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Interactive teaching in the National Numeracy Strategy: tensions in a supportive framework

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INTERACTIVE TEACHING IN THE NATIONAL NUMERACY STRATEGY: TENSIONS IN A SUPPORTIVE FRAMEWORK

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Interactive teaching in the National Numeracy Strategy: tensions in a supportive framework

by

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Interactive teaching in the National Numeracy Strategy: tensions in a supportive framework

Abstract

This thesis is an exploratory study of teachers' and children's understandings of the National Numeracy Strategy, and of *interactive whole class teaching* in particular. It starts by identifying aspects of the Strategy that are of significance to teachers and develops these by detailing the challenges that face them in teaching in this way. Data are collected by means of interviews and classroom observations, progressively focusing the study. In particular, the way in which teachers and children understand the role of *discourse* in whole class discussion is examined. This understanding illuminates a tension between the rhetoric of the Strategy, which appears to promote a view of learning that is based firmly on negotiation of meaning through discourse, and its practice, which is seen to be little different from forms of pedagogy that have preceded it.

The contribution to knowledge made by the thesis is represented by several features. First, it lies in the detail of the exploration of the interaction between teacher and children, illuminating new ideas about the nature of such interaction in the context of whole class teaching. Though discursive interaction has been examined in some depth through previous studies, few have done so in this context. Second the study's findings relate specifically to the National Numeracy Strategy and again, in complementing other recent (mainly quantitative) studies, it therefore relates previous theory to this particular contemporary initiative. Third, in addition to new knowledge in the field of class interaction and mathematics pedagogy, it develops a novel method of data collection from children, making use of video of children's own involvement in mathematics lessons to stimulate reflection in interviews.

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Author's declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award.

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Throughout the study, internal seminars and external conferences were attended, including, in relation to the latter, the British Society for Research into Learning Mathematics.

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Chapter 1 – The National Numeracy Strategy

Introduction

In September 1999 the National Numeracy Strategy (henceforth referred to as 'the NNS', or simply 'the Strategy') was formally launched in schools by the Labour government of the time and the Secretary of State for Education, David Blunkett. Its introduction, in the wake of the National Literacy Strategy a year earlier, signalled a significant change in approach to the teaching of mathematics, both in terms of its focus – with a greater emphasis on numerical calculation – and its pedagogical practice. Politically speaking this was a crucial time for a 'New Labour' government that had come to power two years earlier, after 17 years in opposition, and was desperate to be seen to change things for the better. A sense of this drive is gained from a letter from Blunkett to all teachers in England in September 1998 in which he stated that 'this will be another important year in our crusade to raise standards' and that he 'held out the prospect of a new beginning - a chance to rebuild (sic) pride in the teaching profession and to offer the very best to all our children' (Blunkett, 1998).

This drive to 'raise educational standards' had been fuelled by a number of things. In the wider picture it can be seen as part of the reform of education generally that had taken place so intensely over the previous 15 years under the last Conservative government. This included the introduction of a National Curriculum (subsequently revised twice) with statutory testing for 7 and 11 year olds, the replacement of Her Majesty's Inspectorate (HMI) by Office for Standards in Education (OfSTED), a new National Curriculum for teacher training (Department for Education and Employment (DfEE), 1998c; and subsequently Department for Education and Skills (DfES), 2002), the implementation of a mandatory headship qualification, the introduction of *performance* *management* with a strong emphasis on test results as a measure of success (DfEE, 2000), performance related pay via *threshold standards* which require that the pupils being taught show gains in test scores and *Achievement Awards* which paid direct financial bonuses to teaching staff and were designated centrally by the DfEE to schools which achieve exam success.

All these initiatives were taking place in the context of a new 'managerialist discourse' (see, for example, Woods et al, 1997) in which schools were being handed more and more responsibility for their own financial governance, though less and less for their own curriculum organisation. A part of this was a greatly increased accountability, with schools being ranked in 'league tables' according to end of Key Stage (KS) test scores. As a result, schools were being forced, often against their will, to take Standard Assessment Test (SAT) scores more seriously and, in the majority of cases, to change their approach to teaching, particularly in Year 6 as the KS2 test approached (Earl et al, 2001, 2003).

Most fundamentally, rather than leaving the teaching approach to the whim of the teacher, the NNS advocated a particular format for each 'numeracy lesson'. This format was in three parts: an opening section of about 10 minutes for *mental and oral* work, in which the whole class rehearsed knowledge and skills together; a middle section of about 30 – 40 minutes beginning with an introduction to the whole class about a *single* mathematical topic and followed up with individual or group work; and a final *plenary* session in which the whole class discussed their work and tried to make sense of the learning that had taken place. Such has been the influence and universal adoption of this approach (and that of its Literacy equivalent) that it is hard now, writing this some five years later, to remember that classrooms ever operated differently. However, Desforges and Cockburn's (1987) lucid descriptions of infant classrooms remind one that, more traditionally, mathematics schooling was characterised by 'teacher-dominated conversation' and 'the domination of teacher instigated routine paper and pencil work' and that

> classrooms as presently [1987] conceived and resourced are simply not good places in which to expect the development of the sorts of higher order skills currently desired from a mathematics curriculum.
>
> (p. 139)

It should be noted that this quotation is taken out of the full context of Desforges and Cockburn's argument and that they were quick to point to much that was done well by teachers. However it was, in part, against this kind of backdrop, with a perceived need to alter structural and organisational aspects of schooling as well as curricula, that change came about and the NNS was conceived.

In relation to these changes, Brown (1999) notes that political and social processes tend to act in opposition to the current state of thinking on pedagogical issues and she charts the pendulum-like swing of these foci over the last 150 years and the range of government interventions (Brown, 2001). However, as she goes on to illustrate, 'the combined good sense and inertia of the teaching profession had substantially damped the pendulum swings recommended in the past, and no doubt will do so again' (1999, p. 15). Such an observation raises questions about the way in which teachers at the level of classrooms both understand and implement initiatives of this sort and the kinds of pedagogical challenges that accrue. Whilst there has been considerable evaluation of previous initiatives such as the Education Reform Act of 1988 and the National Curriculum in 1989 (Johnson and Millett, 1996; SCAA, 1993; Pollard et al, 2000; Osborn et al, 2000; see also Macnab, 2003 for a general review) the NNS was a new initiative and one that raised very different questions for schools in terms of the extent to which practice was being dictated, as opposed to simply a change of curriculum. It was out of this line of thought, coupled with the circumstances of my own job as mathematics education lecturer having to manage the introduction of the NNS into my own undergraduate and postgraduate teaching programmes, that this study was born. In essence, the focus of research was the question:

How does the National Numeracy Strategy affect the way that teachers view both the subject of mathematics and their teaching of it?

It will be seen, however, that although the research began from this point, like many interpretive studies with an initially open focus, the final direction of inquiry changed considerably throughout the course of the work.

An overview of the study

As indicated above, the study begins, in this chapter and the next, with a *review of the National Numeracy Strategy and its origins*, asking the question of what it actually *is*. Literature relating to this aspect of the investigation is reviewed. After these introductory sections, chapter 3 details the *methods* used in the empirical work, alongside a methodological justification for their use relating to the epistemological basis of the study as a whole. In chapter 4, an open-ended exploration of *teachers' understandings of the National Numeracy Strategy* – and of mathematics more widely – at the point of its inception in the summer of 1999 is reported. Through this exploration a number of areas of interest for further study are delineated, of which one, the *use of whole class interactive teaching* for numerical calculation, is chosen in particular. This choice can be seen, in chapters 5 and 6, to initiate further investigation involving a *case study of three teachers* followed by an *examination of children's perspectives* on their mathematics lessons. In carrying out this work, the study moves from a broad view of some potential challenges for teachers to a progressively more focused analysis of the moment-by-moment dilemmas facing them in the classroom. From these analyses, the thesis concludes by relating the findings back to the theoretical base in the literature (chapter 7), particularly in relation to the way in which *talk* might be used in a whole class situation to make learning mathematics more meaningful, and more successful, for children (chapter 8).

The background to the National Numeracy Strategy

Whilst the sections above introduced the study and contextualised the National Numeracy Strategy in relation to educational and political development as a whole, this section now attempts to analyse the *policy* which resulted for the Strategy itself. It begins by asking the question '*what actually is the National Numeracy Strategy and where did it come from?*' before moving on to consider '*what messages might it convey to teachers about practice?*'. In doing so it seeks to address a further issue, namely, '*what is the relationship between this national strategy for **numeracy**, and **mathematics** as a whole?*'

What is the National Numeracy Strategy?

On the face of it this question would appear to be a straightforward one, however, experience prior to undertaking this study suggested that this was far from the case and that different people held very different views of its meaning. Furthermore, the fact that this seemed to be the case appeared to be of fundamental importance. Whilst an identical understanding is not a necessary precondition for successful and positive change in teachers' practice, where different views are held by individuals and/or organisations this is likely to lead to differences in the way in which implementation takes place. Again, one might argue that this may be a healthy thing, with differences in philosophy and understanding creating a professional discourse that is more likely to lead to reflection and adaptation of practice which best fits the context of the practitioner. However, from the perspective of the DfEE, it would seem that this was not necessarily the intention. From the start, the aim did not seem to be to generate dialogue amongst teachers about what constituted good practice in their particular context, but rather to identify 'good practice' per se and then to 'train' teachers to adopt this practice. A taste of this is present in the correspondence between David Reynolds, the chair of the Numeracy Task Force set up to form 'a diagnosis of the numeracy problem (sic)' (Reynolds in DfEE, 1998a, foreword) and the Secretary of State for Education, David Blunkett in which the latter claims that

> The strategy will affect every school with primary age pupils in the country. We shall provide training and support for all teachers to bring about the changes in teaching that the Task Force recommends, based on the good practice that it has identified.
>
> (Blunkett, in DfEE, 1998b, preface)

If the Strategy was to include a set of definitive 'good practice' to be adopted, it seems essential that the intention should be to present it in such a way that all teachers understood it identically in order that it would be adopted in a uniform manner by all. The question of what the National Numeracy Strategy *is* therefore is central to the research presented here and forms the first of the research questions for this thesis.

However, there are many studies showing that it is rarely a straightforward case of teachers' 'taking on' policy in the manner implied above (Alexander, 1992, 1995; Macnab, 2003; Woods et al, 1997; Woods and Jeffrey, 1996). Nias, for example, (e.g. 1989), has illuminated the affective dimension involved in such implementation of policy. More particularly, Woods and Wenham (1995, p.138), in tracking the 'career' of a major Department for Education and Science (DES) Discussion Paper, conclude that a study of its evolution

> throws emphasis upon the document; not as a text with a single, clear meaning, but on how it was constructed, and on how it was understood; on

how people tried to make it understood, and on the influences operating on them in seeking to persuade.

Though different authors propose different models of change in the adoption of policy, the fundamental complexity is well exemplified by Ball and Bowe (1992, p.113) who argue that change 'is best understood in terms of a complex interplay between the history, culture and context of the school and the intentions and requirements of the producers of policy texts'. Thus, it seems safe to say that the question 'what *is* the National Numeracy Strategy?' is not the same as the question 'what do people *understand* by the National Numeracy Strategy?'.

Reynolds himself (Reynolds and Muijs, 1999), whilst still asserting that 'all evidence available converges on the same practice', points out that further research is still needed since 'there will be difficulties in relating the [above] bodies of knowledge to practitioners'. In particular he calls for research that addresses ways to encourage teachers to move away from long held orthodoxies and which explores how 'teachers [can] be enabled to be active, reflexive practitioners involved in knowledge creation about effective practices, whilst at the same time being given defined 'good practice'' (p. 285). Ball and Bowe (1992, p. 100) suggest the terms *intended policy, actual policy* and *policy-in-practice* to explore this phenomenon in relation to the interpretation of the introduction of the National Curriculum into secondary schools. The first of these refers to the ideologies at play in creating policy which, though sharing common goals perhaps, are often competing in other respects. As a result, *actual* policy is formed, namely the legislation, circulars and documents that try to lay the ground rules for action in practice. These, however, are often insufficient, containing 'spaces, silences and contradictions' which allow for practitioners to create *policy-in-use*; the discourse and practical application of the legislation.

The paragraphs below attempt, therefore, to make an interpretation of the *intended policy* of the National Numeracy Strategy. In doing so, four strands stand out as clearly identifiable: first, a *political* agenda on the back of New Labour's rise to government in the late 1990s; second, research interest in *teaching approaches* generally and *international comparisons* particularly; third, contemporary ideas about *children's understanding of number*; fourthly, the *meaning of 'numeracy'* and its relationship to 'mathematics'. Each of these is taken in turn, though in practice they are interrelated.

Intended policy – political agenda

The immediate stated aim of the NNS was to 'raise standards in mathematics', a political objective in response to a perceived need to raise the level of mathematical attainment of primary children.

Prime Minister Tony Blair, shortly after his rise to government in 1997, famously stated that the three top priorities for Labour in its coming term of office were 'education, education and education', and the phrase *raising standards* was used with increasing frequency in both politics and the media following of it. Importantly though, this word lacked (and still lacks) any clearly identified agreement as to its meaning. A safe assumption by implication of the context of its use, however, is that test results are a direct indicator of it and that 'rising standards' equates to improved test scores. For example, DfEE (1998a) states that,

> One of the first acts of the new Labour government was to announce national targets for literacy and numeracy. These are:
>
> - for 80% of 11 year olds, by 2002, to achieve the *standards* expected for their age in English, *i.e. Level 4 in the National Curriculum tests*; and
> - for 75% of 11 year olds, by 2002, to achieve the *standards* expected for their age in mathematics.
>
> (p.4, emphasis added)

In addition to *standards*, a second word, *effectiveness*, became common parlance in educational policy at the same time. Defining the former in terms of test results led naturally to the latter being applicable to anything that led to any such increase. Thus, again, this term too became simply (some might argue simplistically) unproblematic in the managerial discourse of education in the late 1990s and early 2000s.

As Brown (1999) points out, the initiatives mentioned above, together with what was perceived by many teachers as 'policing' of these by OfSTED, made them highly influential and a major force in the *intended* policy of the National Numeracy Strategy. She notes too (2001, p. 7) that these programmes for change have tended to be subject to severe pressures of time and that, though well-intentioned, 'have often led to detailed implementations which are not fully thought-through, and piloted either insufficiently or not at all'.

Intended policy – teaching approaches including international comparisons

The mid 1990s saw several major reports on comparisons between education in England and other countries. In particular, 'The Third International Mathematics and Science Survey' (TIMMS) apparently highlighted weaknesses in 'mathematics' in English schools, as had its predecessor, S[econd]IMMS. More specifically, these equated to poor comparison scores in the *number* categories of the tests given to children from around the world, where English pupils came out comparatively poorly (see Harris et al, 1997). Around the same time, Reynolds and Farrell (1996) published *Worlds Apart?,* part of an 'OfSTED Review of Research', which reviewed surveys of international comparisons of school organisation and teaching style. Reynolds claims that the results from this review 'show a clear relationship between whole-class interactive teaching and mathematics achievement' (Reynolds and Muijs, 1999, p. 18.) and noted the relatively small amount of such teaching in English schools.

Though Reynolds and Muijs' interpretation of the data available to them was criticised by some (e.g. Alexander, 2000) their statement provides evidence of the drive for more whole-class teaching, one of a number of concerns that had been raised four years early in a report authored by Robin Alexander, along with Jim Rose and Chris Woodhead, (1992). This drive was to gather momentum from that point on, as

> The newly established Office for Standards in Education (OfSTED) then decided to monitor the impact of the [Clarke] initiative, and published a succession of follow-up reports. Woodhead's move from SCAA to the position of HM Chief Inspector at OfSTED, of which Rose had already become a senior member, sustained the interest of that body in the debate about teaching in primary schools and led to further publications, each rather more personalised and less corporate than the last, and each prompting a recycling of the shock-horror headlines about plummeting standards and trendy teachers, ...
>
> (Alexander, 1997, p. xv)

This is not to say that whole-class teaching was the only idea to emerge from international comparisons. In many senses this was simply a label for a far more sophisticated analysis of what it was that 'effective' teachers tended to do and the real need was for a 'blend of methods' (Reynolds and Muijs, 1999, p. 22-24). Other reports commented, for example, on our relative lack of attention to mental calculation and the lack of structure in English textbooks (Bierhoff, 1996), as well as the need to change the way that ideas were related to their language and notation (Harries and Sutherland, 1999).

The position of several influential people (including the Chief Inspector of Schools, Chris Woodhead, and the Chair of the Task Force, David Reynolds), as well as that adopted by the media, was that there existed 'a problem' with mathematics teaching. In fact, the situation was not that simple, Harris et al (1997), for example, noting the success of English children in problem solving and their positive attitude to the subject.

The question of the true relative standard of English children remains a complex one therefore, though, at the time of the Task Force report, there could be little doubt that in the narrow sphere of *number skills* English children performed poorly in tests relative to their international peers, and in this sense at least, a 'problem' existed. This 'problem' became particularly acute if one considered *numerical knowledge* to be important over and above mathematical application and process skills. Of course, this might tend to be just the kind of judgement that is typically made by politicians, because, culturally:

- Mathematics is often seen as a set of skills which allow children, later, to become effective members of the workforce.
- An understanding of mathematics itself is often seen as a 'collection of knowledge' to be transferred unproblematically to 'adult' situations.
- Knowledge is often seen as being superior to skills, an attitude reflected and maintained by an examination structure within which people in positions of power have often been highly 'successful'.
- Knowledge tends to be more easily definable than processes and thus lends itself more easily to construction of curricula.
- Knowledge is similarly more easily testable than processes.

Even if one accepts that there was a problem with mathematics, the notion that this could be laid at the door of 'trendy teaching' and the negative results of 'progressivism' only serves to simplify a complex situation in unhelpful ways. Amongst others, Alexander (1994, p.7) has challenged

> The glib political rhetoric of 'trendy teachers', 'barmy theory' and 'back to basics', arguing that this deflects attention from the real problems of primary education: the loss of professional confidence; the increasing gap between

> the educational tasks placed on primary schools and the resources available to undertake them; and the growing confusion over purposes and rationale.

Five years earlier, Desforges and Cockburn (1987) had pointed to deficiencies in mathematics teaching in an in-depth study of several first school and infant teachers. Their insightful analysis of events in these classrooms similarly reflected the kinds of complex problems that research would highlight again almost a decade later, characterised by an over-complexity in organisational aspects of teachers' work rather than any kind of progressive 'trendiness'. Neither was the perception of poor standards in mathematics new. It is well catalogued that such a perception has existed continually for over 100 years (Cockcroft, DES, 1982, p. xii).

These observations of the historical nature of the issue of mathematical standards and of the complexity of the teacher's role provide a first glimpse of a key distinction which will be seen to be at the heart of many of the themes in this thesis, namely two opposing views of what it means to *learn mathematics*. Though these will subsequently be explored more fully, essentially they exist as two poles of a spectrum. At one end lies learning as the memorisation of mathematical knowledge in the form of facts, routines and procedures, with application of these as unproblematic and independent of context. Synonymously, school is usually seen as the only site for learning such knowledge. At the other end of the spectrum lies a more complex view in which learning mathematics might be seen as the development of a unique, personal identity, still encompassing the same knowledge, but in which application is seen as context dependent and learning as cultural, historical and inclusive of emotions and dispositions (e.g. Wells and Claxton, 2002). Learning, from this perspective, takes place in all sites of a child's life, both in and out of school.

Leaving aside, however, such a debate regarding the meaning of learning mathematics, whatever the reality of the situation regarding mathematical standards there was a feeling amongst some researchers (and the politicians to whom they reported) that these perspectives from abroad might prove to be 'the answer' to the perceived problems of English mathematics teaching. Such a view is clearly reflected in the Task Force's report in stating that,

> Our aim has been to build on existing good practices that work, whilst making clear those that do not, and recommending that these are replaced with different, more successful, practice.
>
> (DfEE, 1999a, p. 10)

Such a view was apparent in the training materials for teachers that accompanied the introduction of the Strategy.

> The National Numeracy Strategy is neither 'back to basics' nor entirely new. It builds on good practice already identified from inspection and research evidence and established in the National Numeracy Project, and other schools. It also reflects the primary mathematics practices in other countries.
>
> (DfEE, 1999c, p. 15)

Quite apart from more complex questions about the nature of what it is to learn mathematics, even at the level of increased test scores, such a view runs the danger that it is likely to underestimate the effect of *culture* within the system of education. It takes teaching approaches (in this case) as identifiable and independent and, as such, as transferable from context to context. In this respect it perhaps confuses (or fails to acknowledge the difference between) policy and practice; the former being codified and documented, and therefore transferable, the latter being the manifestation of an interpretation by an institution and/or an individual. Alexander (2000), who has criticised this separation of culture from practice, notes too that even the curriculum itself 'is probably best viewed as a series of *translations* [from syllabus to school plan], *transpositions* [from plan to sequence of lessons] and *transformations* [into action, tasks and classroom discourse] from its initial status as published statutory requirements' (Alexander, 2000, p. 552, comments added). Furthermore, his work points to education as a whole being the synthesis of many parts that can be viewed from the 'levels of system, school and classroom', none of which 'can be understood fully without reference to the others' (p. 563).

Thus, increasingly, not only is pedagogy being seen as the manifestation of a nation's demands, but the very act of learning is considered to be essentially linked to the culture within which it takes place, such that 'cultures play an important part in shaping the development of individual minds; and individuals' thoughts and deeds serve to maintain or to alter the cultural milieu' (Claxton, 2002, p. 3). From such a perspective, education is inextricably intertwined with the culture within which it is based, and the breaking off of pieces to be grafted back on in other cultural contexts may not lead to the desired outcomes. This may be equally true of cultures *within* a national boundary, as with those *between* them.

Alongside, and often as a result of, international perspectives, other research was also examining teaching approaches during the mid-90s. Most influential amongst these was The National Numeracy Project, run by Anita Straker, which already included many contemporary ideas similar to those being used in other countries, and which would become the model for the National Numeracy Strategy. The project was

> based on three key principles:
>
> - mathematics lessons every day;
> - direct teaching and interactive oral work with the whole class and groups;
> - an emphasis on mental calculation.
>
> (Straker, 1999, p. 41)

Meanwhile, research at King's College, London (Askew et al, 1997; Askew, 1999a) identified different orientations of mathematics teaching and concluded that, although teachers may share aspects of each one, the most effective teachers tended to be 'connectionists' who tried to demonstrate the connections between different mathematical ideas, different representations and children's own ideas about the topic in question. Teaching was seen as a complex activity with characteristics of effectiveness, but no specific solutions regarding best practice. Thus, importantly, whilst the most effective teachers seemed to reflect, at least to some degree, the 'connectionist' orientation, the outcomes in terms of numeracy gains were not simply related to 'technical features' of their work. Rather, it was the holistic synthesis of their beliefs, practice and knowledge that was important. It was also noticeable that to change practice the report identified a need for continuing professional development over a long period of time, rather than 'short courses' (Askew et al, 1997, p. 73 ff.).

In addition to all these research projects, inspection evidence was increasingly being used to inform policy decisions and OfSTED (1995; 1996; 1997) published a number of reports relating to mathematics which, amongst other things, identified a perceived need for:

- less individualised work from scheme books;
- greater structure to lessons;
- more emphasis on mental calculations;
- more emphasis on teachers teaching directly and interactively;
- teachers needing better subject knowledge.

Intended policy – children's understanding of number

Whilst many of the aims of international research projects were to focus attention on teaching style, a second strand investigated the different approaches to cognitive development of mathematical ideas, and of number concepts in particular. It had long been recognised that the traditional approach to the teaching of calculation – in which the aim was to ensure that children were armed with a single, procedural, written method of calculation for each of the four major operators (addition, subtraction, division and multiplication) – had some major disadvantages. Many children either readily forgot them, remembered them without understanding, rendering them useless when mistakes had been made and needed to be thought through, or simply failed to learn the procedures. Overarching these drawbacks was a more fundamental problem. Children in other cultures were seen to be far more adept at working with numbers mentally (Reynolds and Farrell, 1996; Harris et al, 1997), having a deeper and more connected understanding of how the number system itself worked and, hence, being able to make use of this in calculating for themselves. As far back as 1979, Plunkett, in accounting for children's errors in written calculation, pointed out that the traditional methods differed fundamentally from methods that one was likely to use when calculating mentally. The Cockcroft Report (DES, 1982) also picked up this point noting the 'central place which working 'done in the head' occupies throughout mathematics' (para. 255) and the decline in 'mental arithmetic' at both primary and secondary level. It blamed, in part, the increased use of individualised schemes which 'reduce opportunities for discussion and oral work generally' (para. 254) and suggested that teachers needed to 'point this [mental methods] out explicitly and to discuss at length the variety of methods which it is possible to use' (para. 256). However, later commentators (see for example Wigley, 1994; Thompson, 1997) went on to indicate that focusing attention solely on these written techniques was not just detrimental in terms of time devoted to mental work and a decline in classroom talk, but actually taught children a *different* set of mathematical ideas.

The essential value of mental calculation and the need to teach it explicitly before children become dependent on the written forms (indeed to *stop* them becoming dependent on them), was observed by Cockcroft in 1982 and has been enshrined in law since 1989 with the first version of the National Curriculum (DES, 1989). This legislation included the requirement that children in Key Stage 2 should be taught to add and subtract two 2-digit numbers mentally and included extensive Non-Statutory Guidance that discussed why mental mathematics was important and how teachers, in *outline*, should approach it. But, given the observation above that mental mathematics was fundamentally *different in kind* to written mathematics, it may not be so hard to see why the move to more mental work was not taken up in practice by teachers in any kind of comprehensive way, for whilst the *principles* for such a shift were clear, any kind of detail about *what* to teach and *how* to teach it was largely lacking (at least in any kind of structured terms). National Curricula, up to and including 1995, simply listed the broad objectives to be taught (such as 'multiplication facts up to 10x10'), but provided no structured, step-by-step advice regarding how to achieve this, nor any support in seeing how one idea was connected to another; a fundamental aspect of making use of mental methods 'flexibly'.

Thus, at the time leading up to the development of the National Numeracy Strategy, when comparisons with other countries were in the limelight, the moment was right in terms of both practitioners and policy makers for a much more detailed and structured approach to calculation, putting mental work at its forefront. This was just what Anita Straker's National Numeracy Project (Straker, 1997) was doing, and its popularity amongst teachers involved in the research was perhaps not surprising therefore.

Along with a change in the nature of calculation, research over the previous 10 years or so had, more generally, highlighted a very different approach to learning number concepts based on mental and oral work (e.g. Gray and Tall, 1994; Gray 1997; Anghileri, 1989, 1997, 2000; Askew and Brown, 2001; Thompson, 1999a, 1999b, 2000). With this development came an associated change in the kinds of tasks that would be needed (Wigley,1994, 1997; Beishuizen, 1999) and these, in turn, implied new ways of teaching.

The National Numeracy Strategy could therefore be seen as detailing how to achieve mathematical objectives that had been statutory, but not clear in terms of practice, for ten years. It was thus likely to be welcomed by practitioners. However, it also implied ways of teaching that were very different to current practice in two senses. First, the change to the conception of calculation as a predominantly written activity, with a host of associated mathematical implications. Second, in relation to the use of different forms of pedagogy, especially the use of more talk in the classroom as the need to make mathematics an oral activity became apparent. However, whilst the content of the necessary changes was being detailed and discussed, there was less being said about the need to change teachers' understanding of their teaching at these deeper levels of principle.

Intended policy – 'numeracy' and 'mathematics'

Having reviewed contemporary ideology regarding the nature of numerical ideas, the wider issue of the relationship between *numeracy* and *mathematics* as a whole is now considered. It should be noted that this undertaking presents a challenge in as far as the nature and meaning of *mathematics* itself is somewhat difficult to pin down. It is not the intention here to explore at any length what constitutes the subject – though the nature of mathematical knowledge is considered briefly later on – but, rather, to establish a working description of some key features. The description used is that suggested by Hersh (1998), namely that,

> Maths deals with ideas. Not pencil marks or chalk marks, not physical triangles or physical sets, but ideas (which may be *represented* by physical objects).
>
> (p. 15)

and that,

1. Mathematical objects are created by humans. Not arbitrarily, but from activity with existing mathematical objects and from the needs of science and daily life.

2. Once created, mathematical objects can have properties that are difficult for us to discover [but which are firmly established and possessed independently of our knowledge of them].

(p. 16, comment added)

Note that this description reflects a belief in mathematics as a socially constructed venture, a view that is now fairly widely accepted (Davis and Pettitt, 1994; Burton, 1999), but makes clear that it is not an arbitrary process *once the meaning of the terms and symbols used as representations are established.* It is thus the establishment of these symbols and their meaning which is the human construction and this has important implications for pedagogy since it implies, as in point 1 above, that 'what we create is a system of interlocking concepts and rules as opposed to a series of discrete facts' (Davis and Pettitt, 1994., p. 10). Significantly, several of the defining features of mathematics therefore are that: it is intrinsically about *thinking* (because it is fundamentally about ideas); this thinking needs to be communicated and negotiated (since 'new ideas' rely on social agreement); the *study of relationships* forms a central focus for mathematical activity; it naturally lends itself to *inquisitiveness*, because it is essentially about discovery; it is therefore essentially *creative* in nature; and, it may be *difficult* at times (since the relationships involved are not necessarily immediately clear).

Whatever the definition of mathematics, and others are possible, the need for clarity about the relationship of numeracy to mathematics appears as one of the features of the written ideological record surrounding the National Numeracy Strategy at its conception. In their preliminary report (DfEE, 1998a), the Task Force stated that 'numeracy is an important part of mathematics, and a major aim of mathematics in primary schools is to teach children to be numerate' (p. 6). They adopted the definition of numeracy being used by the National Numeracy Project, namely:

> Numeracy means knowing about numbers and number operations. More than this, it requires an ability and inclination to solve numerical problems, including those involving money and measures. It also demands familiarity with the ways in which numerical information is gathered by counting and measuring, and is presented in graphs, charts and tables.
>
> (ibid., p. 6)

This was a definition which seemed to acknowledge the practical utility of mathematics but which also legitimised numeracy in terms of a *knowledge* of number more generally, perhaps in a more abstract sense of mathematics as a cultural discipline in its own right. However, in stating 'why numeracy matters' the emphasis is very much a utilitarian one.

> We hope that one of the effects of the Task Force's report, and the wide consultation on it, will be that more people understand the importance of numeracy as an essential life skill.
>
> (ibid., p. 5)

In terms of schooling, they state that,

> Early work in mathematics must begin to lay the foundations for the skills and insights children will use in later life. A solid grounding in *numeracy* at primary school will also help children with the *mathematical* skills needed in other subjects, and later, to develop the higher order *mathematical* skills that are indispensable for large areas of higher education and future employment .....
>
> (ibid., p. 5 – 6, emphasis added)

Note that this statement seems to imply that 'numeracy' is something *separate from* 'mathematical skills' and yet it is claimed that the 'government's national target for 2002, while focusing on numeracy, aims to raise standards of mathematics as a whole' (p. 9) and that 'the Task Force has aimed for a strategy to ensure that teachers teach *mathematics* effectively and pupils achieve high standards of *numeracy* [but not mathematics?]' (p. 9, emphasis and comment added).

In their final report, they sought to clarify this confusion between the two ideas.

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

The definition used to underpin the National Numeracy Strategy was then:

> Numeracy at Key Stages 1 and 2 is a proficiency that involves a confidence and competence with numbers and measures. It requires an understanding of the number system, a repertoire of computational skills and an inclination and ability to solve number problems in a variety of contexts. Numeracy also demands practical understanding of the ways in which information is gathered by counting and measuring, and is presented in graphs, diagrams, charts and tables. This proficiency is promoted through giving a sharper focus to the relevant aspects of the National Curriculum programmes of study for mathematics.
>
> (DfEE, 1998b, p. 11)

It was this definition that appeared in the final version of the Framework for Teaching Mathematics (DfEE, 1999a). Notice, now, that 'numeracy' is a *proficiency* in skills and that the National Curriculum for mathematics both develops these skills and 'lays the foundation for mathematical study' at a later date. This seems to clarify the issue of numeracy and its relationship to mathematics, but leaves open a different door in implying that mathematics at Key Stages 1 and 2 (and therefore numeracy at these key stages) is not 'mathematical study' in itself. One effect of these definitions therefore is, deliberately or accidentally, to identify mathematics in primary schools with 'skill acquisition' and to separate it from a 'process of study'. This might also be seen to be part of a wider omission on the part of the Task Force to make any attempt at defining the nature of mathematics itself; at the very least in terms of the interrelationship of conceptual knowledge and process and, in terms of the latter, the kind of processes and dispositions that might characterise its study.

Brown et al (1998) point to views of mathematics which are very different to the 'proficiency in skills' model adopted by the Task Force and implied by the utilitarian views of politicians. In particular they contrast this with a *social practice* model which 'is based on an acceptance of the social and cultural nature of numeracy as the set of numeracy practices individuals engage with during their lives' (p. 363) – a perspective in line with Claxton's (2002) cultural-historical view of learning mentioned earlier. This social model has important implications for both the *way* in which mathematics is studied and *what* is studied, believing that, if mathematics is to be learnt for utilitarian purposes, it must reflect the social setting in which it will be used and that this is very different in practice from the school setting.

One implication of this standpoint is that aiming to raise scores in examinations which are based on a school mathematical setting may be at odds with improving adults' ability to make use of this mathematics in a real setting. A second, more fundamental, implication is that most perspectives on learning adopt an adult position and assume that deeper and more effective understanding is, *per se*, the desired end goal of such learning. However, for children, and indeed teachers, in school settings this may be far from the case. Individuals, in the cultural milieu of their lives including, though not exclusively, the classroom, are each forming their own identities. Such developing identities will include the end-goals which they aim to serve and these may well be the promotion of forms of learning that are at best surface level and strategic, particularly in as far as such forms lead to success in tests (Boaler, 2002; Kelly, 2000).

Teachers' conceptions of mathematics

In terms of how teachers' view the nature of mathematics and its value as a school subject, research has suggested a range of different views, both theoretical and empirical. In terms of the former, van Oers (2001) identifies three possibilities, namely, mathematics as *arithmetical operations*, as *structures* and as *problem solving activity with symbolic tools*. Ernest (1989) suggests similar views, namely *instrumental* (based on arithmetic procedures and facts), *Platonic* (a unified but fixed body of knowledge) and *problem-solving*, whilst Lerman (1990) unifies a range of views into just two, *absolutist* and *fallibilist*, in which mathematical knowledge is seen as objective and fixed or subjective and open to change, respectively. Andrews and Hatch (1999) not only review this research but note that the key issue is the extent to which conceptions of the subject itself correlate with teaching approaches. Their own study reveals five conceptions of mathematics which include, a *personal economic tool*, a *diverse and pleasurable activity*, a *life tool* and a *service provider* to other areas of the curriculum (p. 212). Andrews and Hatch's conclusion that 'the indications are that teachers' dominant pedagogical beliefs are not inconsistent with their perspectives on mathematics' (p. 221) implies that teachers' practices may well be affected directly by any policy that influences their conceptions of the subject as a whole and the form of its utility.

Intended policy – summary

It is beyond the scope of this thesis to do more than outline the many 'ideologies' present in the development of the intended policy of the National Numeracy Strategy. Indeed it is perhaps unsafe to try to look back at what might have been in the minds of the members of the Task Force set up to implement the Strategy. Nevertheless, the fact that the Task Force included David Reynolds (the Chair), Anita Straker and Margaret Brown – a colleague of Mike Askew and one of the co-authors of the King's College research – as well as a head teacher from a school in Barking and Dagenham where extensive whole class teaching was being trialled, makes it seem safe to say that many of the ideas in the preceding paragraphs would have been high on the agenda in making decisions about teaching practice. The key aspects of these competing ideologies might be summarised as follows in Table 1.

Ideologies from Political agenda	Political imperatives: ▪ a desire to 'raise standards' rapidly (where this equated to test results); ▪ a wish to ensure that English children caught up with their international peers in terms of the 'number' elements of the mathematics curriculum; ▪ a desire to enable schools to be made 'accountable' for results by increasing the significance of the one easily measurable 'output' of their work, test results. Views on pedagogy: ▪ a strong perception amongst some members that there was a 'problem' with mathematics teaching; ▪ a related perception that the lack of success in mathematics teaching lay at the door of 'trendy teaching' (essentially meaning pure progressivism); ▪ a belief in one set of 'best practice' and a will to 'retrain' teachers to adopt it. Aims and purpose of mathematics: ▪ a belief that mathematics is essential for children to grow up to be useful members of the workforce; ▪ an understanding of mathematics as a 'set of skills' to be 'acquired'.

Table 1 ... continued

Ideologies from 'International' research	Issues of curriculum: ▪ a need for greater clarity and structure of curriculum materials; ▪ a suggestion that mathematical ideas, their language and their notation should be introduced alongside each other; ▪ a belief that there should be a much greater emphasis on mental calculation. Issues of pedagogy: ▪ a need for greater structure in lessons; ▪ more emphasis on teaching the whole class together directly; ▪ more emphasis on direct modelling of mathematical ideas.
Ideologies from 'Other' research	Generic issues: ▪ a need for teachers to 'interact' more effectively with children; ▪ a belief that a whole-class situation offers an effective environment for challenging most of the children most of the time; ▪ a belief in the complexity of the teaching situation and the need for long term, teacher-centred professional development. Issues relating to mathematics: ▪ a changing belief from mathematics as a written discipline to using mental methods 'as a first resort'; ▪ associated beliefs about the kind of understandings of number required for this – a change in emphasis from 'cardinal/concrete' to 'ordinal/iconic'; ▪ the importance of mathematics as a network of interconnected ideas and representations (rather than a linear series); ▪ a belief in the importance of higher-order thinking as paramount in children's mathematical development; ▪ the mutual interdependence of application and conceptual knowledge of mathematics in effective learning, and therefore; ▪ the importance of learning mathematics through the use of problem contexts and investigative approaches.

Table 1 – Competing ideologies in the intended policy of the NNS.

This chapter began by identifying two questions: 'what *is* the National Numeracy Strategy?' and 'what do people *understand by* the National Numeracy Strategy?' The latter question is equivalent to examining the *policy-in-use* of the Strategy, requiring an empirical approach and forming the basis for the early part of this study. In attempting to address the former question, those factors which might have constituted the *intended policy* of the Strategy have been considered. This now leads on in the next chapter to examining how these intentions became *actual* policy in legislation and documentation.

Chapter 2 – The 'Actual Policy' of the NNS

The preceding chapter outlined the background and ideology of the National Numeracy Strategy and concluded by highlighting the difficulty of identifying the exact meaning of the Strategy for any one individual. The importance of identifying possible understandings held by teachers, in order to appreciate how its implementation might have affected their work more generally, was also suggested. However, out of the competing ideologies of its *intended* policy, an attempt to identify its *actual* policy (Ball and Bowe, 1992) can be made through its documentation, and this chapter takes up this task.

Documentation relating to the NNS has been extensive and a full summary of every item is not possible. The sources below, therefore, are representative in the sense that they illustrate the key policy ideas that appeared in practice. They include:

- The *Framework for Teaching Mathematics* (DfEE, 1999a): the central document for teachers and the one which was used in practice on a daily basis for planning. It lays out the principles for teaching, recommended classroom practice and then the planning arrangements and yearly objectives. Crucially, the main body of the folder then details a progression of objectives for each year, laid out alongside each other, so that teachers appear to have access to a developmental scheme for planning their teaching. This was the document that every teacher received at the start of the 1999 academic year.
- Training materials, including:
    - A three day training course (DfEE, 1999k) for head teachers and subject coordinators and SEN coordinators (summer 1999) to prepare them to tutor...

- ...three separate days of training (DfEE, 1999c, 1999d) for all teachers in Autumn 1999 and Spring 2000.
- A two day course for 'Leading Mathematics Teachers' (LMTs) (DfEE, 1999b) [who were selected to make themselves available for teachers in the local area to watch an example of a daily mathematics lesson with a follow up discussion].

- Other 'additional' material published to support the NNS.

The 'Framework for teaching mathematics'

To begin with, the Framework for teaching mathematics itself was sent to schools in the Summer of 1999, and by the start of the 1999/2000 academic year most teachers were familiar with it in outline at least, with many others having already worked from the very similar draft materials for some time. The Framework is subdivided into six sections, the first of which is an introductory section which outlines (fairly briefly) what is expected of teachers in teaching the Daily Mathematics Lesson. Part of this identifies four *key principles* for the 'approach to teaching the National Numeracy Strategy', namely:

> - Dedicated mathematics lessons every day;
> - Direct teaching and interactive oral work with the whole class and groups;
> - An emphasis on mental calculation;
> - Controlled differentiation, with all pupils engaged in mathematics relating to a common theme.
>
> (DfEE, 1999a, p. 1:11)

The 'emphasis on mental calculation' (note, not mental mathematics) hints at the deliberate focus of the whole document on numeracy as opposed to mathematics. For example, the introductory paragraph states that:

> The Framework illustrates the intended range and balance of work in primary mathematics to make sure that pupils become properly numerate.
>
> (ibid., p. 1:2)

and that,

> Some of the objectives in the yearly programmes are more critical than others if children are to become numerate. These **key objectives** are listed in a separate section and are also highlighted in bold in the yearly teaching programmes.
>
> (ibid., p. 1:3, emphasis in original)

Similarly, the next two sections answer the question 'What is numeracy?' and outline 'Factors that promote high standards of numeracy', before going on to detail 'the approach to calculation' taken by the Strategy, suggesting that this is the most important feature of the mathematics curriculum. This is followed by a section entitled 'teaching mathematics' in which 'typical lessons' and the 'focus on direct teaching' are exemplified, how to use the Framework for planning is explained and instructions for assessment are given.

All this 'advice' and explanation is followed in section 2 by the 'key objectives' for each year group and then in section 3 by planning grids which detail the 'yearly teaching programme' (i.e. *what* is to be taught) and a week by week plan of how this might be implemented (i.e. *when* it might be taught). It should be noted that the planning materials are exemplary only, though naturally, in the first instance, many schools adopted them as they stood.

The final three sections, which form by far the greatest part in terms of number of pages, detail the objectives which 'pupils should be taught' and then exemplify these with the instruction that 'as outcomes, Year [x] pupils should, for example:' followed by an illustrated list of what should be achieved. On each double page, the outcomes expected of three consecutive year groups for a single objective are exemplified, providing a strong sense of progression within an objective, and similarly, each forms part of one of five broad strands of the Strategy. This stands in marked contrast to the programmes of study of the National Curriculum which are composed of much broader generic statements without the exemplification and, therefore, with little sense of progression identified.

This overview of the Framework serves to give a sense of its character, which might be described as:

- Focused on 'numeracy' – the purpose of primary 'mathematics' being to make all children 'numerate'.
- Focused more on content than on process – the vast majority of objectives focus on concept development, and though thinking and discussion are very much to the fore, problem solving is limited to word problems and Using and Applying Mathematics (one of the strands of the National Curriculum orders) 'is integrated throughout', though it is not clear exactly *how* this is the case.
- Positivistic regarding the nature of teaching and learning – the expectation is that specific ideas (in the form of focused objectives for lessons) are 'taught' to the children at particular times so that they will 'be learnt'.
- Specific in terms of outcomes – objectives are listed independently, coming directly from the teaching plan and the examples of outcomes, and the expectation is that each lesson will teach one specific idea.
- Based on a 'typical lesson format' (the 'three part lesson') which, though not compulsory, 'will generally be the same for all classes so you will also have a common structure for developing ideas and sharing planning and teaching with other colleagues' (p. 1:13).

At the same time, the emphasis in terms of teaching is on the 'direct interactive' style and there is an implicit assumption that children's learning will take place through discussion and oral interaction more than through the traditional written practice that characterised many classrooms until the Strategy's introduction. This is supported by instructions that 'good teaching is achieved by balancing different elements' and lists of such good practice which 'successful teachers' adopt. Again, this practice is optional, but forms the basis of other observational frameworks such as those for performance management monitoring visits and OfSTED.

Finally, in addition to the Framework itself, teachers were provided with a booklet entitled *Mathematical Vocabulary* (DfEE, 1999i) which detailed the mathematical words to which children were expected to be introduced each year. Again, the perspective here is positivistic, with children simply 'being taught' such language. More is said about this in chapter 7.

Training materials

To support the introduction of the framework in schools, vast quantities of funding were given to training materials and human resources – indeed, £400 million has been spent over its first five years (Brown et al, 2003).

The various elements of training were guided by printed materials with OHTs and video to support the 'trainer' in implementing them. Each pack was written in order to be used either as part of a group INSET programme or for individual study. The 'Guide for your professional development' books 1 – 4 (DfEE, 1999c, 1999d, 1999e, 1999f) formed the main part of most teachers' initial training input. The style adopted was one of tightly focused suggestions regarding what should be done and said by the trainer, though it was acknowledged that he or she was free to adapt the materials as they considered fit. Clearly though, the intention was to ensure that every teacher had access to the same training, and the result was a set of materials that are very prescriptive in style and designed for use by even the most inexperienced 'tutor'.

