the class so we've only got the able.

DB And they're all Year 6?

J Yes. And you could see that by the pitch of the lesson because it made certain assumptions about what they could do

DB Have they done any of that before?

J No grouping of data, no, but obviously they will have done bar charts before. I did some work with them on bar charts last year but where they sit within the class is really by accident and they just spread themselves out naturally. Some of them sit by themselves because they want to sit by themselves, some because I've told them to sit by themselves. It depends who they are. There is one particular child who talks too much to his friends so he was moved to get on and he'll be back in time, sitting with his friends.

DB So there are no hard and fast rules, they just want they want to do?

J They just do exactly what they want to do

DB And I saw a boy get up and walk around, and that's alright?

J He'll be doing something related to the lesson. In s small class like this it's fine, it's when you have 30 in the class they have to sit down and although they would class me as a strict teacher I wouldn't tell them off for coming out, in that instance but he would probably know that in a whole class situation you couldn't have children wandering around.

DB Tell me about when you first come into a class, what is your primary objective when you are starting a topic?

J At the start of a topic or at the start of a lesson?

DB Both

J <u>At the start of a topic I would need to think about where the children were at and what they've had before. Well I suppose it is the same at the start of a lesson, you would need to know what they'd had before but at the start of a topic I see it as far more general because the topic is general.</u>

Rel NV
previous learning

DB How do you do that then? How do you find out what they've had before? Is that in terms of the group or in terms of the individuals?

J In terms of both, through data. Obviously, with the core subjects we have testing information. So take science, we have assessments at the end of each science unit so I'll know how well the children have done in that unit and it will give me a numerical, it won't really tell me what they know but it will give me a rough idea at the end of that unit how well they learnt. Obviously you can't take into account their level of English within that, as well. So that'll give me an idea but what I usually do at the beginning of a topic is to discuss with them what they know so I'll actually do some sort of mind map or some way of generating discussion with them at the beginning of the topic. In history we did a mind map on the Tudors, we wrote down every thing they knew about the Tudors and then I said we are going to carry on with some of these things. It is more difficult in maths because we are starting new topics all the time so I'm partly making assumptions as to what they should know and partly making assumptions about the testing information as to what they do know, so it's a mixture of both.

DB So, if you are starting new topics in maths on a regular basis then you are having to do a lot of work outside the classroom checking data to find out where the children are at?

J Yes, but with maths we have more general levels. So I know the children I had today are working at Level 4 towards Level 5 so I am making an assumption because of that they know certain things, so they know how to do a bar chart and that they would know their tables up to 12 times. It's an assumption so I can pitch the lesson at the correct level so if you came in and saw them drawing pictographs, that is way below what they should be doing, it would fit the objective but it wouldn't be at their level.

DB How do you handle the Numeracy hour? Do you stick rigidly to it or .....

J No, I don't. It has to be flexed but often, with this class, they need that something at the beginning to wake them up. They some sort of short, sharp something to get them awake because they do not respond particularly well to discussion within lessons so to get them awake we have something. It's effectively, the warm-up but it's the teacher input bit that becomes a bit more disjointed and they are spending time discussing and doing. If I were to think about the lesson again I may have actually given them the data sheet and got them to think about the groupings and to actually got them to write down the groupings together in pairs. I like to flex the hour but the hour is very restrictive I that we only have a hour. Year 6 need more time to work and less time for me to talk but it's trying to get the balance between have I talked enough to get them to do the task or have I just thrown the task at them.

DB And is it important to finish on time? I saw you looking at your watch more as the lesson came to the end

J It is important to finish on time.

DB To get that particular day's message across?

J Yes, but if it goes over it goes over but then we have problems with lunches and the kids only get three quarters of an hour break as it is so if I'm going 5 minutes over then fair enough but if I go ten minutes over it's not fair on them.

DB It was interesting that about five or six times you said '*turn to the person next to you*'. Tell me why you do that?

J It's formative assessment. It's the idea that sometimes children can't verbalise what they want to me so therefore they verbalise with their partner and often it supports the weaker ones and gets them to think about what they are going to say before they say it and gets them to think around things but it is also linked to extending the wait time. So, what's the answer to this, I want it now. We try to get rid of that and move more towards time to think about something to come up with a proper answer. We had an instance this morning, not related to this lesson where we had a child this morning when a child was giving information that didn't link to anything that we were talking about, it was a very tenuous link. If he had spent more time discussing it with his partner he may have realised that that was inappropriate. It's extending the wait time and getting them to talk around something. And it works really well. I didn't use talking partners but in a whole class setting we would use this, where an able child is linked with a less able or the way put it is you are working with someone you don't normally work with, because effectively they work within their groups so they are working with somebody else who will, more than likely, be on a different level to them and it supports the less able child through the more able child's ability but it also supports the more able child because often they have to explain things more carefully and they have t think about what they are saying. The answer can't be '*just because I know*' because the other person might say '*well how do you know?*' So they have to verbalise it more carefully for the other person so it helps both ways.

Rel WV
↳ formative assessment (AfL)

DB I also found it interesting at the beginning when you asking the class '*what type of* *graph might we use here?*' but the suggestions you got weren't what you were looking for but you allowed those suggestions and followed them through.

J Well because you can't say '*no*' because '*why no?*' but when we see that we can't use a line graph because they involve time and we don't have the element of time there, we could use pie charts but we haven't actually learnt how to use pie charts. and we can't use a Venn diagram, where Venn diagram cam from I don't know, but. What I thought about then though was that perhaps the lesson should have been guided by a question, something that would actually guide them towards having a final answer. It might have helped.