In some senses the material encourages ideas and discussion amongst staff. However, each discussion is followed by a 'summary OHT' provided at the end of each section with instructions to the tutor that 'the last action will be to show this OHT and highlight the key points with everyone'. This style is implicit in all the training materials and brings to mind Henry Ford's reassurance that one could buy his model 'T' automobile in any colour one liked as long as it was black. In many ways it makes for an interesting comparison with the Strategy itself which also requires teachers to discuss ideas with children but then to ensure that the children arrive at particular points of view.

A second, and more fundamental, feature of the materials is the focus on ideas at the surface level rather than addressing the underlying principles from which these come. So, to illustrate with just a few of the many possible examples,

- 'Effective teaching' is characterised, but without explicit reference being made to any theory regarding how learning takes place.
- Features of what teachers should 'do' are described, but without any in-depth focus on the criteria that would make it appropriate to carry out these actions at any one moment (when, for example, it is better to choose to 'demonstrate and model' than to 'question and discuss').
- The approach to calculation adopted by the Strategy is outlined in detail, but no explicit reference is made to the shift in the conception of number from a largely cardinal view to a more ordinal, language-based view on which this approach rests (Wigley, 1994, 1997).
- Teachers are told that children's work on shape and space 'should be more than drawing and labelling shapes' and should include 'handling and constructing' shapes,

but there is no deeper exploration of the purposes of studying geometrical ideas in the first place.

It seems clear, given the nature of the discourse involved, that the thrust of these training materials was not to engage teachers in fundamental questions regarding 'why', but rather to instruct them in issues of 'how'. The training materials themselves therefore reflected a positivistic, technicist approach to learning in which knowledge about best practice, accepted as correct, was simply to be passed on to new end-users. As will be seen below, in this sense they mirrored one possible interpretation of the Strategy which teachers might adopt in their own teaching.

'Additional' policy material

In addition to materials sent to schools, documentation surrounding the NNS was produced for a number of other contexts. One of these was for the general public, and parents in particular, to try to promote the subject more widely as part of 'Maths Year 2000'. Though not specifically 'Strategy material', these publications were part of the drive to raise levels of numeracy and the profile of the subject and they often referred to the NNS. Booklets were written promoting the Maths Year events and attempting to explain the importance of mathematics to everyone (e.g. DfEE, 1999g, p. 3). One of the main emphases of all these publications was the attempt to point to the utility of maths, for example claiming that 'we all do maths every day'.

However, the manner in which this was done ran the risk of relegating mathematics to the status of a practical tool. No examples of 'doing maths' were given which were purely conceptual and which were not 'for' anything. Similarly, no distinction was made between making use of mathematical ideas and 'working mathematically'. The key factor here is that mathematics was being portrayed as *content*; namely as addition, proportion, counting numbers, indeed just those elements that make up the Framework for teaching mathematics. Where *process* was involved it was purely numerical calculation and its application to everyday contexts. The use of higher order processes, such as reasoning, justification etc. were conspicuous only by their absence.

This view of mathematics confuses the idea of mathematics as a form of *analysis of* an activity with the activity itself (Sierpinska, 1995, p. 4). So when we are led to believe by the DfEE (1999h) that 'you use maths when you bake a cake' it is in the mistaken belief that cooking and doing mathematics are synonymous. Clearly they are not. When one makes a cake one is baking; when one *analyses* the contents of the cake one may *choose* to use mathematics.

This confusion stems from a view of education which fails to take account of the cultural and social nature of learning – both in terms of what is learnt and how it is learnt. If an inadequate appreciation of this issue is reflected in the materials for parents and for wider society beyond the school, so too is it apparent in the Framework and its training package. For example, the Framework itself, in referring to problem solving, deals almost exclusively with 'word problems' involving 'real' life, particularly contexts using measures and money (though problems in the form of puzzles within mathematics itself are also included). No reference is made in the objectives to problems that are not in word form and the training materials seem to justify this focus by claiming that 'exercises of word problems are a traditional part of mathematics lessons and are a common feature of mathematics tests' (DfEE, 1999e, p. 90). Critics, however, argue that it is just such features of our testing mechanism that render them ineffective in supporting teaching and learning (van den Heuvel-Panhuizen, 1999; Close, 1999) and disadvantage children from certain social groupings (Cooper, 1993; Cooper and Dunne, 2000).

Summary

The preceding chapter and the sections above have identified the 'intended' and 'actual' policy of the National Numeracy Strategy respectively. The first of these finished with a table summarising the ideologies surrounding its introduction. This is now reconsidered with an analysis of how each point became actual policy or otherwise.

Intended policy	Actual policy
Political Agenda...... **...Political imperatives:**	
▪ a desire to 'raise standards' rapidly (where this equated to test results);	▪ massive resourcing and a focus on test results as a measure of success;
▪ a wish to ensure that English children caught up with their international peers in terms of the 'number' elements of the mathematics curriculum;	▪ a refocusing of the mathematics curriculum towards numeracy at the possible exclusion of other, wider, interpretations of the subject;
▪ a desire to enable schools to be made 'accountable' for results by increasing the significance of the one easily measurable 'output' of their work, test results.	▪ upping the stakes for test success through performance management requirements and inspection criteria.
...Views on pedagogy:	
▪ a strong perception amongst some members that there was a 'problem' with mathematics teaching;	▪ the perception given that the NNS is a tried and tested 'solution' for schools;
▪ a related perception that the lack of success in mathematics teaching lay at the door of 'trendy teaching' (essentially meaning pure progressivism);	▪ a move to a managerialist discourse which emphasises standardisation of practice;
▪ a belief in one set of 'best practice' and a will to 'retrain' teachers to adopt it.	▪ a positivistic view of 'effective' teaching methods to be adopted by all teachers; high levels of funding to implement this.

Table 2 ... continued

...Aims and purpose of mathematics: ▪ a belief that mathematics is essential for children to grow up to be useful members of the workforce; ▪ an understanding of mathematics as a 'set of skills' to be 'acquired'.	▪ an emphasis on mathematics as a 'practical tool' and contexts that refer to 'the workplace'; ▪ a Framework composed of specific, focused objectives with calculating strategies at its heart.
International research agenda.... **...Issues of curriculum:** ▪ a need for greater clarity and structure of curriculum materials; ▪ a suggestion that mathematical ideas, their language and their notation should be introduced alongside each other; ▪ a belief that there should be a much greater emphasis on mental calculation. **...Issues of pedagogy:** ▪ a need for greater structure in lessons; ▪ more emphasis on teaching the whole class together directly and more emphasis on direct modelling of mathematical ideas.	▪ a framework which provides a detailed breakdown of mathematical concepts and examples of these in practice; ▪ more explicit reference to mathematical language (through a yearly vocabulary book); ▪ one of the four stated principles for the NNS as a whole. ▪ the introduction of a standardised three part lesson; ▪ part of the four stated principles for the NNS as a whole.
'Other' research agenda.... **...Generic issues:** ▪ a need for teachers to 'interact' more effectively with children; ▪ a belief that a whole-class situation offers an effective environment for challenging most of the children most of the time; ▪ a belief in the complexity of the teaching situation and the need for long term, teacher-centred professional development.	▪ part of the four stated principles for the NNS as a whole; ▪ part of the four stated principles for the NNS as a whole; ▪ not apparent in actual policy – teaching tends to be seen as technical and training 'delivered' in short course format.

Table 2 ... continued

...Issues relating to mathematics:	
▪ a changing belief from mathematics as a written discipline to using mental methods 'as a first resort';	▪ made explicit in the Framework and other associated documentation;
▪ associated beliefs about the kind of understandings of number required for this – a move from 'cardinal/concrete' to 'ordinal/iconic';	▪ implied, but not made explicit, through training materials and suggested resources;
▪ the importance of mathematics as a network of interconnected ideas and representations (rather than a linear series);	▪ made explicit in advisory material, though the itemised structure of the framework may mitigate against this view;
▪ a belief in the importance of higher-order thinking as paramount in children's mathematical development;	▪ not apparent as specifically identified mathematical processes, though reasoning and justification emphasised as part of increased use of discussion;
▪ the mutual interdependence of application and conceptual knowledge of mathematics in effective learning, and therefore;	▪ not apparent – mathematics seen as an abstract 'tool kit' to be applied at will.
▪ the importance of learning mathematics through the use of problem contexts and investigative approaches.	▪ problems only in word form; investigative approaches mentioned, but the short and highly structured lesson time and the lack of explicit reference to Using and Applying Mathematics might be seen to mitigate against this.

Table 2 – Intended and Actual policy of the NNS.

Possibilities for Policy-in-use – two ideal types

Having considered the nature of policy relating to the NNS at two levels, 'intended' and 'actual', possibilities for the way in which teachers are likely to turn this into 'policy-in-use' are considered. The policy for the NNS with which they were faced at its inception came in addition to many other changes and pressures at the current time, deriving from changes to education as a whole and to mathematics education in particular (see, for example, Hargreaves, 1994; Woods et al, 1997; Jeffrey & Woods, 1998). It therefore seems sensible to assume that these changes, which have taken place over the last 15 years or so, are likely to have an effect on teachers' transformation of actual policy into policy-in-use.

What then are likely results of these effects? Several possibilities are suggested, related to a number of different perspectives on the teachers' work. Central to these, however, is the degree to which teachers perceive teaching and learning as a complex process, inevitably throwing up 'dilemmas' (Berlak and Berlak, 1981) and 'competing imperatives' (Alexander, 1995). Such teachers are likely to question suggested action and to consider children's previous experiences carefully in relation to current learning. In contrast, 'technicians' (Woods et al, 1997) are more likely to accept given instructions for their behaviour without questioning these and without necessarily resolving the tensions that they might create in other aspects of their practice.

Such a distinction will depend, in practice, on the teacher's own identity as a professional in their particular context. Factors such as the school policy, their relationship with other adults (managers, parents etc.) and their own experiences and beliefs will all play a part in this. However, another crucial difference in approaches may be a function, more widely, of the teacher's understanding of the nature of knowledge. For example, Woods & Jeffrey (1996, p116) make a distinction between 'public knowledge', lying external to the knower and available to all, and 'personal knowledge', which is constructed by, and relates to, the individual frame of reference of any one person. Sugrue (1997, pp17-19) suggests that, broadly speaking, these two views of knowledge are likely to be aligned with more 'traditional' and more 'progressive', or 'child-centred', approaches to teaching respectively.

More widely still, these knowledge forms relate to the distinction between a view of education in which the teacher's role is simply to transmit a body of knowledge from one generation to the next, and one in which each generation plays its part not only in

acquiring that knowledge which the elders of the society consider to be of importance, but also in influencing and developing that knowledge through each individual's interaction with the cultural milieu within which they learn (Claxton, 2002; Lemke, 2002). From the former, wholly individual, view of cognition, the mind is seen as a mirror reflecting the owner's perceptions of the world, 'a container to be filled with reflections of, or structures residing in, the external world' (Sfard et al, 2001, p. 4). In contrast, the latter, *sociocultural* view, sees 'the vision of human thinking as essentially social in its origins and as inextricably dependent on historical, cultural and situational factors' (ibid., p. 5). From such a view, teaching and learning needs to be seen in terms not just of individuals, but in the ways that individuals relate to the wider cultural milieu in which they are operating.

Two perspectives on the Strategy

How then are teachers likely to form policy-in-use for the NNS from the actual policy to which they are exposed? Clearly this is a matter of interpretation and I try below to make clear two perspectives which can be seen as representing two 'ideal types' (after Weber, see Eldridge, 1972), based broadly on the distinction above relating to forms of knowledge and beliefs about learning. This delineation of knowledge/belief structures inevitably leads into a brief discussion about the nature and development of knowledge itself. It is argued that both extremes are reasonable interpretations of the Strategy. The chapter concludes, however, by examining the relative merits of each viewpoint from the perspective of the teacher.

Perspective 1 – teaching and learning as a 'complex sociocultural' activity

This first perspective delineates the extent to which the actual policy of the NNS outlined previously can be aligned with a view of teaching and learning as a process which is both inherently complex and essentially social. At the heart of this view is likely to be a belief in knowledge as personal, in Woods and Jeffrey's (1996) terms, along with a sociocultural view of learning identified in the preceding paragraphs. From such a perspective there follows an emphasis on the communicative discourse (Sfard, 2001) of the classroom as central to the NNS, with the teacher's role being the development of mathematical thinking through this discourse. This view stems directly from Vygotsky (1981) who saw meaning developing on two 'planes'; an 'inter-psychological' plane with understanding being guided and supported by a more experienced agent and an 'intra-psychological' plane as individuals developed their own personal meanings. The term 'social constructivism' has been coined to represent this line of thinking, though labels here are complicated by their adoption and adaptation over time (Lerman, 2001; also Sfard et al, 2001; van Oers, 2001).

Whatever the term used to describe the school of thought, whilst he proposed these two planes of concept development, Vygotsky did not go as far as to outline a satisfactory explanation for the *way* in which the transition between inter- and intra-psychological planes took place. One response to this problem has been to emphasise the perceived cultural and contextual importance of *practice*, focusing on the notion of apprenticeship in which novices learn by adopting the working practices of an expert, and hence describing learning as 'enculturation' into 'communities of practice' (e.g. Lave, 1988; Lave and Wenger, 1991; Rogoff, 1990; Wenger, 1998).

The sociocultural perspectives of Sfard, Lerman and others (above) develop these notion of communities of practice, recognising that the classroom *culture*, and the *activity* that this engenders, are crucial attributes of learning to the extent that 'knowledge, rather than being a stable, individual entity, is co-constructed by individuals and those with whom they are interacting in conjunction with aspects of the situation in which they are working' (Boaler, 2002, p. 42). Thus, learning is seen not simply as *how much* one knows, but as *how* one comes to know it through engagement in the practices of the subject, and the adoption of the discourse and practices of others, some of whom may be more expert. Furthermore, in participating in this way one must learn about the 'constraints and affordances' that the situation presents (Boaler, 1999). Not only, then, is the learner seen to be achieving his or her goals and needs through taking advantage of affordances in the gradual adoption of the working practices, but simultaneously the situation is regulating these goals and needs through the constraints it presents, in a reciprocal process – what Lerman (2001, p. 98) suggests might be seen as 'person-in-practice-in-person', or more particularly, 'student-in-mathematics-classroom-in-student'. In considering the 'how' rather than solely the 'what', in addition to the internalised knowledge developed in the act of learning, one is in a position to take account of the dispositions, attitudes and feelings developed as part of one's growing mathematical identity, which, some would argue, (e.g. Claxton, 1999; Boaler, 1997, 2002), are ultimately the most crucial elements in successful learning.

In outlining this sociocultural perspective on learning, Lerman (1996) has noted the potential dichotomy between individual and social knowledge construction. A potential criticism of viewing learning as essentially the process of induction into communities of knowledge/practices is that this appears not to leave room for the individual, whilst a radical constructivist position appears not to leave room for the social. Indeed, some of those who maintain a strong belief in enculturation into a social practice might deny the notion of knowledge 'within' an individual at all. Jaworski, from her constructivist position, takes a more individualised view of cognition and has written that 'my own position, currently [1994], is to see individuals as constructing meaning within the socio-cultural settings of the classroom and its surroundings – a constructive process that occurs while participating in a cultural practice, frequently while interacting with others' (1994, p. 211) and that the result is 'intersubjective' or 'taken-as-shared knowledge ... where participants seem to agree on certain interpretations represented through discourse and non-verbal communication' (ibid.). As she herself points out however, this leaves a problem in as far as the status of intersubjective knowledge becomes far from objective. Her claim that constructivism is a theory of how knowledge is learnt, not of knowledge itself (it is 'post-epistemological') and that, anyway, 'status seems less important than the value of the concept, which is to provide a bridge between individual construction and some consensus in mathematical understanding within a community' (ibid., p. 212), rather dodges the issue.

Rather than dodging it, Sfard et al (2001) deal with the individual/social dichotomy by trying to deconstruct it, claiming that by 'defining thinking as communicating [one is therefore] sidestepping the split rather than bridging the gap' (p. 10). Thus, 'when one realises that the cognitivist ('individualistic') and interactionist ('social') approaches are but two ways of looking at what is basically one and the same phenomenon: the phenomenon of communicating', then the dichotomy is 'no longer an issue' (p. 10).

Finally then, having reviewed various lines of thought regarding the nature of knowledge, the view taken here is more in line with the latter than the former position. Knowledge is seen to be a personal construct of a world that has a physical reality, in as far as memories of experiences of interaction with this world (including social interactions with others) remain stored by individuals. Furthermore, such stored memories include emotions, feelings and dispositions in addition to what we might term *information*, all of which form the basis of 'cognition'. The brain makes associations between these memories and these associations organise them into conceptual structures or 'understandings'. However, since what is observed and the way that this is processed will inevitably be different in individuals, the resulting structures themselves will be different and there is therefore no absolute objectivity possible. There is, though, still very much a 'reality' to observe and this includes concepts as much as physical objects so that, say, 'multiplication' is considered every bit as real as a door might be.

In trying then to communicate about these structures with others – for example in teaching/learning – there is no way to do so other than by sharing understandings through discourse (largely, but not exclusively, verbal dialogue). Since such discourse makes use of culturally agreed semiotic signifiers (such as language itself) and since these are historically constituted within the society and its culture, the act of teaching and learning (as a specific example of communication) inevitably becomes a historical/social/cultural endeavour. Understanding can only ever be seen in terms of what is 'taken-to-be-shared'– *intersubjectivity* – since we can only know what we ourselves mean, not what others mean (Jaworski, 1994; Voigt, 1994). Note though that this does not eliminate the idea that one can also gain feedback from the physical world, as Fox (2001) points out.

Despite sharing the essential nature of Jaworski's interactionist approach to these issues, the role of the 'social' plays a bigger part than she appears to acknowledge in stating that,

> The view of learning that I have come to value is one in which individual constructions are influenced by cultural domains and social interactions, and the social and cultural environments are continually regenerated by actively cognizing individuals.
>
> (Jaworski, 1994, p. 212)

Here, the role of the social and cultural interactions is focused on the process of cognition. Whilst the social is acknowledged, Jaworski, at this point, still seems to see learning in terms of experiences – social or individual – creating perturbations in thinking which then lead the individual to *re-construct* their ideas. As Lerman (1996) argues, this does not make sense in as far as it cannot explain how individuals can 'share' the same idea intersubjectively. What is also missing is the additional role of these interactions in the generation of *dispositions* and *attitudes* in the development of the personal identity of the learner. This is the point made by Boaler (2002), who demonstrates that practices and identities are not merely additional to knowledge but are intrinsically dependent in determining the type of knowledge that results from students' mathematical activity. For her, the cognition that takes place, the dispositions and attitudes that constitute the learner's identity, and the practices they operate within, are all *mutually constitutive*.

Lerman's solution to this dichotomy between individual and social, which I share, is, like Sfard et al (2001), to change one's understanding of individual construction of knowledge and to 'recognize the shift from a view of the autonomous cognizing subject constructing her or his subjectivity and knowing to one of the construction of human consciousness in and through communication' (1996, p. 136). Furthermore, rather than seeing cognition as the internalisation of social/linguistic experiences such that existing planes of consciousness are *reorganised*, he suggests that such internalisation is better viewed as 'the process by which this plane is formed' (Leont'ev, 1981, quoted in Lerman, 1996) so that 'language is not seen as giving structure to the already conscious cognizing mind; rather, the mind is constituted in discursive practices' (ibid.). This view fits with the model of social practices advocated by Boaler, above. It is the engagement in such practices that exposes the individual to different discourses within which, and with which, they learn to communicate and it is the need to make sense of this communication that drives the individual to 'learn' – rather than, in the Piagetian view, the need for sense in terms of rational argument. One implication of this is that rather than reorganising conceptual structures, experiences *add* new planes of consciousness in the form of *practices*.

All of the above is aimed at clarifying the view of learning adopted here in this thesis. It is *from* such a view that a perspective on the National Numeracy Strategy as a

'complex sociocultural activity' has been articulated and, in summary, this perspective is one which:

- Recognises learning as inherently complex, dilemmatic and negotiable.
- Considers knowledge to be an individual representation of a 'real world'; but that this individual representation is constituted through social interaction.
- Aims for *intersubjectivity*. Since knowledge can only be communicated through semiotic means it can only, therefore, be 'taken-as-shared' between participants.
- Considers knowledge, practices and attitudes to be functions of each other, rather than merely related to each other.
- Considers discourse, mainly in the form of written and spoken language, to be generated by the imperative of communication – and therefore values discourse in the classroom.
- Applies these notions of process of developing mathematics knowledge to the process of teaching itself and therefore rejects the idea of there being 'best practice' *per se*.

The following examples, which are merely representative of the whole, now serve to illustrate how teachers might legitimately interpret the NNS in terms of this 'complex sociocultural' perspective.

First, there is the National Curriculum for Mathematics itself (DfEE, 1999j), which is still the legal entitlement for children and which, since its revision in 2000, is now 'fully aligned' (p. 62 and p. 67) with the NNS in terms of its content. A fundamental part of this curriculum is the *use and application* of mathematics as a central aspect of the whole approach to the subject. Indeed, whilst the original curriculum from 1989 had this as a separate programme of study, the newly revised curriculum of 2000 chose to integrate it

into the other programmes of study. This reinforces the idea that 'children should be taught the knowledge, skills and understanding through' engaging in the *process* of the subject, thus providing an opportunity for knowledge, practices and identity to be formed together, as Boaler (2002) suggests. Thus, the focus on reasoning, and the communication of this to others – in addition to the development of skills – point to a view of the subject that is active, investigative, interconnected and based on the need for challenge in terms of conceptual demand.

Second, the interconnected nature of the subject is projected strongly in actual policy with the assertion, for example, that the most effective learning of mathematics takes place when,

> There are well established links ..... between and across topics within the mathematics curriculum. New knowledge needs to be linked to what has already been learnt and understood, whether in the same lesson or earlier.
> (DfEE, 1999a, p. 18)

As part of this, the need to integrate mathematics into a range of contexts – both mathematical and non-mathematical – is made clear.

Third, there are many references to the importance of children's *own* involvement in a process of 'coming to know' ideas. For example, 'direct teaching and interactive oral work' (DfEE, 1999a, p. 1:11) is identified as one of four key principles for teaching and defined as follows.

> High quality direct teaching is oral, interactive and lively ... It is a two-way process in which pupils are expected to play an active part by answering questions, contributing points to discussions, and explaining and demonstrating their methods to the class.
> (ibid., p. 11)

This 'direct interactive' style, which forms the central tenet of the NNS's approach to *whole class interactive teaching*, is further exemplified in a range of ways, for example,

> We believe ... that every pupil should receive good direct teaching in the daily lesson that:
>
> gives them instruction and demonstrates, explains and illustrates mathematics, setting the work in different contexts and linking it to previous work;
>
> maximises the opportunity for the teacher to interact with the pupils, so that they can talk and be listened to, and receive feedback that helps them to develop their mathematical knowledge, skills and understanding; and
>
> allows pupils to show what they know, explain their thinking and methods and suggest alternative ways of tackling problems.
>
> (DfEE, 1998b, p. 14)

In addition, the Framework claims that,

> .... better numeracy standards occur when teachers:
>
> question pupils effectively, including as many of them as possible, giving them time to think before answering, targeting individuals to take account of their attainment and needs, asking them to demonstrate and explain their methods and reasoning, and exploring reasons for wrong answers;
>
> involve pupils and maintain their interest through appropriately demanding work, including some non-routine problems that require them to think for themselves.
>
> (DfEE, 1999a, p. 1:5)

Once again we see here the suggestion that mathematical ideas will be 'negotiated' by children in a social setting with the teacher supporting them through appropriate intervention in a range of pedagogical contexts.

Fourth, 'effective questioning' is given a high profile, since 'there is positive benefit from asking questions that challenge children to think about the mathematics before giving an answer' (DfEE, 1998a, p.20). This is linked to a wider condemnation of individualised schemes and the expectation that these should be largely replaced as a primary *teaching* source.

Last, and overarching all the points above, is the focus on 'mental calculation' and, more importantly, its wider implication that mathematics as a subject should, essentially,

be about cognitive challenge rather than the laborious and mysterious recording of symbolic procedures. Amongst its 'desired outcomes' for teaching methods and classroom organisation, the DfEE (1998a, p. 22) includes:

> All children have the opportunity to take part regularly in oral and mental work ......
> More time in mathematics lessons is devoted to interactions between teachers and pupils and mathematics.....
> Less time is spent .... in asking questions that do not challenge pupils to think.

All of the above illustrates how it is possible to make an interpretation of the NNS in terms of teaching and learning as a complex sociocultural process. Teachers who choose to adopt such a 'participation' metaphor for learning (Askew, 1999b) should have little difficulty in using the NNS to justify this perspective.

Perspective 2 – teaching and learning as a 'technical' activity

Whilst the messages from the NNS seem clear on the one hand in supporting a complex view of learning based on social participation, an examination from a different perspective seems to highlight different aspects of the teaching process with an associated, opposing, model of pedagogy. Note that the intention here is not to say that either view is adopted by teachers but, instead, that both perspectives might be possible. Again, the potential for this second perspective is justified here with just some illustrations representative of the whole. These are examined under two headings: *organisational* issues and *structural* issues.

Organisational issues

As the heading suggests, the issues discussed here are to do with ways in which the NNS suggests that teachers *organise* their teaching. Perhaps paramount amongst these is

the call for more *whole class* teaching, a call that lies at the centre of the recommended teaching approach. Actual policy is quick to point out that 'this does not mean a return to the formal 'chalk and talk' approach, with the teacher talking and the pupils mainly just listening' (DfEE, 1998b, p. 14), and indeed, in stating that 'good direct teaching with the whole class is characterised by genuine communication about mathematics' (DfEE, 1998a, p. 19) this return to working 'directly' with the whole class would appear to be firmly rooted in a sociocultural approach.

However, what is being established here is not how teachers *ought* to interpret the messages from the NNS, but, rather, how they *might* do so in practice. Alongside the desire to increase the interaction between teachers and children, training materials tell teachers that 'effective teaching involves ... directing; demonstrating and modelling; instructing; explaining and illustrating; questioning and discussing; developing and consolidating; evaluating children's responses; summarising' (DfEE, 1999d, p.20). Contained within these instructions for teaching, talk seems to be well to the fore, though it appears, given the nature of these teaching actions, that it may be mainly the teacher who is talking for the majority of the time. In addition, and perhaps more importantly, the difficulty of maintaining an active dialogue with 30+ children is not to be underestimated and whilst it may be desirable for all teachers it may not be achievable for all.

However, there may be a more powerful 'technifying' influence on teachers' practices here than any explicit message from the NNS about whole class teaching or otherwise. This influence is one of assertion about 'best' teaching approaches, for whilst the NNS is ready to acknowledge the individual nature of children's learning – albeit as but one part of a whole class – the same idea is not applied to the individual nature of teachers' teaching.

The positivistic approach to pedagogy and the unproblematic nature of 'effectiveness' were highlighted as features of 'actual policy'. Of course, this is not to claim that teachers cannot *be* effective, nor that research, inspection evidence nor many other things cannot help them to be more or less effective. However, the notion that teachers simply *are* effective, or not, *per se* needs questioning since it seems to deny any sense that the act of teaching is dependent upon contextual factors. Nevertheless, asserting that effectiveness is a permanent and static quality of any one teacher or institution allows for there being certain, specific actions that *make* teachers effective. This, of course, fits nicely into a political model that wishes to standardise teachers' work in order to be able to measure it – though it may be unlikely to resonate with teachers' lived experience, possibly creating competing imperatives in relation to external and internal (i.e. personal) expectations. It relies too, of course, on a view of knowledge as objective and absolute, such that it can be made 'public'. Thus we are told, to cite but a few examples (DfEE, 1998a) that:

> An effective teacher of mathematics conveys information to children personally, rather than relying too much on curriculum material or textbooks. (p. 19)
>
> Effective learning of mathematics occurs when there are well established links between different parts of the lesson, and between and across topics within the mathematics curriculum. (p. 17)
>
> Effective teachers have high expectations of all pupils (p. 9)
>
> Research and inspection evidence shows that there are methods that teachers in all contexts need to use to improve children's achievement in mathematics - these are set out in this report. (p. 48) .... The changes in teaching practice that the Strategy envisages will benefit all pupils (p. 49).

But, whether or not one agrees that teachers who are teaching effectively may, on the whole, be *doing* the things above, there remain three objections.

First, there is an assumption – made explicit above in relation to training materials – that factors identified as being 'associated with' effective teachers are, in fact, causal; it is these factors which are *making* them effective and that therefore other teachers simply need to copy this behaviour.

Second, the assumption is that these things are transferable actions, independent of the teacher herself, which can be removed from one context and applied successfully to all other contexts. This is a necessary assumption if the idea is that other teachers can copy their actions in order to 'help all teachers become as effective as the best in the teaching of numeracy' (ibid., p. 12) and that three days of training materials 'will entitle all teachers to an opportunity to *acquire* basic knowledge and skills that will enable them to teach mathematics effectively in the primary classroom' (DfEE, 1998b, p. 40, emphasis added). Clearly, this assumption is based on a positivist paradigm in which actions are able to be seen independently of any individual and their associated values.

Third, an assumption is being made that the meaning of the term 'effective' is unproblematic and is seen by all people to be the same thing. Of course, in the managerialist discourse, effectiveness has come to mean simply test scores, which does indeed make it unproblematic for those who choose to adopt this stance. However, managerialism was preceded by other discourses which may well be tenacious in their ability to resist change (Alexander, 1994, p. 28 – 29; 2000, pp. 145 – 149).

Structural issues

Whereas the paragraphs above outlined various issues which focused on how organisation of the teaching approaches recommended by the NNS might lead to teaching as a form of technicism, this section deals with those which are a product of the way in which it has been *structured.*

To begin with, the training materials have been shown to be positivistic in their approach to teaching and learning. In this respect they modelled the strong emphasis within the Strategy on teachers teaching to *focused objectives* in short, self-contained 'daily mathematics lessons', where 'clear objectives [are] shared with pupils' (DfEE, 1998b, p. 18) and rounded up in a plenary which training materials say should include,

> Feedback – assessing, often informally, some of the children's work and what has been achieved, sorting out common misconceptions and errors, marking together some of the written work and rectifying any errors ......
> Reflecting – reviewing the main teaching points, summarising key facts, processes and ideas, discussing what to remember and how to remember it, emphasising the mathematical vocabulary used.
>
> (DfEE, 1999c, p. 119)

If seen in their 'complex' form, these elements of the lesson could be interpreted as being prompts for discussion and shared agreement regarding learning. But a 'technicist' interpretation is likely to result in, first, an atomistic view of the subject as a series of objectives to be reached and, second, the notion that it is the teacher who controls the learning, decides what is correct and what is 'worth' remembering. Indeed the greatest contribution to this suggestion is the layout of the Framework itself, with its page-by-page exemplification of objectives and its list of 'key objectives'.

The danger then is that the implication quickly becomes that an *understanding* of the subject is equivalent simply to the sum of all its parts; that knowing all the bits is to know the whole. An example of the problem with this perception of 'understanding' is clearly illustrated by Threlfall (2000, p. 86), who notes that

> A direct and explicit approach to teaching mental 'strategies' through a sequenced rehearsal of types of method, practised in the context of number combinations which each approach 'suits', relies for its success on the children being strategic [in the sense of planning ahead] in the deployment of what has been learned......
> Unfortunately, however, since mental calculation is not normally strategic, what is being learned will not develop into an efficient and effective ability to calculate mentally [an outcome central to the NNS]....
> It is also unfortunate that the structure of the National Numeracy Framework (DfEE, 1999), in which 'strategies' to be learned are set out clearly and systematically, may be pointing teachers towards such an approach (even though there is nothing expressly written to require it).

As Threlfall implies here, there is a certain sense of irony that this situation arises as a result of the 'clear and systematic' layout of the outcomes within the Framework. It seems not unreasonable therefore that teachers may interpret the Framework (and hence the NNS more generally) in terms of such an atomistic approach.

It is important to make clear that to reject such an approach is not to reject the notion that teachers can teach methods of calculating directly, nor that these methods cannot be practised. Threlfall suggests a resolution for this (see also Sugarman, 1997), stating that 'a different [to the 'acquisition and application'] approach is needed, with 'strategies' introduced as possibilities, and lots of opportunity for children to find their own way through number challenges in an atmosphere of invention rather than correct choices' (ibid. p. 88). Note that this approach mirrors the sociocultural perspective outlined previously, with children creating personal knowledge together based on their own historical understanding of the ideas in question. Furthermore, whilst Threlfall's argument here is in the specific context of calculating 'strategies', it is easy to see how the same idea applies in the wider context of the application of any mathematical concept – a product of a belief that ideas themselves are not independent from the contexts in which they are learnt or applied (Boaler, 1997, 2002).

What is more, the NNS objectives – now (literally) the daily bread of mathematics teaching – are implied as *endpoints* for each lesson; by definition, 'objectives' to be reached by children at the end of the hour's lesson. The increased emphasis on a set of acquirable *techniques*, provides further evidence of this idea. It seems likely therefore that teachers may be driven into conceptualising their role in terms of the 'delivery' of these elements; that is to say, teachers, especially those who may not have studied mathematics in sufficient depth to have reflected on its nature, are likely to adopt a stance that assumes that the NNS itself reflects a view of the subject as a *fixed body of knowledge* rather than an *approach to understanding phenomena.* In this way, it becomes about teaching 'public

knowledge'; not about developing 'personal knowledge'. Burton (1999, 2001) points out how different this is to the practices of professional research mathematicians who are involved in the exploration of mathematical ideas and the uncovering of new knowledge, personally constructed before being *made* public. Of course, this is not to suggest that children can be at the forefront of the generation of new mathematical knowledge, however unless they are being asked to create mathematics which is at least new to them, they are not engaging in the practices of mathematicians.

In summary, therefore, this second perspective, in contrast to the first, is one which:

- Recognises learning as straightforward acquisition of knowledge and skills.
- Considers knowledge to be an individual acquisition, linked to, but not intrinsically a function of, social interaction.
- Aims for objectivity. Knowledge, being objective, can be communicated as it stands to others without any uncertainty between them.
- Considers knowledge, practices and attitudes to be related to each other, but not interdependent.
- Values discourse, but still sees knowledge as largely transferable from individual to individual and 'explainable' by an expert (teacher).
- Because of beliefs about knowledge, is willing to believe in the idea of 'best practice' *per se*.

A question of interpretation

I am arguing here then, that two opposing interpretations of NNS policy are possible and are characterised by two 'ideal types' of pedagogy. On the one hand, teachers with a view of teaching and learning as a 'complex sociocultural activity' might see themselves being urged, in practice, to:

- Work interactively with children, listening and responding to their ideas.
- View objectives as *centre-points* to lessons, working with ideas around them, but always returning to them.
- Involve the children in the development of these ideas, using their thoughts as teaching points and encouraging the shared negotiation of meaning.
- Use mistakes constructively to further develop ideas.
- Make use of a range of problem situations as part of a focus on the interdependent mathematical dispositions and attitudes being developed.
- Respond to the needs of individuals.

On the other hand they are urged to:

- Believe in the idea of teaching methods that are 'effective' per se.
- Direct their teaching at focused objectives.
- Make these objectives *endpoints* for their lessons.
- Look out for misconceptions that 'need correcting'.
- Work on word problems in particular ways, focusing on procedures and routines for interpreting them.
- Tackle attitudes and dispositions independently of knowledge.
- Try to ensure that the whole class remains together and that children are not 'tailing off'.

If one accepts these two 'ideal types', one immediate dilemma that teachers are likely to be faced with is apparent: the NNS, framed as it is in the language of *teaching*, might well reflect the lack of reference in policy to models of *learning* on which this teaching is based, making it hard for teachers to fully understand the recommended practice. More generally, the teachers are faced with a model for their teaching which, though it has the potential to be interpreted in a way which makes the social resolution of mathematical ideas between individuals its major focus, may, more likely, be seen as a template for technicism on the part of the teacher.

Having examined the intended and actual policies of the National Numeracy Strategy in this chapter, the rest of the study now goes on to explore aspects of this policy in use. To begin this, chapter 4 reports on teachers' own views of the nature of the Strategy at the point of its inception, identifying those aspects that appeared to be most relevant to them and which presented the potential for challenges to their teaching. These particular elements of the Strategy are examined in more detail in the chapters that follow; especially the process of teaching mathematics by means of interacting with a whole class of children at once. Through this examination, interpretations of the Strategy by both teachers and children, already outlined here in theory, are revisited. However, before beginning to report this work, the methods of study and their methodological underpinnings are discussed.

Chapter 3 – Methods and methodology

In this chapter I consider the research methods used throughout the study. I begin by briefly discussing *why* the chosen approaches were adopted, before detailing more fully what was actually done. Writing about these methods *post hoc* it is easy to give the impression of linearity; of action calmly and precisely following well reasoned and considered decisions about method. In practice, particularly given the exploratory nature of the early part of this inquiry and of the interpretive research approach which will be seen to have been adopted, this was often far from the case. The reality was a research process that was more iterative than linear and this should be borne in mind in reading the rest of this chapter.

Methodological overview

Research paradigms

Research strategies are essentially delineated by two opposing paradigmatic positions: *positivist* (also referred to as *normative* by, for example, Cohen and Manion, 1994) and *interpretive* (referred to variously as *relativist* (e.g. Robson, 2002), *naturalistic* (Lincoln and Guba, 1985), *constructivist* and *phenomenological* (Maykut and Morehouse, 1994)). In essence, the former is founded on *objectivism*, 'the notion that truth and meaning reside in their objects independently of any consciousness' (Crotty, 1998, p. 42) and aims to 'establish a comprehensive 'rational edifice' ... to account for human and social behaviour' (Cohen and Manion, 1994, p.37). The latter – *interpretive* – is based on a belief in a more relative world view where one 'looks for culturally derived and historically situated interpretations of the social life-world' (Crotty, 1998, p. 67) with the aim of gaining 'multifaceted images of human behaviour as varied as the situations and contexts supporting them' (Cohen and Manion, 1994, p. 37).

Each perspective sheds its own, different light on an issue under consideration, with neither holding a claim of superiority. Indeed, the value of such a complementary stance has been shown during the course of my study which, though taking an interpretive stance itself, will be seen to have benefited from the findings of other studies with positivist/quantitative outcomes (Brown et al, 2003; Hardman et al, 2003a, 2003b, Andrews and Hatch, 1999).

Though discussed by a great many authors, the postulates upon which each paradigm are founded are neatly summarised by Maykut and Morehouse (1994) under six headings, which they note '[are] liberally adapted from Lincoln and Guba, 1985', as follows:

	Questions	Postulates of the positivist paradigm	Postulates of the interpretive[1] paradigm
1.	How does the world work?	Reality is one. By carefully dividing and studying its parts, the whole can be understood.	There are multiple realities. These realities are socio-psychological constructions forming an interconnected whole. These realities can only be understood as such.
2.	What is the relationship between the knower and the known?	The knower can stand outside of what is known. True objectivity is possible.	The knower and the known are interdependent.
3.	What role do values play in understanding the world?	Values can be suspended in order to understand.	Values mediate and shape what is understood.

Table 3 ... continued

[1] Note that Maykut and Morehouse use the term *phenomenological* here, rather than interpretive

4.	Are causal links possible?	One event comes before another event and can be said to cause that event.	Events shape each other. Multidirectional relationships can be discovered.
5.	What is the possibility of generalization?	Explanations from one time and place can be generalized to other times and places.	Only tentative explanations from one time and place are possible.
6.	What does research contribute to knowledge?	Generally, the positivist seeks verification or proof of propositions.	Generally, the interpretive researcher seeks to discover or uncover propositions.

Table 3 - Comparison of postulates for the two major research paradigms.

To some extent the methods adopted within a study, and their related paradigmatic basis, interact with the subject of study. Whilst it is the subject that offers up research questions, and hence a specific choice of method/paradigm in order to generate data suitable to answer them, so too the choice dictates to some extent the focal plane of the study – what can, and cannot, be 'seen' – and hence affects the questions that can be addressed. Nevertheless, such iterations need not usually dictate the overall paradigm adopted and since this study aimed, in the first instance, to explore teachers' understandings of the National Numeracy Strategy an *interpretive* approach seemed most appropriate.

On important aspect of this choice was the sense of 'self' involved. Woods (1996, p. 1) has claimed that

> one often does research in part to discover more about oneself. ... it is chiefly through the self that one comes to understand the world. In turn, the discoveries one makes reflect back upon the self, which is then fed back into research, and so on.

Thus, the choice of approach in a research study must also reflect, to some extent at least, the personal identity of the researcher. It is for this reason that Woods (ibid.)

suggests that sharing something of one's own history is an important part of reporting interpretive research findings, in that claims to validity must be judged by the reader in the context of such history. Though space limits an extensive description, several events in my life are worth noting in that they appear most relevant to my choice of paradigm. These, themselves, are self-selected and therefore form part of the process of 'tuning' myself as an 'instrument of research' (Cohen and Manion, 1994, p.26).

Autobiographical details

First, in terms of background, my father was a university lecturer who became a professor of music, whilst my mother holds a first degree and an MA in environmental science and has been a teacher for much of her life. I thus come from an academic background, with both scientific and artistic sides. I took science and mathematics A-levels and went on to study Engineering Science at Oxford, seeing myself very much as a scientist and learning the essentials of the scientific method. Importantly, the nature of study on this course required almost complete independence on the part of the students and this, coupled with the nature of engineering as a subject that requires mathematics as a tool and a very exam focused secondary schooling in mathematics, meant that my understanding of the subject became both highly instrumental and based on a view of learning as almost entirely individual. The significance of this is that, despite being apparently successful in the subject, when I later came to teach mathematics education to students teachers I began to see the limitations in my own understanding. I therefore found myself relearning the subject, but from a new point of view. For the first time I could learn it without the pressure of an exam imposing a particular style of learning on me and, furthermore, my own revision of many basic mathematical areas was being carried out in the context of supporting student teachers in developing their own ideas. Crucially, I came to understand during this time that *not understanding* provided the lever necessary to generate the *intention to make sense*. Put another way, I have come to believe in *indeterminacy* as an ally in learning rather than as a threat to understanding – a perspective that will be seen to be of significance later on in this thesis.

At the end of my undergraduate course I chose to do a post graduate certificate in primary education at the University of Exeter – almost unheard of in Oxford engineering circles where many of my colleagues were going on to be management consultants, business executives etc., though strangely, not engineers in the majority of cases. This choice to teach young children reflects, I think, what might be called a basic 'human-centeredness' on my part. Conflict and expressions of emotion were largely taboo in my upbringing. This is not to say that my childhood was oppressive though; indeed humour (albeit in an appropriately intellectual and linguistic form) and artistic events, largely in the form of music, were a constant feature. Sport took up the major part of my spare time, whilst music was rejected. My brother on the other hand, though less academically successful, was a successful violinist and this gained the approval of my father. One product of this upbringing has been that from an early age I developed a high awareness of people's emotional states. For much of the early part of my life this was simply a sub-conscious protective mechanism against the possibility of conflict, before a combination of growing maturity and professional counselling helped me to begin to make more productive use of this characteristic. At the same time my father's academic background meant that intellectual argument, as a form of mental jousting, became a regular feature of family life and with it came the almost habitual act of problematising anything that came into mental focus. Other people's ideas were there to be challenged, whilst one's own were to be defended at all costs; particularly as a male.

The move from Oxford directly into teaching took place in 1989, just as the first version of the National Curriculum came out in draft form. My time at Exeter, and in my first job, thus straddled the transition from the complete independence of teachers to design and manage their own curriculum to their having the broad 'programme of study' dictated by central government. It was thus a time of considerable debate regarding the nature of education and the role of the teacher, a debate that rumbles on still and has culminated in the introduction of national testing and, most lately, the National Literacy and Numeracy Strategies, the second of which forms the focus of this study. In addition to this being a transient time in education, I benefited from working with a number of exceptional tutors at Exeter who were eager to critique the current changes to practice and to engage the students in critical thinking about education more generally – a process that my upbringing made me eager to join in with.

In teaching for five years in a 5 – 12 school in Exeter I discovered that though I seemed quite capable of working in the class teacher's role I quickly became relatively disillusioned with the job in terms of what I saw as a growing divide between the principles that I wanted to work with and the reality of practice with its associated accountability. Central to this was the extent to which education was being made quantifiable through assessment processes that seemed to me to be at variance with the individual nature of children. This feeling fuelled my interest in the relationship between people – teachers and children in particular – which at that stage was simply a sense of dissatisfaction, but which became over time a more reflected upon set of beliefs about the effects of the interaction between teacher, child and task. The dissatisfaction also hid to some extent a realisation that I gained more satisfaction from the intellectual task of thinking about teaching than from the, often rather monotonous, task of planning, teaching and assessing children's schooling. When, therefore, after six years in the primary classroom a temporary secondment to the University of Plymouth mathematics education team became permanent I made the move into higher education and began to develop a particular interest in the way in which children and HE students came to understand mathematics.

This brief autobiography is intended to capture several important features of my own identity relevant to both the focus of study and the choice of paradigm for its exploration. Unlike a positivist stance, an interpretive stance cannot rely on claims of objectivity based on detachment from the objects of study – indeed the essence of this perspective is that the researcher claims *not* to be detached in this way (Bassey, 1999; Hammersley, 1993; Scheurich, 1997; Woods, 1996). Rather, research is seen as a construction of the researcher and issues of validity will need to be judged, at least in part, as a function of the researcher's own stance.

In these terms, first, my early career coinciding with the National Curriculum has contributed towards a doubtful outlook on all centrally imposed policy – such as that outlined in chapters 1 and 2. Such policy has subsequently made the National Numeracy Strategy a natural source of both curiosity and scepticism. Second, my changing understanding of the nature of coming to know mathematics has developed in me an awareness of the need for an essential indeterminacy as the driving force for learning and a related scepticism towards any claim that a particular form of activity will *necessarily* result in particular learning products. Such 'cause and effect' approaches to learning seem misplaced and, again, this makes the rhetoric of the National Numeracy Strategy a focus of interest. Third, my development as a child of a sensitivity towards emotions, coupled with an essentially human-centred approach to education, has meant that interpretive approaches feel natural as a means of making sense of the complexities of interactions. Finally, my almost habitual tendency to problematise issues has meant that the process of interrogating qualitative data for possible meanings has come, I believe, relatively naturally to me – despite an early apprenticeship in mainly 'scientific' disciplines.

The mode of study as a reflection of the object of study

As chapter 2 has already made clear, the stance taken in this thesis towards learning mathematics is a sociocultural one, in which social interactions between learners and teacher(s) form the major mechanism by which knowledge is constituted.

I entered the process of researching mathematics classrooms with a view of teaching/learning that was intrinsically *interactionist* in nature. Crotty (1998, p. 45) describes the interpretive research perspective in similar terms, noting that,

> because of the essential relationship the human experience bears to its object, no object can be adequately described in isolation from the conscious being experiencing it, nor can any experience be adequately described in isolation from its object....

Clearly, this perspective is very much in line with the view of teaching/learning outlined in the previous chapter and brought to the research study, which in turn, through the autobiographical details above, has been seen to be a product of my own identity as a learner/teacher/researcher of mathematics.

It is important to clarify that the objective of this research was not to try to demonstrate that the nature of teaching and learning *is* intrinsically social and interactionist – this view is taken as read from the start. What is thus being explored is, assuming the social character of teaching/learning outlined in chapter 2, how *then* does the National Numeracy Strategy appear to have been designed by policy makers and interpreted by practitioners in relation to this perspective?

One final corollary of the point above is the nature of the 'truth' of the research. If meaning is seen as being the product of interaction between individuals, if one can only know what this 'means' to oneself and if meaning between people is only shared in as much as it appears to be intersubjective, then meaning is not 'truth' in the objective sense and nor is it 'present' in the moment of interaction. Rather, it is constituted in the moment of interaction, and can only be made conscious to the individual participant through reflection *post hoc* (though this may be almost immediate, or may take place some time after the event). Since the act of research is a process of meaning making in itself, it is not claimed that the meaning that I am now writing about in the construction of this thesis holds any objective 'truth' nor was actually 'there' in the event.

Trustworthiness

The epistemological view of the research process outlined above presents challenges for the researcher. Accepting the essential interdependence of the investigator and the investigated challenges notions of validity; acknowledging the transformative process of interaction itself problematises reliability.

Woods (1996) discusses at length some differing responses to these challenges, noting that positivist perspectives have been challenged in recent years by 'those who prefer to seek ends like 'understanding', 'fidelity' and 'trustworthiness'' (p. 56). His central point is the need to acknowledge a sense of 'artistry' in qualitative research whilst maintaining sufficient rigour to ensure that what is reported remains trustworthy (after Lincoln and Guba, 1985). He notes the distinction between different elements of the research itself, some of which is likely to be exploratory – and hence potentially largely interpretive – and some more focused on verification with the associated need for the 'usual practices of triangulation, immersion, respondent validation and so on' (p. 60). In this sense the research process must demonstrate *internal* validity – factual information must be accurate and rigorously collected/analysed and what is reported must follow from the data, even if this involves some interpretation. However, its *external* validity will be subjective in relation to those who read it and dependent on the degree of trust they feel can be placed in it given the openness and extent of the information provided as to how the research was conducted. It is this approach to *trustworthiness* of the research that is adopted here.

Bassey (1999, p. 75) uses an analysis from Lincoln and Guba (1985) to develop a set of eight pragmatic questions for use in testing such trustworthiness, as follows. Though the list refers specifically to case studies, it serves as a useful tool for interpretive research in general and is used in evaluating the effectiveness my own data collection and analysis in the following sections.

1. Has there been prolonged engagement with the data sources?
2. Has there been persistent observation of the emerging issues?
3. Have raw data been adequately checked with their sources?
4. Has there been sufficient triangulation of raw data leading to analytical statements?
5. Has the working hypothesis, or evaluation, or emerging story been systematically tested against the analytical statements?
6. Has a critical friend thoroughly tried to challenge the findings?
7. Is the account of the research sufficiently detailed to give the reader confidence in the findings?
8. Does the case record provide an adequate audit trail?

Finally, whilst much of the above has been about validity, the reliability of interpretive research is also problematic. As has already been observed, the assertion that any form of data collection that involves an interaction between participants affects the understanding of those involved – that researcher and researched are interdependent – implies that one can never repeat the 'same' research. Indeed, in this sense the research undertaken here did not 'uncover' theory. Rather, it constructed theory as a result of reflection on the interactions that were taking place between myself and those with whom I was working; the research discourse itself. The work is not therefore reliable in the sense that another researcher working with the same people would necessarily have found the same things. However, it is reliable in the sense that the theoretical categorisations that I created were recognisable, once explained, to another person. In practice this meant explaining the theoretical categories to a colleague who was then given data samples to check in this respect – as explained in detail in a subsequent section below.

Generalisation

My research here involved the study of particular 'cases' (see methods below) and whilst the trustworthiness of these can be established in the ways above, the extent to which single cases can be generalised has been the basis of considerable thought in the literature. Bassey (1999) summarises a number of positions in this respect, in particular those of Stake (1995), Yin (1994) and Atkinson and Delamont (1985). He also notes that the danger in studying single cases is that findings can be overstated because of a misunderstanding of the nature of generalisation itself. Yin (1994) uses the term 'analytic' generalisation to focus on the need to relate findings from a case to *theory* rather than to other cases, so that 'case study' is not about sampling, but is 'analogous to the way in which a scientist generalizes from experimental results to theory' (p. 37). It is thus theory that can be generalised. Meanwhile, Stake (1995) focuses on the quality and density of the report of a case study, noting that individuals can make their own personal generalisations (what he terms *naturalistic* generalisation), often through vicarious experience, if the quality of the report is good enough. He notes too that it is the very nature of case studies, which 'may be epistemologically in harmony with the reader's experience' that make them a 'natural basis for generalization' for that individual (quoted in Simons, 1980, p. 64). Golby (1994) follows a similar line in wanting to see cases in terms of their 'particularity' and 'intelligibility', rather than their uniqueness, placing the emphasis, like Stake, on the ability of an internally validated and carefully presented case to illuminate understanding in the reader. Bassey (1999) has taken the discussion a step further in rejecting *scientific* generalisation (in the sense of contextually independent, causal relationships) and

statistical generalisation (the study of samples leading to statistical measures of likelihood) in favour of what he terms *fuzzy* generalisations. These are generalisations that

> say that something *may* happen, but without any measure of its probability. It is a qualified generalization, carrying the idea of possibility but not certainty.
>
> (p. 46)

The idea has been criticised by Hammersley (2001), claiming that it fails to understand the essentially contextual nature of even 'scientific' generalisations. He notes that the problem is not the nature of generalisations, which are intrinsically causal in nature, but the ability to define the boundaries of the context within which this causality is valid. Thus, the problem is not that case study alone is unable to create laws that will predict outcomes in all cases but that, in fact, *any* type of research fails to be able to do this, so that even if educational research could produce scientific laws these would only tell us what *could* happen and not what *will* happen.

Though Hammersley's point about the nature of generalisation is valid, he himself acknowledges the value of the notion of 'fuzziness', particularly in 'suggesting that we can have theoretical knowledge of causal relationships before we can produce precisely and fully formulated scientific laws – indeed, perhaps even when such precision and completeness are unobtainable' (2001, p. 223). Nevertheless, there remains a further point to be made about fuzzy generalisations. Both Bassey's original conception and Hammersley's critique fail to take full account of a central aspect of generalisations in influencing practice; namely that the practitioner is not a *passive* recipient of the research in the way in which formulations of generalisations (of any sort) seem to suggest. Thus, whether they are suggested in the form 'do x instead of y and something positive *will* happen to your practice as a result', or in their fuzzy equivalent 'do x instead of y and something positive *may* happen to your practice as a result', both formulations imply that

the changes in practice happen *to* practitioners rather than that practitioners *make* changes happen within their practice.

The important aspect here is the function of research and the role of researcher and practitioner within it. From the point of view of the researcher, the aim of the research is to analyse a situation in order to understand it better and then to disseminate this new understanding in order that others might share in it. From the point of view of the practitioner however, the aim of the research is to make use of the fresh insight in *effecting change* in his or her own context. Note that, in the first of these, the aim is the *formulation* of understanding, whilst in the latter, the aim is the *utilisation* of understanding. If research merely aims to describe a studied case then an analysis of what happened *to* the practitioner suffices. However, if it aims to offer the opportunity for practitioners to change their practice as a result of understanding the studied case, then it seems sensible for the research to present the analysis in a form that emphasises the action that may be taken to facilitate that change. Indeed, this is what Bassey seems really to be proposing.

> A fuzzy generalisation carries an element of uncertainty. It reports that something has happened in one place and that it may also happen elsewhere. There is a possibility but no surety. There is an invitation to 'try it and see if the same thing happens for you'.
>
> (1999, p. 52).

I would suggest, however, that fuzzy generalisations might be taken a stage further (see also Pratt, 2003 in appendix 11). Instead of stating that 'doing x rather than y may *result in* a positive change to your practice' we might state that 'you may be able *to facilitate* change z in your practice by considering doing x instead of y in your particular context'. One might claim that this is simply a change of syntax. However, in the same way that Bassey himself suggests that a small change in wording from 'will' to 'may' produces a significant change in meaning, so I make the same claim here. What is

important is not – as Hammersley rightly argues – the *form* of the generalisation, but nor should it be simply an 'invitation to try it and see' – as Bassey proposes. Rather fuzzy generalisations can be seen as a way in which researchers may share with practitioners their understanding of how the latter *might* reconsider their practice in order, *proactively*, to make change happen in their own context – reflecting Stake's (1995) 'naturalistic generalisation'. Furthermore, the invitation remains open for the practitioner to report back on the process of trying to effect the change, to describe whether or not it worked, and to analyse the aspects of the practice which facilitated this. It thus maintains, as Bassey suggests (1999, p. 52), the opportunity for case study to become cumulative as individual practitioners identify those features of their practice which seemed to be significant in effecting the change.

Finally, in considering the nature of generalisation from a case, Simons (1996) notes the demand in the current political climate to 'derive scientific literacy from large samples' (p. 227) and the pressure on case study to make use of more traditional methods 'only slightly enhanced by the contextual utility of case studies' (p.226). In response, she urges the case study researcher to 'live with paradox' in the belief that 'to live with ambiguity, to challenge uncertainty, to creatively encounter, is to arrive, eventually, at 'seeing' anew' (p.238). It will be seen that such advice is well placed in the context of the findings of this study which, in essence, claim the need for exactly this same kind of ambiguity in the teaching and learning space of the classroom. What Simons promotes for case study researchers is just that form of engagement with ideas that I will come to claim as necessary for children and teachers in the mathematics classroom and it brings one back to Woods' (1996) claim about research as a process of self-discovery.

Methods

Having reviewed the overall methodological arguments I now describe the methods used in the empirical work undertaken. The work was undertaken in two distinct phases, the second of which was, itself, in two parts. These are summarised here, as follows:

Phase 1: an exploratory study of teachers' initial understanding of the National Numeracy Strategy at the point of its inception.

The aim here was to find areas of interest to both teachers and myself, as researcher, for future research, as well as to document teachers' understanding at this point in order to contextualise any future work. This was an exploratory stage therefore, in which potential avenues for investigation emerged, were initiated and subsequently altered. In summary, this led to a number of possibilities for research from which one was chosen specifically, namely: the nature of the interaction between children and teachers in *whole class interactive teaching* situations. However, it also led to the development of several theoretical lines of thinking that were of interest in their own right and which are reported briefly in the chapters that follow.

Phase 2: an investigation into whole class interactive teaching situations.

Having identified *whole class interactive teaching* in general as a key issue in teachers' thinking at the point of inception of the National Numeracy Strategy, this process was explored in more detail in two stages:

1. observations of three teachers at work in their classroom settings;
2. interviews with children regarding their perspectives on such settings.

These two stages resulted in further 'progressive focusing' of attention (Hammersley and Atkinson, 1995) and subsequently in findings that help one to understand the teaching process in use in the National Numeracy Strategy. Again, this understanding is in relation to the interactionist perspective that was adopted for the study.

Though different methods were used during each phase, a common tool used throughout the whole process was a research journal. This consisted of notes, reflective memos and analytical statements which built up as the research progressed and formed a significant part of the data, as well as being a tool for thinking.

Methods adopted for phase 1

The following research questions were used as the basis of study for the first phase of the research:

What are teachers' understandings of, and feelings about, the National Numeracy Strategy?

- In what sense do they understand it in terms of its mathematical and pedagogical dimensions?
- What element(s) of control do teachers feel they have over its implementation?
- How does their understanding of the Strategy relate to the actual policy of the Strategy delineated in the previous chapter?
- How does it relate to their own understanding of what mathematics is?

How do teachers' perceptions of what the NNS is affect the way they perceive they are trying to teach?

- What do they see as the key aspects of the Strategy?
- What might be the implications of these key aspects for their teaching?

In order to explore their perspectives, ***interviews*** were undertaken with fifteen teachers in seven schools with which I was currently working, or had recently worked in the past, with initial teacher education students. Five of these schools were located in towns in South or East Devon and Somerset and the other two were village schools in Mid-Devon. The teachers were chosen in order to include a range of differences in terms of age, gender, professional position and age range taught. These choices were based on a desire for depth of data and not for proportionality in terms of the profile of teachers in general. The resulting profile of teachers was as follows:

Gender	3 men 12 women
Position	6 mathematics coordinators 7 class teachers 1 deputy head teacher 1 advisory teacher
Age	3 aged 20 – 29 5 aged 30 – 39 5 aged 40 – 49 2 aged 50 – 60
Age taught	6 taught Key Stage 1 8 taught Key Stage 2 the advisory teacher had no class responsibility

Table 4 - Profiles of teachers in phase 1

The interviews all took place in the summer term of 1999, just as the National Numeracy Strategy was appearing in schools. Because of the nature of this phase of the research, the interviews were semi-structured in design (e.g. Robson, 2002) with each one lasting between 30 minutes and an hour. Such an approach allows for a wide range of issues to be addressed whilst remaining within a general area of focus, as well as for respondents to raise their own ideas which could be followed up during the course of the interview. It thus holds great potential for generating rich and insightful data. Nevertheless, this flexibility carries a potential problem too. 'Since an interview is an inherently social interaction it is governed by the conventions of such discourse (Scheurich, 1997). Thus, respondents are likely to give most when they feel at ease with the interviewer. Similarly, *what* they say is most likely to be valid – in the sense that it is a faithful record of what the interviewee 'believes' at that moment – only in as far as the respondent trusts the interviewer. However, as Cohen and Manion (1994) point out, the increased validity likely to be generated where both interviewer and interviewee are at ease with each other also means that the interview becomes ever more a product of the particular relationship of the two participants. Such a dilemma can only be addressed by ceasing to consider the repeatability of the interview and focusing instead on the extent to which others can agree *post hoc* to the way in which data has been *categorised.* A procedure for this is described in the sections that follow.

The interview design was based on an approach suggested by Maykut and Morehouse (1994, p. 84), the main elements of which involved:

- 'Brainstorming' the area of focus for the interview.
- Clustering ideas according to similarities into related categories.
- Developing open-ended framing questions for each category and ordering these into a schedule.

- Rehearsing this schedule in a pilot.

The result of this process was a semi-structured interview schedule which explored four key areas: introductory questions relating to the interviewee and their *context*; the interviewee's *understanding of the nature of the National Numeracy Strategy*; the *changes to their teaching practice* made, or envisaged, by the interviewee; the interviewee's *understanding of the nature of mathematics* as a subject. The interview schedule can be seen in appendix 1. The intention was that each question should be open-ended enough for the respondents to talk freely about the issue under consideration. However, possible *prompts* and *probes* (Robson, 2002, p. 276 – and see appendix 1) were included to use if certain aspects of the issue, imagined to be of particular interest prior to the interview, did not accrue or if answers did not seem to explore the issue in any depth. Again, Maykut and Morehouse (ibid. p. 90) recommend the use of a range of different question types for this purpose too, in order to explore a fuller range of human experience, including: feelings (affective states); opinions (values and beliefs); and knowledge.

The analysis of phase 1 interview data

The interviews undertaken with teachers were audio recorded and transcribed, mainly by an administrative assistant. The approach taken to analysing the resulting data was broadly that advocated by Strauss and Corbin (1990), and made use of the *constant comparative* method in order to generate *grounded theory*.

In outline, data, in the form of interview transcripts and the original audio tapes, were analysed as soon as they had been prepared. This analysis began with *open coding* of phenomena, as I saw them, within the utterances of the participants. Crucially, since a real danger of transcript analysis is that words are taken out of context (Scheurich, 1997), transcript and audio recording were used alongside each other in order to try to maintain a trustworthy sense of the meaning in the context of the interview as a whole. Simultaneously, an attempt was made to remain attentive to ways in which the interviewee might have been led in the course of the interview towards particular statements (bias). With these checks in mind, the transcripts were scrutinised for *concepts* that appeared inherent in the discussion between interviewer and interviewee and these were given *conceptual labels* as they appeared (see appendix 2). As Strauss and Corbin (ibid., p. 65) note, as one progresses with this labelling, so one starts to notice links between concepts which gradually coalesce around wider *phenomena* and which can, in turn, eventually be seen as distinct *categories*. These categories 'have conceptual power because they are able to pull together around them other groups of concepts or subcategories' (ibid.). As further interview transcripts were analysed, so the clarity of the categories began to be developed until an attempt was made to define each category precisely. Thus, *rules for inclusion* of data within categories were defined and the data were scrutinised once again in order to establish whether the phenomena identified within them were justifiably part of any one category. This iterative process of moving between the data and the developing theoretical categorisations is the characteristic element of the notion of *constant comparative* analysis. In practice, categories and their related rules for inclusion were changed until data were either rejected or sat clearly within a category, and each change to categories required a fresh reconsideration of the data. This process continued until there seemed to be little more that the data could contribute to new thinking, and the categories were considered 'saturated' (ibid.). These developing categorisations are shown in appendix 3. Strauss and Corbin (ibid.) refer to *properties* and related *dimensions* of the categories and these were developed as part of the process of defining the rules for inclusion. As part of this development of categories, but also in relation to literature and my ongoing work in mathematics education as a university lecturer, *theory* was developed in respect of the research questions and it is this theory that is reported in chapter 4. It is in the sense that

the theory developed out of the process of engagement with the data and my ongoing thinking about the issues involved which leads one to refer to it as *grounded*. Though this process tends to lead one to look inwards at the data, care was taken to try to maintain an outward looking stance too through the use of continuing reference to literature, a research diary and regular working memos (Woods, 1996; Strauss and Corbin, 1990), as well as critical appraisal through seminars to colleagues and supervisors. In addition, *negative cases* (Woods, ibid.; Strauss and Corbin, ibid.; Robson, 2002) were sought out in the data and were part of the process of refinement of categories of analysis. Furthermore, transcripts from interviews, along with notes about my thoughts in relation to them, were returned to each participant for comment.

Finally, having outlined the approach taken to the analysis of the interview data, it should be noted that in reporting it here, the sense of linearity of the whole research process is grossly distorted. In practice, data collection, analysis, theory generation and fresh interviews were all taking place alongside each other and there was often a strong sense of confusion, followed by periods of breakthrough. More generally, Scheurich (1997) has critiqued Strauss and Corbin's approach noting how at the collection stage the process produces data which is 'very similar to quantitative data' and how during analysis the attempt to systematise the process results in categorisations which are formed 'from a mold (sic) that is then shaped from the researcher's conscious and unconscious assumptions and orientations' (ibid., p. 63). Again, the approach taken to dealing with this dilemma has been to allow the reader to see the resulting theory in the light of the researcher's own history (ibid., p. 74).

It should be evident, in reading the description of the interviewing process above, how the theoretical discussion of epistemology with which this chapter began starts to be realised in practice, and in particular how the researcher's own perspective does not simply affect the analysis of the data, but is central to the way in which this analysis is

undertaken. In order to try to gauge the trustworthiness of the results, however, I now return to Bassey's (1999) eight questions outlined above and use them to consider this first phase of the study.

Question:	Attempts at ensuring trustworthiness:	Potential weaknesses:
1. Has there been prolonged engagement with the data sources?	Interviews were open-ended and extensive. Few interviews were interrupted due to time constraints.	No return was possible to interviewees to explore issues further, though transcripts and comments were sent.
2. Has there been persistent observation of the emerging issues?	Not applicable	Not applicable
3. Have raw data been adequately checked with their sources?	Transcripts and comments returned to respondents.	Little comment from respondents may suggest that few took the trouble to engage with issues and respond.
4. Has there been sufficient triangulation of raw data leading to analytical statements?	As above, and analysis led to writing of research memos in relation to literature. Also, my own personal history has been made explicit and available to the reader.	Limited opportunity to really engage with respondents in relation to data and resulting theory.
5. Has the working hypothesis, or evaluation, or emerging story been systematically tested against the analytical statements?	Resulting theory largely exploratory and aimed at conjecture generation for future study. Nevertheless, constant iteration between data and categories provides some confidence in the care taken of testing.	Exploration of a relatively new field of inquiry makes the outcomes inevitably conjectural.

Table 5 ... continued

6. Has a critical friend thoroughly tried to challenge the findings?	Findings presented at internal faculty research seminars. Also discussed with supervisors and critical colleagues.	
7. Is the account of the research sufficiently detailed to give the reader confidence in the findings?	Detailed presentation of both method (above) and findings (see chapter 4).	Account can never give full and accurate picture. Process is inevitably 'messy' and not open to full analysis.
8. Does the interview record provide an adequate audit trail?	Careful preservation of process (see appendices) aiming to show development of ideas.	Reader must inevitably trust the judgement of the researcher in terms of what is chosen for presentation.

Table 5 - Analysis of the 'trustworthiness' of the research: phase 1.

The table above allows me to assert a relatively high level of trustworthiness in the findings, at least in as far as they provide 'thick description' (Geertz, 1973) of the respondents' views and theory that is both faithful to this description and consistent, internally within itself and within the theoretical base already existing.

Methods adopted for phase 2 – stage 1

The first phase of research, which was exploratory in nature, led to a number of potential avenues for further study, of which whole class interactive teaching as a potentially exciting 'new' teaching approach was chosen. In order to begin to explore this aspect of teachers' work, *classroom observations* were initiated with three teachers. All three of these had expressed an interest in being involved from the point of view of their own professional development and two ('Heather' and 'Mary', both from 'Townleigh' primary school) had contributed to the initial interviews, with the other ('Frances', from 'Riverview' primary) being a teacher from a school in which I was a governor. Though self-selecting in that they had volunteered to work with me after I had outlined my ideas to staff at both schools, they represented a reasonable cross-section in terms of their own self-declared confidence in teaching mathematics. They also taught two different age groups – Year 1 for Mary and years 5 and 6 for Heather and Frances. Chapter 5 provides more comprehensive biographical information for each teacher.

In terms of the methods of study, having identified whole class interactive teaching as the general focus of investigation, a way was now needed to explore this in more detail. Hammersley and Atkinson (1995, p. 206) suggest the notion of 'progressive focusing' in that 'over time the research problem needs to be developed and transformed, and its eventual scope [is] clarified and delimited'. They note too that 'it is frequently well into the process of [ethnographic] inquiry that one discovers what the research is *really* about' (ibid., emphasis in original). In this case, *what* to focus on was still open; whole class interactive teaching had been identified by teachers as simply 'of interest', but with little insight yet as to why. In one sense, therefore, there was the opportunity for a *case study*, though the meaning of 'case' needs careful attention. In reviewing different attempts to define 'case', Bassey (1999) refers to examples in which the case is defined in terms of the participants (e.g. Cohen and Manion, 1994) and others where it might also refer to a phenomenon (e.g. Yin, 1994). It is in relation to this latter meaning that it makes sense to talk of the *interaction between a teacher and a whole class* as a case. Indeed, Robson (2002, p. 179) claims that more importantly case study is: a *strategy* (not a method); *empirical*; about the *particular*; focused on a *phenomenon*; and, involves the use of *multiple methods*. In these terms the label seems to fit well, and as Yin (1994, p. 15) notes, the real value of case study is that it has the potential 'to explain the causal links in real-life interventions that are too complex for the survey or experimental strategies'.

Whilst being a case study, therefore, the work was also *ethnographic* in nature. As Robson (ibid.) again points out 'classical ethnographies' meant years of participation in a situation and for all but few researchers this is impossible. He therefore refers to taking an 'ethnographic approach', and again, it is this meaning that is used here where the key features are:

- A focus on cultural meanings and interpretations.
- Gaining an insider's perspective.
- Study in the natural setting of the phenomenon.
- A grounded approach to theory development.
- Prolonged data collection from a range of sources, focusing on description and interpretation.

(adapted from Robson, 2002, p. 188)

In practice, classroom observations were undertaken with the three teachers and a total of 20 mathematics lessons were observed (7 each for Mary and Frances and 6 for Heather), with particular focus on the occasions where the teacher and class were working together 'interactively', as defined in the terms of the National Numeracy Strategy and its three part lesson. In addition, each observation was followed by a discussion with the teacher involved in which they were asked to identify issues that they felt had arisen during the observed session. As chapter 5 makes clear, this was not always as easy as it sounds, both in terms of finding quality time to do it and in terms of teachers' willingness to take the lead in this respect. Finally, once all the observations were finished, a post-observation interview was held with each teacher in which a structured set of prompts in the form of a questionnaire were used with the interviewee as the basis for the interview (see appendix 4).

From an epistemological point of view, observations of practice are susceptible to the same dilemmas as all other forms of data, being, once again, the product of the interrelationship of researcher and observed, and the same caveats apply in this respect for phase 2 as for phase 1 of the study. Not withstanding this point, a variety of stances can be adopted by the observer, of which the most important are perhaps the distinctions between

the level of *formality* of the observations and the degree of *participation* involved. In terms of the former, an informal approach was adopted in which I left myself 'considerable freedom in what information [was] gathered and how it [was] recorded' (Robson, 2002, p. 313). Given the still exploratory nature of the early part of this phase, this presented the best opportunity for identifying issues of significance for teachers. In contrast, more formal approaches to observation which structure the style and focus of the observer, though useful in that they may help to deepen the understanding of particular issues, run the risk of denying the possibility of remaining open to all possible lines of investigation. Instead, early on in the observations particularly, I simply watched the events as they took place and noted anything that seemed relevant to the process of interaction between teachers and children. I also attempted to capture the dialogue between teacher and children as it happened. Although impossible to capture completely, I was able to write enough so that gaps could be filled in after the event and, with practice, this became relatively achievable. In making these observations I relied heavily in the first instance on myself as 'expert' in respect of the classroom situation – researcher-as-instrument – and on my experience watching classroom events with an analytical eye with support student teachers. Then, in consulting with the teachers involved after each lesson, and bringing observations and existing theory together, the focus of further observations became progressively sharper. Clearly, the consultation with the participating teachers remained a crucial element here in avoiding regression to my own preconceptions. Also vital was the process of using analytical memos and notes (Hammersley and Atkinson, 1995; Strauss and Corbin, 1990) which promoted reflection on the research process and its findings and helped in remaining detached enough to consider potential flaws in the process (see appendix 5 for an example of these). In practice, the progressive focusing led to a particular focus on the way in which children gave their attention to issues at hand and how the teacher controlled the agenda of the classroom activity. This is reported in chapter 5. It will be seen too that further triangulation of these findings was undertaken in stage 2 of this second phase, when similar observations were discussed with children, though in this first stage no consultation with the children involved took place. Looked at retrospectively, this perhaps represents a missed opportunity.

Clearly, being in the classroom as an observer meant that I became a *participant* in some respect. The extent of this participation is complicated by the different possible roles I may have been seen to adopt within the setting. At issue here is what it means for an adult, such as myself, to 'participate' in a mathematics lesson. Whilst many examples given in methods texts may be clear-cut (e.g. Cohen and Manion, 1994; Robson, 2002; Yin, 1994), as a guest in a classroom my presence may have had many meanings. To the teachers involved I was at best a critical friend (remembering that they volunteered their own involvement) and at worst, an inspector of their practice. Indeed, though I might like to think of the former, the fact that all the teachers seemed eager for my judgement on their work, often asking 'how did I do?', suggests that the latter was, at least in part, the case and their actions were certainly affected by my presence. Frances and Mary, for example, noted higher levels of preparation when I was coming to observe and Heather referred to a more conscious use of interactive strategies for her teaching. In considering the resulting data from my observations, care was taken to keep these comments in mind in drawing conclusions and to be aware of those aspects of their teaching which may have been particularly distorted by my presence.

To the children, I introduced myself as a lecturer 'finding out more about mathematics teaching so that I could help my own students to teach it better'. Quite what they understood this to mean or what effect it had on their work cannot be known. However, the children seemed quickly to ignore my presence in the classroom and the teachers reported that they noticed little in the way of unusual behaviours. This is perhaps symptomatic of the many adults in modern classrooms and the familiarity, therefore, of

one more such individual to the children. Furthermore, I *am* actually a qualified and experienced teacher and therefore I already understood the culture, in general terms at least, of these classrooms. This allowed me to 'indwell' (Maykut and Morehouse, 1994; Woods, 1996) more readily than might be the case for researchers in other situations, acting as a teaching assistant might do, for example, when appropriate. Rather than trying to categorise my involvement therefore, it is perhaps more useful simply to describe it.

In essence, I would normally watch the introductory, whole class part of the lesson from the back, making notes as I went. Though I would choose a position out of eye-line with the teacher and behind the majority of the children, I made no attempt during this observation to be 'invisible' and if children chose to speak to me I would respond readily, if appropriate in the context of the lesson. Similarly, where children spoke to me at inappropriate times, or where disruption occurred in close proximity to me, I would deal with this in the way that a classroom assistant might. Once the children moved to working individually or in groups, I would then involve myself in this as a teaching assistant, moving amongst the groups and supporting the teacher. On occasions the teacher planned for this involvement and 'gave' me a group to work with. In this way, not only did I hope to become more a part of the classroom culture, but such involvement sometimes helped to illuminate the children's perspectives on aspects of what they were involved in. As the lesson came together again at the end, so I would return to my note taking role at the back.

As with the interview data in phase 1, observational data were analysed on an ongoing basis, with observations from one event cross-referenced to other events. The extensive use of analytical memos and notes meant that developing ideas from one observation were formulated as conjectures and then taken back into the observational arena. Observations continued until it was felt that what was being gained in terms of fresh insights did not merit the effort of further visits – *saturation* in Strauss and Corbin's (1990) terms. Theoretical constructs resulting from this stage, formed of a series of dilemmas experienced by participants, were presented to the teachers during post-observational interviews for comment, resulting in some minor changes as well as greater insight into their accuracy and potential generality.

Methods adopted for phase 2 – stage 2

The final stage of the empirical study moved on from working with teachers in classroom settings to exploring *children's* understandings of the nature of whole class interactive teaching. Rudduck and Flutter (2000, p. 75) suggest that 'to manage school improvement we need to look at schools from the pupils' perspective'. Similarly, McCallum et al (2000) suggest that 'the pupil's voice is seen as an increasingly important element in understanding teaching and schooling more generally' (p. 276) and review a number of studies that have explored these voices, concluding that 'children ... have views and opinions about teachers, teaching and the classroom climate, including the subtler aspects of negotiation and control of what counts as knowledge' (p. 278). It was noted above that gauging children's perspectives on their mathematics lessons had been, perhaps, a missed opportunity in the first stage of the classroom work. In practice, because of the progressive, exploratory nature of the work, it was not until some way into it that this became apparent. By this time the summer holidays were almost starting and the Year 6 children who constituted the majority of those involved were about to disperse to high schools. Even working with the younger children would have meant returning to talk to them after the summer vacation and it was decided that this was not a useful way to proceed. Furthermore, two of the three teachers involved were leaving, one to have a baby and the other to a new job in a different part of the country. Instead, two new teachers from a different school were found to join the remaining one – again, volunteering after I had spoken to the staff of the school – and this provided two Year 6 classes and a mixed Year 3 and 4 class.

The progressive focusing that had taken place over the first two phases of the study meant that the research focus was, by this time, quite sharply on aspects of interaction between teacher and children during whole class interactive teaching events. In essence, therefore, the intention was to try to unpick the children's understanding of what was taking place on these occasions; of the way in which the teacher worked and on their own role in the event as they saw it. For this, interviews were used, and in general terms these were methodologically similar to those already undertaken with teachers and described above. However, the fact that children were involved might be expected to intensify the difficulties identified earlier, particularly the extent to which they feel comfortable with the interviewer and hence how they choose to reveal events. Furthermore, the reflected-upon conceptions offered by children in the interviews were unlikely to have been held *a priori*. What is reported here, therefore, are these children's reflected upon conceptions of their role, and that of the teacher, in the particular context of the lesson/interview. Such conceptions did not exist before the interview and no claim is being made that 'truth' was being *uncovered* here. Nevertheless, their *post hoc* views still provide a way to make evaluative judgements about the teaching/learning situation, though one needs to take care that these judgements are made with the implications of the foregoing discussion in mind.

Further to these general difficulties regarding the nature of beliefs, Lewis (1992, p. 417) discusses the particular challenges of working with children, noting the potential danger of

> children's distractibility, memory limitations, over-attention to certain perceptual features in the situation, desire to give some sort of response, however nonsensical, susceptibility to leading questions from an adult, ... willingness to be dishonest in some conditions and receptive and expressive language limitations.

In practice, several features of the method were designed to accommodate these difficulties. First, in order to minimise the extent to which the children simply created their own version of events, a video recording was made of the teacher operating in whole class interactive teaching mode and edited clips were shown to the children as prompts for discussion during the interviews the next day. Thus, the children were encouraged to talk as soon as possible about *actual* events, rather than reconstructing these mentally during the interview. Because of the focused nature of the investigation by this point, the choice of clips, which of course affected the focus of the interview considerably, was taken in order to illustrate those dilemmas and problematics in whole class interactive teaching that had been identified in the previous stage of the research. Once again, however, a semi-structured interview schedule was used which allowed the children plenty of opportunity for discussion of wider aspects of their experience as they saw fit, whilst at the same time focusing them on several very specific aspects of the teacher's behaviour towards the end of the interview. Overall, one lesson from each teacher was videoed and interviews were undertaken with 36 children, 20 from Year 3/4 and 26 from Year 6. Chapter 6, in reporting the findings of this stage, gives details of the procedures.

Previous to this study, Clarke (2001) has made similar use of video taken of secondary teachers and shown to the children. Also, McCallum et al (2000) have used picture cards as prompts with Year 6 and Year 2 children to discuss their views of learning in interviews. The use of video as a prompt for child interviews is reported by Punch (2002), though she used recordings of commercial television programmes with teenagers, noting the need to consider 'children's generational positioning and adults' perceptions of children' (p. 45). Hargreaves et al (2003) have coined the term *video stimulated reflective dialogue* (VSRD) to describe a similar use of video for *teachers* to reflect on their practice. In my own study, however, the video was used with children in order to support them in focusing on actual events, helping them therefore to talk about particular experiences rather than reflecting more generally on their past experiences. In doing so, not only could they be encouraged to focus on the particular kinds of events that constituted the study at this stage, but it was also hoped that it would prevent them regressing to the kinds of potential difficulties outlined by Lewis above and particularly reference simply to general stereotypical impressions of schooling. Finally, the video formed a quick entry into talking about their experiences in class and, in practice, it was found that all but one pair of children readily wanted to discuss the lesson and their roles within it, along with those of the teacher. Indeed, because the video had clearly been recorded with the permission of the teacher for the purpose of discussion, there was a strong sense that it signalled to the children their entitlement to discuss what was going on quite freely. The children were also told that their discussion would remain confidential and asked at the end of the interview whether or not they would allow me to use the tape recording – though, whilst this was done in good faith on my part, one has to ask whether or not they were likely to refuse me given the power relationship in schooling between adults and children in general; with obvious ethical implications. Nevertheless, the end result was discussions that appeared to be remarkably honest in terms of the children's comments on both the teacher and themselves.

A second feature of the interview design was the use of pairs of children as opposed to individuals. Lewis (1992) has noted that responses given by individuals can change when in group situations – reflecting the power of discursive conflict in the formation of ideas and beliefs. She also notes that child groups tend to generate ideas between them and that a comment started by one can elicit a response by another that he or she might otherwise have been too timid to make. Groups might be seen to make interviews potentially richer therefore. On the other hand, she notes that young children in particular may have difficulties in a group in terms of the skills needed to negotiate turns, domination by a few, the appropriate pace for all children, as well as pragmatic concerns

over transcribing multiple voices and physical arrangement in relation to social setting and recording equipment. It was in light of these observations that pairs were chosen for the study.

In other respects the interviews with the children were carried out in a similar manner to those with the teachers at the start of the study. Analysis was, again, by means of the constant comparative method of Strauss and Corbin (1990), with categories identified and delineated. These are reported in chapter 6 and examples of interview schedules and category inclusion rules for the data can be found in appendices 6 and 7 respectively. It should be noted that participant validation was not undertaken with the children themselves, largely as a pragmatic response to the timing of the research which once again pushed up against the summer vacation, and partly because it was felt that the children would be unlikely to be able to conceptualise the findings in the abstracted form in which they inevitably resulted. Nevertheless, findings were presented to the teachers involved via discussion and each of them was asked to comment on them and the extent to which they felt they represented a trustworthy record of their own classroom environments. In addition, a research colleague tested the extent to which categorisations created through the process of analysis could be recognised from the 'rules for inclusion' for each category. Units of analysis were selected at random from all the data used to develop the categories, including some data that was additional to act as potential distracters. Reliability was then judged by the extent to which the colleague's choice of category for each data sample matched that made by myself; that is, the extent to which that person recognised the categories from the data through the inclusion rules. Of 32 data units sampled, 20 (62%) matched the original choice with no negotiation, 7 (22%) matched after brief discussion and only 5 (16%) resulted in disagreement. This indicates a good degree of reliability regarding the relationship between 'conceived category' and data, and suggests that the 'rules for inclusion' were well formulated in terms of the degree of saturation of the data. Of course, it says nothing about the formation of the categories *from* the data in the first place.

Finally, before turning to a discussion of the ethics involved in the research, Bassey's eight indicators of trustworthiness are considered again in relation to phase 2 of the research.

Question:	**Attempts at ensuring trustworthiness:**	**Potential weaknesses:**
1. Has there been prolonged engagement with the data sources?	Number of child interviews large enough to generate significant amounts of data.	Lesson observations constrained to some extent by limitations on research time. More observations might have been useful.
2. Has there been persistent observation of the emerging issues?	Child interviews in conjunction with teaching observations mean total data set is relatively comprehensive.	Two stages of research relate to differing contexts and therefore limit what can be said about each to some extent.
3. Have raw data been adequately checked with their sources?	Regular checking of meaning of events with teachers after observations. Child interviews checked against teacher perspectives and with original video footage.	
4. Has there been sufficient triangulation of raw data leading to analytical statements?	Good triangulation of observations with teachers. Triangulation of interviews with teachers. Good match in reliability of data to conceived categories (research colleague)	Classroom observations could have been triangulated with children.

Table 6 … continued

5. Has the working hypothesis, or evaluation, or emerging story been systematically tested against the analytical statements?	Yes. Regular iteration between observational sites and theoretical analysis. Interviews carried out on four separate occasions with intermediate data analysed in between.	
6. Has a critical friend thoroughly tried to challenge the findings?	Regular supervision. Seminar presentation internally in Faculty and at external conference. Regular informal discussion with colleagues.	
7. Is the account of the research sufficiently detailed to give the reader confidence in the findings?	Attempt made to make both resulting findings and method transparent in this thesis.	Complexity of issues challenges the extent to which one can report on all aspects of the work in sufficient detail.
8. Does the research record provide an adequate audit trail?	Interview schedules and analyses available in appendices as part of preservation of process.	Reader must inevitably trust the judgement of the researcher in terms of what is chosen for presentation.

Table 6 - Analysis of the 'trustworthiness' of the research: phase 2.

Ethical issues in the research

Clearly, research of the kind carried out here raises a number of issues regarding ethics. Though the focus of the study was not on a strongly controversial area in which physical safety or major issues of privacy were likely to arise, it still aimed to critique an aspect of the work of teachers and children and, as has been made clear, originated from a position that was strongly influenced by my own values in respect of teaching and learning. Studies such as those by Nias (1989) and Woods et al (1997), amongst others, have pointed to the highly personal, affective, work of the teacher, in which professional and personal lives are closely intertwined. Professional criticism therefore needs careful thought in educational research of any kind.

The empirical work was undertaken here in three distinct phases and for each one the key ethical issues, in terms of potential dangers of the research, are now identified and discussed.

Phase 1 – interviews

Key ethical issues:

- Teachers asked to talk about their practice and their viewpoints on the NNS with little opportunity to follow this up.
- Ownership / gatekeeper of data.
- Extent to which discussion was confidential between interviewer and interviewee and made anonymous in reporting it.
- Time to undertake the interviews.

Discussion:

Issues of confidentiality, anonymity and ownership of data were dealt with via an ethics protocol (appendix 8) given to each participant before interviewing and its main points were discussed. This protocol was in line with the University of Plymouth's guidelines for research. Interviewees all had the right to withdraw from the study, though some had been recommended by their head teacher rather than volunteering independently and for these interviewees extra care was taken to ensure that they felt comfortable about the interview and that they understood that they were at liberty to ask for data not to be used in the final study. All participants were given copies of transcripts after the interview with the option of asking for sections to be removed or to make notes to clarify anything that they felt was misrepresented. Similarly, I made clear that the tape used for the interview was theirs, but that I would assume that they would allow me to use it unless they said otherwise. Finally, in exchange for time for interviewing I offered my own

services as a maths education lecturer to the individuals and the school as a whole, to be used as they wished (for example to undertake INSET). This was taken up by two schools. In this way, although the one-off nature of the interviewing process tended to mean that participants were not deeply involved in the study themselves, there was at least a sense of reciprocal partnership involved in it.

Phase 2: stage 1 – classroom observations

Key ethical issues:

- Possible coercion of participants.
- Sharing of research foci such that participants knew what the focus of the study was on.
- Judgements regarding teaching quality made by observer.
- Participant / non-participant observation and interference in teaching.
- Issues of anonymity etc., as in interviews above.

Discussion:

Again, issues of anonymity, ownership of data and right of withdrawal were dealt with through an ethics protocol (see appendix 9) as was a commitment to ensure that observation was overt rather than covert. Woods (1996) notes that this is rarely a clear cut distinction however and, in practice, though what was being looked *at* was made clear to participants, what was being looked *for* was not always made clear since this might have had too much of a effect on the participants' behaviours.

All three participating teachers volunteered independently, meaning that, at the outset at least, they were willing participants in the research. A fourth teacher initially volunteered but withdrew herself from the research after a short time because of personal circumstances. From the outset, the intention was to share the results of the research with the teachers involved. Indeed, their perspective on my observations was an integral part of the establishment of trustworthiness of the process. From an ethical point of view

however, sharing the findings went beyond this and was intended to ensure that the teachers were involved in the research process themselves as far as possible. The intention was not for me to judge their work in terms of its effectiveness, but rather to engage them in discussion about this themselves. By doing so I hoped to get a deeper insight into their thinking, as well as to ensure that, ethically, I was not simply researching 'on' them, but rather was researching 'with' them. In practice, although this was successful to a certain extent, the teachers appeared to want a degree of judgement about their lessons. I cannot therefore claim that my observation did not affect the way the teachers behaved, nor that they felt that they were in genuine collaboration with me in this respect. Nevertheless, conversations with them after each lesson seemed to suggest that they were willing to discuss their teaching in a fairly open way, even if they also sought confirmation of its effectiveness from me. For my part, I attempted to reassure each of them that my role was not to judge their overall teaching performance, but rather to suggest to them areas of their work which, from an outside perspective, seemed challenging and of interest. Of course, having said this, it is impossible, as an observer, *not* to judge the teaching one is witnessing to some extent, albeit internally. Inevitably, therefore, I witnessed classroom events that I judged, privately, to be either effective or ineffective. However, by referring these back to the teacher as issues for discussion – reporting the incident using phrases such as 'I noticed that .... How did that feel to you?' – I was able to negotiate them with the teacher in as non-judgemental a way as possible.