Relativist World View

→ Errors to develop

DB When you say '*you can't say no*' I think you there probably are teachers who would say 'no' in a certain way. Perhaps not in a forceful way but …

J But then the child doesn't understand why. There has to be a reason why. Another thing that I try and do is t get away from the answer and get more towards what the children are thinking because the answer is only a part of maths and it is more the thought process that gets towards the answer and we need to formalise this thinking process and talk more about it because if we don't talk about it they may think the answer is the right thing and sometimes they can go completely on the wrong tangent and get the wrong answer or on the wrong tangent and get the right answer but it is how. So if they don't know the answer '*tell me what you think the answer might be*' or get them to talk with their partner and give the answer your partner thought not what you thought because often they are happier giving somebody else's answer.

Relativist World View

DB Do you always have time to allow incorrect answers to be developed, almost up a dead-end, do you know what I mean?

J Yes, you've got to because again they are then saying '*why?*'

DB But do you always have time to do that?

J Not always. I would try as far as possible to allow them to get themselves into a dead-end.

Restrictive aspects of NC → time

DB Let me link something back to what we were talking about when we had that chat when we first met. We were talking about SATs, do you remember that?

J Yes.

DB Tell me about your thoughts on SATs.

J A necessary evil. I agree with SAT testing within class because I think it does give us an idea of where the children are at and it gives us an awful lot of data to look at where we are going wrong as teachers or where we are going right. But it tells us which area of our curriculum is weak and which area we need to strengthen but in terms of the publication of SATs, That's where I disagree because we then have a problem that all schools aim high or aim to achieve, but when they don't achieve the teachers feel bad, the kids feel bad, the schools drop in the league tables and when they drop in the league tables, parents don't want to send their children there. I've been in two schools that have been high in the league table and you have parents phoning when they come out to try and register their children in that school because it is seen as a good school. So there is too much emphasis placed on SATs.

Realist WV → contradictory beliefs

DB But you also said that they give you a lot of valuable information about where the children are at.

J Yes, they do. The optional testing we do gives us a lot of information. But there is also a discrepancy because the way that the SATs work there isn't a common thread of levelling from baseline up to Year 6 so what you would class a Level 3 at Year 2 will not necessarily be a Level 3 at Year 3 because there is a discrepancy between what they need for a Key Sate 1 level and a key stage 2 level and there is also a discrepancy between maths and science that how do you know that that child is working at a particular level across the board? Because there are so many areas in maths and so many areas in science that you can't say for definite that that child is a level 4. You can say that on that day with that piece of work they are a level 4. And the other problem with SAT testing is that it is comprehension based and we have children who can't read, their maths is super but can't read. One have one child here whose maths is super but whose comprehension skills are absolutely appalling, although we can help him by giving him a reader because his reading skills are sufficiently low that we can do that.

Barriers?

DB Do you feel under pressure as a teacher?

Restrictive NC

J Horrendously under pressure. We are the top school in [name of LEA] so the pressure is on me, not just to get level 4s, but now to get level 5s. Because our children come I with a good baseline the authority say that they should be at X by the time they get to Year 6 and we have to meet that as far as possible but sometimes it's unachievable.

DB And what happens when it isn't achieved?

J Well, ultimately, if it were such a big gap we could have Ofsted back in or we could have HMI in, or we could have the authority in saying '*well, why not?*' It's not in terms of getting sacked but there is pressure.

DB That must impact on your teaching?

J It does but it's not a bad thing because you are aware of levels, so you are aware that what you are teaching is what the children need to move them on.

Barriers Restrictive NC time/content

DB And do you feel under pressure to get through the topic, whatever it is, quicker than you would like?

J Well in terms of the Numeracy strategy, you only have a certain number of days to do that any way. It would either be 3 or 5 days to teach whatever. The thing we are teaching at the moment is data handling and probability, in a week. So, in terms of finding out where the kids are and working with them to improve them I that area, you are limited in the amount of time you've got to do that. So, if on the Friday, so and so still doesn't understand probability, you going to have to try and find time somewhere in your oral/mental starter or at the beginning of the lesson to bring that out or use another strategy because you can't say I won't start addition and subtraction on Monday because they didn't understand on Friday. Otherwise, you would fall so far behind. You would need to pick it up elsewhere or try to use the cross-curricular type of teaching so you can engineer it.

DB When marking your pupils' work, do you give them marks out of ten or do you sit them down and talk to them?

AfL

J Well, the marks out of 10 or 20, no. That would be reserved for SATs or things you need numerical data for, spelling, where they actually enjoy getting a mark and that strives them on but in terms of marking within the books I use more of a formative assessment strategy so the work is marked, obviously, but there will be some form of positive comment and then some form of what they need to do to improve. So, it's like a good comment and a wish or a target, so it's not just so many marks out of ten.

DB Do you ever use the 'critical incident' technique? Have you ever heard of that?

J No

DB Thanks [name], I've really enjoyed this morning.

Interview Two (Tuesday 8th November 2005)

This interview followed a lesson that dealt with the twenty-four hour clock and appreciating different times around the world and relates to Lesson Two set out in *Appendix V.*

DB Well [name], how did that go?

J That was frantic. I think they all got it in the end, from the evidence of work that I saw they all understood the concepts but there was too much of the twenty-four hour clock and not enough of discussion around the map and the time differences.

DB And where did that come from, that problem?

J Me. I was the main problem because I just spent too much time with the games at the beginning assuming that they wouldn't have had as much knowledge of the twenty-four hour clock as they had.

DB So you were surprised by how much knowledge they had?

J I was.

DB I think they enjoyed that though, didn't they?