One final issue remained, namely that the headteacher in one of the schools, having given permission for his staff to be part of the research, was keen to get some feedback on events from me. This presented an ethical dilemma in as far as I felt some obligation to both interested parties. To overcome this I made clear to the headteacher that I needed to maintain the confidentiality of the teachers' work, but that I could give feedback about general issues that may have arisen from the research and that were relevant to the school as a whole. For example, where one or other teacher found children's attention wandering from the topic under discussion, 'keeping children focused on the task' was an area that I might discuss with the headteacher, but without reference to particular incidents or particular individuals. Even so, since I was working with only three teachers, anonymity was difficult to maintain and care was therefore taken to err on the side of caution and to ask for permission from the teacher concerned before reporting some issues. In this way I was able to offer areas for possible development to the school without breaking the confidentiality and anonymity of the teachers themselves.

Phase 2: stage 2 – interviews with children

Key ethical issues, in addition to those above:

- Establishing rights with young participants.
- Confidentiality between researcher, children and teacher.
- Anonymity.

Discussion:

In terms of videoing classroom lessons and using the video to show to children, the teachers involved were given the same forms of ethical protection described above in stage 1. They had each volunteered into the project in the first place but, nevertheless, the ethics protocol ensured that they had the right to withdrawal, personal ownership of the tape and anonymity in the final report.

Establishing the right to withdrawal with the children was a harder challenge. The adult-child relationship in a school carries with it an authority imbalance that makes it hard for children to assume the right of authority, even with a stranger. Furthermore, the teachers, acting *in loco parentis*, had selected children to be interviewed who were not therefore voluntarily offering themselves. Though I was careful to explain to each child interviewee that they could stop the interview at any time and that they need not take part, the extent to which any of them genuinely felt able to do so remains unresolved. Indeed, for one pair of Year 6 children the interview was clearly a stressful and unwanted event, yet they did not ask for it to be stopped, leaving me to bring it to an early conclusion as a result of my own perceptions of their discomfort. This highlights the need when working with children for the interviewer to remain as sensitive to the feelings of the participants as possible, and suggests that the responsibility for judging the appropriateness of the interview must lie to a large extent with him or her. More effective, perhaps, than offering the right to withdraw was ensuring that they were happy for me to use the results of the interview, and that they understood that they would remain anonymous in reporting it. Thus, I was careful to say to each child prior to beginning the interview that, though I may discuss general ideas with the teacher, I would not reveal who had said what. Again, in practice, bar one or two small items of information that were told to me as 'secrets', the children appeared happy to talk about their teachers without fear of reprisal, and this perhaps reflected the open and friendly nature of the relation between each teacher and his or her class. The overall feeling was that, for the children, the interviews offered an opportunity for an amusing and unusual encounter; a welcome change to the regular pattern of the school day.

Summary

The sections above have documented the methods employed in the study and the underpinning methodological considerations. It should be clear that the methodological issues relate not just to the process of research itself, but also to the focus of study – the nature of interaction in teaching/learning situations. Furthermore, my own stance in the research was far from neutral, and an attempt has been made to articulate this positioning in order that the reader might make his or her own judgements about the trustworthiness of the research process. The thesis now goes on to report the results of the various stages of the empirical work, starting with the interviews with teachers undertaken at the outset of the National Numeracy Strategy.

In considering data during the study, care was taken to separate the data itself from the process of its analysis. However, in reporting the findings here, the two elements are reintegrated in order to make the account coherent.

Chapter 4 – Teachers' initial conceptions of the NNS

Introduction

In the summer term immediately prior to the official introduction of the NNS, fifteen interviews were carried out with teachers in order to try to gain access to both their understanding of the National Numeracy Strategy and their thoughts, more widely, about mathematics as a subject and its pedagogy. As a reminder to the reader, the research questions relevant to this aspect of the study were as follows:

What are teachers' understandings of, and feelings about, the National Numeracy Strategy?

- In what sense do they understand it in terms of its mathematical and pedagogical dimensions?
- What element(s) of control do teachers feel they have over its implementation?
- How does their understanding of the Strategy relate to the actual policy of the Strategy delineated in chapter 2?
- How does it relate to their own understanding of what mathematics is?

How do teachers' perceptions of what the NNS is affect the way they perceive they are trying to teach?

- What do they see as the key aspects of the Strategy?
- What might be the implications of these key aspects for their teaching?

It is important to remember that these interviews took place before teachers had completed the training package distributed to schools in the summer of 1999 (DfEE, 1999c, 1999d, 1999e, 1999f), although this package was already in the schools and those teachers who were coordinators of the subject had already been on a three day training course (DfEE, 1999k) to prepare them to 'deliver' it to their colleagues. Thus, the latter set of questions could only relate, at this stage, to their ideas about how it *would be*, actual practice being considered in the next chapter. The intention was, therefore, only to raise awareness of the *potential* issues that teachers had in mind at the commencement of the NNS.

The analysis of the teachers' perspectives led to the creation of a number of *categories* which describe ways in which these particular teachers understood both the Strategy and the subject at this point in time. Despite what has just been said about the intention to use them in focusing future research, data from this phase of the study actually provide the opportunity to be used in two further ways. First, they provide insights in their own right into teachers' perspectives on aspects of mathematics teaching – albeit tentative ones given the limited sample and the method of data collection which did not consider practice. Second, they document the ways in which a sample of teachers were thinking about the National Numeracy Strategy as it began and therefore provides the opportunity for a comparative, longitudinal study in this respect.

Limitations on the length of the thesis mean that these two further potential uses cannot be undertaken in depth here. The additional insights the data provide are, however, sketched out sufficiently to provide a picture of the professional landscape in respect of the Strategy at the moment of its inception in order to contextualise the study as a whole.

After first eliciting details about their role in the school and their teaching history, the interview schedule (appendix 1) provided for three focal areas in initiating discussion with the teachers: their current understanding of the NNS and what it was about; their perceptions of what they might need to change in terms of practice in their own classrooms as a result of the Strategy; and, their understanding of mathematics in general as a subject. In practice these areas interrelated, as might be expected, and the schedule was outlined to

interviewees at the start. Participants were then encouraged to talk freely, crossing the boundaries of each area and initiating new areas for discussion as appropriate.

Analysis of the discussions, undertaken in the manner discussed in chapter 3, led to the identification of a number of themes. These are addressed here by first considering teachers' nascent views of the National Numeracy Strategy and then, briefly, their views of the subject of mathematics. Finally, these are drawn together in terms of their implications.

Teachers' views of the NNS

One of the targets of this research was to discover more about the way that teachers were approaching the Strategy in terms of their understanding of its key ideas. The initial conjecture was that there may have been differing ways in which the Strategy was understood and that these might impact on the way in which teachers turned policy into practice in their classrooms.

In order to elicit teachers' conceptions of the Strategy each interviewee was asked, as part of the interview, to describe how they would explain it to an imaginary group of visiting American student teachers. This approach proved highly successful, at least in as far as it seemed to encourage teachers to articulate their ideas and to provide a picture of their 'immediate' thoughts about it. My own preconception regarding responses to this question suggested that there might be three areas of response: ideas relating to practice at curriculum level; ideas relating to practice at classroom level; and ideas relating to philosophy in terms of both teaching/learning and mathematics itself. With these areas in mind, once teachers had completed an initial response, they were prompted to think about these other aspects.

In analysing responses from the teachers, several categories seemed to emerge, in the sense that patterns in the data appeared with repeated reference to ideas that had not previously been considered. The result was the following set of categories, each of which is subsequently outlined in terms of its 'dimensions' (Strauss and Corbin, 1990):

- 'The NNS as...' – describes teachers' differing perceptions of what they took the Strategy to 'be'.
- 'Power positioning' – describes teachers' perceptions of where the power is held in terms of the introduction of the new initiative.
- 'Validation by the NNS' – describes the degree to which the NNS made teachers feel that their ideas were valid.
- 'Valuable elements of the NNS' – describes those aspects of the Strategy that were welcomed by teachers because they were seen to be valuable.
- 'Problems with the NNS'– describes the things that teachers perceived as likely to be problematic.

'The NNS as ...'

Teachers' responses to describing their understanding of the NNS led to three distinct images of the Strategy being identified, of which one, or all, might be held by an individual teacher. In essence, these were *a set of objectives*; a *plan of development* for the children's learning, and *a set of procedures* for 'effective teaching'. However, overarching these perspectives was a fourth perspective on the meaning of the NNS, namely that it was a *means of achieving/reaching these goals*. In this way, the NNS was seen as both a *structure* – a set of things to do/reach – and as a process – the means of achieving this.

Each of these perspectives had a range of dimensions associated with it which are outlined below:

...a set of objectives:

Teachers in this perspective viewed the NNS as a set of individual, though connected, objectives to teach about and to be learnt by the children.

> It's a set of objectives that make maths teaching a whole lot easier because you've got something really to hang every lesson on. Once you've ascertained the level the children are working at you can pick out from it the key objectives.
>
> (Heather, 20.5.99)

In this way they were seen either as ***exemplars*** of what one might teach or as ***targets*** in terms of what children needed to achieve.

As *exemplars*, they were seen as supportive, helpful and full of good ideas, as ensuring consistency and progression, avoiding gaps in children's learning, and as preventing repetition.

> I've been using them [examples] this year anyway because I love it, I think it's absolutely wonderful. ... There's just so many good ideas, so many ways of looking at everything.
>
> (Janet, 17.6.99)

As *targets*, they were seen as helpful for assessment and validating if achieved, or punitive in the sense that teachers might be to blame if they were not.

> C It's actually more clear than the National Curriculum, it does state what should be learnt in each year group and with their key objectives that's very useful to have and sort of guidelines.
>
> NP Right
>
> C And so it's, I think it's really useful to have those clear guides as to what to teach when.
>
> (Catherine, 5.7.99)

Both these characteristics shared a *sense of compulsion* in that objectives and targets were things that children 'should' at least attempt to achieve, as opposed to the teacher being free to choose whether this should be the case or not.

...a plan of development:

This conception of the Strategy was similar to the 'set of objectives' and teachers who perceived this 'plan' generally implied the 'set of objectives' view too. The converse was not necessarily true however, for in this meaning, rather than a sense of isolated and individual objectives, the Strategy was viewed as a whole, forming a coherent 'route map' of the way in which children's mathematics (nearly always number in practice where examples were given) needed to develop in order for them to be successful in it.

> I see it as being a document which lays out in a very organised, structured way what we are supposed to teach when, during the different years of schooling...
>
> (Mary, 20.5.99)

> I suppose it's the whole mathematical curriculum. It's all of what we need to teach the children from reception through to Year six. I don't think it goes any ... and it is suggested it's almost a plan, that this is what children should know at reception, this is what children should know by the end of each year group in all the areas of mathematics.
>
> (Janet, 17.6.99)

In particular this 'plan' featured the idea that mental mathematics should have a pivotal role in learning to calculate, something that was seen as an important change of philosophy as it moved away from the dominance of traditional, standardised pencil and paper procedures. Furthermore, it was seen by nearly all the teachers as helpful and supportive since most felt that it was something they wanted, though a few observed that for some colleagues it might be threatening because it represented something new. However, it also reflects a very linear and positivistic view of learning composed entirely

of the acquisition of *public knowledge*, rather than a more sociocultural view in which the social nature of knowledge development is emphasised leading to far more *personalised* knowledge (see chapter 2).

… a set of procedures:

In this conception of the Strategy, which again often accompanied the others above, teachers viewed it as a set of teaching practices; actions to be carried out in the classroom. Again, these were rarely, if ever, seen as dogmatic and the overall sense was that they were supportive. In this way teachers appeared to view them as optional, in contrast to the objectives and development, for which there was a much stronger feeling of compulsion. Adrian summarised this in describing what he would do with the staff in discussing the NNS.

> The thing I suppose I'd look at would be the actual, um, format of the hour, of the three main elements of the mental maths section, the teaching points and then the consolidation of that and then the plenary at the end.
>
> (Adrian, 17.6.99)

Meanwhile, Catherine pointed to the dual nature of the NNS, as a set of objectives and as a means of teaching.

> Yes I mean because that's sort of a separate issue from the framework really, it's like two things we're taking on board here. I mean the Strategy that they've given us and the framework that we're working around and then the hour, how the hour is structured.
>
> (Catherine, 5.7.99)

... a means of achievement:

> I think I'd say basically the reason the numeracy strategy has been developed and has now come into operation is because the government has been concerned about basic skills, essentially, of eleven year olds in this country. So they've developed a way of teaching maths and of supporting teachers to teach maths in order to raise standards, basically.
>
> (Julian, 15.7.99)

Here, Julian identifies an overarching dimension to the Strategy, namely that the Framework is a *means of achieving its desired outcomes*. This conception, in parallel with those outlined above, was prevalent amongst nearly all the teachers in the interviews, for example,

> ....it will ensure progression throughout the school to make sure that the children are reaching the targets at the end of each year group, to make sure that we're covering all areas of number, language, topic maths, that we're supposed to be covering in each year group. That the children are reaching the targets and to try and raise standards.
>
> (Mary, 20.5.99)

> [The NNS is] guidelines on what to teach when so the progression of aspects of number. I suppose really just a scheme of work that's been passed on to us to try out and see how it goes. The aim of it is to raise standards and targets set by the government.
>
> (Amy, 14.7.99)

These two quotations illustrate that, whilst most teachers referred in some way to the NNS being a 'means' of achieving something, they took very different views of the compulsion attached to it. For Mary, this was a set of targets and procedures which, though not necessarily a bad thing, indeed even supportive in many ways, was being imposed on teachers to 'do'. In contrast, for Amy, it was a suggested approach which was

being 'passed on' to be 'tried out' by teachers. These contrasting notions bring us to the next category in teachers' perceptions; the placement of power.

Power positioning

Brown (1999, p. 15) points out that,

> Under the first Labour government for 18 years, we have the tightest ever control by government on primary mathematics, with central prescription not only of national curriculum and national tests, but also of teaching style.

Such an observation might suggest that teachers would feel constrained by this controlling power and that such a constraint might be observable in terms of a reaction against it. For example, Woods et al (1997), in researching the effects on teachers of the policy changes throughout the early 90s across the whole curriculum, suggest that most teachers were experiencing 'role tension' in which demands on teachers were in conflict with their beliefs and desires. This is contrasted with 'role conflict' in the earlier era of the 60s, 70s and early 80s, where conflicts were largely 'dilemmatic' and, 'as such, subject to professional appraisal and resolution' (ibid., p. 48) The new role tension, with changing accountability and increasing demands on the teacher which place the ability to influence intended and actual policy (Ball and Bowe, 1992) beyond the reach of the individual, 'is altogether of a different order from that of the previous era for many teachers' (p. 49). In categorising ways in which teachers responded to these changes, Woods et al (ibid, p. 50–51) identify four different responses, namely: teachers who were *enhanced* by the challenge of resolving the tensions; those who became *compliant*, the result of which was reduced creativity; those who were *non-compliant* and fought to maintain their values and practices; those who became *diminished* by tensions which devalued and disillusioned them. In coming to these categorisations, they also point out that others before them have categorised similar responses in slightly different ways (ibid., p. 50). However, whatever the form of categorisation, given the observation by Brown above, one might expect to hear teachers castigating the Strategy and vowing not to be party to it, appearing to carry out its 'will' but planning subversion, or simply submitting to it. Certainly, this project began with a certain preconception that this would be the case; a reflection of my own powerful desire for intellectual control over what I do, a feature of my own professional identity as outlined in chapter 3. So, how then did the teachers in the interviews respond to its introduction? In particular, how did they perceive the notion of 'power' in relation to the National Numeracy Strategy?

No attempt was made to ask these questions directly of teachers. Rather, the teachers were encouraged, through discussion about what they perceived as the major features of the Strategy and the changes to practice that they envisaged might result, to reveal their feelings about the issue. In general, teachers did indeed acknowledge that the Strategy had, in some sense, been imposed on them. Janet's comment, noted earlier, coins an image of some kind of 'power from above' in describing the Strategy as being,

> All of what we need to teach the children from reception through to Year six, I don't think it goes any further, and it's come down from above.
> (17.6.99)

There was a strong sense that this 'power from above' (which was often equated with the *Framework for Teaching Mathematics*) constituted a *controlling* influence, and there is a feeling of the *compliance* of Woods et al (1997). Nevertheless, Julian claimed that,

> Basically, cos well I mean the way that I've taught maths up to now isn't a million miles away from what the numeracy strategy is suggesting you do, um, but I guess it's just a question of fine tuning different areas and moving more into line with what they want you to do or would like you to do.

(Julian, 15.7.99)

Later on, he stated that 'I've sort of wanted to work in this particular way', and so whilst there is still a strong sense of power residing beyond Julian's control, his attitude to the situation seemed much more in line with Woods et al's notion of *enhancement.*

So, even though there was a sense of the Strategy being 'imposed' on him, Julian felt that his desired approach was validated by the external power that the Strategy represents. In my discussions with teachers, this was far from uncommon, and whilst most acknowledged that the Strategy was being imposed, and that this inevitably implied an 'imposing power' of some sort, the extent to which teachers in the study acknowledged any sense of compulsion in terms of practice was very slight. Indeed, a few explicitly expressed feelings of freedom in choosing what to do.

> Yes, but I mean it says 45 [minutes] to an hour doesn't it, it doesn't have to be on the dot does it. One day you might need a long session on the end and one day you might need a shorter session.
>
> (Avril, 15.7.99)

Others, like Amanda, saw the possibility of learning something new.

> Anyway, I think that's something that's very important to us, that you do have freedom to do things in your own way. But I think we're trying to... what I would like to see is people giving it a go first and then finding their own way on from there.
>
> (Amanda, 14.7.99)

Whether the intent was to follow the Strategy, change it, or try it out, the vast majority of teachers, though acknowledging some kind of sense of 'power from above', did not seem to experience this in a *controlling* sense. Indeed, even Mary, who appeared to exhibit signs of compliance, acknowledged that,

> Personally I quite like having the structure there, I quite like having that as a resource to refer to, to know where I'm going or where I should be going,

and that,

> Although that part of it [too much to implement] is quite negative, I think in the end it'll work out to be quite a positive experience and it will certainly improve our teaching, I think, in the long run.
>
> (20.5.99)

For her it seems, any sense of loss of control is complemented by the benefits she perceives it will bring.

Validation by the NNS

It would seem, in the light of the discussion above, that despite the tightness of control to which Brown refers, the teachers were not in fact experiencing the implementation of the Strategy in the way in which one might imagine. They did acknowledge a belief that the NNS was something that they were going to 'have' to do,. and in this sense at least it was the product of a controlling power, however there was little or no sense of simple compliance, refusal to comply, nor diminishment about their reaction. Rather, there was a feeling amongst many of the teachers that the Strategy *validated* a way of working that they approved of – a finding supported by the larger, longitudinal study of Earl et al (2001). For Heather this was in terms of providing confidence that she was already doing the right thing.

> H I probably did see it [working on individual mental strategies] before but it's given me the confidence to say yes we can do it this way and we can do it that way and it doesn't matter which way we do it in.
>
> (20.5.99)

Similarly, Catherine described the same kind of validating support.

C If somebody's telling you this is OK to do, you do it. If you're doing it totally off your own back you think well actually I think it's a good idea if I stand like this for half an hour really teaching keeping the children with me. I think 'oh gosh they've written nothing in their books'.
NP And no-one else is doing it.
C That's right but if you've been told this is a good way to teach then I think it's fine to go along with it.

(5.7.99)

For others, the Strategy *demonstrated* the way to work.

A I think so and also I mean Donna was saying she doesn't feel confident about teaching maths and she was saying I've been waiting for this. Today we're having her 25-year-at-school party
NP Ah
A You know and she's been there all that time and she's been just waiting for someone to come along and say this is what you do, so that you know that you're doing the right thing, because otherwise you can be so isolated can't you. You're in your room and you're getting on with it although you work in teams and stuff nobody really knows unless you actually say I don't know what I'm doing.

(Amanda, 14.7.99)

For Julian, the Strategy supported and validated his teaching approach, but also provided him with an assessment framework which he found supportive in a similar way.

Yes, I think I feel quite supported by it all really and quite sort of guided in the right direction and that, if I know that my class are to all intents and purposes reaching those targets and those goals, then I must be doing something right, basically, at the end of the day.

(15.7.99)

In considering, therefore, why such a tightly controlling framework should lead to feelings of enhancement amongst teachers, the answer seems to include the extent to which teachers felt that the NNS provided 'validation' of their practice, and this could be seen in:

- provision by the NNS of a sense of solidarity – the comfort of knowing that you were doing the same (i.e. as well, or as badly) as your colleagues;
- its approval of (by means of its similarity to) one's current chosen style;
- its seemingly definitive description of 'success' in terms of test-related learning outcomes.

It seems immediately obvious from the list above that these items suggest a strong degree of 'technicism' as outlined in the preceding chapter. This effect is characterised by a growth in conformity in terms of behaviours and outcomes and a reliance on others to dictate 'correct' practice, all of which are apparent here. However, whereas in other contexts this has been a negative experience for teachers (for example in the context of inspection – see Jeffrey and Woods, 1998), in terms of the NNS it appears, at least at its outset, to have been perceived as almost universally positive. The strategy seems to *remove responsibility* from teachers for their practice in the sense that it provides a definitive style which, if carefully followed, is safe from criticism.

> You know, I think every school now has had OfSTED so you all know what good teaching is about. We've all had the checklist; you know, are you interacting, are you demonstrating, are you using examples? There are so many things that make up a good teacher which, in maths it's very easy to do all those things.
>
> (Catherine, 5.7.99)

However, this is not to suggest that teachers simply acquiesce to this style against their better judgements. The teachers involved in this study were not resigned in any way to having to do this and, crucially, what seems to mark out the Strategy from more negative experiences of policy implementation was the extent to which teachers seemed to identify aspects of it that they considered *valuable*, alongside having enough freedom to make it work in their own context.

I don't really see why anybody should be against this cos, I mean, it seems to me a fairly helpful thing. It's not particularly prescriptive, it just says these are the things that you should be teaching, this is the standard at which you should be aiming, and this is a suggested order of doing it with things being revisited over and over. So I can't see that it's particularly contentious myself, but perhaps I'm politically up the spout, I don't know.

(Avril, 15.7.99)

Valuable elements of the NNS

Without exception, every teacher in the study identified elements of the Strategy which they considered to be valuable in helping them in their teaching practice. Whilst not universal to every teacher, a number of dimensions repeatedly appeared in the data.

The discussion above has already highlighted the notion of the NNS being 'seen as' a set of objectives which formed part of a planned sequence of work for the teacher to teach. Teachers valued this planned sequence considerably.

It's actually more clear than the National Curriculum. It does state what should be learnt in each year group, and with their key objectives that's very useful to have, and sort of guidelines, because I think previously it tended to be ruled rather by the scheme that you were using if any.

(Catherine, 5.7.99)

Personally I quite like having the structure there, I quite like having that as a resource to refer to, to know where I'm going or where I should be going.

(Mary, 20.5.99)

Um, it shows great progression within that [the examples of objectives] which is super. It also, the supplementary booklets that you've got, the vocabulary that should be being used, is also another [good thing], looking at another progression, ensuring that we're all focusing along the same lines.

(Adrian, 17.6.99)

The feeling of release from responsibility regarding decisions relating to the order of teaching is apparent in the references to what 'I should' be doing, and in the sense of conformity within and between schools, which was seen as a good thing. Julian, in

particular, as an NQT, valued what he saw as the removal of this responsibility for planning:

> With the numeracy strategy and the framework it actually tells you what to teach and how to teach, for how long to teach it which just takes away that pressure really of maybe not knowing how things pan out over the whole academic year. Plus the fact that, you know, they're giving the targets, they're showing you what to aim for and giving you ideas of how to aim for it.
>
> (Julian, 15.7.99)

Teachers criticised the National Curriculum in this respect and compared the NNS favourably to it because of the exemplification of objectives given throughout:

> NP And will the Strategy help you to do that [support more able children]?
>
> J I think it will because it's there and it's all ready, you know, a lot of this and... I think those ideas and examples are wonderful because you can see a solid bit of your lesson whatever you do as 'go on keep going'.
>
> (Janet, 17.6.99)

> I was doing Kay's planning with her for years three and four and she read the statements, something about scales and she said 'well what kind of scales? I don't know,' and I said 'well alright, have a flick through, have a look at the examples at the back, see what kind of things they suggest' so that the direction is there and you don't have to make interpretations. So you're hoping that when people read that all the Year three and four teachers will be saying 'scales, oh can't look at the gaps' [i.e. the divisions on the scale] that kind of thing. And you're working along the same lines.
>
> (Amanda, 14.7.99)

As well as at the detailed level of information that the NNS provided in terms of teaching objectives and examples, equally valuable was the holistic perspective relating to children's development of mathematics. This perspective was not simply founded on the feeling that it made life easier for the teacher. It reflected a seemingly well reasoned and evaluated feeling amongst a number of the teachers that the Strategy was carefully thought out in terms of both teaching and mathematics.

C And so we [the school staff] did talk quite a bit about that [the structure of the lessons] and I just kept emphasising how simple it was compared with the literacy hour. Because it is.

NP Do you feel it is.

C Oh yes I really did.

NP What are the major differences for you?

C Beginning, middle and end, which just makes sense. And so really the only sort of difference is this sort of five or ten minute mental starter which everybody can see is fun and the children can see as fun.

(Catherine, 5.7.99)

But it makes a lot of sense and even, there's... its an awful thing to say, but for the first time really I've had them chanting tables ... and I think I haven't done enough of it.

(Janet, 17.6.99)

...I do feel that the maths should be better, I just think its based on something that really works...

(Heather, 20.5.99)

Thus the NNS was seen to be valuable in terms of helping teachers to decide both *what* to teach and what order to do it in, and *how* to teach it most effectively. Janet perhaps encapsulates the feeling of the majority of teachers in saying,

I think we quite like new things. Every teacher surely just wants to be a better teacher. Every teacher is daily faced with failure, 'oh they still haven't got it, [it] must be me!' Um, there's gotta be a better way, and actually, why haven't we had it before?

(Janet, 17.6.99)

Problems with the NNS

The preceding section identified that teachers had found a great deal that they felt was of value in the Strategy. Whilst this related in the main to ways in which it would seemingly make their job easier (planning, understanding the mathematics, teaching and responsibility), this was not to say that they simply wanted an easier life at the expense of the children. Rather, they saw many aspects of it that 'made sense' within their teaching beliefs and values and which fitted well with a preferred style of working. However, the

Strategy was not seen to be without its problems. To begin with, the timing of its implementation was an issue.

> I don't like it because I think it's come at the wrong time. I think we're all still getting to grips with the literacy hour and there are a lot of changes going on in the school at the moment.
>
> (Mary, 20.5.99)

In other respects though, whereas the valuable elements had been plentiful and common amongst different teachers, problems were less so and tended to be individual. The need for different resources, fitting a new structure into current planning, keeping up with the 'pace' of the Strategy and the speed at which it dealt with topics, and the difficulty for some in changing from a traditional approach towards written calculations to a greater emphasis on mental calculation were all mentioned. However, the only recurring theme in teachers' responses was with respect to differentiation, an issue that, again, Earl et al (2001) identify as common to a wider sample of teachers across England.

> [I can see] that it's a good idea to keep reinforcing these things [in regular oral work] but the problems tend to be in how do I include everyone? How do I include my [SEN] unit children?
>
> (Catherine, 5.7.99)

Similarly, Jenny was concerned about an increase in whole class teaching,

> Now if you're talking, and we're supposed to be talking to the children for say 20 minutes about doing mental maths, yes I can mix [it], I could have Year 6 and reception in a class and I could do mental maths with them, and I'd have no trouble cos you just fire your questions according to the child's ability. But the moment you're trying to get a concept over which is the teaching point, which is what you're going to go on to whatever, whether it's time or shape or whatever, you know, the spread is just phenomenal.
>
> (15.6.99)

This might be seen to represent a warning shot across the bows of technicisation, the flip side of conformity and homogeneity, in which Jenny identifies the uniqueness of individuals and suggests some possible implications of ignoring this.

Teachers' views of mathematics

Though the main focus of the interviews with teachers was to explore their initial conceptions of the National Numeracy Strategy, they also elicited a significant quantity of data relating to their understanding of mathematics as a subject. Space limits the extent to which this can be reported and I present here just the major ideas emerging from this aspect of the study. Similarly, a full justification for each idea is difficult and appendix 10 therefore contains additional data that should allow the reader to judge the extent of the trustworthiness of any assertions made.

The nature and structure of mathematics

The meaning that the teachers gave to the nature and structure of the subject was initially explored through their descriptions of what it meant to 'be' a mathematician, before subsequently asking them directly to make explicit the nature of the subject if necessary. In chapter 2, the wide range of (often fairly limited) conceptions of the subject was noted, and it is no surprise therefore that, without exception, the teachers found this direct explication very challenging. Despite this difficulty, several different perspectives were evident, namely:

1. A strong distinction made between the *content* of the subject – seen as the conceptual ideas of addition, counting, shape etc. – and the *process* aspects of it – such as problem solving, reasoning etc.

2. The related implication that mathematical 'stuff' needed first to be 'understood' before children could then 'make use' of it.
3. Despite this separation, a commonly held view that mathematical knowledge is highly interconnected with great emphasis placed on the need for children both to be shown these connections and to establish them for themselves.
4. Similarly, the need for mathematical ideas to 'make sense', rather than children being reliant simply on procedures.
5. The need for both an understanding of abstract interconnections and application in problem contexts in order for this 'sense making' to happen.

In summary, sense making in mathematics appeared, therefore, to be a case of understanding concepts abstractly in relation to each other *and* understanding how these could be used by transferring them directly into contextualised problem situations. However, despite this, there was little implication that mathematics could be learned *through* problem situations, never mind that such approaches might lead to a *different form* of understanding of the abstract ideas (Boaler, 2002).

There was also a related view of learning mathematics as an individual endeavour, dependent only on the mind of the learner and being distinct from an alternative, situated, view of cognition in which coming-to-know mathematics is dependent on context, one which 'attends to the inter-relationships of knowledge, practice and identity' (Boaler, 2002, p. 47; see also Boaler, 1997; Lave and Wenger 1991).

The purpose of mathematics

The separation of mathematics into content and application was mirrored by a similar separation regarding the purpose of mathematics, as follows:

1. Practical utility reflecting a perceived need for mathematics in one's everyday life.

2. A more 'esoteric' purpose reflecting a view that mathematics could be fun and fulfilling in its own right as an abstract discipline.

Accompanying this dual perception was a separation of the children themselves in terms of those who were likely to be able to access the more abstract, enjoyable curriculum and thus to be working with reasoning and connection making, and those who were unlikely to be able to do this and were thus stuck in the concrete, 'taught' world of the 'necessary'. Overarching these conceptions was a view that to be a mathematician one had to be particularly able at it, particularly in its abstract, 'esoteric' form.

Feelings about mathematics

It is widely acknowledged that mathematics is an emotive subject that tends to bring out strong feelings in people (see, for example, Crook and Biggs, 1991; Hoyles, 1991). It is perhaps surprising therefore that not one of the interviewees claimed to dislike mathematics (or teaching it), though many reported that they had not liked it during their own childhood. In addition to the enjoyment shown by the teachers, they reported a similar enthusiasm in their children.

Two points are worth noting however. First, teachers here are talking about *teaching* the subject, not doing it for themselves. One wonders therefore whether there might be a mismatch between the satisfaction gained from seeing children 'acquiring' mathematical knowledge (relatively easy to 'see', and interesting from a pedagogical point of view) and the eventual effect of such a focus on the children's appreciation of the purposes of the subject. Boaler (1997, 2002) has observed how the working practices of mathematics classrooms interact with the child's growing identity and how teachers whose predominant form of pedagogy is presentation of particular ideas can engender a dependence on the part of the child which eventually conflicts with their growing desire for intellectual independence.

Second, at the time of the interviews, there was undoubtedly a sense of 'novelty' about the NNS, and this too may have had a positive effect on teachers' feelings. As was apparent in previous sections of this chapter, the NNS was also being seen positively by many teachers as a new form of support.

Implications and discussion

The paragraphs above have laid out the major features of teachers' perceptions of the National Numeracy Strategy at its inception. Perhaps the most striking feature to emerge from the interviews was the almost universal approval, in general terms at least, of the NNS. Of the fifteen teachers interviewed, all of them, without exception, reported themselves to be enthusiastic about the Strategy, either because they saw it as an exciting new approach to teaching mathematics and/or because they simply felt that it would make their job easier for them in practice. Thus, whatever the effect of the 'the tightest ever control by government on primary mathematics' (Brown, 1999, p. 15), neither non-compliance nor diminishment seemed to figure in the teachers' reactions to it, and the majority seemed to be enhanced by its prospect (if not yet its practice).

The previous chapter identified two *ideal types* in relation to teachers' perceptions of the Strategy. On the face of it, the enthusiasm of the teachers for the Strategy, at least in as far as it relieved them of some responsibility, would suggest a tendency towards the 'technicist' end of this ideal spectrum and it would be easy to dismiss this positive reaction as being a de-professionalisation of these teachers' roles; one endorsed by the teachers themselves. Critics might argue that the teachers were simply happy to 'have work done for them' in relation to planning and organisation and that working to a single, centrally endorsed teaching style represented a submission on their part to the inevitability of centralised doctrine. Indeed there is some evidence in the data for this argument in the way in which a number of teachers referred to a degree of deference to a 'higher power' and perhaps more strongly in their readiness to accept the NNS as a 'means to an end' in achieving greater success in mathematics, or as a definitive measure of their 'success'. However, such a criticism of the teachers' thinking would, based on a fuller examination of the evidence, be to misrepresent them. Their comments did not, generally, imply any resignation on their part simply to toe the party line. Rather, they suggested a belief that the NNS had 'got it right', reflecting an approach both to teaching style and to mathematics that 'makes sense'. In this way, as Amanda reflected, the NNS is 'what we have all been waiting for'. On the other hand, Earl et al (2001, p. 54) have noted that for some teachers beyond the sample here, the NNS was being used as a tool for forcing change in school policy. However, amongst the teachers here, there was no sense of 'submission' to the Strategy. Instead the feeling was of a freedom to make use of it in individual ways, though staying broadly within the guidelines suggested.

On the other hand, the 'validation' of their work appeared to be of great significance to them. Nias (1989) has pointed to the predominantly individual nature of the primary teacher's job and the potentially isolating effect of this. However, as the profession becomes increasingly accountable to outside agencies (O'Neill, 2002; Woods et al, 1997) so the need to find a 'plausible defence' for one's actions increases and the enthusiastic take-up of the Strategy may well reflect this to a large degree. In Catherine's words 'you all know what good teaching is about', and thus the willingness to go with the Strategy may be a reflection of the extent to which it makes sense, in terms of a defence of their professional practice, for teachers to 'buy into' a model that promotes standardisation. This view fits with the perceptions of the Strategy identified above ('NNS as…'). Treating it as a 'plan of development' relieves teachers of the need to plan independently in the medium term, and a belief in it as a 'means of achievement' provides one with a sense of *faith* – a reason for investing professional energy in it. To others,

however, the Strategy appeared to represent a genuine aggregation of the best ideas for teaching a subject that is particularly difficult. Clearly, such justifications for practice are complex in their relationship with other aspects of teachers' professional and personal lives and with the way in which teachers view the 'public and personal warrants' (Corbin and McNamara, 2001) provided by policy.

The two *ideal types* might well be thought of as creating a role tension (Woods et al, 1997) in that they seem to require teachers to work in two opposing approaches simultaneously. However, for the teachers in these interviews, at the outset of the NNS, they did not seem to envisage that this would be the case, at least in terms of the rhetoric of their claimed practice. So, for example, they spoke of 'effective teaching methods', but implied that they were open to interpretation and change within individual contexts; they liked the idea of interaction with the whole class, but felt confident that this did not have to mean a move away from working with individuals; and they felt confident that they would be able to use children's own ideas in 'correcting misconceptions' and moving children's thinking forward.

However, despite this confidence in their ability to work at both ends of the spectrum there seem to be two respects in which the teachers were unanimously at the 'technicist activity' end:

- The focusing of lessons on specific, identifiable objectives.
- Numerical calculation being seen as the most important part of the NNS (not one teacher gave an example of something that they might do in the classroom which was not a numerical one) with the emphasis being on the development of strategies for calculating mentally before learning to translate these into standardised procedures involving pencil and paper.

In these respects, all the teachers had 'bought in' to one particular interpretation of the Strategy, namely the over-riding importance of numeracy as a proficiency in skills and

procedures, with an associated atomisation of the curriculum into a series of interconnected, but identifiable, parts. They were happy too, it seemed, to rely on the Framework to be the definitive guide regarding the 'means of achievement' of these aims.

In trying to make an interpretation of this perception of the Strategy, one can come back to the insecurity felt by so many teachers regarding the nature of the subject (e.g. Ball, 1988). Few of the teachers could articulate their understanding of the subject explicitly, and few could do so even when prompted with possible alternatives. Whilst these teachers may claim to enjoy teaching the subject, chapter 2 noted that many teachers generally tend to have only a surface level understanding of its fundamental principles, and its potential purposes. Although the effect of a teacher's conception of the subject on their practice is still not fully understood (Thompson, 1992; Brown and McNamara, 2001), Lerman (1990) and Askew et al (1997) have suggested that teachers' beliefs about the subject tend to affect their teaching practices and Andrews and Hatch (1999) claim that conceptions of the nature of the subject correlate, broadly speaking, with conceptions of forms of pedagogy.

It seems sensible to assume that where a teacher feels unsure about her understanding of a mathematical idea, she is less likely to feel inclined to explore the process-orientated aspects of the subject and the interconnections between ideas. Rather, her focus is likely to be on the conceptual content itself. An analogy might be the way in which, when learning to play chess, say, one's attention is on the surface level detail of *how* the pieces move, rather than the significance of the moves and positional structures they create in terms of a wider strategic whole. In this way, teachers for whom the purpose of mathematics and its underlying principles may not be clear (such as the fundamental importance of generalisation as a key element in its power to connect and explain situations) are more likely to focus on its content detail (for example, doubling as a strategy for multiplication or the operation to use to solve a word problem in which the word 'total' appears).

This focus will affect the teacher's understanding of the nature of 'success' in mathematics, and may subsequently affect children's perceptions of the subject and what they consider it to be about. Kelly (2000), for example, has identified that the majority of primary children in a small scale study viewed mathematics as 'work to be done in school' with a focus on the academic nature of it and Boaler (1997, 2002) has illustrated how children taught in qualitatively different ways come to understand 'different mathematics' (as opposed to simply more, or less, of the same mathematics).

Thus, when teachers talked of their confidence that the NNS would lead to greater 'success', I might assert that, without a deep understanding of the subject, this may refer to a surface level effect in which just those areas supported by the NNS (calculation in particular), and then tested by the SATs, will indeed improve. However, I might also assert that more fundamental aspects of the subject, including a deeper perception of what it might be *for*, as well as the ability to identify and use applications of it beyond simply the 'word problems' on which it focuses, may be missing. Brown et al (2003) and OfSTED (2000, 2003) provide considerable evidence that the first of these assertions may indeed be happening, with SAT scores reaching a plateau and success measured by other means showing little improvement over the first few years of the life of the NNS. Whether the second assertion regarding applicability is seen to be true too may not be so immediately apparent – nor so easily identifiable.

Finally in this section, attention is turned towards the teachers' perceptions of how the introduction of the NNS was likely to change their working practices, a question included in the interview procedure used. In short, and perhaps surprisingly, although all the teachers acknowledged that there would be a degree of change to their practice as a

result of the NNS, the majority *did not* see this as being dramatic. Avril's comments, whilst not made explicit by everyone, were typical of the majority's meaning.

> Yes, to be honest I don't think it's incredibly different from ... I mean some aspects have probably got more emphasis, but I don't think it's incredibly different from the sorts of things that I've been doing. Perhaps the format of being absolutely sure that you have the introduction and the plenary ... [but] ... I don't find it a threatening thing.
>
> (Avril, 15.7.99)

Again, this fits with a view that the NNS seemed to 'make sense' to the teachers. Here was a strategy that had some new ideas in it but which fitted well with the reality of the classroom. As such it was seen as a development of, rather than a change to, current practice.

It needs to be seen too in the light of the National Literacy Strategy that had been introduced a year earlier. In many ways this had led the way, and its broadly similar (though more complex) lesson approach meant that the majority of teachers were already familiar with the overall teaching patterns required by the NNS. Almost every teacher compared the Numeracy Strategy to the Literacy Strategy, with the over-riding feeling being that the former was far more coherent and manageable (see also Earl et al, 2001). Thus, part of the acceptance of the NNS may well have resided in it being perceived as 'relatively simple' in comparison with the NLS.

> And so we did talk quite a bit about that [structure of the hour] and I just kept emphasising how simple it was compared with the literacy hour. Because it is.
>
> (Catherine, 5.7.99)

> I think it will be helpful that the children are used to working to that format with class teaching, group work, plenary and getting on. I mean for some people it was in place anyway, but for those that did work differently, it must be a help that that backbone's there because you've already established the sort of routine. I think that will be a lot easier.
>
> (Avril, 15.7.99)

Hence, for the majority of the teachers, the NNS was the continuation of a process already begun.

There were, however, two aspects that were perceived by the majority as being significantly different, in the sense that they required a major change in practice. First, there was the change in the overall emphasis towards numeracy and, more specifically, away from standard written procedures towards mental calculation. Second, there was a greater emphasis on whole class teaching, using discursive interaction, for the development and practice of mental mathematics and for introducing new concepts at the start and end of each lesson.

This attack on arithmetic, learned mentally through discursive interaction and direct instruction as a whole class, was considered by the majority of the teachers to be 'the new bit that people want to focus on the most' (Catherine, 5.7.99). Janet commented that,

> This year [in trialling the NNS] we've all been trying to do a lot more mental arithmetic,

and that,

> I've done a lot more on trying to teach strategies rather than just, you know, 'How did you do that my dear'?, 'Did you all hear that?, Let's try somebody else', which we've always done.
>
> (Janet, 17.6.99)

Similarly, Julian reported that,

> The one thing that people are talking about a lot is this issue of allowing children to develop their own strategies to work out problems, you know, which children can work out in their head basically .... I think that some people are quite concerned about that because I think that's quite new.

(15.7.99)

However, mental mathematics largely replacing written forms, though seen as 'new', was again welcomed, or at least accepted as sensible, by all the teachers. Chapter 2 noted that this message had in fact been statutory since 1989, but the Framework seemed to be providing teachers with the kind of support they had not previously had, creating sufficient confidence that they would be able to do what was being asked of them. Similarly, the greater emphasis on whole class teaching, (the introductory mental 'revision' period and the plenary especially), though new, was being received positively in general. Heather described her view of it as,

> Lots of skills practice and then me teaching the area that I want them to learn and then them doing a bit of work on it and then, hopefully, picking up at the end of the lesson anything that I've noticed or just giving them an example that might be just a little bit different. So I suppose it's all the classic things that teaching should be about....
>
> (20.5.99)

and, Adrian, claimed that,

> [The plenary is] as important as all the other sections put together and I think that will be an element that a lot of people will be working on.
>
> (17.6.99)

Of all the areas of interest uncovered therefore, the greater emphasis on whole class interactive teaching appeared to be the one which appeared most significant in the minds of the teachers in terms of change to their practice. The enthusiasm they showed for it, though, stemmed from a belief that it seemed to offer a way of achieving something that had always been required of them but never made clear; that is, *how* mental work can be developed. It was thus seen as an apparently novel, but 'sensible', form of teaching.

Summary

All the categorisations and their respective interpretations above serve to provide a snapshot of the professional landscape at the time of the National Numeracy Strategy's introduction. The overall sense was that the NNS was turning their work into a more technicist activity in terms of *what* to cover. Similarly, *how* it should be covered was being dictated in structural terms, but teachers appeared still to believe that there was room for them to use their own professional judgement in terms of the detail of their practice.