J They did, yes. So it's a balance as well. Too many concepts and perhaps…well, I would argue that they do need to know why the time difference is there, so when I was planning the lesson I thought I've got to put a bit in a bit in about the reasons why, because you can't just say '*there are time differences*', end of story, there's got to be an explanation and I think sometimes they look for the harder solution to something than the easier solution. So when we were talking about how would you calculate the time we had four different ways of calculating the time, the last one was the easiest which was simply to count the bars across the map, but having said that some of the ones that did do that miscounted the bars. Now that is possibly an inaccuracy in the sheet.

DB When they are assessed, on that, what type of question would they be asked? For instance, would it be a subtraction question or a ….?

J I don't know, to be honest, whether they would be assessed on that. If you are thinking about assessment as in SATs I've never seen a question on time differences in that context. The time difference might be simply that '*It is this time in the UK if X is five hours ahead. What time would it be?*' It would be as simple as that. But that would be too easy for the able ones so that's why I chucked in the flight times and that would be about right for the poorer ones, or the lower ability ones.

DB And you had them both together this time?

J Yes.

DB Why was that?

J Only because now I am an AST I am released on a Thursday so we have a shared class Mondays, Wednesdays, and Fridays because we identified that there are quite a few children who need extra support. So the easiest way for us, because there was such a percentage, was to split the class. And then you could guarantee that they would be getting focussed support.

DB There was something I wanted to talk about that you raised last time we spoke. When we talked about managing the Numeracy Hour you talked about the need for it to be '*flexed*' and if you'll allow me I'll quote what you said. You said '*Year 6 need more time to work and less time for me to talk*'.

J I know and I did the exact opposite today.

DB But it seems to me that it is about trying to get the balance between '*Have I talked enough to get them to do the task or have I just thrown the task at them?*' Now when I read that I thought that was very interesting. How do you manage that balance?

Didactic tension

J You can't. [laughs]. It's as simple as … so today there was more talk because the concept didn't 'click' as quickly as I'd hoped. I'd hoped that it would 'click' so almost … the way in saying '*there is a method, there is a method, there is a method*' is possibly not the best way. It is possibly better in this instance to say '*This IS the method*'. So we are almost going away from what we've said about constructivism to a more didactic approach and saying '*this IS how you do it*'. I think another example would be fractions because fractions and particularly addition and subtraction of fractions and things like that, they just need a method.

Didactic tension

DB So you are saying that there are some instances where you have to forget about teaching in a constructivist way altogether?

J I'm saying from a class teacher's perspective and ease of teaching, … yes. And others lend themselves beautifully to discovering methods. Having said that, it's possibly more a criticism of the Numeracy Hour and the time that we have to do it in because according to the National Numeracy Strategy I have a day to teach that and yes I could bring it up in other subjects but in the Numeracy Hour I have a day to teach it. Even if I took it to two or three days I would have missed out the other bits and pieces that I need to teach them that week so I would then have a difficulty in fitting in the next. But we are looking at that as a school. We are talking about doing away with this time for teaching separate units and actually chunking all the Numeracy together so all of your fractions would be taught in one block and apparently, although I haven't looked at it, there is research that says that the children retain more focussing on fractions for, say, a month than they would focussing on it for a week, four times in the year.

Barriers to Restrictive NC

DB And doing that would allow more time to ….?

J Well, it would consolidate and it would give you more idea of how the children were doing because you would test at the beginning and you would test at the end, formally or informally, whatever way you want to do it and then you would have a definite picture of how they had improved whereas at the moment we are just throwing things at them almost and hoping that it sticks. If it sticks, great. If it doesn't stick, we are frantically trying to find time to fit it in. Last week, as an example, we did some work on triangles and my kids didn't have a clue, not a clue in the differences between triangles and that is an assumption from me because they should have done it last year. So I then had to try and find time which I did the following day in an oral/mental starter, looking at properties of triangles but it is that 'eating in' of things that isn't ideal. So if we had more time to concentrate on something we would then have more time to build up and really assess how they were doing on that particular subject.

DB You said earlier that there are some aspects of the curriculum that lend themselves beautifully to this constructivist idea, can you give some examples?

J Erm, certainly Shape and Space. Anything like that. So, if you're talking about properties of shapes, tessellation, that sort of thing, great.

DB But do you still find you still have that tension between allowing the children to discover what it is you want them to discover without actually giving them the answer and making sure that they actually get the point in the end?

J Yes. Yes. But having said that, the session we had last week on quadrilaterals they were just given the shapes and asked to find the properties of the shapes from the shapes and they just spent the time doing that and so they were then just discovering it for themselves.

DB And did they?

J Oh yeah. Very much so. But again, the able ones did, the less able ones didn't because the less able ones didn't have the understanding that '*those angles are equal*' or didn't have the skill to measure them accurately enough to find that they were equal or know that there were parallel lines, etc.

DB Is that frustrating for you then? As a teacher who wants to teach like that.

J No. It would be nice to …. No, because they are learning at their level. We could almost be saying that the more able would take to constructivism more easily than the less able or we could have two separate … not curriculums but two separate objectives so they are actually learning at their level. We've got another tension here in that we are teaching kids things when they don't have the basics so if we were properly constructivist then they would be learning at their level and the more able ones would be learning at their level. At the moment, they are learning at their level but we've got to support them to make sure they can learn at that level. So, I'm putting the scaffolds in, but I'm not really developing the underlying skills as much as I would like to.

DB Do you think the National Curriculum has been a good idea?