This phase of the study was designed to be exploratory, allowing for the identification of areas for future investigation, and in this sense was highly successful in producing a rich source of potential questions for exploration. The data raise a number of possible avenues in this respect, suggesting a range of potential research questions. For example:

- How do the conceptions of the National Numeracy Strategy identified here change over time?
- Do changes to pedagogy affect teachers' and children's beliefs about the *purpose* of mathematics and their dispositions towards it?
- Do teachers tend mentally to separate *mathematicians* from *non-mathematicians* in their classes and what effect does this have on teaching and learning?
- What effects do changes in pedagogy have on pupil attainment (where *attainment* might be measured in a number of different ways)?
- What connections do teachers continue to make between the NNS and the NLS, and how do these affect each other?
- How do teachers manage the whole class in what is seen as a 'new' interactive approach to teaching mental calculation?

Because of the teachers' apparent interest in the interactive approach, alongside my own critical interests in interaction as outlined in the previous chapter, it was the last of these that was chosen as the major focus of further study. In order to begin this study, the

actual practice of three teachers was investigated through classroom based observation of their teaching, focusing particularly on the parts of their work that involved them interacting with a whole class simultaneously. The next chapter discusses this phase of the research.

Chapter 5 – Teachers' classroom practices

Introduction

That *whole class interactive teaching* was seen as a new and interesting development by many teachers at the outset of the National Numeracy Strategy has been demonstrated by the results of the interviews of the previous chapter. This perception on the part of the teachers is supported by the extent to which the guidance and training materials focused on this same aspect of the Strategy too, with considerable input being provided to teachers to try to induct them into this way of working. However, whilst teachers in the interviews had expressed their interest and excitement about this phase of the Strategy's approach, they had not made explicit what it was about it that might challenge them. Furthermore, as chapter 2 made clear, elements of pedagogy are not independent of each other, and whole class interactive teaching taking place at the start and the end of the lesson needs to be seen in the context of a teacher's approach as a whole.

In the light of this, and in order to be able to focus in depth on practices, a small group of just three teachers was identified for a field study. Reported here are the results of lesson observations and discussions carried out with these participating teachers, Heather, Mary and Frances, and a follow-up interview with each of them after observations were completed (see appendix 4). Whilst the observations focused in particular on those parts of their teaching that were interactive with the whole class, they also took account of lessons as a whole in order to contextualise the foci.

The research questions relating to this phase of the research were as follows:

How do teachers' perceptions of what the NNS is affect the way they perceive they are trying to teach?

- What do they see as the key aspects of the Strategy?
- What might be the implications of these key aspects for their teaching?

The chapter begins with a pen sketch of the three teachers and their schools, followed by an overview of their teaching approaches. It will be seen that, though they all ostensibly worked 'to' the National Numeracy Strategy, their practices were very different in many respects. Nevertheless, one particular challenge in relation to the use of whole class interactive teaching was common to them all and this is explored in the final section.

The schools

Heather and Mary both worked at Townleigh, a one form entry school with six members of teaching staff, on the edge of a market town. This town was acknowledged as having a high level of social deprivation although the proportion of children having free school meals was 8%; below the national average. Around 11% of children were on the Special Needs register. From a subjective viewpoint, the children generally appeared lively and there was always the potential for disruptive behaviour, but the teachers managed to control this effectively most of the time. This was perhaps a reflection of the strong ethos within the school in terms of behaviour; an ethos stemming from the head teacher and supported by all the staff. They appeared to have created a caring environment in which children's ideas and interests mattered, and they were free to express their views within a clear set of boundaries in terms of what was acceptable behaviour.

Frances worked at Riverview school, a one and a half form entry school with 10 teaching staff in a large seaside town. The level of free school meals was around the national average of 15% and the school had about 20% of pupils on its Special Needs register. Like Townleigh, the school had a positive feeling in terms of behaviour and expectation and the children generally seemed happy and secure throughout. Whilst there were difficult children to work with in every class, there was a clear view on how to handle poor behaviour and support from the senior management for staff where it was needed.

As part of an attempt to compare the classes, I taught one session with each one myself and, in experiential terms, there was nothing on these occasions that marked each class out as 'exceptional' in any strong sense. However, that may not have been the case in the longer term, and Heather's class in particular were perceived by the teachers at Townleigh to be particularly challenging.

Heather

Relevant biography

Heather, aged 37, was a Year six teacher and both the mathematics and Key Stage 2 coordinator at Townleigh School. She had qualified via a PGCE with a specialism in mathematics in 1990, having previously gained her first degree in economics some time before that. In the intervening time she had stopped working to bring up her family and had had another break immediately after her PGCE course for another child. As a result she had been teaching full time for 6 years at the start of the study and was in her second job.

My impression of Heather was as a quiet but intelligent and reflective teacher who thought carefully about her teaching and cared about the children *as* children, rather than simply as pupils. Teaching, to her, was more than just achieving academic success, though she recognised that test scores were important for the school in the current educational climate and was very aware of her responsibility as mathematics coordinator. A perceived

potential conflict between children's needs and political imperatives was something to which she referred on a number of occasions and was a source of some dissatisfaction to her. Whilst committed to her job, Heather did see it as just that. Having a family contributed to a sense that working and personal lives should be separated and that the former, whilst needing time and attention to do it well, should not be allowed to dominate to the detriment of the latter. Again, this was a source of tension for her on occasions and, as a result, she appeared to be under considerable pressure at times in trying to balance the two.

Heather had a particular interest in mathematics and it was the subject that she most enjoyed teaching:

> I sometimes teach other subjects and I think have I got it across, but with maths, you know, the response is almost immediate isn't it? ... I do find it's not an easy subject to teach, it's just a subject I feel that I'm getting further with than I am with others.
>
> (Heather, interview, 20.5.99)

Her first degree in economics and an A-level in mathematics meant that she had considerable knowledge of the subject itself and she had kept up to date through INSET.

The teaching context

Heather's personal character was reflected in the classroom, where she was relatively quiet and relaxed about her teaching. The room in which she worked was a fairly dark one, considerably longer than it was wide. Tables were arranged individually facing the front for most of the mathematics sessions, with two children to a table. However, Heather was happy to change this arrangement where she saw fit and it was by no means 'fixed'. At the back of the room there was a set of four networked computers arranged around a work unit. Whatever the arrangement of the desks, they essentially

filled the room and there was little or no space for other 'areas'. During the study, Heather was teaching mathematics to the upper of two sets, arranged by ability. This was a large group of over 30 children from a year group that were acknowledged throughout the school to be particularly 'difficult' in terms of their behaviour. Heather was well aware of this difficulty and referred on several occasions to her work with them as being partly about 'survival' (Woods, 1983) until the end of the year. One of the challenges for her, therefore, was the task of trying to implement the 'whole class interactive teaching' approach advocated by the NNS whilst still managing the behaviour of the group effectively. More especially, the group was easily dominated by a sub-group of about six very able boys whose behaviour was of particular concern to Heather.

It should also be noted that the period during which the majority of the observations took place was the run up to SATs, and that the need for these children to be prepared for the tests was always in the forefront of Heather's mind. By her own admission, this had some effect on her approach in the classroom. Though it is impossible to measure this effect, Heather suggested that she was probably a little more focused on 'revising' certain specific topics than she might otherwise have been, in particular regarding 'a tendency to ask more closed questions to assess knowledge as opposed to higher-order, open questions to generate thinking' (field notes, 13.3.00).

Mary

Relevant biography

Mary, aged 23, was the youngest of the three teachers in the study and had been teaching for three years at the start of the project. She had responsibility for the Y1 class at Townleigh Primary and was the art coordinator. At the start of the academic year she had also begun to take on some responsibility for mathematics at Key Stage 1, sharing the responsibility for the subject with Heather. This had come out of a need for this role to be filled, coupled with a desire on Mary's part to become more involved in the management of a core subject for her own professional development.

Mary's own formal mathematical education was limited to GCSE where she had obtained a B grade. She had then gone on to take a B.Tech. in Social Care before getting a place on a B.Ed. programme as an art specialist student. The programme included the usual training in mathematics education that would be expected of an ITE course. Despite this lack of formal qualification in mathematics, Mary felt that she had a "reasonably good" understanding of the subject in terms of what was necessary to teach it, even when this involved working with Y6 children. My own view was that this was an accurate self-assessment of her understanding and, though not a mathematics specialist, she certainly enjoyed teaching the subject on the whole.

Like Heather and Frances, Mary was dedicated to her work, though again, not to the exclusion of other aspects of her life. She was perhaps the most ambitious of the three in terms of her own professional achievement, citing a desire to move on in her career as one of the factors that had persuaded her to become involved in the project with me. Indeed, shortly after the period of field work reported here, she found a new job as a Key Stage 1 leader in a new school.

The teaching context

Mary's classroom was light and airy and had space for different areas of interest. The class comprised 30 children, none of whom were on the SEN register for behavioural reasons, though several had been identified by the school as needing Individual Education Plans (IEPs). Nevertheless, the spread of ability was typical of a Y1 class of 30 children.

In support of her work, she had the help of one teaching assistant for all of her mathematics lessons.

Mary had a very friendly and relaxed relationship with the children based on a belief that the key issue was to engage their attention. However, this is not to say that she was over-relaxed and her sessions had considerable structure and well established boundaries. Within this though, children were encouraged to express their opinion and to contribute at will, inevitably leading at times to boundaries being stretched to near breaking point. The overall feel in the room was of a lively atmosphere, constantly simmering and occasionally bubbling over. Children clearly enjoyed being in her class and spoke easily with her both before and during teaching sessions. She encouraged children to bring objects and things that they had done out of school to 'share' with their peers and there was regular time set aside for this each day. In these respects, Mary's approach to her work was that although 'lesson' time was important, and was the main way in which children would learn, their learning should be an holistic experience, if possible, in which different curricula subjects needed to be brought together in a context that made sense to the children. This was apparent too in her mathematics teaching in which she placed great emphasis on working with practical materials – though this did not extend to combining her mathematics work directly with other areas of the curriculum.

Frances

Relevant biography

Frances, aged 35, was responsible for one of three combined Year 5 and 6 classes in Riverview. In addition she was the PE coordinator and had had a career as a professional dancer herself before coming into teaching via a B.Ed. as a relatively mature student in the early to mid 90s. Her background reflected her beliefs in the importance of

developing 'the whole child', particularly through the use of artistic and physical disciplines and she confessed to feeling frustrated at times with the increasing domination of literacy and numeracy in the education system as it stood. Whilst she acknowledged the importance of these subjects, she spoke of an overemphasis on test results in the system as a whole which was inevitably tending to creep into the day to day life of her own teaching and would have welcomed a change in the curriculum that focused more on the integration of subjects.

Frances had no particular expertise in mathematics beyond that which one would expect of a competent primary teacher. In terms of qualifications, she had obtained a B grade at O-level approximately 20 years ago but had not gone on to study it at A-level when she went to dance school. She referred to being "glad never to have to do it again" when she left school but, having come back to it as a teacher, now felt that it was a subject which had developed considerably since starting to teach it. However, by her own admission, there were occasions when she wished that her subject knowledge was stronger and that she was better able to identify relevant features of the children's responses. Overall, of the three teachers involved, she was the least confident in teaching the subject.

The teaching context

During the study she initially taught mathematics to a group of the least able Year 6 children before changing to a set comprising some of the less able Year 5s. This change was significant in terms of the focus of Frances' teaching. With the first group of children, her emphasis was on trying to ensure that they were able to cope with as much of the impending KS2 tests as possible and that they were as prepared as they could be to take them. In contrast, with the second group her focus was more on the introduction to, and development of, new skills and concepts.

A second significant feature of Frances' teaching was the physical environment in which she was working. Numbers in the school had been rising steadily over the previous few years and they were awaiting a new classroom as part of building work due to take place at the end of the academic year. This meant that Frances taught most of her mathematics sessions in a space designed to be used for the dining area, open to 'through traffic' around the school and to general observation by all. Though the children seemed remarkably unaffected by it on the whole, the effect on Frances of this environment was, not surprisingly, considerable. It is not possible to know exactly how her practice was changed, however it was certainly true that her work was very 'public' and it seemed, in observing her, that she was conscious of the level of noise that children made and of her own responses to situations to a greater extent than she might otherwise have been in a more 'private' circumstance.

Though containing children who were considered by the Year 5/6 teaching team to be the least mathematically able, neither of the groups of children with which Frances worked were deemed to be especially challenging in terms of behaviour; certainly, none of the children were on the SEN register for behavioural or learning difficulties, though there was one child who had a learning assistant present as a result of his cerebral palsy. Certainly, my own experience was that the children were friendly and generally polite to me, a guest in their classroom, and both Frances and the children seemed at ease with each other too, enjoying a friendly and mutually respectful relationship both in and out of lesson time.

The teachers' practices

In this section I begin with a general overview of the practice of the three teachers. Progressively, the focus moves towards whole class interactive teaching. However, this

cannot be understood outside of an analysis of their practice as a whole, with which I begin.

In short, it will be seen that all three used the structure suggested by the National Numeracy Strategy, both in terms of teaching approach and planning, and felt it to be successful in general terms. There then follows a more detailed analysis of the teachers' practices in relation to the 'policy-in use' they made manifest (Ball and Bowe, 1992). This analysis leads to the identification of several particular challenges for the teachers in their teaching which are explored in the final section.

General overview

I begin with the question of how, in general terms, each teacher was working in relation to what the guidance for the Strategy suggested they 'should' be doing.

Heather, Mary and Frances had all adopted the hour-long structure recommended by the National Numeracy Strategy. For Heather and Frances working with Year 6, the tasks set were predominantly written, though Frances in particular tried to make use of physical resources whenever possible which she considered to be effective in supporting the children's learning. The written nature of the tasks was, undoubtedly, partially a result of the approach of SATs, the work tending to be focused on consolidation rather than exploration. It is typical too of the tendency to remove practical experiences as children get older and to require them instead to work with abstractions and symbols alone (see, for example, DES, 1982, para. 247). In contrast, Mary used practical equipment with her Year 1 class in nearly all of her group tasks, and saw it as a fundamental part of her work.

> It's [the work given] not lists of sums for them to do. But just by providing them [with] as many practical things as I can where they don't get bored, where they're enthusiastic, excited about what they are doing. They just seem to be far more settled when they're interested, so if you can get their interest at the beginning.

(Mary, interview, 20.5.99)

It was, to her 'absolutely essential' and this belief was clear in her practice in the classroom . However, her work was with younger children, was not focused on SATs and tended, therefore, to be more about concept development and practice than consolidation of previous learning.

Whilst all three teachers began their lessons with 10 – 15 minutes of 'mental/oral mathematics', Frances was likely to separate 'practice' from an introduction to the main theme, whereas Heather and Mary would often run these together.

In terms of the plenary, Mary included this element conscientiously and it was not missed on any of the occasions when I watched her. Frances, too, was reasonably conscientious about bringing the group together, though on occasions the sessions ended rather hastily and Frances herself was dissatisfied with the outcome in this respect. Heather tended to be rather more relaxed about the use of a plenary, and though she would include one if it fitted 'in the moment', she had no concerns about simply omitting this part of the session if she saw fit.

The teachers' essential adherence to the suggested approach was a reflection of their satisfaction with the National Numeracy Strategy as a whole, as interviews carried out post-observation demonstrated. Frances commented that,

> It's improved my maths and improved my teaching and given children better ways of approaching maths I think.
>
> (interview, 22.3.01)

It was clear too that, for her, the NNS had been a contributing factor in a growth in confidence.

> I used to ask to teach the less able groups but, whereas now, over this last year or so, I think now I would quite like to have a go at a more able group because I feel more able to stretch them more.
>
> (ibid.)

For Mary, there was a 'reassurance that we are teaching what we are meant to' and she liked the structure that the planning grids provided for her. Similarly she commented that,

> The children like the mental/oral bit, which is the new bit really; the group work is just as it always was.
>
> (Interview, 26.3.01)

Meanwhile, for Heather, when asked if she liked the Strategy, she stated,

> Yes, definitely. It's taken some of the hard slog out of what we used to do, because I don't have to search around for my objectives.

Similarly,

> The structure [3 parts] does work. I like the zappy beginning [and went on to explain how she felt that it made the children take notice and tuned them in to what was to come].
>
> (Interview notes, 26.7.01)

In general, therefore, there was a clear overall picture of all three teachers teaching broadly in line with the suggested lesson format set out in the Framework and taking their planning directly from this document, or school planning based directly on it, as well as making use of the examples in the folder. They were, in this sense, 'following the Strategy', even if they tended to alter their approach in small ways at times. Their practice over the first two years of the Strategy therefore seemed to have changed little, in general terms, from that which they had described when first interviewed just prior to the official launch.

'Policy-in-use' – an analysis of the teachers' practices

Chapter 2 analysed the way in which *intended* policy for the National Numeracy Strategy became *actual* policy in the documentation that surrounded it, and this was summarised in Table 2. The table is repeated here, though it has been rearranged to reflect three distinct aspects of the actual and intended policy, namely:

1. aspects which relate to the perceived need to change practice *in general*;
2. aspects which relate to the *nature of the subject and the curriculum*, and;
3. aspects which relate to *specific* recommended changes to teaching practices.

The resulting *policy-in-use* of the three participating teachers is now considered in general terms in relation to each element of this table.

1. The perceived need to change practice in general

Ideology from:	**Intended policy**	**Actual policy**
Political agenda:	**Political imperatives:** ▪ a desire to 'raise standards' rapidly (where this equated to test results); ▪ a wish to ensure that English children caught up with their international peers in terms of the 'number' elements of the mathematics curriculum;	▪ massive resourcing and a focus on test results as a measure of success;

Table 7 ... continued

	▪ a desire to enable schools to be made 'accountable' for results by increasing the significance of the one easily measurable 'output' of their work, test results. **Views on pedagogy**: ▪ a strong perception amongst some members that there was a 'problem' with mathematics teaching; ▪ a related perception that the lack of success in mathematics teaching lay at the door of 'trendy teaching' (essentially meaning pure progressivism);	▪ a refocusing of the mathematics curriculum towards numeracy at the possible exclusion of other, wider, interpretations of the subject; ▪ upping the stakes for test success through performance management requirements and inspection criteria. ▪ the perception given that the NNS is a tried and tested 'solution' for schools;
Political agenda:	▪ a belief in one set of 'best practice' and a will to 'retrain' teachers to adopt it.	▪ a move to a managerialist discourse which emphasises standardisation of practice; ▪ a positivistic view of 'effective' teaching methods to be adopted by all teachers; high levels of funding to implement this.

Table 7 - Teachers' perceived need to change practice as a result of the NNS.

Policy-in-use:

There can be no doubt that the political drive to measure the success of schooling by league tables derived from SAT results has impacted both on teachers' work and pupils' emotions considerably over the last few years (Connor, 2001; National Union of Teachers, 2003; Earl et al, 2001, 2003). Pressures and rewards are inevitably transferred to the teaching staff, particularly those such as Heather and Frances teaching Year 6 classes for whom SATs are imminent from September each year. Certainly, this was

reflected in many comments made by these two teachers during the study. Heather, described the need to make 'rehearsal' for tests part of the Year 6 programme.

> I know I did lots of games at the beginning of the year, and as the SATs approached I did quite a lot more formal stuff just to prepare them for the tests, whereas the other teachers hadn't been doing that [in previous years] so obviously that's probably had the effect [disappointing scores]. So I mean I don't feel too disappointed by that cos I think we can, you know, we'll just have to put some extra teaching in at the end that just prepares for the test. Unfortunate, but we'll have to do it really.
>
> (Interview, 20.5.99)

Similarly, Heather referred on occasions to 'feeling driven by SATs' (field notes, 13.3.00) and suggested that this was manifested in her practice by a tendency to work in a more closed way with the children, asking fewer higher-order questions and more recall questions in order to check knowledge rather than develop it. Frances felt that there was 'too great an emphasis on SATs' (field notes, 9.12.99) in her school and felt frustrated with the resulting focus on literacy and numeracy at the expense of the arts. Indeed, much of her work was aimed at providing a group of low achievers with the best opportunity to do as well in the tests as possible, and this tended to result in teaching aimed specifically at 'revising questions like those in the SATs' (field notes 14.3.00) and making this explicit to the children. Frances felt a transfer of this pressure to the children themselves too, and was concerned that the expectation of ever increasing scores meant that 'children get concerned not whether they are *able* but whether they are *super-able*'. Test scores were therefore high on the agenda of all three teachers, and for the two in Year 6 particularly they could be said to dominate their teaching to some extent.

More widely, there were other signs that the NNS itself was seen in standardised, managerialist terms. One such sign was the notion of *lessons* which dominated all the teachers' thinking. Mathematics (and everything else) was taught in lessons which began and ended with specific routines and were very much self contained. The sense that these

lessons somehow 'contained' specific ideas that the children were to acquire was strong, particularly in Frances' teaching, and to a lesser extent Mary's. On more than one occasion, Frances referred to a sense of ownership of the lesson, saying to the children, for example,

> If we are late out to play because I haven't finished *my lesson*, it will be your fault.
>
> (Field notes, 29.6.00, my emphasis)

This might be seen as simply a turn of phrase were it not for the implicit implication each time that the lesson would be 'finished' only when Frances herself had completed what she wanted to say. In this sense, the lesson was what was done *to* the children, not what they themselves might be constructing as a result of it. This, of course, is perfectly in line with the instructions from the NNS training materials which told teachers to start each lesson by 'making clear to the children what they *will learn*' (DfEE, 1999c, p. 49, emphasis added) and reflects the 'getting done' approach which characterises the 'technicist' end of the spectrum (Woods and Jeffrey, 1996 after Apple, 1986).

However, whilst there were signs in all three teachers' work that they had been strongly influenced by the managerialist discourse, to imply that they were somehow *constrained* by it would be incorrect. Whilst they all taught mathematics every day in specific 'lessons', and whilst these followed the guidance quite closely in terms of teaching format, the fact that this was the case was a reflection of the support and trust that they felt it offered to them in their mathematics teaching. The semi-structured questionnaire used in the follow-up interview (appendix 4) with each teacher asked specifically the extent to which they felt that the National Numeracy Strategy could be considered a 'blueprint' for success. All three indicated that they felt this was true to a large extent. In this way, all three teachers seemed to consider the Strategy to be a 'best approach' and a 'solution' to the challenge of raising SAT scores for schools.

> Not that I'm spouting the government line, but I think it's a genuine go at, if you like, people trying to make children just be more aware of maths and have different ideas and different ways of approaching things, problems. I mean I remember when I was at school it was very formal, you didn't understand anything. So I think there's much more trying to de-mystify it.
> (Frances, interview, 22.3.01)

Importantly, this sense that it was the right approach was not out of any positivistic view based solely on quantitative measures of achievement, but seemed, rather, to be based on a deep, personal sense that their own teaching was better than it had ever been and that the children responded more positively to it than had been the case in the past.

> I'd definitely agree too with that [the aim of the NNS is to achieve the overall aim to 'raise standards']. It is there to raise standards. But

> hopefully, standards aside, I mean published standards, league tables, just to make children more confident mathematicians.
>
> (Frances, interview, 22.3.01)

Whether it had been imposed on them or not, the Strategy was not 'good' just because someone had told them it was; it was good because it fitted sufficiently the *working practices* of the teachers as described in the previous chapter. In addition, though it reflected these working practices, it also appeared different enough to challenge them, creating in all three teachers a willingness to re-examine their own teaching. Frances commented that,

> I think it's made my mathematics teaching better in the way it's made me re-examine my practice and made me think about how to teach it.

Similarly, Heather claimed that she had,

> Moved on from seeing the NNS as objectives to thinking more about teaching: demonstrating, explaining, the value of each of the three parts etc.

and that,

> It's changed the way I construct my lessons. We're thinking beyond what we teach, to how we are teaching it.
>
> (Interview, 26.3.01)

In this sense, Heather was suggesting that the 'what' to teach was now 'in place', and, as a result, she had been freed up to think about how to teach it more effectively.

2. The nature of mathematics and changes to the curriculum

Ideology from:	Intended policy	Actual policy
Political agenda:	**Aims and purpose of mathematics:** ▪ a belief that mathematics is essential for children to grow up to be useful members of the workforce; ▪ an understanding of mathematics as a 'set of skills' to be 'acquired'.	▪ an emphasis on mathematics as a 'practical tool' and contexts that refer to 'the workplace'; ▪ a Framework composed of specific, focused objectives with calculating strategies at its heart.
International research:	**Issues of curriculum:** ▪ a need for greater clarity and structure of curriculum materials; ▪ a suggestion that mathematical ideas, their language and their notation should be introduced alongside each other; ▪ a belief that there should be a much greater emphasis on mental calculation.	▪ a framework which provides a detailed breakdown of mathematical concepts and examples of these in practice; ▪ more explicit reference to mathematical language (through a yearly vocabulary book); ▪ one of the four stated principles for the NNS as a whole.

Table 8 ... continued

'Other' research:	**Issues relating to mathematics:** ▪ a changing belief from mathematics as a written discipline to using mental methods 'as a first resort';	▪ made explicit in the Framework and other associated documentation;
	▪ associated beliefs about the kind of understandings of number required for this – a move from 'cardinal/concrete' to 'ordinal/iconic';	▪ implied, but not made explicit, through training materials and suggested resources;
	▪ the importance of mathematics as a network of interconnected ideas and representations (rather than a linear series);	▪ made explicit in advisory material, though the itemised structure of the framework may mitigate against this view;
	▪ a belief in the importance of higher-order thinking as paramount in children's mathematical development;	▪ not apparent as specifically identified mathematical processes, though reasoning and justification emphasised as part of increased use of discussion;
	▪ the mutual interdependence of application and conceptual knowledge of mathematics in effective learning, and therefore;	▪ not apparent – mathematics seen as an abstract 'tool kit' to be applied at will;
	▪ the importance of learning mathematics through the use of problem contexts and investigative approaches.	▪ problems only in word form; investigative approaches mentioned, but the short and highly structured lesson time and the lack of explicit reference to Using and Applying Mathematics might be seen to mitigate against this.

Table 8 - Teachers' understandings of the nature of mathematics and changes to the curriculum.

Policy-in-use:

The preceding section indicated the qualitative sense that all three teachers shared that the National Numeracy Strategy offered an effective model for teaching mathematics. Heather's claims that the 'what' in mathematics teaching was 'now in place' suggest that the desire for greater clarity and structure to the mathematics curriculum, emanating from research into comparisons with other countries, had taken place and was largely welcomed by the teachers. This view was confirmed by both Mary and Frances too. In post-observation interviews, they were asked to rank the value of different aspects of the Strategy. All three ranked the following statements at 1 (= most effective) :

- the objectives are clear;
- the approach to calculation is right;
- there are helpful examples to follow;
- it contains lots of good ideas;
- it is based on good research.

Mary had clearly put her faith in the objectives being a suitable progression for her to follow, claiming that,

> It's a broad and balanced set of objectives, or guidelines, which show what good teachers should cover in mathematics
>
> (Interview, 26.3.01)

and speaking of the 'reassurance that we are revisiting the same things regularly'. What is more, although she felt free to go her own way in terms of teaching approaches if she felt it was justified, the objectives for her year group 'needed to be covered at some point, otherwise why would they be there?' (ibid.). It would seem that she was happy therefore to divest herself of responsibility for planning the mathematical ideas that her children needed to address and to put herself in the hands of the Strategy in this respect.

The evidence seems clear here that the teachers felt the curriculum was better organised than ever before as a result of the National Numeracy Strategy, and that this was helping them in their teaching by allowing them to be more specific in identifying mathematical objectives. Similarly, all acknowledged the focus on mental mathematics, welcoming the move away from too much recording at an early stage. Adopted simplistically, the focus on clearer objectives could have led to teaching as a technicist activity, with the transfer of objectives being the endpoint for the teachers. However, again, the reality was more complex. Instead, all three claimed to see mathematics very much as a *process* and not simply as a set of concepts to be developed in children. This 'process' was two-fold. First, there was a process in terms of *application*, namely that concepts needed to be applied, as well as learnt as abstract ideas. Heather spoke of this as a mutual dependence, recognising that concepts could be developed from contexts but that 'sometimes the situation has to be manipulated. You can't just use real life problems all the time, you need to do a bit of both', meaning that at other times concepts need to be taught separately *before* being applied. Mary too claimed that they went 'hand-in-hand' saying 'I'd introduce it [a new concept] in a context' and pointed to the importance of 'linking it to different things so that they see it in different contexts'. Similarly, Frances suggested that 'I think the two [understanding and application] work together, because you pick up bits of maths, you learn how to apply it and then you take it to its next step on.'

The second sense of 'process' in mathematics was in the *linking together* of mathematical ideas and the use of 'processes' such as investigation to support this. Again, the teachers were in favour, at least in theory, of the use of investigation, though Frances admitted that,

> I do a mixture of both. Sometimes I get them to find things out for themselves, but sometimes I just tell them stuff .... But sometimes I take the coward's way out if I think it's a particularly difficult concept, and again, it's that pressure of 'test coming up. I've got to get them through this!'
>
> (Interview, 22.3.01)

Heather felt that 'there are gaps left by the Strategy in terms of problem solving and lengthy investigations' and that this was a weakness.

In terms of the first of these senses of 'process', despite the *reported* belief in the interconnection between conceptual development and application, I did not see real contexts being used to help children *develop* conceptual ideas in any of the lessons I observed. Use was made of practical equipment from time to time (especially by Mary) and of representations drawn on the board, but the use of a context *from which ideas were developed* was completely absent. Again, this may reflect the approach of the NNS and its planning format particularly, where the objectives relating to skills and concepts to be 'learnt' are separated completely from the objectives for 'problem solving', the implication being that the former are simply a 'tool kit' for the solution of the latter. This was most evident, though not exclusively, in Frances' teaching, where, in her lesson of 14.3.00, 'four steps for solving word problems' were being taught to the children in preparation for the SATs. Thus, children were being instructed to:

1. read the problem carefully;
2. underline important words and numbers;
3. work out the operation; ("work out what maths to use");
4. work out an approximate answer by estimating.

Field notes made the following comment about this section of Frances' work.

> I'm really struck by the way in which F. is focusing on the language of word problems. All the focus is on how to solve the words, not the maths [nor the problem]. It's more like a foreign language lesson than a maths lesson. What has it to do with real problems?
>
> (14.3.00)

Thus, though the teachers all spoke of the intertwining of context and content, evidence that they genuinely used contexts *to develop mathematical ideas* seemed hard to come by, and there seemed to be a separation of the subject's conceptual ideas and their application in the way that the actual policy of the NNS suggested. In this way, mathematics appears first to be 'learnt' and then to be 'used'.

In terms of the latter sense of process, the *planned* interconnection of ideas was, again, not very evident in their teaching. However, Heather, and to a lesser extent Mary, both seemed adept at noticing connections between ideas as they arose and at pointing these out to the children. For example, in the following episode, Mary is teaching about doubles and is working on doubles to 10+10. She has asked a number of oral questions for the children to call out answers to and is just starting to draw their attention to a pattern in the units digits of the answers.

Ch1: [calling out] I know what double 20 is ... 100.
M: Is it, that's interesting.
Ch2: No it's not. Double 50 is 100.

M: Let's have a think about that.

[Mary draws 2+2=4 on the board and then, asks what 20+20 is. She writes 20+20=40 underneath the 2+2=4. She then repeats this for 3+3=6 and 30+30=60 and so on, pointing to the pattern created when 'there is a zero on the end'. The children quickly see that 50+50 will be 100.]

(Field notes, 14.7.00)

Frances on the other hand, though aware of the need to make connections, was less able to do so, and recognised this as a weakness in her teaching, though she felt that 'it has definitely improved because of the numeracy strategy'. This led to opportunities missed, increasing the feeling that 'the NNS makes me have a very fixed agenda in my teaching', and she recognised that it frequently caused her to 'push ideas onto the children' (field notes, 9.12.99).

In summary, though the teachers clearly viewed the subject as a complex and interrelated one, and did their best to connect abstract ideas and to relate them to contexts, the format of the Strategy, with objectives listed individually and isolated from their application, did seem to structure the way in which the teachers approached their teaching. To some extent, therefore, they demonstrated elements of 'technicism', at least in as far as they:

- released responsibility for planning progression of their teaching to the Framework;
- taught in discrete 'lessons';
- tended to associate each 'lesson' with a discrete idea;
- allowed concept development and application to be separated;
- allowed SATs to alter their teaching approaches making them less focused on higher-order thinking and more focused on recall.

One might assume from this that the minute-by-minute work with the children itself resembled a technicist activity, with the focus on teaching rather than learning and 'teaching being directed at the whole class' (DfEE, 1999c, p. 64). However, as we shall see in the following section, this was far from the case.

3. Specific recommended changes to teaching practices:

Ideology from:	Intended policy	Actual policy
International research:	**Issues of pedagogy:** ▪ a need for greater structure in lessons; ▪ more emphasis on teaching the whole class together directly and more emphasis on direct modelling of mathematical ideas.	▪ the introduction of a standardised three part lesson; ▪ part of the four stated principles for the NNS as a whole.
'Other' research:	**Generic issues:** ▪ a need for teachers to 'interact' more effectively with children; ▪ a belief that a whole-class situation offers an effective environment for challenging most of the children most of the time; ▪ a belief in the complexity of the teaching situation and the need for long term, teacher-centred professional development.	▪ part of the four stated principles for the NNS as a whole; ▪ part of the four stated principles for the NNS as a whole; ▪ not apparent in actual policy – teaching tends to be seen as technical and training 'delivered' in short course format.

Table 9 - Recommended changes to practice as a result of the NNS.

Policy-in-use:

It is evident from the preceding sections that, in many ways, the actual policy of the National Numeracy Strategy had become policy-in-use for the three teachers represented here. The three part lesson structure had been adopted universally as a good idea and the teachers felt free to alter it if they felt it was appropriate, though, as Heather noted (interview, 26.3.01), 'if OfSTED came in I'd probably stick more closely to the suggested approach'. Similarly, an increase in teaching using interaction with the whole class was reported by all three and they seemed happy to take this on, particularly Heather who expressed the view that this was 'in line with what I'd want to do anyway' and who, it was noted above, felt released by the structure of the content to re-examine her practice in this respect. Whilst there was no direct evidence to indicate that the teachers believed that the whole-class situation offers an effective environment for 'challenging most of the children most of the time', it seems a safe assertion that this was the case given their readiness to work this way. In addition, the post-observation interview asked them to indicate the extent to which they felt that working with a whole class endangered the less able in terms of being left behind. None of the teachers considered this to be a problem, though the gap between least able and most able was perceived to have widened despite the fact that the level of work of the least able was higher than in the past. Thus, all three teachers seemed happy to be working in an 'interactive' way with the whole class. In this sense the National Numeracy Strategy had achieved its aim, in these cases at least, in raising the level of use of whole class interactive teaching. However, this is to say nothing about the *quality* of that use, nor about the challenges that faced the teachers in doing it, to which attention is now turned.

The challenges of 'Whole Class Interactive Teaching'

Chapter 3 described the methods adopted for this phase of the research and noted that it was my intention to try to engage the teachers themselves in identifying the key aspects of their practice (in terms of significance to them). Thus, observations began by watching each teacher in turn before discussing the session with them and trying, through this discussion, to identify what they considered to be the key moments in their own teaching. 'Key moment' is taken to mean those moments which, retrospectively, seemed to stand out to the teacher, either because they presented some kind of particular challenge, because they were successful in some way or because they seemed to be turning points in some sense. It was the intention that, by involving the teachers themselves in these discussions, their personal judgements regarding what was significant could be validated to some extent.

In practice, this proved more difficult than its description might suggest, in part because of the inevitable practicalities of finding good quality time for discussion in the teachers' working day, but also because, for the teachers themselves, their everyday focus is naturally on carrying out rather than analysing practice. Thus, in reality, having observed them teaching, the discussion about our primary focus was based on several suggestions from me about what I had observed, from which the discussion and eventual selection of issues developed. Initial observations focused on issues that had been raised in the preceding interviews and, in particular, the whole class teaching that was taking place (mental/oral sessions, introductions and plenaries). For all three teachers the greatest challenge was the same: how to keep all the children in the group focused and involved during whole class interaction. In addition, both Mary and Frances expressed a strong feeling that they wished to develop their ability to teach in this style more generally and that they were still working on this to a great extent. Both teachers were aware of the demands made by this approach in terms of subject understanding and the skills involved in effective interaction, and sought to develop these.

The issue of validity in relation to the choice of foci needs to be examined carefully, with a clear distinction needing to be made between two possible interpretations of what was done. On the one hand, I can make no claims for validity if the suggestion is that the selected areas of focus came from the teachers alone and that they represent *the*

most significant areas of their work in mathematics. On the other hand, if the suggestion is that these were indeed areas of practice that *were significant,* though not necessarily the *most* significant, then their selection is valid, since my influence on their selection was mediated alongside the teachers' own ideas. Furthermore, as chapter 3 made clear, I must make the same claim regarding validity in relation to the events that I choose to report in this chapter. Again, the choice made regarding observations to be reported is based on the premise that they seemed 'significant' in relation to the findings from the interviews with teachers analysed in chapter 4. Indeed, the very fact that they were 'seen' in the first place is based on the same premise. My claim to validity in this respect is, therefore, based on two things: first, the clarity and validity of the claims made in chapter 4, and their coherence in terms of the theoretical perspective outlined in chapter 2; second, the fact that I attempted, at all times, to seek the views of the teachers involved in respect of my observations and ideas in order to check whether or not they recognised them as significant in their own practice.

Each teacher is considered in turn, before the challenges common to them all are identified and discussed.

Heather

Based on observations over six lessons, it is possible to describe various characteristics of Heather's classroom. In general, her lessons were reasonably orderly, but with plenty of interaction between pupils. Children were generally productive, completing work set by Heather and to a standard that my experience would suggest most teachers would consider 'good' in terms of both quantity and quality; a view reflected by the headteacher who held Heather's mathematic teaching in high esteem.

In whole class interactive teaching situations, the responses of the majority of children lay on a spectrum between willing participation and deliberately hiding behind the

sub-group of dominant boys noted at the start of this chapter. These boys typically tended to call out answers when this was not wanted and to switch themselves off from the class proceedings when they perceived that the lesson was not of interest to them. The latter behaviour included talking amongst themselves, 'fiddling' with unwanted articles and acting in deliberately unhelpful ways such as calling out unwanted answers. My perception was that, like many such children, they were very skilled in knowing how to be disruptive in a subtle but challenging manner and in demonstrating an air of disinterest through the use of body language and verbal responses. On a few occasions this disinterest became more explicit and included direct insubordination towards Heather. Whilst these particular children were disruptive in the whole class setting, Heather did not dislike them as individuals. Indeed she was quick to point out how able they were and she enjoyed the challenge that they presented in mathematical terms when this could be harnessed in a profitable way. The children themselves would often bring interesting ideas to Heather to discuss both during and after the lesson, and clearly demonstrated that they enjoyed her sessions as much, if not more than, others. Heather made explicit that she admired these children in terms of their ability to work mathematically, even if their behaviour was problematic. However, she was faced with the twin challenge of handling a particularly dominant and disruptive group whilst ensuring that other, less able and less willing, children did not simply 'hide' in the background.

Despite this, Heather seemed skilled in keeping her whole class teaching moving. Her mental/oral 'starters', far from being simply a period of 'practice' unconnected to the rest of the session, were usually built in to the main focus for the lesson and were used as a way both to rehearse skills that would be needed later on and as the means of exploring the children's understanding of the concepts in question. Thus, typically, she would begin with a series of closed questions which probed understanding in a number of areas and

would then seek clarification as children became less sure of their responses. This is exemplified by her lesson of 6.6.00:

Session begins by counting as a class in quarters both up and down.
This is followed by placing fractions written on cards on a number line. $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$ are all correctly placed by children. Heather then asks about $\frac{1}{7}$. A child is asked to place this in relation to the other fractions and does so correctly placing it to the left of them all.

H How did you know where?
Ch1 The bigger the number on the bottom the smaller the fraction
H Ok, so what about $\frac{3}{8}$ then?
Ch2 Um. Not sure

This leads to asking where $\frac{3}{8}$ lies on the number line. Ch2 places it between $\frac{1}{4}$ and $\frac{1}{3}$.

H Are you sure it goes between $\frac{1}{4}$ and $\frac{1}{3}$?
Ch2 No, not sure.
Ch3 It doesn't. I don't think so.
Ch2 Oh no it doesn't!

Ch2 gives an extended reason why not, based on converting all three fractions into 24ths. Other children don't understand this and say so in a joking manner. Ch2 re-explains his (correct) reasoning and this is taken up by Heather who then explains it again on the board. In turn, this leads to a long class discussion about finding equivalent fractions in order to compare sizes.

(Field notes, 6.6.00)

Though only a short sample of Heather's work, it exemplifies her approach in that it illustrates several features which repeatedly stood out. First, having asked about $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$, she was able to recognise the more difficult fraction $\frac{1}{7}$ as a logical next step. Second, whilst the session was, in part, aimed at rehearsing knowledge, she placed emphasis on the child's explicit understanding of *why* the fraction was to the left of the others already placed and was not content simply that it was. Thus, in addition to this knowledge rehearsal, Heather was on the look out for opportunities to develop new thinking. Third, she recognised the limitation of the child's answer ('the bigger the number on the bottom the smaller the fraction'), namely that whilst being true, it is not

sufficient for dictating the size of the fraction since it does not take into account the value of the numerator. Fourth, she was able to find a subsequent question which matched exactly the idea that needed further exploration and was able to use it to push forward the child's thinking.

In general, Heather showed a keen willingness and ability to hear what children were saying and to make use of this in what was said next. Field records from the same day note that:

> Heather seems very skilled at actually letting the children have their say in explanations and letting their words stand. She also manages to be sensitive to the explanation when she does re-explain [children's own explanations], often saying things like "I think what you meant was ..." or "was that right?". In addition she is happy for children to interrupt both her and other children with questions and points / disagreements.. Indeed she positively encourages this by saying "X doesn't agree with you...". In this sense there is a strong feeling that the discussions about number are real ones for the children in the sense that what they say is going to be considered of value.
>
> (Field notes, 6.6.00)

Overall, observations over six lessons, and discussions after each one, suggested that Heather's use of whole class interactive teaching was characterised by the following features, which reflect closely the characteristics of 'teaching as a complex sociocultural activity' outlined in chapter 2:

- She was able to identify children's apparent conceptions through effective questions which probed their understanding and could thus readily identify potential misconceptions.
- She had the mathematical knowledge, and pedagogical knowledge, herself to be able to identify progressively more difficult aspects of the concept under consideration and to probe this with appropriate questions.
- In doing so, she aimed to help children to develop conceptual links *between* mathematical ideas.
- She was keen to hear the children talking about their own ideas, providing space for this and actively encouraging them to reason aloud and to challenge each other.

- Though starting the lesson with a clear objective in mind, she tended to view this as a 'pivot' *around* which the ideas in the lesson developed and she was happy for the lesson to change its focus as a result.
- She was sensitive in the way in which she 'corrected' children's ideas, encouraging them to rethink rather than requiring them to substitute their thinking with her own.

Frances

In comparison to Heather's class, the children in Frances' groups (two different low ability sets during the period of observation) were less focused and more often disruptive. Again, this disruption was of essentially two kinds, 'switching off' attention and 'disrupting' proceedings with unwanted or distracting behaviours. This behaviour was just as likely to be from girls as from boys and, unlike for Heather where the disruptive group were mainly of high ability, was just as likely from all ability levels. Whilst the children were disruptive to some extent in group work during the main part of the lesson, their behaviour was at its most difficult during the whole class interaction between them and Frances. She herself had acknowledged this difficulty at the start of my work with her; my notes from our discussion after the first visit (17.11.99) describe the challenges she faced.

> We noticed that their attention and their engagement was very different at different times of the session and suggested that this may have been due to several things: the cramped nature of the room in which you were working; the nature of the tasks at any one time (they seemed more involved in the main group tasks than the intro and plenary); the way in which questions went backwards and forwards between you and the group; the nature of individuals in the group.
>
> Afterwards we noted that you also reacted differently in the different parts. You noted that this issue may be related to the one above about seeing opportunities for mathematical connections before they occur.

Thus, in the lesson referred to here, Frances had been working on three dimensional shapes with the children and tried to draw this together in the plenary by completing a table showing the number of faces, edges and vertices of each shape. The focus of the session was entirely on completion of the table, and field notes record that,

> Faces, edges and vertices were recalled, but F not drawing out *why*, say, a cube has 8 vertices given that it has 6 faces.
> Idea of 'inclusion' [i.e. that the set of cuboids *includes* the cube] was not picked up on despite the children finding the ideas hard because of this.
> [Frances states that] "the cone has one vertex", even though she previously just defined a vertex as the meeting of edges. She justified this [paradox] by calling it a 'special case'.

Again, the above is representational of Frances' teaching in general. Points to note include:

- Her strong focus on knowledge (the names and properties of shapes) rather than reasoning (for example, that a shape made up of six square faces must have 12 edges).
- Her related focus on the product of the session (the table in this case), rather than the process of arriving at it.
- Her own lack of subject knowledge (relating to the idea of inclusion and to her inaccurate claim that a cone has one vertex).