J Yes, I do think it's been a good idea because pre-National Curriculum people were teaching whatever they wanted whenever they wanted and they were just forgetting about ... but what I do think is the problem is unit plans, the QCA schemes. We've gone more down that route so the National Curriculum states the set of objectives and then teachers can put any theme to those objectives that they want, they didn't, that was the problem, or they didn't do it quickly enough, they moaned, they complained, whatever. The QCA said '*there are some schemes, follow those*', and everybody took them as gospel and followed them to the letter. Some of them are absolute rubbish and some of the themes don't fit with what you're doing. They don't make cross-curricular links, they are not interesting for the kids. So what we are doing is we are going right back to the National Curriculum and looking at the key skills within the National Curriculum and taking those key skills and saying '*right, it doesn't matter whether you teach through a QCA scheme or whether you've got a visiting artist in or whether you fancy doing something on* [name of local place] *because you are going to be doing work with your international school, as long you are teaching those key skills, that's it, that's great*'. Your fall back would be QCA but if you want to be more adventurous or if you want to make the links between the subjects, use the key skills. This guy called [name] has developed these key skills and when you look at them and match them to the National Curriculum they are virtually identical but what they also do is they focus on, not just the skills for that subject, so if you take Geography, not just geographical skills but there will be mathematical skills, speaking and listening skills and ICT skills, and social skills and group management skills within the key skills for Geography. So really, if you just teach the key skills for Geography you also hitting literacy, speaking, listening.

DB Is this a nationwide initiative?

J No. It's something new that's just come out. The Head went to a conference on it. So we decided that this was definitely the way forward because a forward-thinking school can't be stuck with these QCA schemes. They have to be thinking '*what can be exciting for the kids to do?*' Because the schemes aren't ...they can be made exciting but it's probably going to take more work to make those exciting than it is to say '*right, let's move to the key skills*'.

DB Is it an 'off the shelf programme'?

J No, you just get the key skills and you have to do a lot if work around them. An example being, next year it is the Church's 250th anniversary. Where does that come in the curriculum? It is really important for the kids of this parish to know about the church. Yes, you could fit it in with your literacy but if it was history and it does fit in with the key skills, why not just teach that instead. Why not take two weeks out and as long as at the end of the term you've finished those key skills and you can say that the children have had experience of all those key skills.

DB What about the assessment that might come after? Do you worry about that or not?

J No, because if we link this with the chunking of the curriculum you can then have more idea of where they going from and to. But also, these key skills are levelled so it takes the worry away from '*Am I teaching the right level?*' because if you are teaching the correct skill you know that that child has learned a Level 4 skill and if they can do that you can say '*that child, Level 4*' or again match up the number of skills that they've got and say that they are roughly working towards the end of Level 4 or the beginning of Level 5.

DB So where did he get the Levels from?
J The National Curriculum. But it begs the question '*who put the levels in?*'
DB Because the levels imply a sort of average pupil.
J Yes, well nationally, that is what they say. The expectation for Year 6 is Level 4 or it was, it is now Level 5.
DB Is that Level 5 nationally or Level 5 for you?
J It's tongue in cheek because it IS Level 4 but Level 4 has sort of passed by now. There was a time when the schools were happy that they all got Level 4s – schools nationally.
DB Well, that was the requirement, wasn't it?
J That's still the requirement but they are now considering publishing Level 5 results as well as Level 4 results so that would indicate to me straight away that the government are saying Level 4 isn't good enough, it's Level 5 that we now want.
DB It's strange that at the outset of the National Curriculum, it was implied that Level 4 was the level that an average pupil of that age would get but it's changed somewhat, hasn't it? It's now not what the average gets, it's not 50% above and 50% below, it's what's required.
J Yes, definitely
DB Thanks again [name].

Interview Three (Wednesday 1st February 2006)

This interview followed a lesson that dealt with the use of all four mathematical operations in solving problems in 'real life' and relates to Lesson Three set out in *Appendix V.*

DB [Referring to an aspect of the lesson just observed] I got the answers to the task completely wrong. I'd written down the answers, what I thought were the answers, but they were totally different from the answers you gave at the end.

J So which bit ...

DB I'll tell you why I got them wrong. I misunderstood the question. I thought the pocket money was the pocket money they had got from their parents and that they would donate to the cost of the trip.

J Yeah, I understand that....

DB So in effect I deducted the pocket money from the cost of the trip instead of adding.

J Yeah, I suppose it was me just thinking that the pocket money would be something they would submit to the cost.

DB If it had been identified as 'spending money' rather than 'pocket money' I think I would've interpreted it correctly. I wondered if, as you walked around the class, did any of the children struggle with that or is it just me?

J The ones that you would call the middles to the bottom struggled but I don't think that was the actual concept, it wasn't because of that. I don't know, it might be a local thing. Obviously the way that problem was built up was to make a multi-stage problem to reinforce to them that they must have accuracy all the way through, there were very few that actually got through the multi-stage problem that they had on the sheet because they brought an error into it straight away. Strangely enough the biggest error was when they did 90 times 30 pence, a load of them, they did it as 9 times 30 pence

DB 9 times 30 pence, what was that for?

J Not the one that was on the board it was the multi-stage problem that I gave them, I'll give you the sheet. They did 9 times 30 pence instead of 90 times 30 pence and most of them put £2.70 as the answer and that threw their sum completely.

DB Let's talk about the 'School Trip' problem then. Did any of the children work out the problem both cumulatively and as separate problems? For instance, the second part said that the cost of the coach had just gone up by £50 so how much would it cost each child now? They could've just added a pound onto the previous answer.