Thus, in contrast to Heather, Frances' use of whole class interactive teaching was characterised by the following features:

- There was a strong focus on knowledge, and less on processes such as reasoning.
- Her subject knowledge was weaker, meaning that misconceptions were not always identified.
- Similarly, where they were, ideas to remediate them were not always accessible.
- Though keen to hear children contribute, the lack of remediation strategies limited her ability to help them in linking mathematical ideas together.
- She started with a clear objective and tended to make it an *endpoint* for her lesson; a 'place to arrive at'.
- As a result, though eager to hear children's ideas, she was unwilling to be too distracted from her planned course towards this objective.

In relation to the last of these points, Frances' feelings form an interesting comparison with those of Heather.

> And then problems arise if, you know, the child wants to know about something else, what do you do, do you go with that, do you say 'sorry that's not on my agenda today...'
>
> (Frances, interview, 22.3.01)
>
> *Proposition put to Heather post-observations:*
> 'You are conscious of the need to follow the objectives planned for the lesson, but if other ideas crop up you are happy to follow them even if this means deviating from the plan.'
> *Response:*
> States (laughingly) 'I'm a bit prone to doing that' and refers to 'the really interesting ideas that the children have' and to 'the momentum that we build up'.
>
> (Heather, interview, 26.3.01)

It would seem that what appears to Heather simply as a dilemma – a conflict that is 'situational in the sense that [it is] largely resolvable by professional action' (Woods et al, 1997, p. 19) – appears to Frances as a 'tension' – 'the product of trying to accommodate two or more opposing courses of action where choice is limited or circumscribed' (ibid. p. 21). For her the limitation here is two-fold.

> I think it [the tension above] does cause difficulties. Firstly, there's the external pressure, that we are supposed to cover so many objectives and if you don't how are they going, at the end of Year 5, oh we haven't done this and we haven't done this. So from that point of view I feel that the Strategy, the school is under pressure to get children to a certain level, so you don't want to be knocked off your path because otherwise you can't tick it off your list, whether they've got it or not. The other reason I think is issues of classroom management. Sometimes if you go off down one particular path, then if the other children, if they're not interested then it can cause problems in terms of keeping them all focused. Whereas I think it's a shame because you need to be a bit spontaneous and give them a chance to discover that they are wrong and then you can get [them] back on board and hopefully work towards your objective. And in terms of putting the onus back on the children, I think I do do that .... I am a bit more flexible in that respect, but in terms of the Strategy and these objectives that we are supposed to cover

> and get children to at different stages, yes I do feel that sometimes 'oh no, no, we can't go off down that way'
>
> (Frances, interview, 22.3.01)

Mary

If Heather and Frances are seen as two ends of a spectrum in terms of the tensions experienced in interacting with the whole class, then Mary would lie somewhere between the two, though perhaps nearer to Heather than to Frances. Her lessons were lively and she offered a good deal of opportunity for her Year 2 children to talk, both to her and to each other. They were, however, well managed, with children seldom getting to the point where Mary had to use disciplining strategies. However, once again, there was a proportion of the children about whom Mary was concerned in terms of her ability to keep them involved in the interaction. These included both high and low achievers, with the latter giving her the greatest cause for concern. Indeed, both Mary and the teacher in the adjoining class had spoken to me about their fear that these less able children had learnt to 'act' during these interactions, in the sense that they had become very clever at knowing how to give the appearance of understanding when, in fact, they did not. This is a phenomenon identified independently by Denvir and Askew (2001) and illustrates the concern that Mary felt about her own teaching.

The following extract is intended to illustrate elements of Mary's whole class interactive teaching.

> Mary is working on adding three single digit numbers most efficiently by counting on from the biggest number.
>
> M: If I've got three numbers like this [9, 2, 1], which number do I count on from?
> Ch1: One.

M: Do I? Oh. Find a partner. Let's try that. With your partner, talk for a couple of minutes about this number sentence [1+2+9]. See if you can find the total. Start at one and see if you can find the total.
[Children discuss this for a minute or so.]
M: [Ch2], what did you get?
Ch2: We put nine in our heads and counted on one and counted on two.
M: Oh, but [Ch1] said to start with the one.

The discussion then continued, identifying the difference in efficiency of the two approaches.

(Field notes, 4.7.00)

Points to note, which are representative of her whole class interactive teaching more generally, are:

- Mary's sound understanding of the (relatively simple) subject knowledge.
- Her willingness to let the children explore the ideas themselves.
- Her desire to let them come to an understanding of it themselves.
- Her willingness to let the discussion change direction to some extent – though she would always bring it back to her objective relatively quickly.

In terms of the last of these, it was noted earlier that Mary had placed her trust in the objectives of the NNS ('otherwise why would they be there') and, though willing to deviate to some extent from these, wanted always to arrive at an endpoint that was pre-planned.

Common challenges in interactive teaching

It is apparent from the preceding paragraphs that Heather, Mary and Frances were all doing as the National Numeracy Strategy training had instructed them, and were using a high degree of whole class interactive teaching. Furthermore, they were all engaged in practices which the training materials (DfEE, 1999d, pp. 22-3) asserted would 'ensure' that they taught 'effectively', namely that they had:

- 'high expectations of what the children can do';
- 'clear objectives, outlining what is to be taught and learned';
- careful plans;
- a 'suitably organised class for each lesson';

and that they were, amongst other things:

- 'demonstrating or modelling' mathematics;
- 'giving instructions or directing children's work';
- 'explaining or illustrating';
- 'questioning, using a good range of questions';
- 'developing, consolidating, rehearsing or reinforcing some work';
- 'evaluating and correcting children's responses'.

It should also be apparent from the data presented so far, that all three teachers felt that the focus on these ideas – whether new or not – and the introduction of the National Numeracy Strategy more generally, had been a good thing, both in terms of their feelings towards their teaching and the achievement of their pupils. It is perhaps worth reiterating that this was the case, since, in any critical analysis of practice it is all too easy to focus on the issues that present a challenge and to fail to highlight the positive aspects of the situation. Nevertheless, the value of the Strategy in the eyes of the teachers did not remove particular challenges. In addition, whilst all the teachers were ostensibly 'doing what it said', this was not to say that their practice was the same, nor equally effective. As is apparent from the preceding sections, superficial adherence to the suggested approaches did not necessarily effect the desired results, since this depended heavily on subtle, but important, aspects of the *way* things were done. Put plainly, all explanations, demonstrations, questions, plans and so on did not seem to be the same.

One explanation for this disparity in practice might be based on Alexander's observation, (credited to Edmund Leach) that models which aim to *describe* practices need to be kept as simple as possible, but that,

> With *prescriptive* models, however – those which are intended to be translated into a course of action – he [Leach] suggested that the most effective models are also likely to be the most complicated, because they have to engage in a convincing way with real-life contingencies and with what cannot be predicted as well as with what can.
>
> (Alexander, 2000, p. 323, italics in original)

Complexity is not a claim that can be made of the training materials, nor the Framework of the National Numeracy Strategy. The whole of the training was designed to be 'delivered' in four days, often by staff who were not experts, and this is reflected in the prescriptive, and simplistic, style of the materials. Thus, in the list of attributes above for the 'effective teacher', what is starkly missing is a detailed description of what exactly is *meant* by a 'suitably organised class for each lesson', not to mention *when* it is appropriate to 'model', 'demonstrate', 'explain' or 'question' etc., nor what constitutes a 'good question' in the last case. Thus, the criticism that might justifiably be levelled at the Strategy is that it describes in outline *what* to do, but does not detail *how* or *when* to do it. It is interesting to note that Earl et al (2003), in their independent study of the implementation of both the literacy and numeracy strategies, reported that 'teachers will need to be highly skilled and more knowledgeable about teaching literacy and maths than is currently the case' but that 'many teachers have not yet had the sustained learning experiences necessary to develop a thorough understanding of the Strategies or of the best ways to teach literacy and mathematics to their pupils' (p. 6).

In terms of the three teachers observed in this study, all three had reported that, in the whole class situation particularly, the children did not remain engaged in their learning to the degree the teacher would have wished – where the term *engaged* is used to mean

legitimately and productively involved in the ongoing activity of the classroom. Observations therefore began with a closer inspection of what was happening in these whole class situations, and data is presented here in order to illustrate the findings. One characteristic of this lack of engagement was that the least attentive children were as often the most able as the least able. Furthermore, any disruption they caused tended to be of two sorts:

- *Switching off* (that is, disengaging themselves from any attention to the task), leading to inappropriate behaviour which distracted the class.
- *Interrupting* the class with comments that broke up the flow of discussion.

During teaching exchanges it was noted that children were more or less *attentive* at different stages. Before recounting examples of such exchanges, this observation needs some explanation in terms of how attentiveness was 'measured'. Clearly this presents a problem since attention is difficult to quantify. Nevertheless, previous studies (for example Myhill, 2002; Boaler, 1997) have attempted to quantify attention by measuring the time spent by children 'on task', often using time samples across the duration of a lesson. However, in practice, watching a group of children, the mutually exclusive implication of the terms 'on' and 'off' task did not seem appropriate. Instead, children seemed not just to drift 'onto' and 'off' any one task, but appeared to be involved, with different levels of focus, in a range of tasks simultaneously; including the very business of monitoring whether or not they needed to be paying particular attention to the teacher at any one time.

> When watching Mark [the teacher] it has become apparent that children who are displaying these kinds of behaviours [looking away, playing with other children's hair etc.] are not necessarily 'off task' because they seem to be able to join in again when it is necessary and so must be at least partially tuned in to what is going on around them. On the other hand they are

> certainly not fully involved and their attention seems to be of a very particular type. To me it looked as though they were listening for particular tones and intonation of the teacher's voice, ones that signalled that they might be 'in danger' of being asked something. So, when a question was focused at another child in the class they turned back to their own affairs, but had a 'radar' operating almost subconsciously which alerted them to the sound of the teacher looking to call on someone else. This would prompt them to begin to display their protective behaviour again, pretending to look alert, puzzled expression on face etc. What is apparent is that, far from being 'off task', these children are simply engaged in a very particular task of trying to avoid teacher questions and simultaneously get something else done. ... [It is appropriate to use] the phrase 'multiple tasks' meaning that for the children there are multiple things that they are trying to achieve in the lesson, of which only one is 'the work'. The others are surreptitious, such as trying to play with a calculator under the desk or whisper without being seen, or pragmatic in relation to the protocols of the lesson, such as trying to/not to be asked a question.
>
> (Field notes, 1.7.02)

The sense here was of children managing their role in a discourse in strategic ways, aimed not at learning anything new, but at 'survival'. Such observations are not new, for example Woods (1983) identified pupils' strategies such as this in secondary schooling. However, they point to the need to explore the notion of whole class interactive teaching from the child's point of view, as well as to the temptation to 'explain' behaviours from the perspective of the adult only, and, they suggest the limitations of trying to quantify attention.

My measure of attention was therefore based solely on my own subjective sense, in the moment. Clearly, certain behaviours such as talking amongst themselves, visually focusing on things other than the interaction in hand and 'vacant' looks were highly suggestive of inattentiveness and were coupled to an inability to re-engage with the discussion when prompted to do so by the teacher. Similarly, attentiveness was signalled by the directness of eye contact between individuals and their ability and willingness to engage in verbal and non-verbal interaction. However, none of these were quantified, and instead I relied on my ability to sense these situations as an experienced observer of

teaching situations, along with an attempt to validate this through reconstruction after the event with the teacher.

Having made this observation, several teaching exchanges are now reported.

Exchange 1: (Frances, field notes, 9.12.99)

> [Frances is asking children to calculate the complements of various two digit numbers to 100 (i.e. complement of 65 is 35 etc.). Children are using digit cards to make the answer and holding these up to show Frances.]
>
> F: 85?
> *Children hold up cards at varying speeds. Frances waits and those who are waiting with her begin to call out the answer.*
> F: {Ch1} how did you get 15?
> *{Ch1} begins to explain his answer. Other children are very quiet and apparently listening carefully to him. His explanation stops before it is complete and Frances takes over [offering an interpretation of how he might have reached 15]. The children are less attentive once this happens.*
> F: {Ch2}, tell us how you did it.
> *Again, children less attentive to the explanation.*
> F: Ok. What about 42?
> *Children begin to work out the answer and hold up their cards. Frances' focus is on supporting one child. Others get inattentive whilst they wait.*
> F: {Ch3}, tell us how you did it.
> *Explanation from {Ch3} is long winded, but accurate. Other children listen attentively. Frances interrupts explanation and gives her own, different explanation. Children immediately inattentive again.*

Exchange 2: (Mary, field notes, 1.3.00)

> [Mary is working on 'doubles' with her Y1 children. She begins with oral questions for the children to respond to with hands up.]
>
> M: If I want to find out what three and three makes…?
> Ch1: Four.
> M: Do you think?
> Ch2: Six!
> Ch3: Six!
> M: {Ch3} can you tell us how you worked it out?
> *Children all listen attentively to {Ch3}'s answer.*
> M: What do we call it when we add two numbers the same?
> Chorus: Double.
> M: Zero and zero? This will be a tricky one.
> Ch4: Zero.
> Ch5: One and two zeros makes a hundred.
> M: Yes you're right, it does.

Two and two?
Lots of answers offered and received by Mary. Children all remaining focused and attentive.
Mary then asks the children to find a partner and to work together to 'find the number which when doubled makes ...'
Children chat enthusiastically about each question, offering answers each time until Mary stops.
M: Right. I'm going to ask some children how they did it.
Children are chosen a pair at a time to explain their answers. The others are quiet during these explanations, but there is a strong sense they are not really listening to them [not looking at speaker, not choosing to comment etc.].

Exchange 3: (Heather, field notes, 1.3.00)

[Heather is asking children to multiply decimal fractions by 100 and to respond by holding up answer cards.]

H: Who'd like to explain this one [3.5 x 100]?
Child explains [though I didn't hear it]. Other children appear attentive.
H: One point two multiplied by one hundred?
Children all still focused on finding the right answer and displaying it.
H: Twenty point two times one hundred? [Waits for responses.] Who would like to explain this one?
Child explains and others are attentive. Heather then reinterprets the answer and the children are less attentive during this.

Heather then begins to ask children to come to the board to write down the value of the digits in different numbers.
H: Can you come and write it [the value of the digit] as a decimal or a fraction?
As different children come to the board to do this, a group of children switch off and pay little attention.

In focusing on the children's behaviour during these three exchanges, several points stand out. First, the attention of the children varies greatly during the exchanges. This variation does not seem to be related solely to the length of time that the children are being asked to concentrate, since children would re-focus themselves after having been previously unfocused. Rather, the attention given by the children seems to be dependent on the task with which they are engaged. At the start of exchange 1, a child is asked to explain his answer to a calculation and the other children listen carefully to this. However, attention is lost at the point where Frances takes over the explanation. This same pattern is repeated at the end of the exchange, even though the explanation being given by child 3 is long-winded and, to me at least, difficult to follow. Despite this, the other children are listening attentively to it up until the point at which Frances interrupts and takes up (her version of) the explanation. Similarly, during exchange 3, children are listening carefully to the explanation of one of their peers but switch off as Heather takes over and reinterprets the response.

Whilst only illustrated here briefly, this pattern of behaviour, where children appeared to listen attentively to their peers' explanations, but not to the teachers' reinterpretations or repeated versions of the same explanation, happened again and again. One interpretation of this might be simply that children are more willing to listen to each other and less willing to listen to the teacher. However, the data suggest that the situation may be more subtle than this. Exchange 2, for example, has children engaged in explaining their answer and exchange 3 has them writing answers on the board, the attention of their peers in both cases being poor. An alternative interpretation can be made in terms of the way in which the fellow students are engaged in the tasks in which they have a *legitimate and worthwhile part to play*. We have seen that the National Numeracy Strategy expects teachers to engage a whole class in 'discussion' about mathematical ideas, and to ensure that teaching is 'interactive'. As a reminder, the Framework clarifies this by stating that 'interaction'

> is a two-way process in which pupils are expected to play an active part by answering questions, contributing points to discussions, and explaining and demonstrating their methods to the class.
>
> (DfEE, 1999, p. 1:11)

However, these actions on the part of the children must have a purpose to them if they are to be meaningful, and this purpose must be shared by all involved. From the interactionist perspective (Jaworski, 1994; Voigt, 1994; Woods, 1996), the meaning

attached to the symbols at play in the situation must be common to all the participants; 'taken-as-shared'. Looked at in this way, the interaction between pupils and teachers above takes on a different perspective. In each case the teacher asks children for explanations of their thinking. This request might be seen by the children as a symbol either for them to *explain their meanings* – in the belief that others might accept it, challenge it, learn from it etc. – or for them to *confirm to the teacher* that they, as an individual, 'understand' the concept under discussion. What then becomes apparent in considering the exchanges above in these terms, is that the teachers' requests for explanations take on both these symbolic meanings variously. Furthermore, in each case, the teacher begins with a request for an explanation in a manner which implies the former meaning – the implication is that the child is to explain their understanding in order that others may share in it. However, she then moves to the latter meaning by one of two strategies: by asking for another explanation without having allowed an opportunity for criticism of the first one, thereby implying that the explanations are simply to 'be heard' (end of exchanges 2 and 3); or, by commandeering the explanation herself, thereby taking ownership of it and endowing it with the associated weight of authority which the teacher's explanation carries (exchange 1).

What is more, the reaction of the children tends to be attentive when the former meaning is implied and less attentive when the latter meaning is implied. Thus attention is high when a child is asked for an explanation, but dips when either the teacher takes this over or when other children are asked to offer explanations to the same example with no comparison or criticism of each one. Seen in terms of 'working practices' (Lave and Wenger, 1991; Wenger, 1998; Boaler, 2002) one can see this as the child being positioned in two, inherently different, sets of practices: on the one hand the practice of joint meaning making; on the other the practice of assessment. Not only are these practices

apparently in conflict with each other but it appears that it is the former practice that is seen as the more legitimate by the children.

To illustrate this further, my observation of Frances on 14.03.00 records her setting a range of numerical problems for the children to solve mentally in preparation for the oral test of calculation skills in the approaching SATs test. The exchange progressed as follows.

> F: [asking each question and then pausing for a few seconds for the children to record their answers] Multiply 9 by 6 ..... 130 subtract 60 .... How many 20 pences in £2.40 .... [etc.]
>
> *The children all work silently and attentively, calculating the answers mentally and then recording their responses.*
>
> F: Ok. Before we do the answers, talk to the person next to you about it.
>
> *Children willing to do this. Seem able to both explain to, and understand, each other. Attentive and busy, discussing their answers and their reasoning.*
>
> F: Right. Now let's look at some of these together.
>
> *Explanations are given by different children to the whole class. These seem much harder for the other children [and me] to follow, being unclear in terms of both reasoning and verbal communication. Children's attention soon wanes and Frances is struggling to get the children to listen to each other.*

In analysing this situation after the event, my notes record the following observations.

> The children are being asked to explain their thinking to each other, and in pairs this explanation takes place in a 'genuine' way. The explainer is forced to give a real explanation since if the listener does not understand she will say so. Similarly, the listener is free to interrupt and to ask questions, to add their own ideas and to challenge those of the explainer. When I translate this to the whole class interaction things are very different. Here, children's explanations are appropriated by Frances (and hence the explanation is not being received in the way that an explanation should, namely as an idea presented for discussion); where children struggle to explain clearly Frances 'props them up' by interrupting and finishing the explanation for them; there is no officially approved opportunity for others to challenge the explanation and there is no opportunity for other children to ask questions or for clarification. Interestingly though, what Frances recognises as disruption – children not listening, calling out, etc. – is in fact all these things actually happening. Thus, the children are drifting off because they no longer need the explanation (and would make this clear to

each other if in a pair), or because they are talking instead to their neighbour about something that was said and comparing it to their own ideas; their calling out is often to disagree or to ask for further clarification or to add their own ideas to the 'discussion'; if they are lost in the discussion (as they often are because children's explanations are often not very articulate) they have no opportunity to ask for further clarification. In other words [to some extent] they are participating in the discussion as if it was a genuine one when in fact it clearly is not, and this is being perceived by the teacher as disruption.

Two features stand out. First, the difference in the whole class and paired discussions which, despite both being made out by Frances to be opportunities for discussion, clearly are not equal in this respect. Second is the 'propping up' of the children in the giving of explanations. This is nicely exemplified by Frances in a subsequent observation in which she is trying to get children to identify the properties of various shapes.

F: Can anyone hold up an irregular pentagon?
[Ch1] does so.
F: Why is it irregular?
Ch1: Because it's got different sides.
F: Yes, all of its sides are different lengths.
This is a regular pentagon. Why is it regular?
Ch2: Same length
F: Yes. All its sides are the same length and all of its angles are the same.
(Field notes, 8.6.00)

In this exchange, the actual responses of the children are insufficient ('different sides' rather than 'different length sides'; 'same length' as opposed to 'all the sides are the same length') and they present opportunities for the teacher to discuss at greater length what is actually required for a necessary and sufficient response. This opportunity is missed, perhaps because of Frances' own lack of appreciation of these ideas. More straightforwardly, it may be a sign too of her desire for the 'right' answer to be 'heard' by all in the belief that this will ensure that the children can reproduce it in a test of their knowledge – an idea that is considered further in the next chapter. Such a desire was most

noticeable in, but not exclusive to, Frances' work. In the following exchange, for example, Mary demonstrates a similar desire to control the focus of the children's attention, but this time the control is exerted not by propping up insufficient explanations but by denying the children the opportunity to talk about their focus of interest.

[Two children have used building blocks to build a 'building' with a tall tower attached to it.]
M: Tell us what you've made then {Ch1}.
Ch1: A square based pyramid.
M: Is it a square based one?
Ch1: Triangle.
M: How many faces on it?
[Someone answers but the majority seem not to be listening.]
M: How many corners?
[Ditto.]
M: This is two 3-dimensional shapes joined together. Can anyone tell us which shapes they are?
Ch2: Rectangle.
M: Yes, the face is a rectangle. What's the 3-d shape?
[Throughout this exchange {Ch1} has been trying to gain Mary's attention again.]
Ch3: Cuboid
Ch1: [In frustration] This is the building and this is the lift!

(Field notes, 20.6.00)

A third example of how 'hearing the right answer' seemed important to the teachers is seen here in a slightly different way, with Frances seeking alternatives to an incorrect idea, but not to one that is correct.

F: Hold up a regular pentagon. How many lines of symmetry does it have?
Ch1: One.
F: One? Why do you think that?
Ch1: Because the only way you can fold it is straight down the middle [i.e. vertically].
F: Ok. What do other people think?
Ch2: Five.
F: Five, ok. Now hold up regular *hexagons*. How many lines of symmetry do they have.....

(Field notes, 8.6.00)

The point to note here is that, in responding to the first child by asking for alternative ideas, Frances implies that she is interested in a discussion about what people think and how they have arrived at that idea. In practice though, the request for alternatives appears only to serve to provide her with the *required* answer, and any opportunity for discussion about what was wrong with the first response is not provided. Repeated again and again it became a pattern in Frances' work and resulted in children showing little interest in what she was saying. This stood in marked contrast to Heather who would ask for alternative answers even when the first one was correct, and by doing so managed to engage her children in meaningful discussion on a more regular basis.

H: What is 200 grams as a fraction of 1 kilogram?
Ch1: One fifth.
H: Everyone agree?
Ok, so what is 200 grams as a fraction of 3 kilograms?
Ch2: A fifteenth.
Heather makes no comment here either verbally or physically and allows time for other responses.
Ch3: Three fifths.
General murmur amongst class about each response.
H: A fifteenth? Three fifths? Which one is right, and why?
Children begin to consider this and Heather sits back and allows them to think about it for several minutes. One child then gives an accurate explanation as to which is correct and there is general agreement from the rest of the class.
H: So, what fraction is 600 metres of one kilometre? Show me with your cards.
All the children I can see display three fifths with digit cards.
H: Very good. You all got three fifths.

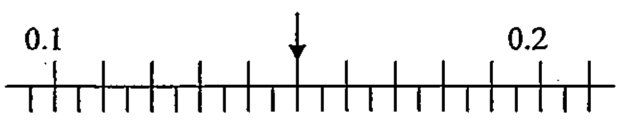
(Heather, observation notes, 20.6.00)

Clearly, both Heather herself, and the children, have an understanding that her request for different answers is part of a genuine (in the sense of 'shared') dialogue *about the meaning* of the mathematics that is being examined. Coupled with this, Heather again displays the subject understanding to identify an appropriate follow-up question which tests new-found understanding in a slightly different context.

Despite Heather's apparent skill, these interactions were by no means straightforward for her either. The following exchange illustrates the difficulties involved in asking for, and valuing, explanations from the children, whilst still being able to accurately illustrate the mathematical ideas involved (italics indicate commentary on my own interpretation of what is happening).

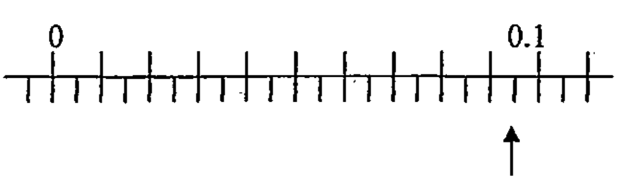
Heather is using number line segments with the whole class, marking numbers at either end and then asking children to identify intermediate points on the lines. Each time, she seeks an answer from several children before requiring an explanation from one of the respondents. Each exchange is recorded below, the arrow showing the number that Heather wanted the children to identify.

Exchange 1:



H: So what would this one be?
[Various answers given by children including 0.15.]
H: I think we need this one explaining. Liam, you got it first.
L: 0.15. You go up in nought point oh fives....
(Note that this is not true. The gap between the larger marks are 0.01)
H: [interrupting the explanation] Good, so it's nought point one one, *(Heather over-rides the child's error – does she notice it I wonder?)* nought point one two, nought point one three, nought point one four, nought point one five.

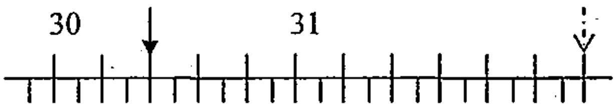
Exchange 2:



H: What about this one? What would this little one be here?
[Various answers given by the children again]
H: Who would like to explain this one? Andrew?
A: The big one is point eight, point nine, point nine five.
(Again, not true. The 'big one' is 0.08, not 0.8 – and this assumes that other children know which 'big one is being referred to.)

H: Good. So, each big gap is point nought one, *(Again, corrects without seeming to notice error)* so we count up nought point nought one, nought point nought two, ... up to nought point nought eight, nought point nought nine, then it's nought point nine five.

Exchange 3:



H: Who can explain this one?
Ch.1: 30.4. Because every bigger one between 30 and 31 is thirty point two....
(Again, not accurate, though reasonably clear in terms of meaning.)
H: [Taking over] ... Because, look, we are going up in point twos, so it's thirty point two, thirty point *four*.
So what's this one then, right the way up there? [pointing to position marked by dotted arrow].
Ch.2: It's just going up in point twos until you get to thirty two then it's thirty two point two.
H: Where's thirty two? [Child guides Heather's hand towards the appropriate point]. Good, so it's thirty two point two.

(Field notes, 13.3.00)

Crucially, throughout the whole exchange, whilst the children were keen to give their answers to Heather's questions, they appeared to be paying little attention to her explanations which followed. Although Heather worked hard to elicit and make use of the children's own ideas, it is apparent that the responses were inadequate as working explanations because of their inaccuracy. Importantly, Heather's reinterpretation of the children's contributions comes about as a direct result of her (implicit) acceptance of children's use of an informal register, when, for the purposes implied by the situation, a more formal register is required.

A summary of tensions in whole class interactive teaching

The paragraphs above have noted the differences in approach between the teachers despite them all working within the guidelines of the National Numeracy Strategy.

Nevertheless, some tensions were common to *all* the teachers, particularly in relation to teaching in a whole class interactive style. There now follows a summary of these tensions (though it should be noted that whilst I refer to them here as 'tensions', they may in practice have been 'dilemmas' in the sense given to these terms by Woods et al (1997, p. 19)). These are considered in terms of interactions between teacher and children in which the interaction is initiated 'through different constructions of reality and conflicting definitions of the situation, leading to a breakdown in order' (Woods, 1996, p.33).

However, as Voigt (1994, p. 286) points out, in the classroom resulting interaction may be far from smooth.

> In contrast to the observer's point of view, the participants may not have to experience the discourse processes as limiting their creativity. If in a usual classroom a participant presented many of these alternatives [different ways of thinking about something], (s)he might provoke irritations, might be accused of straying from the theme, or might be valued as being unfamiliar with school mathematics. .... Presumably, the students try to figure out the teacher's expectations, and the teacher can be confident that the students develop a feeling for the context taken for granted by her.

In the case of the National Numeracy Strategy this is of particular interest, since the very idea of Voigt's student 'creativity' is at the heart of the whole class interaction which the Strategy promotes so vigorously. Thus, as we have seen, students are expected to engage with the teacher in 'direct teaching' which is 'oral, interactive and lively' and which is 'a two-way process in which pupils are expected to play an active part by answering questions, contributing points to discussions and explaining and demonstrating their methods to the class' (DfEE, 1999a, p. 1:11). At the same time, teachers are expected to 'make clear to the class what they will learn' (for example, DfEE, 1999c, p. 45) as part of the *intended* curriculum. However, Voigt (1994, p. 283) points out that pupil 'creativity' will inevitably mean that the mathematical themes under discussion are not

bodies of knowledge fixed *a priori* in terms of how they will appear to the child, but become a 'realised curriculum', negotiated between teacher and children.

Thus, in practice, for the teachers in this study (and presumably for all teachers working with the National Numeracy Strategy), there are two related tensions. First, there is the difference between the 'intended' and 'realised' curricula. Second, there is the tension between student creativity (a 'proper' part of whole class interactive teaching, but also, potentially, a form of distraction from the intended objective) and teacher direction (potentially limiting creativity, but more likely to allow the teacher to reach the intended curricular objective). Furthermore, it can be seen that the latter tension is, to a large extent, driven by the former, since the need to control the children's interaction arises as a result of the desire to minimise the distance between the realised and intended curricula. Indeed, this desire may well be intense when the aim of the teaching is to ensure success in a test based on an externally provided 'intended' curriculum, and it is suggested therefore that the tension is likely to be *systemic* in relation to the National Numeracy Strategy.

Such a suggestion is supported by the common occurrence of the tension in all three teachers as well as by other studies, in particular the three year independent evaluation of the Strategy commissioned by the DfES which concluded that,

> Targets and high stakes testing may have unintended consequences, such as narrowing the curriculum. From the data available to us, we conclude that the high political profile of the 2002 national targets [for test results] probably skewed efforts in the direction of activities – some of them misinformed and counter-productive – that were intended to lead to increases in the one highly publicised score.
>
> (Earl et al, 2003, p. 7)

It has been seen above how these tensions, whilst common to them all, may be manifested for the participating teachers in many different ways. However, throughout the observations several key moments were apparent, each of which can be interpreted as

representing an aspect of 'good direct teaching' from the National Numeracy Strategy (DfEE, 1999a, p. 1:11 – 12), but which seemingly led instead to tensions for teachers in making pedagogical decisions. In the figures below, each of these moments is analysed. The action recommended for the teacher by the National Numeracy Strategy (in italics at the head of each table) is considered in terms of two possible interpretations for action on the part of the teacher. Each of these is then compared with possible interpretations that children might make as seen during the classroom observations. In turn, tensions or dilemmas for the teacher are identified, resulting from the potential conflict between these interpretations. Each of these three stages of analysis appears in the subsequent 'row' moving down the diagram.

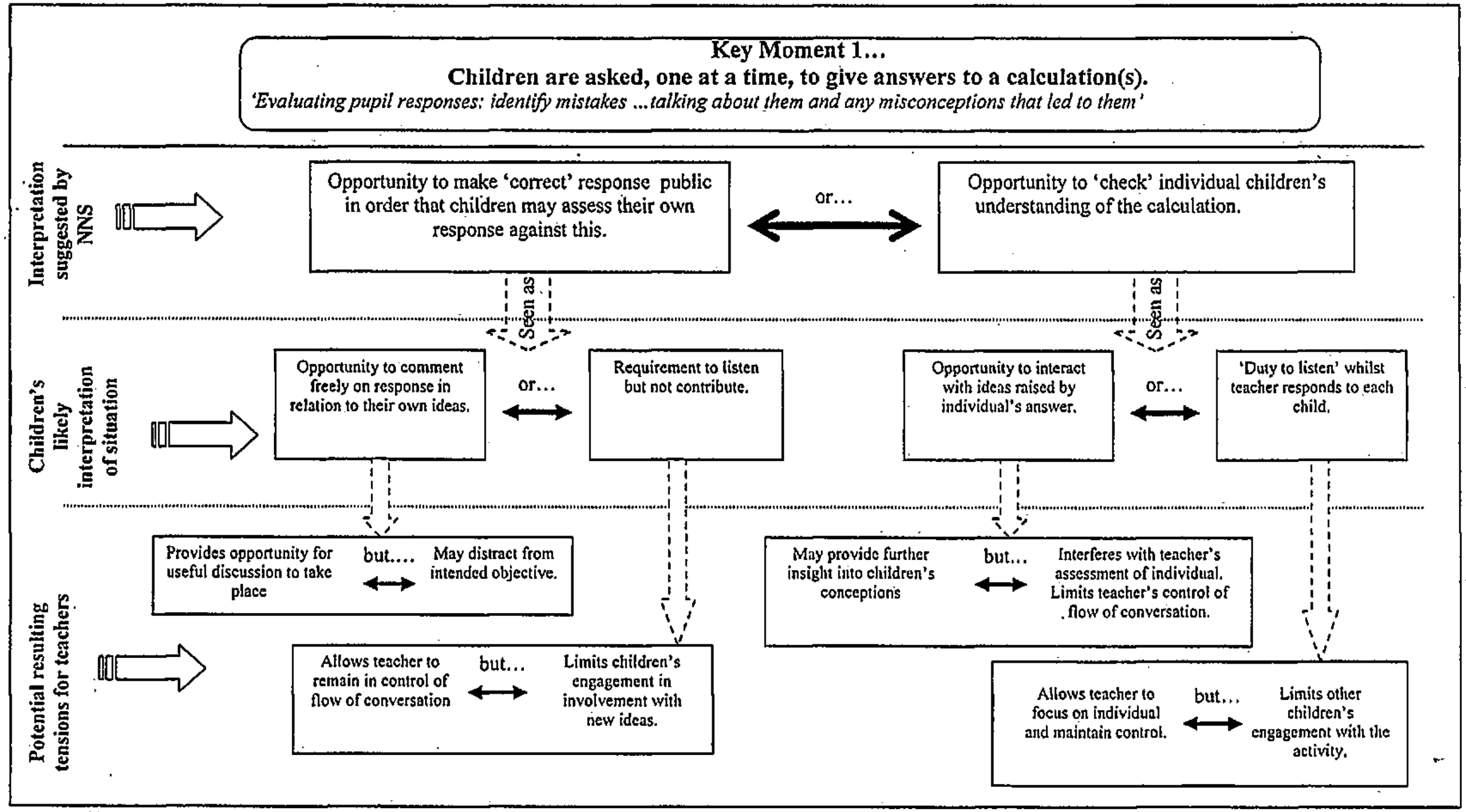


Figure 1 - Key Moment 1: children are asked to respond to teacher questions.

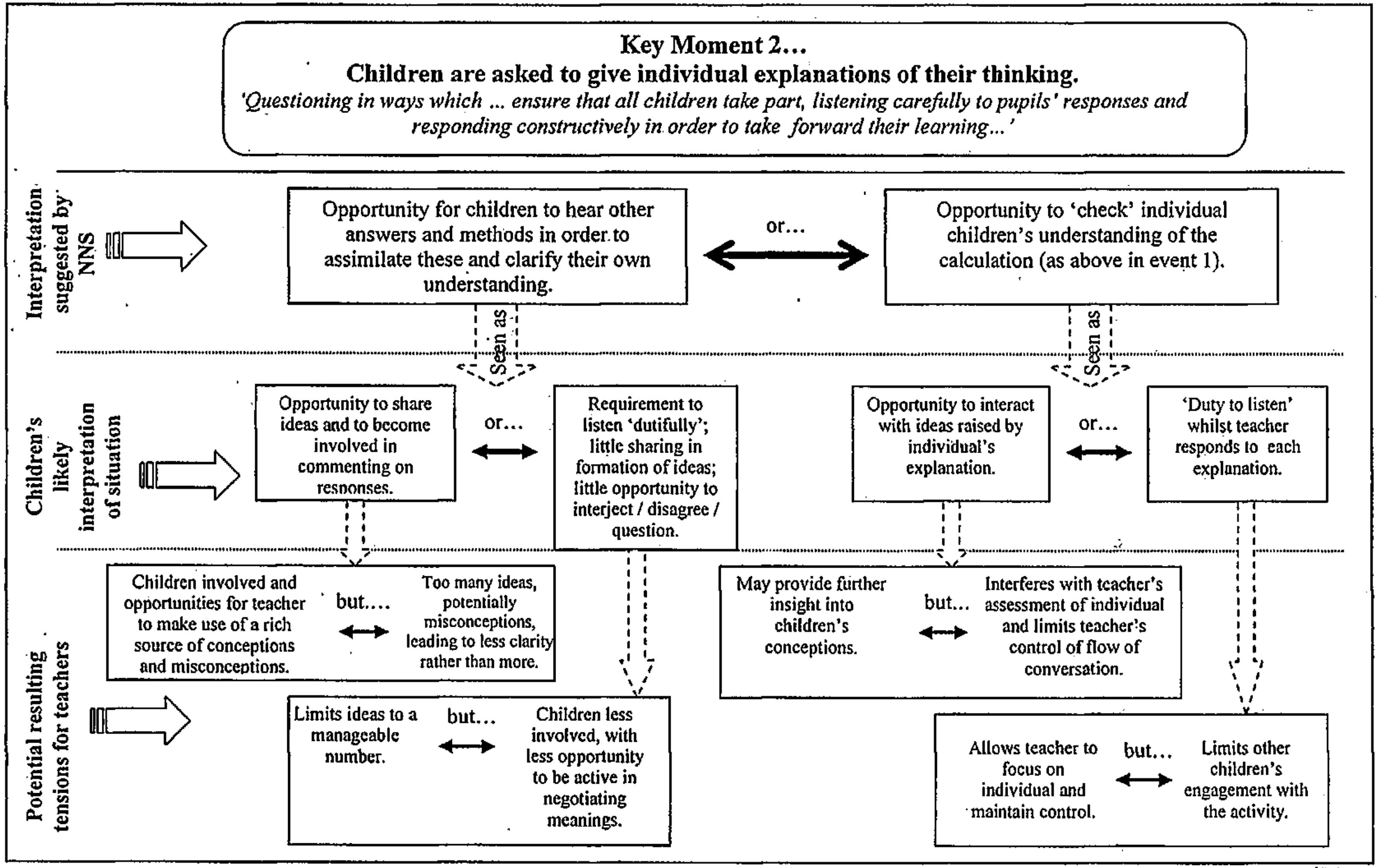


Figure 2 - Key Moment 2: children are asked to give individual explanations.

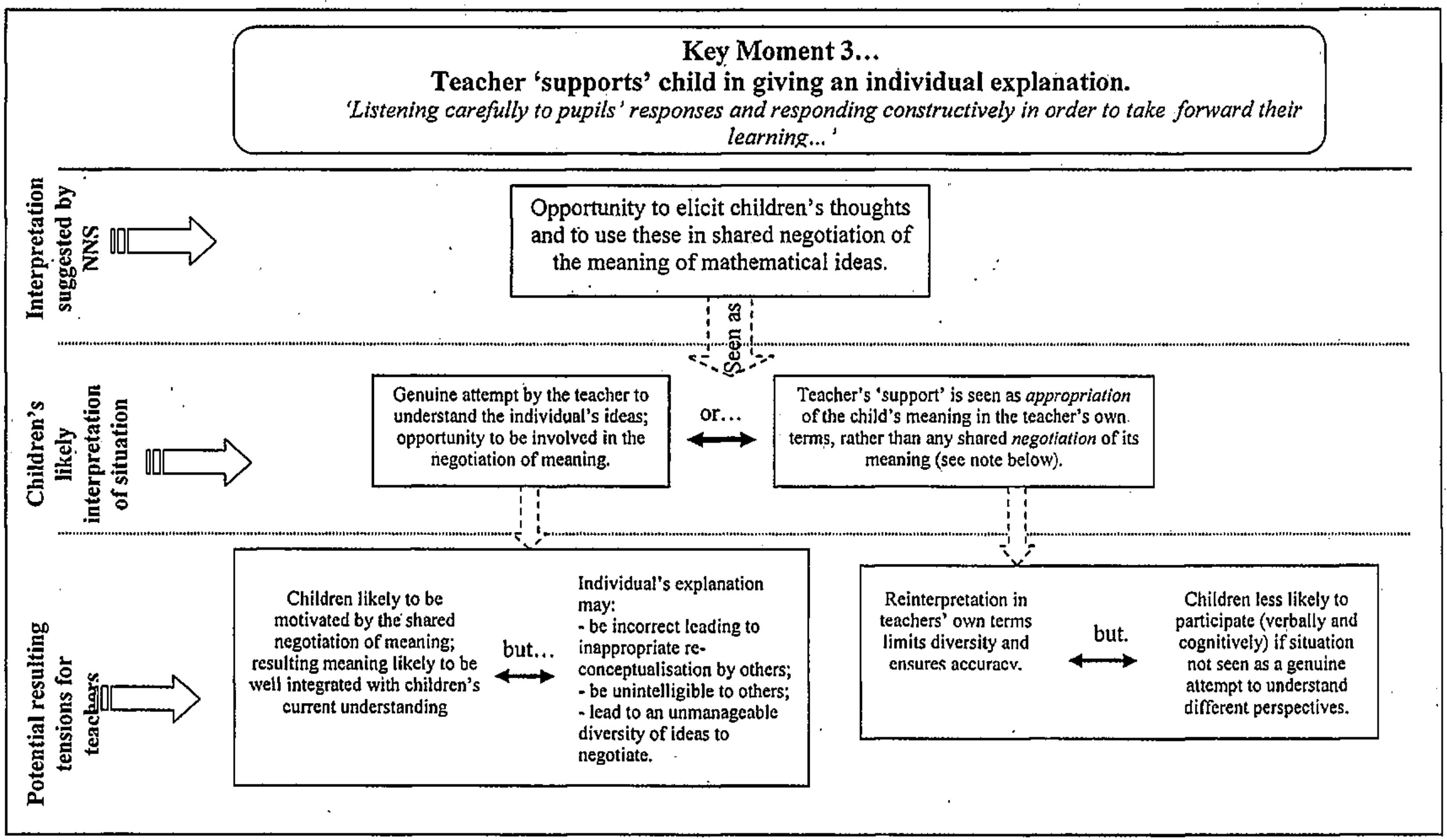


Figure 3 - Key Moment 3: teacher 'supports' a child's explanation.

Note: The teachers in this study were seen to *appropriate* children's explanations as in the diagram above) in a number of different ways. These included:

- *interrupting* answers to questions and/or finish them off in their own words ('propping up');
- *reinterpreting* what had been said to mean something different;
- *ignoring* the whole answer because it didn't match the teaching point;
- *ignoring* the whole answer for fear that it could not be understood sufficiently;
- *ignoring* elements of the answer in order to refocus it on something new;
- *repeating* the answer, emphasising certain elements of it and thereby changing the meaning;
- *selective hearing* where unwanted responses are deliberately ignored;
- using *value judgements* ("good", "I'm not sure about that", quizzical looks etc.) thereby endowing certain aspects of the answer with special significance.

All of these forms of appropriation regularly appeared to lead to children disengaging from the process of shared negotiation, in the sense that they withdrew themselves in one way or another from the discussion taking place.