J Which is what we did but what I was battling with was my middles and my less ables not seeing the link or questioning themselves that it can't be as easy as £50 and 50 people, therefore it's a pound and this is where we come back to the 'talking partners' and the security of the 'talking partners' and them worrying they are going to give the wrong answer so just not saying anything but when they talk with their 'talking partner' they suddenly think *'well hold on a minute, she's saying the same as me, therefore it must be right'*. So after 'talking partners' I have a lot more people putting their hands up.

DB How are the 'talking partners' paired?

J Well they are paired by ability just as they are but for some sessions we would pair them able with less able.

DB But that wasn't the case today?

J No. Because the question on the board was really aimed more at the middle, it was far too easy for the more able.

DB And the more able are seated at the back of the classroom here?

J Yeah, you have a large band of about 15 children that are towards the more able side and that are working towards the level 5 bracket whereas you have your middle ones

that are in the middle of your level 4s and your poorer ones that are low level 4s if not level 3s.
DB So how did you think the task went then?
J It is very enlightening for me, do you mean the task on the board?
DB Yes.
J I think it was more confusing for them than it was any thing else.
DB Why was that then?
J I think it was just the way it was presented. I think putting that number of questions together, they were thrown. One girl at the end said '*Is that SATs? Are we going to get more of those in SATs?*' And '*No*' is the answer so I think they are getting used to sort of SATs questions where you really only have a two stage problem.
DB Were they thrown by the fact that it was a multi-stage problem or was it the wording of the task?
J Possibly.
DB As I was looking around I saw some puzzled faces and actually when I put my answers down, I put several answers down according to whether you included the pocket money or not, and I was perhaps thinking about things too much and I wondered if the children did the same.
J They didn't seem to. Certainly when we had the answers coming back they were fine.
DB Because there is a history of badly worded SATs questions.
J Yeah, it's comprehension
DB And children are penalised because they have misinterpreted the question.
J From the answer I was getting back it seemed fine.
DB Let's move on then. I wanted to pick up on something you said on a previous occasion. You said you disliked league tables but that SATs gave you a lot of valuable information about the children.
J Yes.
DB If we've got to have SATs, do you think that they should be standard, or standardised?
J In what sense?
DB Well, each child gets the same SAT paper.
J Yes, unless somebody that's very, very clever can sit down and can create levels within papers. So that if you knew that a child was a level 3 you could give them a level 3 paper and then it would give them a proper level within that level 3. If you knew the child was a 4 you could do the same. Now they tried this in lower Key Stage 2 but it didn't work. If the child gets to a certain level, it gets a certain score on the first paper and they are then allowed to go on to the second paper, so effectively it's a level 3 paper and a level 4 paper. It doesn't work because the questions on the second paper sometimes are easier than on the first paper, you are not taking into account the broad spectrum of maths so a child may not be able to do the addition and subtraction of the first paper but could do shapes, space and measures questions on the second paper no problem at all. I think the way the SATs are is fine because I think in n terms of the question papers, yes, you need to teach to the test and yes if you just gave it to them cold they would do really, really badly. The reason I like them is because the majority of the children, whether they are good or not so good, can attempt most of the questions so I think they've levelled the questions quite well, they've sort of hit them for the middle. I mean one girl today, who is a middle level 4, answered an algebraic question for her homework because we had done a little bit in class and she'd had a bit of support from Mum so she'll remember that. So there needs to be a balance there.
DB Because the SATs give you the ability to compare children, is that important? I'm just trying to figure out how SATs as a way of assessment fits in with this idea of constructivist teaching and learning given that ...
J I don't think it does [laughs].

Real WV
contact beliefs

DB Why?

J Why do SATs not fit in with constructivism? Because children aren't really guiding their own learning, we are guiding their learning for them. If, once they had done the SATs test, the children could identify the areas for improvement themselves .....

Contradictory beliefs (see other comments)

DB Let me say that I absolutely agree with you, I think SATs don't fit in with the idea of constructivism.

J No but having said that a lot of the emphasis that I put on SATs now is for the children to identify their own areas for improvement, to look through the question papers, to say to themselves '*right, I struggled on .... coordinates. So what I'm going to do is I am going to do find out how to do that, I am going to do some revision on that area, I am going to come and talk to my teach, I am going to come and talk to my Mum and I am going to improve that area because I know that that is a weakness*'. So in a sense they are guiding their own learning and those ones that are self-motivated are doing wonderfully because they are picking up areas that they need to improve on. So in that sense, yes it is, but in the true sense of the word, no, it can't be because the children aren't really guiding their own learning far enough.

DB What type of assessment would be consistent with it then? What could we do? If we agree that children learn best by constructing their own conceptions of things ....

J Well ideally, it would be like a portfolio-based assessment, that's the standard answer.

DB Do you think that would be possible?

J No. In schools, no, definitely not ... unless ... that was what my [name of qualification] was on producing a portfolio-based assessment for [name of subject], that worked to a certain degree but it was very, very messy, lots of kids, lots of bits of paper, and it becomes very unwieldy. However, if we took and broke down the standards for Year 6 maths, the objectives effectively, but now your then saying 'objectives' and you're then going away from the children constructing their own learning because you are imposing on them a set of objectives, but if we forget about that, if we took the objectives and if we then had children needing to produce pieces of evidence to match those chunks of objectives or whatever, that would work in a sense but then arguably how would you guide their learning towards those objectives?

DB Alright, maybe it wouldn't be perfect but would it be more consistent with the idea of constructivist teaching and learning than SATs?

J But SATs are not the only form of assessment that we have although they are the ultimate form of assessment for Key Stage 2. Yes it would be much better because then we'd have more chance to really reflect the child's level and really for the child to be saying '*this is what I need to improve throughout the year*'. Whilst we have targets and whilst most schools have targets for the children to achieve because the teacher is guiding their learning all of the time the children struggle to really meet their targets that are set. You either have the scenario that they are so incremental targets that it's unmanageable because the teacher needs to be on at the child all the time or you have them so broad that they don't work at all. It would be better.

DB And achievable? Workable?

J Some schools are using that sort of thing anyway but not in a true constructivist sense but then no schools really are following true constructivist teaching, they are doing some elements of it but the fact that we have a National Curriculum that specifies in such detail what the children need to learn means you can't set the child off on an open-ended task and then reign them back because they are going in the wrong direction.

Restrictive NC

DB So what you're saying is that truly constructivist teaching and learning is inconsistent with the National Curriculum?

J With our prescribed National Curriculum, yes. The National Curriculum that is as prescriptive as we have, yes. If it was slimmed down or if it was mixed ... I have this vision in my mind of all these objectives and if you could sort of wash over them

Restrictive
NC

to make a general mash of what they need to know roughly, not specific objectives, then yes you could engineer learning for the children within that sphere, say electricity, you know there are so many prescriptive things, you couldn't direct it towards that but as a general overview then you could directly aim them towards that. So I think it needs to become less prescriptive for it to become truly constructivist.

DB Let me quote to you a writer who thinks that constructivist teaching is possible in schools and see what you think. He argues that a constructivist approach to teaching would be one that: '*First considers what the child already knows, by perhaps using a test task that requires the children to use this knowledge. Secondly, takes account of previously published research findings that reveal the alternative conceptions or misconceptions shown by children of that age, thereby alerting the teacher to the possibility that some of his or her pupils may hold the same misconceptions. And thirdly, brings a child's awareness to any misconceptions diagnosed by the previous two steps*'. (Selley, 1999: 16).
I have several questions. I'll come on to the others later but the first is, is that possible?

J Within constructivism?

DB No. Is that possible for you as a teacher now?

J Yes, we are doing it?

DB All of those things?

J What we are doing, not with the numeracy but with the literacy, or what we are playing with at the minute, I wouldn't say we are doing it across the school, is at the beginning of a unit of work we are getting the children to write a cold piece of whatever, a narrative piece of report writing, we are then aware because of the broken down levels that the children are working at and because we have frameworks, we are aware what the increments are between those levels, so that's effectively the misconceptions, you know the children at that certain level will not be including speech marks for instance or they won't be including commas in lists, that is how I see the misconceptions.

DB And where have those misconceptions been identified from? Because he talks about '*...previously published research findings that reveal children's misconceptions...*'.

J Well, I am assuming that it would be ... I don't know if anyone has done any specific research on the level of children's understanding within literacy and breaking it down, it's something that comes to us, probably from SATs, well in fact, it is from SATs. From SAT testing they break down and they know levels and increments between those levels.

DB So the misconceptions are identified by previous attempts at SATs questions?

J I am only seeing misconceptions in terms of where that child would be at, so a child at that level would be writing in this particular way, it's all best fit and all a bit airy fairy at times but if you are writing in that particular way you then know what the next stage is for them to improve, it's incremental.

DB Literacy is not my thing so let's leave that to one side. So you saying you are playing with that in literacy but not in numeracy?

J Yes, but we are looking to, and I mentioned this last time, to chunk the curriculum. If we chunked the curriculum and taught addition and subtraction for a block of time that would work but it is unmanageable to do a cold piece of work on the Monday, set targets with the child and expect them to reach those targets by the Friday or in some cases by the Wednesday, because we teach five day blocks or three day block of numeracy and the next week we could be onto shapes, and the following week we could be onto coordinates and then we could be back to subtraction, so it's all over the place. We do have targets but the targets because they are so specific to numeracy areas, they don't work. Your target could be addition and subtraction bonds to 100 and they may not come across that for 3 or 4 weeks so in a term you might only meet it once, so if they only meet it once it's difficult to get that target met.

DB As it currently stands do you do the things set out in that quote.

J Am I doing what they are saying there? No.

DB Selley thinks that constitutes constructivist teaching and it involves those three steps. Is that what you are currently doing?

J No. But I would argue against his view of constructivist teaching because I don't think ... how can you be truly constructivist if you are *telling* a child what to put right, because he is saying to the child '*look, this is what you are doing wrong*', before, as I see it, before they've even had a go. My vision of constructivism would be that the children start with something and through discussion with the teacher and with their peers, find their own errors.

DB Well, just to support Selley here, I'm not sure he means that. First he says '*consider what the child already knows*', you are already doing that, I know you're doing that, I've seen you do it.

J Yes.

DB Secondly, and this is the problem I had with his viewpoint of what's possible, he says the teacher also '*...takes account of previously published research findings that reveal the alternative conceptions or misconception shown by children of that age, thereby alerting the teacher to the possibility that some of his or her pupils may hold the same misconception'*. He is still giving them the opportunity to try things out and develop their own strategies ....

J But he then says '*... and sharing those misconceptions with the children?*'

DB And thirdly '*...brings a child's awareness to any misconception diagnosed...*'

J Right. '*brings*'. Different to '*tells*'. Right, fair enough.

DB I'm not disagreeing with you I just want us to agree on what he is saying here.

J I know.

DB It's not the first step I have trouble with.

J I know, it's the second step.

DB Yes, its the second step I have trouble with. It's this '*...takes account of previously published research finding...'*. I wonder whether teachers do that?

J No.

DB Not because they don't want to do it but because they haven't got the time to do it?