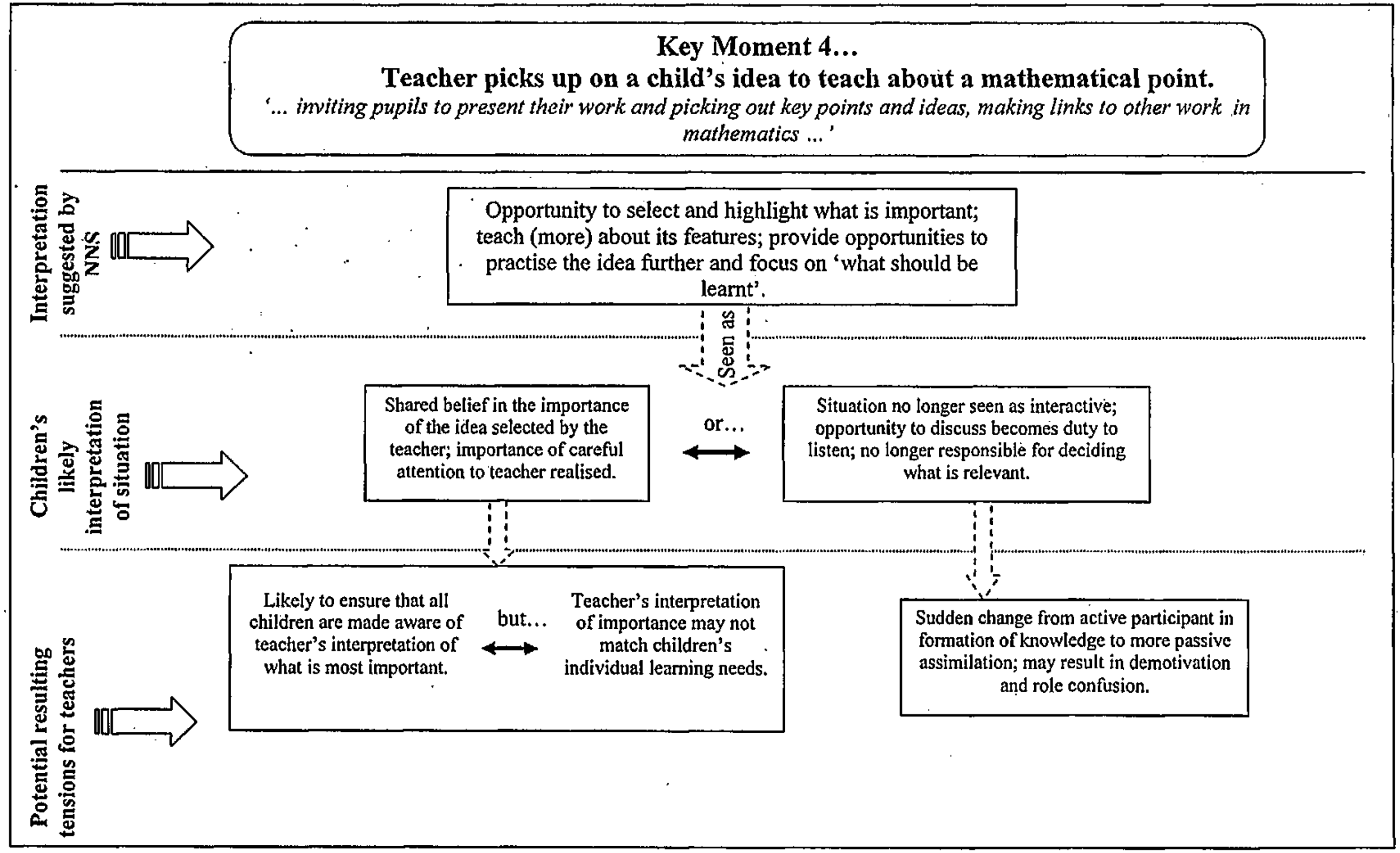


Figure 4 - Key Moment 4: teacher picks up on a child's point to teach an idea.

The early part of this chapter showed that teachers' various interpretations of what it meant to 'do' the National Numeracy Strategy led to differences in their practice. These were dictated by contextual issues and differences in subject knowledge, but also by the teachers' willingness and ability to allow the children full and genuine opportunity to negotiate meaning for their mathematics. The second half of the chapter has identified and detailed the sources of potential tensions for teachers in whole class interactive teaching. In respect of these common tensions it is being suggested that the issue at the centre of all of them is the question of what is deemed 'important'. Where difficulties are likely, they are the result of potential confusion about the legitimacy of the children's agency in contributing at any given moment; their ability to decide independently what is important and what merits their cognitive attention. For whilst the teacher is asked to encourage – indeed, make use of – their contribution under a view of teaching as a complex sociocultural activity, she is simultaneously asked to control it by a form of technicism aimed at *ensuring* certain outcomes from the lesson. It is this tension that appears to be at the heart of the challenges for teachers in 'whole class interactive teaching'.

In drawing these conclusions from the data, considerable reliance was placed on observations of children's behaviour. In turn, these were used to make statements about the teachers' actions. In the next chapter the focus is returned to the children in an attempt to find out more explicitly their perception of the dynamics inherent in whole class interactive teaching situations.

Chapter 6 – Children's perspectives

Introduction

The last chapter described the common tensions felt by teachers in attempting whole class interactive teaching. To a large extent, the tensions were a result of systemic difficulties relating to the proper focus of teachers' attention in their teaching – to reach particular ends regardless of pupil contribution or to follow, flexibly, children's responses and to negotiate meaning accordingly.

Whilst teachers' perspectives have been documented, Askew et al (2000, p. 74) note that,

> At a time when the focus at the policy level is on the 'daily mathematics lessons' as though this were an objective event providing the same experience for all pupils, [children's] behaviours demonstrate that this is not the case.

This chapter therefore looks at the situation from children's points of view, reporting the results of interviews with 36 children in one Year 3/4 and two Year 6 classes, in two different schools.

The children in this part of the study were asked to talk about their experiences of a particular whole class interactive teaching event as a way to elicit how they perceived such teaching in general. The method involved videoing a mathematics lesson in which the interviewees had taken part and then editing three or four short clips from the whole tape to show to them the next day. A semi-structured interview schedule, organised around the viewing of these clips, formed the basis for the interviews, which were carried out with pairs of children each time. The pairs were chosen by the teacher to represent children from across the attainment spectrum and also to provide children who were likely to be willing to talk with me fairly freely. Eighteen pairs involving ten Year 3/4 children and twenty-six Year 6 children were interviewed. For just one pair, and in complete contrast to the others, the interview seemed rather daunting and the children were unwilling to talk with me. The data from this interview was so limited that it was not included in the final analysis, leaving data from a total of 34 children in all. In addition, post-lesson interviews were conducted with each teacher after the lesson and their views were triangulated with the findings from the children's interviews.

The video clips used in these interviews aimed to exemplify one or more of the features of whole class interactive teaching which had been identified as significant to the teachers in the previous chapter, as follows:

- Situations in which the teacher was asking children for their views, or for approaches to solving a particular problem.
- Situations in which children were talking collaboratively, either as a whole class or, for short periods, in pairs/groups.
- Situations in which teachers were selecting examples from children and having to make choices about what to focus on and what to ignore.
- Situations in which children were expected to explain their understanding of an issue publicly in order that others might share in it, particularly where this seemed problematic in some way for the speaker or the listeners.
- Examples of the teacher explaining an idea to the class.

It is important to bear in mind that the content of the clips was chosen deliberately to illustrate some of the tensions that the teachers of chapter 5 had described in their teaching. The research question was not therefore whether these children *agreed* that these were 'key moments', or whether they would independently have identified similar moments as being important in some way. Instead, the question was what the children believed was happening at certain moments in terms of their own role in the lesson and their perception of the teacher's role. In this way the chosen incidents were aimed at both illustrating some particular features of the lesson and also acting as the prompt for children to talk about their experiences of interactive teaching as a whole. No claim is being made then that the selected clips were key moments for the children themselves. What is claimed is that *given these incidents* the children have particular understandings of the events and that these, though specific to the three lessons videoed and analysed, shed some light on how children perceive their mathematics teaching, and whole class interactive teaching in particular.

Three other features of the method are also important to remember. First, as chapter 3 pointed out, of the three teachers involved in this part of the study, only one had been involved in the earlier study of classroom practice which meant that it was not possible to explore issues identified during these earlier observations with the same children. Having the same teachers and children might have allowed some insights to be gained that were not possible as things stood.

Second, because the interviews were carried out just before the end of a school year and the children in Year 6 dispersed to high school, it was not possible to triangulate the results by participant validation with the children; a considerable weakness of the method – though triangulation with the teachers, discussing the children's reactions, was undertaken.

Third, the nature of responses given by the children needs to considered with caution for the methodological reasons outlined in chapter 3 relating to the way in which interviews generate *post hoc* reflections on events, rather than uncovering 'truths' held *a priori*..

All of these three features mean that one has to take care in interpreting the data. What is claimed is that, given these children's apparent understandings of the roles inherent in the particular whole class interactive teaching events under consideration, some 'fuzzy' generalisations (Bassey, 1999; Bassey et al, 2001; Hammersley, 2001 – see chapter

3) can be made which might help to shed light on classroom interactions and ways in which practitioners can effect change in their own contexts (Pratt, 2003). Similarly, in considering the teachers' perspectives from the previous chapter, the intention is clearly not to claim that the children's comments here relate directly to the findings there in the sense that the children are commenting on the same situations. However, in choosing video clips that it was felt represented the kinds of issues that had come to light in that chapter, a deliberate attempt was made to try to illuminate the same lesson *characteristics* from a child's perspective. Furthermore, the very fact that such characteristics identified in one context appeared again with two new teachers in a different school, lends some weight to the general nature of the findings in chapter 5.

Before presenting the data from the interviews with the children, the context of each lesson is given.

Context – the three lessons

The teachers

The three lessons videoed and subsequently discussed with the children took place in two different schools and with two different age ranges. One of the teachers involved, Heather, had also been involved in the early part of the study and she was teaching a mixed Year 5 and 6 class at the time of this second phase of data collection. The other two classes were in a new school with which I had professional connections and, after being invited to talk to the staff about the project, two teachers volunteered to be involved. One of these, Mark, who taught a mixed Year 3/4 class, was at the end of only his second year of teaching, though he had been a reasonably mature (aged 36) student teacher. He was also the PE co-ordinator. I had worked previously with Mark as a tutor during his BEd and we therefore already had a fairly good working relationship. The other, Jane, was the

deputy head and mathematics co-ordinator, an experienced teacher aged around 55, who appeared very willing and interested in continuing to develop her own teaching practice.

Significant features of the three lessons

Heather

Heather's Year 5/6 class were involved in multiplication and division using whole numbers and decimal fractions, with her intention being to support the children in developing efficient and effective ways of performing calculations in which whole numbers and decimals were being multiplied or divided (for example, 60 x 0.5). During the lesson a number of different problem situations were presented, some of which required immediate recall and others of which involved a more extended problem solution.

As was the case in lessons described previously, Heather was adept at allowing children the opportunity to contribute their ideas to the session, using phrases which encouraged participation without prior judgement, for example: 'Can anyone explain why she's right?'; Has anyone got a way to prove that?'; 'Yes, would anyone like to explain it?' etc. (Field notes, 29.6.02).

She also had excellent understanding herself of the mathematics, allowing her to choose questions which seemed to me to challenge the children effectively as well as to make useful pedagogic choices (though the validity of such a statement rests only on the extent to which I can claim to provide an 'expert' view as an experienced mathematics tutor and observer of mathematics lessons). Field notes from the observation note at one point that,

> Children were asked to divide 0.5 by 0.25. This is conceptually difficult and seemed to me to be crying out for calculators to work out the answer .... And they appeared!
>
> (Field notes, 29.5.02)

Thus, as she had done during earlier observations, Heather was teaching in a manner that certainly tried to encourage children to participate and which created the possibility for them to both think and talk about their ideas. Nevertheless, her teaching also exemplified familiar difficulties for her too, in particular:

- Children's varying attention to what was being said and done.

> It strikes me that most of the children are not following [the discussion] and are only following Heather's record [of it] on the board. But what can they make of the partial record that she is keeping on the board?
>
> (Field notes, 29.5.02)

- The multitude of different ideas presented by the children and the challenge of keeping track of all these and of finally bringing them together.

- The clarity of the children's responses and the difficulty experienced by other children of hearing and of making sense of them. This led to Heather repeating children's answers each time someone said something.

In discussion after the session it was clear that, though she consciously created opportunities for children to talk and to listen to each other, Heather had no explicit reason for why she did so, noting simply that 'it must work somehow'. Of course this is not a criticism since it has long been recognised that teachers do not (nor need not) necessarily make explicit the theory for their actions, tending instead to make use of 'theory-in-action' (see, for example, Alexander 1984). Commenting, however, on her constant repetition of children's statements in the class, Heather emphasised that this was something that she did consciously, noting that 'at least then I can be sure they have heard it'.

The implication here was that children's contributions needed to be heard by others in order that they could be 'acquired' by them and that learning in this context was a matter

of hearing versions of the problem solution that were different from one's own; replacing the latter with the former if, in one's own judgement, it seemed appropriate.

In the last chapter it was noted that this was a common pattern of teacher behaviour and that the teachers (Frances is particular) seemed to want answers made public as a result of an understanding that other children could then acquire them and reproduce them. It is also a teaching action that is promoted by the National Numeracy Strategy itself in asking teachers to identify and correct pupils' misconceptions (chapter 3). It was further observed that, in asking children to talk about their answers in public, there was often a subtle shift in purpose from requiring an *explanation* of meaning to a *confirmation* that they understood. On the other hand, having emphasised the need to repeat children's contributions, Heather also commented that she was conscious of 'tending to teach to [her] own preferred method' (Field notes, 29.6.02). Here then was the tension in Heather's own mind, explored in chapter 5, regarding the balance between controlling the direction of the learning and allowing children themselves to be in control of this procedure.

As a result of the observations made and the discussion that followed, video clips were chosen for the interviews which, in my judgement, illustrated:

1. Children evaluating each other's solutions to decimal multiplication problems.
2. Heather repeating answers back to children.
3. Heather trying to balance the need to reach a particular teaching point (that multiplying by a number less than one makes the product smaller) with the desire to involve the children in their own thinking.
4. Children providing a range of different solution methods to a single problem (converting 5 feet eight inches to metres and centimetres).

Jane

Like Heather, Jane's Year 6 class were engaged in a lesson on multiplication and division. They were asked, first, to practise multiplication facts in pairs, monitoring and commenting on each other's work and reporting this back to the class, and then to work with small white boards, recording answers to rapid multiplication questions and showing these to the teacher using the board. These initial 'mental/oral' exercises, lasting about 20 minutes, were followed by a 40 minute period working as a whole class on a number of division problems in which children were asked to discuss solution methods in pairs. These were then made public with Jane recording them on the board.

In discussion after the lesson she reported that the intention of this whole class period was to establish a variety of methods of solving these kinds of problems allowing children to extend their range of solutions. However, the final 15 minutes of the lesson were spent working individually on a work sheet prepared by Jane. This was aimed at practising the same kinds of division problem but was formatted in such a way that the children had to solve them using just one particular method and layout, apparently in direct opposition to the purpose of the preceding part of the lesson – a tension that Jane herself subsequently recognised and described as 'a mistake'. Nevertheless, Jane's mathematical and pedagogical subject knowledge generally appeared to be effective; for example, having been working for some minutes on verbal multiplication problems of the kind 'What are 7 nines?', she initiated the connection between multiplication and division with a clever change of wording, namely 'How many 7s in ninety one?'.

Jane made it very clear to me both before and after the lesson that she wanted children to be explicitly aware of the value of communication during their mathematics lessons, to the point where learning to share ideas in this way was part of the objective for the lessons she taught. It was noticeable that the whole class element of the videoed lesson lasted for an hour, though this may not have been typical and might have been as a result

of Jane's understanding that my research was focused on interactive teaching. She frequently emphasised 'meta-learning' to the children too and many of her interventions were aimed at getting them explicitly to evaluate each other's ideas: 'Can you help each other do 7x7?'; 'Tell us what happened when your partner did…' (Field notes, 18.7.03). As a result of her focus on such sharing and her insistence that the children took part in it, there were a great many control comments from Jane, designed to keep the children's attention high and to require them to listen. At one point, Jane asked the children 'why are you listening to [Ch1's] way of doing it [solving a problem]?' and spent a minute of the lesson time hearing reasons from the children, who all, rather dutifully, said that it was to 'learn from each other'. At another point she emphasised the purpose of listening to each other's solutions to problems as 'weighing this [the solution] up in your minds'. However, my notes record that,

> She does so [insists on sharing] to the point where the children seem to be taking it on as 'one of her rules for behaviour' not out of any real sense of appreciating its value. In turn, she herself is selectively listening and directing the children's attention to what she considers 'worth' listening to or not. Thus, in one sense she urges the children to listen in order to be in control of their own learning, but in practice she does the controlling for them. … [Furthermore] the meta-cognitive element of the lesson was so over-riding that it interfered with the children's thinking and the more I watch the video [after the lesson] the more I'm convinced that the children don't listen to each other's strategies because the teacher doesn't require them to engage in considering them (other than to say a low level, 'good' or not).
>
> (Journal notes, 18.07.02)

Thus, from an observer's point of view, whilst the quantity of listening-to-share was high, the quality appeared quite low in the sense that the children were seldom required to offer meaningful comments that were then taken up by others (Jones and Tanner, 2002). Any comment that was made was responded to by the teacher rather than by the other children. This created the familiar tension for Jane, experienced by the teachers in chapter 5, of having to field responses that did not 'fit the bill' in terms of her intended outcomes. For example, in asking for solutions to the problem 133 ÷ 7 (= 19), one child responded that 'I know that 63 [7 x 9] is the only multiple of 7 which ends in a 3, so I added nine 7s to ten 7s'. This is a sophisticated response based on a great deal of knowledge about the number system and multiplication/division. It could lead to an interesting discussion in which children generalised such a procedure, looking for patterns in the digits of products to help them identify similar efficiencies in their calculating approaches. However, in this case it represented a distracting problem for Jane, who politely acknowledged it and then moved on.

The observations noted above led me to choose video clips for the interviews which, in my judgement, illustrated:

1. Paired work and peer evaluation.
2. Meta-learning – looking for ways to remember key multiplication facts.
3. Rapid recall of knowledge via white boards so that teacher could see the answers of each member of the class.
4. Children offering various methods for solution to a problem (133 ÷ 7) including one solution which was subtle but complex and was politely acknowledged then ignored by Jane (described above).

Mark

Mark's Year 3/4 class were also engaged in calculation involving number, though in the context of measurements of capacity (litres and millilitres). The overall objective for the lesson, written on the board at the start, was 'to become familiar with standard units of capacity and the relationship between them'.

The lesson began with a 'warm-up'; the description that Mark himself used, quite literally it appeared, in repeatedly suggesting to the children that its purpose was 'to warm up the brain'. This description was used frequently by the children themselves in the subsequent interviews and is probably a reflection of Mark's subject leadership in PE – his favourite and most familiar subject.

To begin the lesson, every child was asked for a 'fact' about 200 (for example, '4 fifties make 200'). These were many and varied and apparently demanded considerable thought from the children. However they were all isolated and individual and no attempt was made to help the children to make connections between the ideas. For example, one child noted that 200 was even and another subsequently noted that you could divide it in half, but nothing was made of these related ideas. On the other hand Mark himself clearly understood the mathematical ideas well. For example he noted to one child who claimed that 200 had 'no tens and units' that 'it does have tens and units. It has 20 tens and 200 units, but I know what you mean. We'll say that the tens digit is zero and the units digit is zero' (Field notes, 1.7.02). Furthermore he might legitimately have argued that since the intention was simply a warm-up it would have been inappropriate to dwell too long on each contribution.

Subsequently, the lesson developed with Mark giving a fairly long (15 minutes) explanation of how millilitres and litres were inter-related, interspersed with questions for the children to respond to, before finishing with some individual problems to solve relating to conversion of one form of units to another.

Several features of Mark's teaching stood out to me as an observer, again influenced by previous observations (chapter 5) which attuned my attention in particular ways. First, Mark's stated intention was that children should always see maths as 'fun' and that this would be the case if the interaction was lively. However, he added that after a recent interim assessment in which the children had generally 'done badly' he had had to change his approach.

> I asked them whether they enjoyed maths and all the hands went up. I asked them whether they thought they had done well in the assessment and all the hands went up as well. So we had a chat about that and I was saying we needed to calm it down a bit. Since then the children haven't been quite so keen to come into maths, not quite so enthusiastic. It's hard. It's a hard balance to find.
>
> (Field notes, 1.7.02)

Like Jane, in the same school and in line with the school's policy, Mark was trying therefore to involve the children in developing their own input into the session and in learning how to learn from each other, though this was proving less easy in practice than in theory. It was noticeable that whilst Mark asked a range of different questions which exposed children's difficulties with the mathematical ideas, once the difficulty had been exposed he worked almost exclusively with closed questions, aimed at 'shaping' the child's responses (Woods, 1983) until they matched his own view of the solution. There was no attempt in these situations to encourage children to take part in any joint meaning making whereby other children might have been asked to offer explanations to each other. Perhaps unsurprisingly for such a new teacher, the overall feeling was that Mark was following a set of procedures which he believed would lead to effective teaching, rather than yet having the experience to have developed his own rationale for his teaching actions. For example, at one point in discussion immediately after the lesson, he remarked that,

> I have been on the five day course [NNS training course for teachers] and they were saying that the first part was a 'warm-up'; for recapping ideas that the children have already done.
>
> (Field notes, 1.7.02)

The use of the phrase 'they were saying' suggests that he viewed the NNS as 'a set of procedures' and as 'power from above' in terms of the categories identified in chapter 4. The effect was similar to Jane (though reached in a different way), namely that though

there was a large number of interactions, the intellectual demand of each individual interaction was quite low.

As a result of all these observations of Mark's lesson, video clips were chosen in order to illustrate:

1. The 'warm-up' task asking for 'facts about 200'.
2. Mark 'shaping' children's responses with closed questions (in this case attempting to get one boy to see that 4 fifties, not 5 fifties, were 200).
3. Testing of understanding through questions to the whole class which assessed their understanding of conversion from litres to millilitres.
4. The dilemma faced when a child offered an idea which Mark felt was beyond the rest of the class (knowing what one sixth of a litre is in millilitres – Mark's response being to say 'I don't want to go there yet').

Child interviews – data and analysis

Data collection

Though the context for the three videoed lessons was clearly different in many ways, the purpose of the interviews with children was to explore their reactions to common themes in whole class interactive teaching. Therefore, whilst video clips were chosen to illustrate issues that were particularly pertinent to the children's own experiences, it should be apparent above that the issues were largely common to all three classrooms. Each interview involved two stages (usually running into each other rather than distinct). First, it started with an examination of the video clips and used a semi-structured schedule (appendix 6) which aimed to explore children's reactions to being involved in this part of the lesson and hence the lesson as a whole. As noted in chapter 3, the emphasis was on participants' perceptions of the particular events seen on the video, the aim being to root the children in describing the actual events themselves rather than providing generalised 'explanations' for behaviours. These descriptions then allowed interpretations to be made

regarding their perceptions of the effect of different teaching events on their learning. In this way, questions began by asking children whether they could remember the lesson and to describe what was happening. Without exception, children appeared to have a very clear memory of the lesson and the video served as an excellent prompt, it seemed, in helping them to recall clearly what had happened. Children routinely remembered even very particular answers to questions, could describe 'what happens next' with great accuracy and appeared to have no difficulty re-entering the lesson in terms of their feelings and thoughts. The success of the use of video to initiate this recollection of their experiences would appear to be a strength of the method.

Having been asked to recall the events from the lesson, for each clip children were asked:

- How did you feel?
- What sort of things did you think about in this part of the lesson?
- What do you think [teacher's name] is thinking about here?

With respect to the last question, it was found, in practice, that asking children to imagine being able to 'replace their own brain with the teacher's and describe what you would be thinking' appeared to be an effective way in which to present the question.

The second stage of the interview explored more deliberately six key teaching practices common to all the teaching situations. These were selected in light of my observations and aimed to explore children's perceptions of how the particular behaviours helped or hindered their learning. The six issues were:

'the extent to which the teacher:

- asking questions ....
- repeating your answers back to you ....
- writing on the board ....
- listening to you talking ....
- telling you things ....
- encouraging you to talk and listen to other children ....

.... helps you to learn maths'.

Clearly, this part of the interview might appear to take a more direct approach, asking children to talk about learning in general. In practice, though this was true to some extent, by starting with actual experiences from the video children were used to talking about the particular events in the lesson in question by the time they reached this stage of the interview. Indeed, each issue had often already arisen in looking at the clips of video and did not need to be addressed directly anyway. Where it had not, attempts were made to continue to relate the issue back to one of the clips or to another moment in the lesson which the child could remember. In addition, before exploring the issues, the children were asked if they agreed that their teacher did indeed act each way or not and were also asked to add anything to the list of 'common things that the teacher does', thereby adopting some ownership of it. Moreover, children were encouraged to give examples where appropriate.

Data analysis

Interviews were audio recorded and transcribed before being subjected to analysis of the type used previously for the teacher interviews in chapter 4, and described by Strauss and Corbin (1990) (see chapter 3).

Although the interviews related to children's experiences of teaching situations with three different teachers, the main themes being explored were similar in each case. In the first instance data were therefore pooled and analysed together, though references were maintained regarding where the data had originated in order that findings could be related back to individual teachers. Notes from observations and discussions with teachers were included as data and used to inform the process of categorisation and the building of theory. In reporting the findings below, attention is paid to both generic points common to all three groups, and to points that seemed specific to one or more group. However, it is

important to bear in mind that claims that these results generalise beyond the particular children involved would be unwise, though some fuzzy generalisations are made which might invite other practitioners to consider how these findings relate to their situation.

As outlined earlier, circumstances meant that it was not possible to triangulate the results of the analysis with the children. Results were, however, taken back to the three participating teachers who each gave their opinion and discussed the implications. Finally, a colleague with considerable experience of interview analysis using the same method was used as an independent judge to assess the reliability of the match between data and the categories to which they were allocated. A sample of 32 units of interview data were considered by this judge against the theoretical categories which had been developed, including some which related to no categories and were added as distracters. Reliability seemed very high in this test with 69% of the units matched with no need for negotiation, 19% agreed after negotiation between us and only 12% resulting in non-agreement.

Children's perceptions of whole class interactive teaching

The analysis of the data led to two distinct, though related, themes regarding children's perceptions of what whole class interactive teaching involved, namely:

1. children's perceptions of *what*, and *why*, they were learning, and;
2. children's perceptions of *how* this learning took place.

Each theme is discussed in turn and excerpts from transcripts are used to illustrate the ideas under discussion.

(Note, in these transcripts, the reference after each excerpt gives the year group and class: 3M or 4M for Mark; 6H and 6J for Heather and Jane respectively. This is followed by the interview number so that 6J:4 refers to Jane's Year 6 class: interview 4. Ch refers to

'Child' and these are numbered Ch1, Ch2 etc. within each excerpt. Children can therefore be compared across interview excerpts.)

Children's perceptions of *what*, and *why*, they were learning

All three lessons dealt with numerical calculations of one sort or another and, as part of the lesson at least, involved children making methods of calculation public and examining these jointly as a whole class. It was no surprise therefore that all of the children, and particularly those in Year 6, referred to the idea of learning calculation strategies as the primary goal in the lesson. However, two sub-themes emerged in relation to this general understanding of what and why the children were learning.

Sub-theme 1 – Jointly refining efficiency

Given that Jane had made the development of 'more efficient' methods of calculating a major focus of her work and had been at pains to make both me and the children aware of this, it was perhaps of some satisfaction that her children clearly understood this idea, at least at a rhetorical level. The same was true of Heather's children who, though Heather made it less explicit, again clearly saw the 'refining of techniques' as a central part of what the lesson was about. Such a view was exemplified repeatedly, particularly in relation to video clips which showed the teacher asking several children for their solutions. Typically, children made statements such as the following:

> INT: Why is [Jane] getting lots of different methods and sharing them do you think?
> Ch1: We could only know one way and it might be a hard way but if she is asking lots of other people their way, it might be quicker.
>
> (6J:1)
>
> Ch2: That [sharing different methods] helps because you can like listen to their ideas which might help you. Cos that might help you. Like listening to their

ideas for doing adding and taking away and times and something like that, and then when you come to do it there might be an idea which they said you could do.

(3M:1)

INT: So there were three different ways of doing it. Why do you think [Heather] wanted to see all three of them?
Ch1: To see whether if maybe one of us, like that was a long way, to see if we could shorten it down so we could get it quicker.
Ch2: Like a simpler, less complex way.
INT: Do you think that would help people in the class?
Ch2 & Ch1: Yes.
INT: In what way?
Ch2: So they could think about not only their answers but think about other peoples' and maybe get an even quicker way than they had before. And think about it and if someone else explains their answer it might help them understand it better and they might think, 'oh I could have done that', and then they might get it next time.

(6H:1)

Feelings were mixed regarding the extent to which such sharing was useful. It should be noted too that on a number of occasions children were asked to report their thinking about an issue without any apparent consideration of it by other pupils. Nevertheless, many children claimed that sharing was useful and some could give examples of methods that they had adopted from other children:

INT: And does it work for you?
Ch1: Yes.
Ch2: It helps a lot.
INT: Can you think of any particular example where you manage to work something a different way?
Ch1: Well I always used to do the adding, 7 add 7, and go on like that [in order to solve division problems] and there was another way that someone told us and I have carried on from doing it like that now.
Ch2: And then when it said 7 divided into 184, I would do it like 7 into 100 and then one person said one time 'How many sevens go into 18?' because you couldn't do it into 1 so I do that all the time now.

(6J:2)

Other children were less sure about its value, citing several difficulties with this kind of sharing which are addressed below, but still recognised it as a fundamental part of what the lesson entailed. In this sense at least, children in these classes appeared to

understand and appreciate that the teacher was trying to facilitate a sharing of ideas in order that learning could take place 'from each other'. They viewed the whole class interaction as a means by which they could jointly refine approaches in order to access the 'best' method of doing something.

However, chapter 2 noted Threlfall's (2000) observation that different contexts may imply the use of different solutions to the 'same' problem, and hence that focusing on 'a best' solution, irrespective of any context, is unlikely to lead to better calculating skills in contextualised situations. Contrary to this, a decontextualised sense of 'best' was apparent in the children's comments, for example:

> INT: What is she [Heather] trying to do now. She has got three different ways of doing it and she is showing you all three.
> Ch2: She is trying to show us how to find the easiest way.
> INT Is that going to help?
> Ch1: Yes, it does because like if it is too complicated. She makes it easier and writes it down on the board and says 'what can we do to make it easier?'.
> (6H:2)

In all the children's comments therefore, the sense that they were searching for a 'best' way was over-riding with little or no attention being given to how the solution might be affected by the context of the problem.

In turn, this class search for 'best methods' introduces the second sub-theme relating to the *what* and *why* of children's perceptions of whole class interactive teaching.

Sub-theme 2 – Memorisation of best methods

Children's comments about whole class interactive teaching made repeated reference to the idea that part of their role, as learners, was to *memorise* methods for solving problems that had been shared and identified as 'best'.

Ch1: I think that actually repeatedly saying it makes it stick in her [peer's] head more.

(J6:3)

INT: Do you find that helpful, when there is more than one way of doing it?
Ch2: It does get quite complicated sometimes.
INT: What makes it complicated?
Ch2: Just someone gives a wrong answer, and sometimes you remember the wrong one and not the right one.

(H6:2)

On more than one occasion, this view was coupled to Standard Attainment Tests, with children linking ability to remember responses with increased success in the test.

INT: So what about [the teacher] asking you questions, is that helpful at all?
Ch1: Yeah, cos if you like get them wrong and you thought that was the right answer, when you come to SATs, you'd know, you thought that was right. But if [Mark] had told you it was wrong and told you the right answer, when you came to your SATs you'd probably remember it better.

(M3:1)

Such references to tests is in line with other recent research, for example Pollard (2001) who draws on the longitudinal Primary Assessment, Curriculum and Experience (PACE) project in stating that 'SAT testing at age 7 and age 11 appeared to have had a significant effect on perceptions, with children increasingly feeling the salience and significance of such testing' (p. 21).

It would be wrong though to suggest that children in this study only understood learning in terms of memory or that they thought continually about testing. In the first instance, the particular lessons observed and replayed to the children happened to be about developing 'best strategies' and this content matter might well tend to focus children's attention in particular ways. In addition, it was apparent above that children understood their role in the lesson to be about developing 'best' methods as a class and this clearly implies a conception of learning which involves more than just memory. Furthermore, children of the age involved here may well lack the language for describing the form of their learning in these more complex ways and fall back instead on familiar language. Nevertheless, the frequency of references to 'remembering' suggests that children did appear to associate learning in the context of whole class interactive teaching largely with memory, at least in as far as this being the ultimate purpose, having once worked out which methods were worthy of memorising.

There is a sense in which this is highly ironic. Given the potential of the interactive situation to develop children's power to reason in 'mathematical' ways and to view the subject in process terms as an exploratory venture, the focus on the need for memorised, inert knowledge presents a competing, and potentially over-riding, imperative. The dilemma for children appears to be that, whilst they might be encouraged to experiment with methods for solution, there remains a very real sense in which finding 'the right' answer is the primary goal. In these terms, though there may be much more discursive interaction and much less individual work from text books than there was prior to the NNS (Desforges and Cockburn, 1987), the primary function of identifying appropriate answers to remember may not have changed a great deal. Furthermore, Boaler (1997) suggests that this form of mathematics learning in which the focus is on 'remembering methods rather than thinking about questions' (p. 104) leads to knowledge that is 'inflexible and inert' and of little use in situations beyond the immediate context in which it is learnt. Drawing on research in situated cognition (Lave, 1988; Lave and Wenger, 1991), she points to the need to learn mathematics through its use in a form similar to that in which one might use it again in the future, thus integrating knowledge with practice (Boaler, 2002). Children are unlikely to be successful in using mathematics if they learn it in the 'clear and straightforward way' (Boaler, 1997, p. 105) that the NNS presents it, with ideas broken down into smaller and smaller linear chunks, since this is not the form of knowledge that one needs to be able to make use of it. Successful learning of mathematics, she claims, is not based on knowing, but rather on doing (ibid.); that is, the essence of learning mathematics is to learn how to tackle questions, to analyse situations for mathematical possibilities and to reason in particular ways, all of which *require* knowledge, but within the practice of problem solving.

The paradox then is that whilst the NNS goes out of its way to organise mathematical ideas in a sanitised and linear programme of study, successful learning may require a much messier, interconnected approach in which students and teachers need to 'embrace discomfort as the harbinger of learning' and to 'ride the rapids of our own uncertainty and our students' confusion to arrive at the transformations we desire' (Taylor, 2003, p. 343). Ironically, the NNS provides this opportunity through the very interaction that it promotes, which could lead to learning in which children develop the ability to think about the views of others, reason about them and argue their case, creating knowledge which is flexible and alive. The children in this study did not appear to achieve this and chapter 5 identified the way in which, within an apparently open discourse, teachers sought to maintain control of the ideas involved in order to 'hear the right answers'. This was done through the use of strategies such as careful selection of responses, appropriation of children's answers, changing answers to match objectives and classroom control approaches that regulated children's responses in particular ways.

Children's perceptions of *how* learning took place

Having identified *what* children perceived they were trying to learn about, attention is now turned to the process by which they perceived this to happen. Findings are reported in terms of three elements of this process: the roles of teacher and child in interaction; difficulties in understanding experienced by children, and; the supremacy of the role of listening over talking.

Teacher and child roles in interaction

In chapter 5, several elements of teaching behaviour, resulting in interaction between teacher and children, were identified. In particular these were:

- The varying attention paid by children to teachers and other pupils.
- The difference in quality between talk in whole class and paired discussion.
- The potential for confusion regarding the role of talking in whole class situations (to offer ideas for discussion or to confirm personal understanding of an idea to the teacher).
- Teachers' desire to control learning through: selective listening; 'propping up' of responses, and; the appropriation and reinterpretation of answers.

How then did children tend to understand these issues? First, the issue of control and authority was clear in children's minds. Though, as we saw above, they may have understood the purpose of class discourse to be the negotiation of solutions, refined until they were 'best' solutions, there was no doubt in their minds who was in control of judgements in this respect. It was the teacher who validated knowledge generated by the group and who ultimately decided if things were 'right' or 'wrong'.

INT: He seemed to be telling you that an answer was right or wrong. Would he normally be doing that?
Ch1: Yeah.
Ch2: Yeah.
INT: So for example at one point [Ch] said 5 fifties were 200 and he said no that's wrong and helped him to work it out.
Ch2: Yeah. That's what he does.

(M3:3)

However, often this was not done directly, and children commented on the indirect way in which 'correctness' was established:

CH1: If we get an answer wrong, she'll kind of like look at you and say 'Are you sure that's right?' She won't tell you straightaway. She'll say, 'who thinks it is right?'.
INT: So you end up knowing whether it is right or wrong but she doesn't just say that's wrong. She does it in a careful way.
CH1: Yes.
INT: What about if it is right? Does she say 'That's right'?
Ch1: She just goes 'Well done'.

(J6:1)

INT: What about telling you if an answer is right or wrong?
Ch1: Yes, she does that eventually.

(J6:7)

For Jane and Mark's children in particular, this indirect response to their answers was seen as a game in which their role was to 'work out the solution from clues' given by the teacher:

Ch1: [Saying whether an answer is right or wrong is] Kind of [helpful] cos it's helping us a little bit and if you get a question wrong he'll tell us....
Ch2: He'll tell us a bit of it.
Ch1: Yeah.

(M3/4:4)

Ch1: If you wouldn't know a question, she'll start explaining and giving you a couple more clues.

(J6:1)

This 'clue giving' had two particular features. First, teaching was more focused on wrong answers than right ones:

INT: Would you agree that she tells you if an answer is right or wrong?
Ch1: Not really. She will describe something and she'll...
Ch2: She'll push you along to help you do it [correcting the wrong thing] yourself.
INT: She'll hint that it's right or wrong but she won't tell you directly?
Ch1: She'll direct you into another way of doing it.
Ch2: If there's like an easier way. If you were working and not got the right answer, she'll mark them right or wrong and if they're wrong she will tell you to go and look at it again.

(J6:6)

INT: She has got the answer already and now she is asking someone else. Why is she doing that?
Ch1: To see different methods and work out which one is best.
Ch2: And if one doesn't work then she can show them how they did it wrong and what to do.

(H6:4)

Indeed, Jane and Mark's pupils' responses in particular, and my own observations, gave very few references to occasions when the teachers had spent time focusing on a right answer. Instead, all the teachers' focus was on correcting wrong answers; subsequently reflected in the children's focus too. The role of the children and teacher in this pattern of behaviour might be compared to a more traditional, written approach to mathematics in which work is carried out from textbooks and then 'marked' by the teacher. The 'markings' here though, rather than being ticks and crosses on a page, are oral. Nevertheless, their function remains the same, namely to identify what is right and, more importantly, what is wrong so that children can then 'correct' their errors and be left with an accurate picture of what is 'true'. This picture – now aural rather than visual – can then be remembered.

In many ways identifying such errors might be seen as proper behaviour for the teacher and it certainly matches the National Numeracy Strategy's instructions to 'correct misconceptions'. However, it may also lead children into perceptions of the subject that are less useful, especially that:

- 'Getting it right' is the central task of the lesson, leading to the focus on memorisation of correct knowledge/procedures identified above.
- Children are less likely to spend time reflecting on the nature of 'right answers' and the ways that these link to other mathematical ideas. In other words, children may be developing a better picture of how mathematics

does *not* work than of how it does and opportunities which the discourse presents for reasoning about this mathematics may be being missed.

- Mathematical processes, more widely, are ignored in favour of facts, routines and procedures (now perhaps oral, rather than written). For example, chances to work on ideas about *proof* tend to be missed – children are asked *whether* something is right, not '*how* they know that something is right' – and applications and problem situations tend to remain in the limited domain of the 'word problems' specified by the National Numeracy Strategy.

By implication, children are left with an impoverished view of the subject in which detail, routine and procedure are seen as more important than the wider, more generic processes identified as aims by the National Curriculum. According to this wider view, 'mathematics equips pupils with a uniquely powerful set of tools to understand and change the world [including] logical reasoning, problem-solving skills, and the ability to think in abstract ways' (DfEE, 1999j, p.60). The impoverished perception of the subject is reflected by Pollard et al (2000, p. 74) who observed that, far from developing more creative views of the subject, children increasingly viewed the subject as being about learning routines and procedures as they got older and were less likely to view it as a creative, problem solving activity. It similarly extends the findings of the last chapter where it was noted that even children as young as 6 were already beginning to see themselves as *received knowers* (Boaler, 2002).

It should be noted that Heather was much more likely to focus on alternative solutions, both right and wrong, and to ask the *children* themselves to explain which was which. In this way she managed to avoid quite so much focus on wrong answers and created the opportunity each time to focus on why things were right as well as why they were wrong.

A second feature of 'clue giving' was the perception created that learning was an entirely *individual* process, even though it took place in a social setting. The sense was of responsibility for understanding lying purely with the individual; indeed, the very fact that the teacher felt reticent in revealing the answer directly implies this to some extent. Thus, in describing how the teachers gave explanations when a potential misunderstanding had been revealed, children's answers referred repeatedly to the sense that the teacher's job was to give clues until they, the children, could work it out for themselves.

INT: Some of the time he's explaining things to you.
Ch2: Yeah.
Ch1: Not as much though.
INT: Not as much explaining?
Ch1: Just gives us a little bit of detail and we can do it on our own.
(M3:2)

Ch1: Well if you get it wrong, she would explain, not exactly tell you the answer first but explain a bit more about it and hopefully you might get a better idea.
(J6:1)

This perspective was summarised by one pupil explaining Heather's round-about approach to revealing the right answer, as follows.

INT: I suppose I might say, why doesn't she just tell you the answer?
Ch1: Because we have to work it out on our own.
INT: Why do you think you have to do that?
Ch1: Because it is a maths lesson.
INT: That's what you do in maths lessons?
Ch1: Yes.
(H6:4)

Again, Pollard et al (2000, p.74) found similar views from children, in which 'children were aware of the status of Maths in comparison with other activities and of teachers' expectations that they would get through the work alone and in silence' and in

which 'serious maths was contrasted with more relaxed and chatty [subjects such as] technology'.

The individual nature of the view of learning identified might appear appropriate to those adopting a radical constructivist perspective. From such a stance it would be argued that by providing clues and encouraging individual effort, the teachers were supporting learning by scaffolding children's thinking (Bruner, 1986), acting as the 'consciousness' of them both until the child was ready to understand independently. However, from a sociocultural perspective, such an individualised view of learning might appear less positive, because of the limited extent to which children perceive social interaction as integral to learning. This is a theme which is picked up in the next chapter.

Finally, in terms of teacher and child roles in interaction, it was identified in chapter 5 that teachers tended to appropriate children's responses and to use selective judgement in receiving and responding to ideas, in order to control the direction of the discourse. The children here suggested that the same pattern was evident in all three of these lessons too and seemed highly aware of it, noting that the teachers recorded on the board selectively and that 'sometimes she listens, sometimes she doesn't' (J6:5). In Jane's lesson, one incident in particular, already identified above, led to interesting insights into the children's perceptions of this issue. 'James' had solved 133 ÷ 7 mentally and justified this publicly by arguing that 'I know nine 7s is the only multiple of seven that ends in a three and so I added nine 7s to ten 7s'. This elegant solution to the problem, one of several being offered by children, was politely acknowledged by Jane but not recorded on the board as all the others had been. The event formed one video clip shown to the child interviewees. The accuracy of the solution offered by James was noted and several different interpretations of Jane's response were elicited. One pair understood the choice made by Jane in terms of the example's mathematical value:

Ch2: If she is really like listening to them and they are like long division, she normally writes it on the board.
Ch1: Yes, if it is like short division, she won't write them up on the board.
Ch2: Because it is easy.

(J6:3)

A second pair seemed less sure of Jane's reasoning:

INT: She didn't write it down, I noticed.
Ch2: Oh no [surprised].
INT: Why not do you think?
Ch2: I don't know.

(J6:2)

However, other suggestions were made too:

> She likes her way. She likes it the way she was thinking. If she didn't think of it she didn't want to be embarrassed. (J6:6)
>
> She might have thought [that] it might have been a bit too hard for people to get. (J6:6)
>
> Because it was too complicated to write down, I think. (J6:4)
>
> I know. Because she wanted everyone to focus on that one method everyone else had said, so she decided what she was doing before he [James] said and he said if after and she didn't write it down. (J6:7)

I would suggest that these children had a clear understanding in terms of Jane's own likely reason, namely that it somehow did not fit in to her own conception of 'useful' approaches to division (though in fact one could quite easily argue that it is in many ways generalisable and would be a useful approach to many division problems). Such an observation would suggest that, at least in this case, children appeared to have a clear understanding of the pedagogical challenges facing the teacher. These observations might also explain the shifting attention of children who, in full knowledge of the teacher's likely response to their input, are well equipped to drift in and out of the interaction in safety.

Indeed, as Pollard et al (2001) report in their (PACE) study, 'the evaluative context of classroom life led most [children] to accept and prefer high levels of teacher guidance and control' (p. 20). Past studies have reported on the range of children's strategies for *avoiding* the need for interaction, for example Holt's (1984) 'fence straddlers' who mimed participation whilst waiting for someone else to answer, and Measer and Woods' (1984) 'knife edgers' whose raised hands were timed to avoid questions being directed at them. In the study here, evidence was seen of children turning Mark's selective attention into a game aimed at *gaining* attention, with one group of children reporting that being chosen to answer a question was more likely when they did *not* put up their hand than when they did, since 'if we put our hands down, he thinks we don't know, so we get to answer' (M3:3). These examples serve to remind one that interaction is a complex and subtle social process, extending far beyond the content matter of the teaching in question and that children's aims and intentions may be far removed from those of the teacher.