J No, definitely not. It's only when it filters down from academia, down to either local authority level or whatever. An example being the grid method for division but thinking back 4 or 5 years that wasn't in primary schools. Chunking, division, that wasn't in primary schools. Now somebody has obviously researched this or somebody has obviously researched the calendar starting at the left hand side as opposed to the right hand side, that's a popular misconception. It's those sorts of things but unless it's delivered to the teacher through a course or unless the head teacher is sufficiently forward thinking to jump on bandwagons like we're doing with these key skills, they will never know.

DB There are analyses of SATs that come out the year after that identify the problems children have had with particular questions. Do you ever pick up on that sort of stuff?

J No, if I'm honest. I read it but that tells me how badly the children last year did on last year's test. It doesn't tell me how where the areas are for improvement in my teaching. What tells me the areas are for improvement in my teaching are testing my kids now and me doing similar analyses of those tests.

DB Would they not alert you to the possibility that those misconceptions might occur again in your next cohort of pupils and you could then perhaps adapt your teaching accordingly?

J Yes, but it is the '*might*'. Do I do things twice? Do I plan a set of lessons which target those misconceptions and then plan a separate set of lessons that target the misconceptions that I find from my own SATs analysis? Or do I just target these kids. Now I think these kids are far more important and it would save me the time of doing it twice.

DB Do you think he is being a little optimistic there in what he thinks teachers have the time to do?

J It gives you heart that that is constructivism because you can be constructivist in lots of different ways. So by doing some of those things a lot of teachers have elements of constructivism but it's the actual children exploring their own and finding their own meaning in the classroom that is the difficult bit and he doesn't really come across that, he doesn't really acknowledge that.

DB There are lots of elements of your teaching that I would class as constructivist. Even today you were allowing children to try out the own strategies and methods before coming around and maybe guided them to the one that you though may be least problematic for them.

J But then the Numeracy Stratgey as it stands is constructivist because that's where that comes from. There is no enforced method, there isn't one method that is right. If you look at our school calculation booklet you can do division umpteen different ways, you can do multiplication umpteen different ways. It is whatever the child has got at their stage of development. Yes, we teach different methods and yes we would encourage children if they were still adding by partitioning, that would be one. If they were still doing that I would be encouraging them to move forward to the compound method but only because I am aware of SATs, if we didn't have SATs in then really it is what method is best for the child..... But we can't set effective targets and work towards effective targets in 5 days, give us 3 weeks and that's a different matter.

DB But you don't have 3 weeks?

J Well, that's what we are looking at, chunking the maths curriculum but you have the problem that you might only visit fractions once in a year. Now in terms of retention, that's a problem. Really we need to come back to the revision of the numeracy strategy, which is coming in mid 2006 and see whether that makes it easier but I don't think it will.

DB I think that's it [name] for today. Do you have any questions for me?

J No.

DB I did want to ask you whether you feel our discussions are being useful in helping to develop your thinking?

J Ah yes, definitely. That quote has got me thinking.

DB That's good because one of the aims of this process was to help develop your thinking about your teaching.

Interview Four (Tuesday 28th February 2006)

This interview followed a lesson that dealt with the reflection and rotation of shapes in four quadrants and relates to Lesson Four set out in *Appendix V*.

DB Well how do you feel that went?

J They enjoyed it. They were far more enthusiastic doing that than they were doing the sort of paper-based exercise. The test will be whether they have actually learned what they would have learned with the paper-based exercise.

DB From what you saw in the end what's your feeling about that? Do you think they got it?

J Some of them, not of all, not of all by any means but going round in the independent bit some were still struggling to see almost why we were doing it, not in terms of they knew what they were doing but in terms of '*I don't understand why I am rotating this shape*' and I was trying to get across to them that we just need to see what we can find out.

DB And is that why you said to me during the class that you would usually have employed a lot more structure ....

J Yeah. So, in a sense, although that wasn't wholly constructivist, if we want to move children forward quickly we can't allow them to go off on their own tangents, we need to give them structure to make sure they focus. The likes of the ones across here [points to part of classroom where the more able pupils sat], the likes of [name of pupil] and [name of pupil], not a problem.

DB Did you see them have their 'Eureka' moment?

J No.

DB It was fantastic, they got so excited. You were over here and one of them suddenly said 'I've got, I've got it' and they all started arguing to see who could be the first to write the rule down.

J That's the bit you want to keep and that's the bit you want to give to all of them but it is just unfortunate that some of them, I mean even one of the brightest ones over there [points to part of classroom where the more able pupils sat] fell foul a couple of times. Her first shape was too big to rotate, her second shape she rotated incorrectly, she didn't rotate it around the origin. She got it in the end but she was almost last to get it, it wasn't the actual understanding of it, it was just the mechanics of the rotation of the shape. They are all more confident at rotating and reflecting shapes.

DB You said that they enjoyed the lesson, did you enjoy it?

J Erm, through them, yes. In terms of what they have actually produced, no. Because, ideally, don't do the first bit and just launch into it, less talk but then ... I am trying to sort of free up time because if we had had time at the end, which we didn't have, then we could've got them to write down something, something they had discovered from today and that would've then been sufficient for me to be happy with what they produced. At the moment what we've got is a collection of sheets that, some of them have got a rule written on it which is accurate, others are still in the midst of things.

Barriers
↳ working practices

DB Why is it important that they write something down? Is it so they can go back and look at it?

J No, to satisfy the 'powers that be'.

DB Because they come and look at the books?

J Yes, they would be asking questions like '*what did the children do on this day?*', '*why have you got a day missing?*' If I say '*we did a practical activity that day*' they ask '*where's the evidence for that practical activity?*' It's wrong. It is wrong.

DB So would you say you are torn?

J Horrendously torn, horrendously. My favourite year in teaching, which was a while

Desire to teach in Const way

ago now, when I look back that was a wonderful year, there was lots and lots of practical stuff and I didn't care about whether it was recorded or .... and the kids learned a massive amount, not just in terms of singular subjects but in terms of the inter-connectedness of subjects as well because it could be truly cross-curricular. You know, we would look at one thing in Science that would then reflect in their English, which would then reflect in their History, which would then reflect in their Maths. I they really got the inter-connectedness, now because it is so compartmentalised, we are losing that inter-connectedness.

DB Do you think the children sometimes prefer to have it more structured, in effect, to be told what do and how to do it?

J Certain children, yes, but [name of pupil] there, who was probably one of the first to get an answer, that 'Eureka' moment, give him a sheet [structured] and he doesn't function as well. He is very spatially aware is [name of pupil] as well which obviously is a help but if you'd asked me at the beginning of the lesson '*who's going to get this first?*' he wouldn't have been top of my list, he would've been way down the list. I would have thought somebody like [name of another pupil] who was still messing around with the method of it, would have got it first.

DB So you're saying that that type of teaching is more suited to particular types of children?

J Yes.

Desire to teach in Const. way (explicit)

DB Would you like to teach more like that? From what you said earlier about your really good teaching year ....

J Yes, I would prefer to have more .... Given that we had more space, more time, given that there wasn't an expectation every day to have something in the book which resembled work and which was monitorable, an actual answer, something to tick or something to mark wrong, something that that child has achieved or that child hasn't achieved, yes I would love to but all that would have to disappear first.

DB Are we back to the requirements of the National Curriculum?

J Not so much the requirements of the National Curriculum because I think that could be taught in a more sort of open way. It certainly couldn't be taught in the amount of time, you know you couldn't have three days on rotation and reflection and say to little Johnny '*sorry, I know you haven't understood it but we are now going onto multiplication*'. If we could stretch that as well but this is coming because the new revision of the Literacy and Numeracy documents is advocating more of an open approach and more of a chunked approach that we talked about, when they come out in March, April, May time. They are actually saying '*you should be teaching a few weeks of addition and subtraction so that you can actually see progression in the children*' as opposed to teaching it for a week and not seeing that much progression and ten having to play catch up because they didn't understand.

Barriers → Restrictive NC working practices

DB But as it stands currently, the need for the children to have something in their books prevents you from teaching that way?

J Yes. Well, I wouldn't say it prevents me, it hinders me. It wouldn't stop me. Given a restructure of today's lesson we could've come up with something that was super that they could put in their books that I could tick, that I could comment on, that I could give them a target for improvement on but they would still have done something that they had investigated themselves. It is going more towards investigative maths but there is then that conflict against you can investigate but when do you actually tighten up on the mathematical skills as such, the basic mathematical skills.

DB Was that the first lesson of the year that used an investigative approach?

J Erm no but I would erred more towards Shape and Space type of thing not, although that was partly Shape and Space, because it was co-ordinates I wouldn't normally have said '*say what you see*'.

DB So you would normally choose something that was more amenable to that type of investigative approach?

J Yes. And I would very rarely go with the addition and subtraction or multiplication and division type, or fractions, although the more you think about it the more the more the possibilities appear in your mind and the less opportunities you can see for saying you can't do it.

DB I think you were surprised by what you got from the children today.

J Ah yeah. Yeah, very surprised. Like I say, disappointed with some that I thought might have got it. It would've been interesting to have got them to work individually and see how that went. I certainly don't think it would've worked as a big group because they then start arguing with each other about who is right and who is wrong.

DB We're coming to the end. Do you think your philosophy of mathematics, because that's what I've been trying to tap into over the last five or six months, I wonder if that's developed over that time that we've had together?

J Ah definitely, definitely. If only to reflect on my practice and to say '*where would I like it to go?*' which is what we've discussed. I would like it to be more of a constructivist way of teaching and looking within the bounds of what we've got I certainly think that once we have more time within the curriculum to teach a particular subject then there is no reason why it can't be more investigative, more constructivist.

DB I wondered before I entered this Phase of observing and interviewing teachers whether they would hold a well rounded philosophy, one which could be easily communicated to others. You all seem to have a philosophy but how well rounded that is, how well developed that is, and how easily communicated that is to others, is another matter. I wonder, do you feel that you had a well rounded philosophy of mathematics before we met?

Tacit beliefs / EWVs

J Possibly not. I always think about my practice and always try and make it so that the things that we are doing, not all the time but as far as possible, will be what the children like to do. So, probably not is the short answer.

DB But do you think it has developed?

J Ah definitely. Ah yes, yeah, yeah, because any reflection upon practice and any professional discussion with a critical friend, which is effectively what you've been, challenging what I think, makes you think further. It would be interesting to see whether in six months time or this time next year whether things have changed sufficiently to allow me to do that or whether, I can manipulate sufficiently to make sure that that happens. I would also have been interesting to have had the less able in [the classroom] and to see how that worked in the scenario of things because you had kids that were motivated to go towards the task and knew what they were doing and could achieve all the tings they needed to achieve within that, for starters they could all do co-ordinates, because it falls fouls when they can't. I suppose I could support them in that and work with them on that but that would then take me out of the equation for challenging the others like [name of pupil] to get his solution down to a readable sentence, which he did.

DB But isn't that the nature of the investigative approach that it just suddenly clicks and they get it and I wondered how close the others were to that moment.

J Yeah.

DB Well, thank you very much [name], that's all I've got to ask you.

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