Children's perceptions of difficulties in understanding explanations

The paragraphs above identified some of the children's perceptions of the roles involved in learning in the whole class interactive teaching situation. It was evident that children had a clear understanding of the teacher as authority in terms of right and wrong responses, that the focus of interaction tended to be on what was wrong rather than what was right, that the teacher 'gave clues' about answers, and that these things contributed to an understanding of learning as an individual process, even in a social context. This does not imply that they failed to recognise the role of others in contributing ideas which were then open to public consideration. Indeed, in referring to the 'refinement of methods' detailed at the start of this chapter, children's comments repeatedly demonstrated their understanding of the purpose of talking as a class as 'taking on answers', 'getting a better

idea', peers 'helping you to understand' and 'picking up ideas' from other people. Even the younger children appeared to have a clear sense of how making ideas public was meant to lead them to develop new ideas themselves and all three teachers emphasised this point to their pupils in one way or another. However, though the *activity* may have been joint, it was the process of meaning making that was seen as an individual enterprise.

Regardless of their view of learning though, common to all children was a very clear sense of the practical difficulties of facilitating the process of idea sharing. Two problems were made explicit in particular: the *clarity* and *comprehensibility* of speech of other children, and the children's own *resistance to conceptual change.*

Anecdotally, as both a researcher and student-teacher supervisor in many classrooms, I have often been struck by my inability to hear a response from a child and of generally how poor the clarity of speech is – a view supported more objectively by Alexander (2000) in relation to UK classrooms. For children here, the same seems true, and was a recurring theme of their discussion with me. Almost all could name 'expert' explainers who could be relied upon to give clear explanations, both in terms of audibility and comprehensibility. Conversely they readily identified others whose responses were predicted *a priori* to be worthless. For example (names given are pseudonyms):

INT: And are Pete's explanations clear?
Ch2: Yes,
Ch1: I think Lucy's are alright even though she makes it something complicated.
Ch2: Lucy does really long complicated ways of doing it.
Ch1: And we just do it really simple ways.
Ch2: We do like that sort of one.
Ch1: Yes. Or short division and not long division. Sometimes Len Nokes is quite clear.
Ch2: Yes, he normally gets things right.

(J6:7)

INT: Listening to your ideas. Is that helpful?
Ch1: He [Mark] sometimes can't cos Paul and that sometimes talks all the way through and that.

INT: Are there people who it is easier for him to listen to and people who are less easy?
Ch1/2: Yeah.
INT: Who's particularly easy to listen to?
Ch1: [names Ch2 – laughs].
Ch2: Helen.

(M3/4:4)

A host of difficulties were identified by children regarding hearing and understanding peers including volume, seating position in the classroom, lack of clarity of explanation, complexity and long-windedness. In addition, some children reported feeling that they themselves could not explain how they did something – and therefore could not share it. Others reported resistance to change even when able to understand another idea.

INT: Do you pick up ideas from other people?
Ch1: Yes.
Ch2: Not very often.
INT: Can you say more about that?
Ch2: I don't find it any easier.
.....
INT: How about you John?
Ch1: Sometimes, maybe if I find one way of doing things I stick to it.

(J6:6)

INT: Do you find it difficult or do you follow it, or a bit of both?
Ch1: If there is complicated stuff I just ignore it. If Beth or Sally gives it, if it is not too complicated I listen to it better. With Paddy, it is too complicated.

(H6:4)

Such resistance again raises Taylor's (2003) point about the difficulty of change and the need to live with discomfort in order to be able to take on meaning from others. Put together, the difficulties of hearing and understanding outlined in this section, together with the complexities of the roles adopted by teachers and pupils during interaction, challenge the relative simplicity implied by the National Numeracy Strategy's assertion that children should engage in interaction that 'allows pupils to show what they know,

explain their thinking and methods and suggest alternative ways of tackling problems' (DfEE, 1998b, p. 14).

The supremacy of listening over talking

Finally, in reporting children's understanding of *how* the learning process in interactive teaching takes place, attention is turned to the way in which children understood the purpose of talking and listening.

In choosing video excerpts and listing 'teaching approaches' for children to comment on, a deliberate attempt was made to explore how they understood the role of listening and talking as a *means of* learning. One question in this respect was whether or not children considered the *acts* both of listening and of talking as processes by which they could learn, or whether they were merely incidental in the wider milieu of classroom life. This question was explored through discussion about the video clips during the interviews. In addition, during the latter stages of their interview, each pair of interviewees was asked to comment on the extent to which the teacher 'helping you to talk and listen to each other' was useful in helping them to learn mathematics.

In summary, by Year 6 the children appeared to realise quite clearly that the process of listening to public talk was a means of learning, in so far as they perceived classroom dialogue as a way to access a range of ideas, some of which might be of value in extending their own understanding. Children were able to make explicit examples of this process, to the extent that some compared it to other learning approaches, for example:

> Ch1: Yes, I don't like writing.
> INT: Why not?
> Ch1: I just like doing it [talking about it] with other people and sharing it with other people, whereas if you are doing it on your own you are not allowed to talk to anybody and you might not understand what you are doing.

Ch2: Yes if you don't understand, it is better to hear someone else saying what they have done and they can explain it. Instead of just doing it wrong.
(J6:3)

At Year 3 and 4 the particular children in this study were less clear about how talking and listening contributed to their learning. Of the six pairs of this age, only one pair could readily articulate a reason why 'helping you to talk and listen to other people' might be useful. Though the other pairs all answered 'yes' when I suggested it might be a useful strategy (perhaps reflecting Mark's comments to them during the lesson about listening to each other), none could expand on why, beyond simply referring to features of listening itself, such as being able to 'hear' above the noise created by other children. Of course this is likely to reflect, at least in part, their inability at this age to articulate their understanding of classroom processes.

However, it stands in marked contrast to their responses to questions about the other five elements of teaching – for example the use of teacher questions and of Mark listening to their responses – for which insightful and articulate answers were provided on the whole. Question response times were analysed and children's responses to these questions tended to be within two seconds. In response to being asked about the value of talking and listening to each other, children's average response time was 5 seconds suggesting that this was an issue that they were less confident with; a feeling that appeared evident during the interview.

Whilst one needs to be very careful in making any major claims from such slim data, it certainly seems appropriate to suggest that these particular Year 3 and 4 pupils did not readily view the act of talking and listening to each other as a part of the process *through which* learning might take place. Rather, they tended to view learning in terms of actions taking place between them personally and the teacher. This may not of course be the case with other groups of similar aged children and may simply reflect Mark's own teaching as much as any generalisable view of learning. However, it does, at the very least, raise an important question about the ways in which teaching approaches and curricula in use in NNS classrooms tend to shape children's understanding of the learning process.

In outline, therefore, though the younger children in this study appeared less able to perceive the act of talking and listening as a means of learning, the older children clearly understood the role of listening to public language in refining their ideas about mathematics, for example because 'it gives you a view of what other people are thinking in their minds' (J6:6). A similar distinction between these age groups was found by McCallum et al (2000). However, this view involved quite particular perceptions of each of the two elements of listening/talking. In particular, listening was seen as *more important* than talking and was referred to much more often by the children.

> INT: Helping you to talk and listen to other children in class?
> Ch2: Yes.
> Ch1: Yes, she does do that, yes.
> Ch2: I think maybe not helping you to talk but definitely to listen to other children.
> (J6:2)

> INT: What about helping you to talk and listen to other children in the class?
> Ch1: She just tells us to listen.
> INT: So there is lots of listening but not so much encouraging you to talk, is that right?
> Ch1: Yes.
> (J6:4)

Of course, this is natural in a situation where when one person is talking 30 others must be listening and one would expect children to be highly aware of how much listening they are doing. Indeed, their comments in interviews were highly charged with the feeling that listening was a 'duty', with several references to teachers' *requirement* on them to listen carefully. However, the children's distinction went beyond simply the *extent* to

which they were involved in each aspect to the *purpose* of each. For example (emphasis added):

INT: What about this one – encouraging you to talk and listen to each other?
Ch2: Yes, because say if I said something and it is right, *if they didn't listen they wouldn't know*. Sometimes like if Sam says something, she'll say "Oh that's excellent".
Ch1: If she asks people who don't know, you would be waiting for say Chloe to work it out and then *if she gets it wrong and the teacher would talk to Chloe and let the whole class listen*. Sometimes it helps us as well, if we are listening.

(H6:4)

INT: What about the last one. Encouraging each other to talk and listen?
Ch2: Yes, because *if the class listen* then if they think something has gone wrong or if it is right ... or tell us if there is an easier way.

(H6:3)

The phrases in italics here imply a very particular view of the relationship between talking and listening, and of what each is for, namely that *talk is the fare of listening*. In this sense, talking serves only as the vehicle by which listening can take place. Children's perceptions of the role of listening and talking, and the associated view of learning in the whole class context, appeared to be that:

Teachers ask questions so that ...

... talk, directed back at the teacher, can be 'overheard' by others ...

... with salient points – as judged by the teacher – then remembered.

It is worth noting that a similar view was evident in the previous chapter in relation to whether teachers' requests for explanations of children's thinking represented requests to make meaning apparent or to confirm that a point had been understood. The teachers often began with the former representation and moved to the latter without opportunities for pupil discussion of the ideas involved. Children's responses to this were often to disengage with the discourse. In this pattern of response to children's contributions, talk is perhaps better described as 'listening fodder' and listening as 'overhearing' (the conversation between teacher and child). Whilst this view of learning may be a useful one in that it provides children with access to a range of ideas that they would not have on their own, it again positions learning as an individual venture and suggests that talk appears to serve no purpose of its own in the act of meaning making. The children in this study, encouraged by the actions of their teachers, appeared to view talking as part of the learning process only in as far as it facilitated listening by generating 'something to listen to'. Whilst perfectly legitimate, this view missed the opportunity to view talking as an act *by which* one could form meanings and experiment with ideas. Furthermore, listening itself tended to be passive, with children 'overhearing' conversations between the teacher and individuals and waiting until the 'right thing' became apparent, to then be remembered.

Of course, this view of learning is a simplification of what was, in practice, a more complicated set of understandings on the part of the teachers and individual children involved. In addition, McCallum et al (2000) present some evidence that Year 6 children had a more developed sense of learning through talk, though the general trend described here was very much the same. Nevertheless, I believe that it accurately reflects the essential nature of the situation and certainly, in talking to Heather after her lesson, her perception of the way in which talking and listening contributed to learning appeared to rest heavily on a view that privileged 'hearing'.

> Heather's focus on her own repetition of children's comments was striking. This was certainly something that she did consciously in order to help the children (though she did note that she maybe did it too much). "At least then I can be sure they've heard it".
> The focus is on 'hearing' it. There is no sense here (though there may be elsewhere) that the act of speaking it and of trying to make sense through talk is important as part of the learning experience. Instead the sense is of

> the words [being spoken] 'having' specific meaning which needs to be transferred to the children, i.e. one previous explanation will be acquired by others if only it can be heard clearly – and this is Heather's role; as interpreter.
>
> (Field notes, 29.05.02)

Even if one were happy with the privileging of listening over talking indicated here, there remains an issue about its form. Coles (2002, p.24), adapting work by Davis (1996), identifies three different forms of listening: *evaluative listening*, in which 'they [pupils] would see what others say in terms of right or wrong, and see listening as the others' responsibility'; *interpretive listening*, in which the listener is aware that what is being understood may not be what the speaker intended and that she/he must play an active role in interpretation, and; *transformative* listening, in which the listener is not only aware that there may be a difference in meaning between speaker and listener, but also that the listener needs to be 'open to the interrogation of assumptions [s/he] is making'. What Heather describes, and what the children appear to refer to in all but a few cases, seems to be listening which is interpretive at best, and largely evaluative most of the time. There appeared to be little evidence of children engaging in listening that was transformative.

Summary

This chapter has presented the findings of the interviews undertaken with children in order to attempt to understand how whole class interactive teaching is viewed from their perspective. The picture is, in some senses, a positive one. The children involved, even those as young as 8, appeared to understand the purpose of whole class discourse to a significant extent. They could articulate the intention that by making ideas public they could learn from each other and that such learning could lead them to develop 'better' ways of doing their mathematics. This reflected what they were being told by their teachers who were working hard to articulate the purpose of their teaching as they saw it.

The children understood listening to be important in this process and, naturally, had very clear perceptions of how the classroom discourse was being managed between the teacher and themselves. However, whilst being encouraging in these terms, the children's statements pointed to a very particular view of the roles of listening and talking, with the former taking precedence over the latter. Children also reported difficulties being experienced in practical terms, such as the audibility and clarity of other children's explanations, as well as appearing to have a particular conception of what learning entailed, with memorisation at its heart. All of this is likely to have a negative effect on their developing mathematical identities.

As was made clear at the start of this chapter, it is not possible to generalise these results with any certainty beyond the cases studied. However, the alignment of the findings here with others (notably Alexander, 2000; Pimm, 1987; Pollard, 2001; Jaworski, 1994; Edwards and Mercer, 1987) would suggest that they might extend beyond simply these bounds. Further evidence for wider applicability is provided by the observation that teaching approaches documented in chapter 5 were observed again in the classrooms of two new teachers (Mark and Jane) in a new school.

This evidence allows for the formulation of several fuzzy generalisations (Bassey, 1999) relating to the findings, as follows:

1. Key Stage 2 pupils may perceive interactive teaching in ways which lead to conceptions that recognise their own role in improving comprehension through listening to others (both teacher and peers). Such conceptions are likely to become more developed as the children get older.

Furthermore, *significant features* of this way of perceiving interactive teaching may be that:

2. Children's conceptions of what it means to learn may be largely based on notions of memorising 'best' results.

3. They may perceive the teacher as the ultimate arbiter of right and wrong and this may lead to impoverished interaction in relation to key mathematical processes, such as reasoning.
4. They are likely to understand features of the teacher's role which impact on the form of the interaction, including dilemmas for the teacher, and may have insights into patterns of behaviour and difficulties in communication within the classroom which would be useful for teachers to know about.
5. Listening may be privileged over talking by children and talking may be seen only as a means of generating 'something to listen to' rather than as a form of meaning making in its own right. This may result in important implications for the way in which children engage, or not, with the interaction.

These fuzzy generalisations indicate that, whilst the NNS has changed structural elements of teaching in the UK, it may have had little impact on some of the deeper cultural aspects of classrooms and on teachers' and children's conceptions of the way in which learning is most successfully effected. In particular, the move from classrooms in which individualised, written work was the dominant form of instruction to ones in which whole class interactive and oral work is far more prominent may not have been matched by appropriate changes in teachers' underlying theoretical perspectives on learning. In particular, their understanding of the significant role in learning played by discourse under such a structure, and the interrelationship between identity, practice and knowledge, may not yet be sophisticated enough. In addition, it will be argued in the final chapter that teachers face a considerable challenge in trying to encourage this kind of discourse, as a result of a complex interrelationship between classroom cultures, the nature of the curriculum and the nature of mathematics itself.

Meanwhile, to state above that teachers' understanding of the role of discourse within the National Numeracy Strategy may not be sophisticated enough implies a belief both in the value of joint, public discourse as a means of learning and in the NNS as being an effective structure within which this kind of interaction can take place. The next chapter therefore attempts to make a convincing case for discourse to be used in this way and compares the opportunities available to the practice that has been described in this chapter.

Chapter 7 – The case for discourse in the NNS

Introduction

Alexander (2000) has observed that in English (and US) classrooms, though children do more talking than in other international settings, this tends to be of a very informal nature. In French, Indian and Russian classrooms (which Alexander used in his comparison), children were far more likely to use spoken language as a cognitive tool, as opposed solely to a means of social communication. He notes that pedagogic interaction and discourse in UK classrooms:

> Is relatively informal, conversational, unstructured and above all private. There is little attention to precision and appositeness in the forms of oral expression which children learn to use, and although much is made of sharing, the implications of this collective commitment have not been followed through into a strategy for developing genuinely collective forms of talk. Close analysis of all the [data] force me unambiguously to the conclusion that in English primary classrooms, although much may be made of the importance of talk in learning, and a great deal of talking goes on, its function is seen as primarily social rather than cognitive, and as 'helpful' to learning rather than as fundamental to it.
>
> (Alexander, 2000, p. 566)

The increasing use of interactive teaching has meant that there may now be more talk to the whole class in English classrooms than when Alexander's data was collected (just as the NNS was beginning). However, consideration of the data referred to in the previous chapters suggests that dialogue even in the whole class arena, though superficially public, appeared to be largely private in the sense that it is very much between teacher and individual, with the rest of the class 'overhearing'. Rarely do children appear to be required to listen transformatively (in Coles' (2002) terms) and this seems to be consistent with observations regarding the importance, from the children's point of view, of

memorisation. More importantly, despite this increase in public talk, it is apparent from the data in the preceding chapter that listening is still seen as the key element of learning, with talking seen merely as a means of allowing it to take place, making Alexander's comment about the failure to follow through structural changes into 'a strategy for developing genuinely collective forms of talk' all the more pertinent. Alexander's central theme is that whilst structural changes are relatively easy to make, they do not readily bring about deeper pedagogical changes because of the strong cultural dimension of teaching. Thus, whilst the NNS has encouraged teachers to make changes to the style of their teaching, these may not have been accompanied by an understanding of how such changes could support learning in ways which are more than superficial. This appears to be particularly true of classroom talk.

Alexander suggests a number of changes to classroom practice in order to promote the value of oracy as a vehicle for cognitive development. Whilst some of these have changed with the advent of the NNS (changes to classroom layout; rethinking the balance between writing and oracy in the curriculum; rethinking curriculum specifications) others are more resistant, particularly the need to:

> Differentiate scholastic and conventional registers, and teach pupils to operate within different registers and codes, and to switch from one to another, as appropriate; balance collective, collaborative and individual discourse; shift from random, brief interactions to sustained and longer ones; and manage talk, and especially turn taking, in a way which enables pupils to develop ideas, raise questions and solve problems.
>
> (Alexander, 2000, p. 568)

These are clearly more sophisticated pedagogical challenges requiring an excellent understanding on the part of the teachers both of how learning might best take place and of the nature of the subject. They are however, I would suggest, essential requirements of a pedagogy that aims, as its key focus, to make mathematical *understanding* more than

superficial. Whilst memory, and superficial learning, may well produce short term gains in, for example, test result targets, it is unlikely to lead to the kinds of connected, conceptual understanding that the National Curriculum (DfEE, 1999j, p.60) defines as the legal entitlement for children, in which logical reasoning, problem-solving and thinking using symbolic tools are the key aims.

Moreover, reference to the kinds of pedagogical challenges referred to by Alexander formed no part of the NNS training at the outset, and though teachers have been encouraged to continue their own professional development through both formal training and less formal professional dialogue and interaction, it appears that they may be some way from engaging with the kinds of ideas that Alexander lays out here and which, as he notes, are not part of the deep, culturally embedded practices of primary education in the UK. In particular, seeing talk as a tool for cognition, as opposed to a means of generating something to be heard, does not appear to be part of our cultural heritage. For example, during school INSET a group of 16 teachers and Learning Support Assistants were asked to make explicit the purpose of talk in their teaching (Journal, 01.09.03). Without exception, they all included notions of making ideas public (and also included motivational, self-esteem factors) but none included the idea of the act of talking for cognition – though they all recognised its value once the idea had been articulated.

However, to criticise a system for not enabling teachers to make these deep changes whilst changing the structures that they operate within, one must be able to justify two claims; first, that teachers were asked to work in new ways without substantial access to a theoretical basis; and second, that discourse is, in fact, a valuable tool for learning in a whole class context.

In relation to the first of these issues, Chapter 2 made clear that there was indeed a new approach to teaching advocated by the National Numeracy Strategy, but that the Strategy was not clear in terms of a theory of learning to which it adheres. In all the documentation, encouragement to 'interact' with children appears to be in sharp contrast to views of learning apparently based on more teacher-centred, direct approaches. Such a contrast, it was suggested, led to two ideal types of teacher behaviour, and chapters 4, 5 and 6 have illustrated the effects of these in practice.

Regarding the second claim, that discourse itself is a valuable tool for learning, O'Connor (2001, p. 143) notes that:

> Despite the persuasiveness of the assumption that whole group discussion in mathematics classes may promote mathematical learning, we know little about the mechanics that might underlie such outcomes.

Whilst I would agree that there may be much more to discover about the mechanics of how discussion as a whole class leads to the promotion of mathematical learning, a good deal is already known from a theoretical perspective about the value of discourse more generally. In reviewing this below and comparing it with data from the previous chapters, fresh insights into these mechanics are developed.

Interaction, dialogue and discourse

In considering the role of discourse in learning, the words *interaction, dialogue* and *discourse* require some brief thought in order to clarify their meaning and use. A dictionary definition of *interaction* (*The Concise Oxford Dictionary*) indicates the origin, namely *inter – act*, giving the definition: 'act reciprocally; to act on each other'. The NNS definition of interactive teaching appears to represent this meaning quite literally in talking of 'the two way process' and the need for pupils to 'talk and be listened to' (DfEE, 1999b) and it seems clear that teachers are being encouraged to ensure that they can both act on, and be acted on by, children.

Dialogue will be used to refer to 'talk' between individuals, though it should be noted that the word has been used in many different ways by other authors (see Barnes and Todd, 1995, p. 158 for a summary of some of these). *Discourse* then refers to the communication that takes place between people, which includes dialogue but also includes the many other ways in which ideas are shared and communicated, for example by non-verbal signals and contextual 'rules'.

Jones and Tanner (2002, p. 266) claim that,

> Research provides clear indications as to those factors which lead to effective teaching and learning of mathematics. These include higher-order questioning, the setting of challenging tasks which require pupils to think, requiring pupils to explain and discuss their own mathematical ideas, and collaborative problem solving (Askew *et al*, 1997; Brown *et al*, 1998; Jones *et al*, 2000). ... [and, in addition] ... the importance of dynamic scaffolding and reflective discourse, where pupils were expected to articulate and discuss their own methods and conjectures within a supportive classroom culture.
>
> (References in original)

They note also that to become mathematical thinkers children need both to make sense of mathematical ideas and to develop mathematical ways of thinking – to act as mathematicians. In order to do this, children need to be:

> Participating in a 'culture of mathematising' which is characterised by subjective, personal reconstruction of knowledge through the negotiation of meaning in social interaction. Articulation within this context provides an opportunity for pupils to test their understandings for viability against corporate meaning; it also contributes to the generation of corporate meaning by providing further opportunity for construal to other members of the class.
>
> (ibid., p. 267)

Dialogue then, and the involvement in a discourse about the mathematics, is seen by Jones and Tanner as all important. Such a perspective is based on a theoretical view of learning in which knowledge is generated within social settings and in which communication between individuals plays a major part, as summarised in chapter 2.

Wells succinctly (1987, p. 222) summarises this 'intersubjective' (Jaworski, 1994) perspective, stating that,

> We are the meaning makers – every one of us: children, parents and teachers. To try to make sense, to construct stories, and to share them with others in speech and writing is an essential part of being human.

It is apparent that the role of language – largely, but by no means entirely, talk – is at the centre of this view of meaning making. Edwards and Mercer (1987) note that words evoke perceptions and memories in a listener and that these define the context of the discourse, which is not seen as the physical environment, but as the 'tracks made of common knowledge' upon which conversations run (Mercer, 2000, p. 21; see also Barnes and Todd, 1995). Thus,

> We can say that the process of education, in so far as it succeeds, is largely the establishment of these shared mental 'contexts', which enable them to engage together in educational discourse.
>
> (Edwards and Mercer, 1987, p.69)

Mercer (2000) coins the term *interthinking* to describe this 'dynamic interaction of minds that language makes possible' (p. 16) and uses this to view teaching as the process of carefully linking what is already shared by teacher and children to that which is not, through dialogue. He compares this idea to Vygotsky's famous 'zone of proximal development' and notes that his view implies a slightly different idea; an *intermental development zone* (IDZ). This he describes as a 'shared communicative space' created 'on the contextual foundations of their [teacher and learner's] common knowledge and aims'. Then,

> In this intermental zone, which is reconstituted constantly as the dialogue continues, the teacher and learner negotiate their way through the activity in

> which they are involved. If the quality of the zone is successfully maintained, the teacher can enable a learner to become able to operate just beyond their established capabilities, and to consolidate this experience as new ability and understanding. If the dialogue fails to keep minds mutually attuned, the IDZ collapses and the scaffolded learning grinds to a halt.
> (p. 141)

Rather than meaning being *constructed* by individuals within a discourse, here Mercer is using the notion that meaning is *constituted* in an active, moment-by-moment process of negotiation *between* participants. One of the consequences of this, as Mercer points out, is that both parties need to stay mutually attuned. Another is that the theme of the discussion being constituted is not fixed and will shift as this negotiation takes place 'like a river that produces its own bed. [And hence] the outcome of the dialogue is not clear from the outset' (Voigt, 1994, p. 283). Clearly, this has important consequences for the extent to which teachers can plan and implement discourses in their classrooms which are intended to lead to particular endpoints (O'Connor, 2001). However, if, as the last chapter suggested, children view the goal of learning as the memorisation of ideas that need to be validated by the teacher, the quality of the IDZ is called into question. It was noted that the children in this study seemed more attuned to the strategic goal of 'surviving' the discourse – tuning in and out as they became aware of the possibility of being called upon to respond – rather than in engaging in it as a learning experience in the way Mercer describes.

A third point to note is the power of the discourse itself in driving the thinking that takes place between people. Wells, Mercer and Voigt all point to the resolution of collaborative conflicts in speech as being important in directing children's thinking in classroom activity. Mercer (2000) has pointed to the way in which the very *indeterminacy* of language requires interlocutors to struggle to make meaning and Barnes and Todd (1995, p. 159) refer to Bakhtin's belief that 'it is difference of perspective that provides the inner life of new understanding'.

Sfard (2001) takes this idea one step further in suggesting that, rather than it being *cognitive* conflict that fuels the generation of new meanings, it is actually the social conventions of discourse which are the driving force, with learners adjusting their language to try to stay in tune with that of a teacher. Her claim is that it is this process of adjustment that leads to understanding, not the onset of any *cognitive* conflict realised on the part of the child.

It is important to note in all the above that *dialogue*, *discourse* and/or *communication* need not mean external talk with another person. Barnes and Todd (1995, p. 157) draw on the work of Bakhtin (1981) and note that,

> To participate in a dialogue is to act as a speaking voice and this can be achieved not only face to face in living dialogue but also, for instance, by expressing the assimilation of and struggle with the words of others in a work of prose text.

One implication from the point of view of the teacher/learner in the interactive teaching situation is that as well as oral language it might be prose, images, manipulative resources or other tools associated with mathematics classrooms with which children are 'struggling' in the above sense. Importantly, children need not actually be speaking to be engaged in a dialogue. Rather, it is apparent that it is their *involvement as a speaking voice*, even if this is silent and internal, which marks out engagement – and of course, vice versa, speaking does not necessarily imply engagement either (Denvir and Askew, 2001).

Nevertheless, talk between individuals is likely to be a crucial and effective form of engagement and previous studies have demonstrated the link between language use and thinking. As Pimm (1991, p. 23) makes clear,

> Communication is not the only function of language. Externalizing thought through spoken and written language can provide greater access to one's own (as well as for others) thoughts, thus aiding the crucial process of

> reflection, without which learning rarely takes place. In mathematics, language can be used to conjure and control mental images .... As well as provide access to others.

An example is provided by Mercer et al (1999) who found that children could improve their ability to solve reasoning tests as a result of being taught to use language more effectively, and that there was a correlation between the use of 'exploratory talk' and success in solving problems. This points to the need to *teach* children how to use talk effectively in this way and, therefore, to making talking a more formalised – in the sense of explicit and well understood, not of 'strict' or controlled – part of classroom practice.

All the above leads to the conclusion that there is little doubt about the central role that discourse can play in learning in general. How, though, does this apply to the subject of mathematics and, most importantly, whilst discourse clearly *can* play a central part in learning mathematics, what are the conditions under which this is most likely to take place successfully? In beginning to consider these questions it is worth noting that all the studies above have been based on analyses of talk undertaken in small groups or between just two individuals (with the exception of O'Connor, 2001) and hence, more specifically, it is necessary to ask how the development of learning through discourse might relate to the use of whole class situations. However, before turning to this question, brief consideration is given to the particular issues surrounding language in mathematics classes.

Mathematics and language

Pimm (1987) has remarked on the connection made between mathematics and language and the frequency of reference to the notion that 'mathematics is a language'. He has comprehensively and clearly delineated the various different interpretations, noting that the idea could mean any of: Maths *and* Language, Language *of* Mathematics (or vice versa if the aim is the analysis of language) or Mathematics *as a* Language. This

delineation serves to point to the complexity of the relationship between the two words. In a mathematics lesson there is: both mathematics and language 'going on'; language used to speak *of* or *about* mathematics; the potential for one to view the symbolic nature of mathematics *as* a language – further complicated by mathematicians' use of both word symbols and signs such as +, <, = etc. Thus, in an examination of a mathematics classroom from the point of view of language use, one needs to remain aware that language is both being used to talk about the mathematics (and thereby to develop mathematical ideas), and to develop new mathematical language itself.

Mercer (2000; 1995) and Voigt (1994), from their interactionist perspectives, would see these two elements as being highly interconnected. One learns to talk about mathematical ideas by learning to use language, but the language itself, being symbolic of an idea that needs to be negotiated between participants, must be learnt through a process of trial use and alignment with other 'experts'. From this perspective, neither the language nor the idea comes first. Rather they develop in parallel. Barwell et al (2002, p. 13) suggest that taking a different approach and isolating vocabulary from the rest of children's language use by implying that words simply need to be 'used' accurately is likely to misrepresent 'the complexity of mathematical language and of mathematical meaning' and lead to less effective learning. Thus, they recommend 'seeing language as a process rather than as a fixed entity and as a resource rather than a set of rules' (ibid., p. 15). The aim, ultimately, is to help children to develop competence in the *mathematics register* 'a set of meanings that is appropriate to a particular *function* of language, together with the words and structures which express these meanings' (Halliday, 1975, p. 65) and that 'part of learning mathematics is gaining control over the mathematics register so as to be able to talk like, and more subtly to mean like, a mathematician' (Pimm, 1991, p. 18).

As far as the National Numeracy Strategy is concerned, specific advice about language development is provided in the booklet *Mathematical Vocabulary* (DfEE, 1999i) which accompanies the Framework. However, far from taking a problematised view of language development which reflects the complexities outlined in the preceding discussion, 'the purpose of this information [the booklet] is to identify the words and phrases that children need to understand and use if they are to make good progress in mathematics' and, furthermore,

> There are, then, practical reasons why children need to *acquire appropriate vocabulary* so that they can participate in the activities, lessons and tests that are part of classroom life. There is, however, an even more important reason: mathematical language is crucial to children's development of thinking. If children don't *have* the vocabulary to *talk about* division, or perimeters, or numerical difference, they cannot make progress in understanding these areas of mathematical knowledge.
>
> (ibid., p. 1, emphasis added).

The irony here is that though language is linked to thinking it is, simultaneously, divorced from it. Language, it is claimed, needs to be acquired in order that children can *then* think, rather than being an integral part of the thinking process. Children are therefore required to be introduced to particular words 'at the right time' and may then show their 'failure to understand' them. Such a stance seems to follow earlier publications from the School Curriculum and Assessment Authority (SCAA, 1997) which adopted similar models of the role of language. As Barwell et al identify, the NNS approach bears little relationship to the more complex understanding of register outlined above.

> A 'structured approach' [suggested in the vocabulary booklet] does not necessarily demand 'correct terminology' or 'sorting out ambiguities or misconceptions' nor the categorical advice of the NNS text with its shoulds, needs and directives. Instead [in a more problematised approach] ambiguity is fore-grounded and recognised, multi-modality is invoked, not just vocabulary, and there is an implicit awareness of the interactive and social nature of language in use.
>
> (2002, p. 15)

This problematised approach does not appear to be the position taken in practice by the children and teachers in this study however. All the evidence was of teachers taking control of language and 'appropriating' children's talk for their own ends rather than allowing children the opportunity to experiment with the language in order to gain control over both the words themselves and the ideas that they represent. In particular, the over-riding view of both children and teachers was that children's talk in whole class interactive teaching situations is for *listening to* rather than for acting out meaning, with few opportunities being given for children to gain control over the mathematics register. Rather than encouraging engagement in the struggle to make sense of language in the mathematical context, language needed to *be correct* from the outset. Where children struggled to use language 'correctly', it was taken over by the teacher and reorganised for the class, in order that it could be listened to in the form decided on by the teacher. It is unsurprising that, given such a simplistic view of language, embedded structurally (via the vocabulary book and the framework for teaching) in the NNS, children and teachers seem to mirror this perspective.

In addition to ideas about language use, Pimm (1987) points to the possibility of a very different meaning of 'Mathematics and Language'. He suggests using the *metaphor* of foreign language learning to illuminate a potential approach to learning mathematics, namely that a foreign language can either be taught and *then* used or it can be taught *through* its use. Crucially, being taught a foreign language through use implies the need for communication as the motivational driving force behind the development of the language. Metaphorically, the need to make sense of mathematics within a community of mathematical discourse might similarly drive the need to make sense of the mathematics – to 'understand' at the deep level. In essence, this is Sfard's (2001) argument about discursive conflict again which forms part of the wider view of learning being the involvement in social practices, as outlined in chapter 2. The metaphor, Pimm points out,

therefore mirrors two possible approaches to teaching mathematics: mathematics learnt independently as a body of ideas, to be subsequently inter-related and applied; or mathematics to be learnt by means of an ongoing discourse examining the inter-connections and application of ideas and the meanings carried by symbols, with the need for effective communication driving the learning which thereby *leads to* the development of a body of knowledge.

If the National Numeracy Strategy is viewed in the light of this metaphor then the kind of interactive engagement recommended in the Strategy might be expected to provide a need for effective communication which consequently drives understanding in the group. However, evidence reported in the last two chapters relating to children's and teachers' views of the subject – in particular the focus on memory, the dominant role of listening over talking and the complications for children engaging in any discourse – suggest that this may not be the case and that Pimm's alternative model in which mathematics is first 'learnt' individually as a set of ideas and then applied, predominates.

Discourse and the interactive whole class teaching situation

In summary, the preceding discussion has noted the centrality of discourse, particularly talk, in the process of meaning making, with the indeterminacy of language itself playing a major role in this process.

If one accepts the importance of discourse in learning mathematics claimed here, there remains the question of finding the conditions under which this is most likely to take place successfully, and it is to this that attention is now turned.

Quality, not quantity

There is widespread agreement in the literature going some way back that, though discourse is to be encouraged as a tool for learning, it is not simply enough to have *more* talk going on; rather, it is the quality of the discourse that counts. Alexander (2000) notes that both the UK and USA adopt teaching approaches in which discourse is highly unstructured and unclear in comparison to other countries, notably India, Russia and France, but that despite this relative lack of clarity there is actually more talk taking place (measured in terms of number of interactions per unit time). He suggests, however, that this greater quantity in the UK and USA does not make up for the lack of quality shown in comparison to the other countries where, importantly, though more formal in style, the rationale for classroom discourse is clear to both teachers and pupils.

Mercer (1995, p. 114) comments that, 'a sociocultural perspective ... highlights the need for a rationale, in terms of both procedures and principles, for the activities learners are expected to do as part of their education' and that 'learners themselves need access to that rationale'. Similarly, Sahlberg and Berry (2003) point to the need to train children to learn together through interaction and Sfard et al (1998) discuss at some length the pros and cons of using language to learn mathematics, but all agree on the 'decisive role of the teacher [regarding] whether a given mathematical conversation, designed for the purpose of learning, will be a success or a failure' (p. 50). They note too that 'futile, useless and even harmful types of discursive activities can be observed only too often in mathematics classrooms all over the world' (ibid.). Mercer, like others since Sinclair and Coulthard (1975) refers to the common, and often unproductive, pattern of Initiation-Response-Feedback (IRF) which appears to dominate classroom interactions everywhere (though Wells (1993) points out that it is the *manner* of its use that counts and IRF can from part of effective interaction). Woods (1983) refers to Hammersley's (1977) observations that teachers rarely asked questions that were meant genuinely to explore children's ideas but tended to 'shape responses' towards those that were desired. Pimm's (1987) suggestion that mathematics and foreign language learning might be metaphorically similar is pertinent here in that central to his argument was the suggestion that the *need* to communicate in both cases is a strong driving force for intellectual development. Edwards and Mercer (1979, p. 46) describe the same idea, noting that,

> Most of the questions that teachers ask do not, in the most straightforward sense, seek information. They are part of the discursive weaponry available to teachers for controlling topics of discussion, directing pupils' thought and action, and establishing the extent of shared attention, joint activity and common knowledge.

In trying to illuminate the nature of effective discourse, Mercer (1995, p.115) notes that, 'it is necessary for teachers and learners to establish some agreement about what 'talk' in the classroom is for and how it should be conducted'. In exploring this he makes a distinction between *educational discourse* – the discourse used in the act of teaching and learning – and *educated discourse* which describes the effective use of language for thinking and communicating within any particular domain. The distinction is useful in helping one to appreciate that for teachers,

> The important goal of education is not to get students to take part in the conventional exchanges of educational discourse, even if this is required of them along the way. It is to get students to develop new ways of using language to think and communicate, 'ways with words' which will enable them to become active members of wider communities of *educated discourse*.

Furthermore,

> One problem with most teacher-led discussions in the classroom is that they only offer students the opportunity to make brief responses – there is a mismatch between the educational discourse they are engaged in and the educated discourse they are meant to be entering.
>
> (Mercer, 1995, p. 80 – 81)

All three of the teachers whose children were interviewed in this study worked hard to make explicit to the children the role of listening. Less clear was the role of talking, though Jane noted on several occasions during the lesson that talk allowed the sharing of ideas between individuals – an idea that appeared to have been clearly understood by the children. Nevertheless, the result from the children's perspective tended to reflect a view that what mattered was the quantity of listening they engaged in, rather than the quality of both the listening and the talking. It might be said then that these children tended to remain within educational discourse rather than moving to educated discourse, with listening being largely evaluative or interpretive, but rarely transformative (Coles, 2002), and talking being seen only as a form of 'listening fodder'. Of course it is easy to criticise what is, in reality, a highly complicated and difficult situation to manage and it is worth noting, in relation to Mercer's suggestion about the need for some agreement between teacher and children regarding the purpose of language, that there may be forms of such agreement that do not require this kind of quality. In particular, educational discourse alone may be sufficient when the goals of interaction are related to learning that is more strategic than relational. One question that this thesis raises therefore is the extent to which the National Numeracy Strategy tends to promote one form of learning over another – whether children need to learn mathematics in a deep, inter-connected way or whether it is sufficient to know, strategically, the 'right' things.

In the more particular context of effective discourse in mathematics classrooms, Mason (Sfard et al, 1998) calls for a *conjecturing atmosphere* in which ideas are presented as open to change rather than an atmosphere in which 'utterances are expected to be pre-formulated, correct, and justifiable' (p. 48). He notes too the inter-relationship between personal or group work and hearing what an expert has to say. Mason argues that each can 'prepare the ground for the other', but that this leads to a problem of 'changing modes'.

When children have been working collectively they need the opportunity to move into individual work in order to 'reconstruct ideas, situations and techniques for themselves' so as to be able to reconstruct them again when they are needed in the future. Written just prior to the introduction of the NNS and its three part lesson, this nevertheless provides a strong theoretical basis for the notion of whole class interactive teaching (collective) followed by individual or small group work, ending collectively in a plenary, as recommended by the Strategy. However, Mason goes on to point out that,

> Most difficult is moving from individual work to collective work: listening, adapting to and building on others' thinking, learning to suppress one's own approach in order to appreciate someone else's, learning to express one's own approach in ways in which others can enter and appreciate.
>
> (p.50)

Here Mason identifies the difficulties facing individuals in trying to share their good practice with each other and perhaps begins to explain why discourse in any whole class interactive teaching situation may be more challenging than it is made out to be in the National Numeracy Strategy and why 'quality discourse', though clearly desirable, may be hard to achieve in practice compared to simply raising the quantity of classroom talk. Certainly, these thoughts are echoed in the children's descriptions of the difficulties of learning from each other in a whole class, interactive environment. Hearing clearly, understanding explanations from some individuals and changing one's own established conceptions of an idea, all emerged as challenges to be overcome in doing so.

Interaction and power relationships in the whole class setting

So far this discussion has focused on the nature of language itself in relation to classroom discourse and for mathematics teaching in particular. However, mathematics classrooms form just one part of the wider context of schooling as a whole and within such

a setting there is constant interaction between members. Woods (1983), for example, analyses the school situation in terms of 'contexts, perspectives, cultures, negotiation, and careers' as areas of focus. This interactionist viewpoint helps to maintain the complexity of the situation and serves as a reminder that the discourse of the mathematics classroom, though affected by the demands of communication and of the peculiarities of mathematical language, is ultimately a social setting which will run accordingly to its own (often implicit) 'rules', and that these will be most strongly affected by the inter-relationships between people. Because of the nature of the adult-child and institutional relationships involved, the relative balance of power is likely to be a dominant feature in terms of the effect on discourse. Barnes and Todd (1995), in their study of meaning making through talk, conclude that,

> It has become clear to us in the course of this study that the allocation of power affects how people take part in the formulating of knowledge. The effect of placing control of relevance in the hands of one person is to emphasise his content frame, and this will affect profoundly the basis upon which others participate. If on the other hand, alternative frames are open to negotiation, this will influence not only who takes part but also the knowledge which is celebrated. Thus, what is learned by discussion in a group of peers will be different in kind as well as content from what is learned from teachers.
>
> (p.166)

This idea seems important in the light of the perceptions of the children in this study regarding both what was being learnt and who validated it. On the whole, though many ideas might be shared, children appeared to perceive that there was often a 'right' one to be remembered and that the teacher would identify this. Coupled with this was the more general understanding that there are 'best' approaches to calculating irrespective of context; a notion questioned by Threlfall (2000) and discussed in previous chapters. Again this raises the question as to what kinds of knowledge these children were developing and, in particular, whether it was more strategic than relational.

Bearing in mind the question of the way in which changes in the locus of control affect what is learnt, it is worth returning to a point made earlier, namely that most of the studies on the use of language in learning carried out to date have been focused on small groups of children interacting together or with a teacher. However, the context for this study is a whole class working with a teacher in the public arena of the classroom. It is appropriate to ask, then, how the findings from previous work in the small group context might translate to the larger group, bearing in mind the points made about power relationships above. In order to begin to explore this question the features of dialogue identified in small groups by Barnes and Todd (1995, pp. 158 – 163), who take a Bakhtinian perspective, are considered in turn, with thought given to how they might relate to the whole class setting and the findings from this study in particular.

Barnes and Todd first identify *difference of opinion* as the key element in negotiated meaning. Here, 'difference' does not imply the choice between two ideas, but is, rather, used in the Bakhtinian sense that differing viewpoints constantly influence the moment-by-moment thoughts and related acts of speech – the 'interthinking' (Mercer, 2000). The *mutual attention* given by each participant is then crucial and, where learning appeared most prominent, 'replies took on board and responded to (even if disagreeing with) what had just been said, as a socially and cognitively combined act that transcended surface linguistic forms such as question/answer'; hence 'dialogue, accordingly, pays attention to the other' (Barnes and Todd, 1995, p. 159). For there to be differences of opinion in this sense with related responses, it is essential that children are asking the question 'what do I think about this?', at least implicitly. Simply having children 'report' their thinking with no engagement in considering its relevance, accuracy or usefulness will be of little value. Now, whilst this may be relatively straight forward in a small group of participants, in a class of 30 or more children such mutual attention, as well as the variety of differences of opinion, will be considerably more difficult since the opportunities for the

kinds of interjections, clarifications, signals of understanding etc. that constituted these features of small group talk, may not be possible. Crucially though, there must be a *need* to listen transformatively and to talk coherently and with meaning: transforming one's understanding needs to be the *purpose* of the task itself. An example of this distinction might be the difference between a task which asks children simply to discuss an idea and one in which the task is to 'ensure *everyone* in the group understands the idea'.

Hypothetical cases, in which learners put into words ideas that are still experimental, form part of the process of understanding by 'liberating oneself from ideas that have seemed authoritative so far .... Something one used to take for granted is now something one has begun to resist' (p. 160). Such hypotheses are supported in their effectiveness by the idea of *tentativeness and absence of prior roles by right.* Barnes and Todd use Bakhtin's (1981) notion of two differing forms of discourse: *authoritative discourse* 'which comes as a given, fused with the authority to which it gives expression' (Barnes and Todd, 1995, p.157); and *internally persuasive discourse* in which ideas are developed jointly from the differences of opinion brought to the discourse. They noted in their observations of groups that ideas put forward tentatively tended to be worked on by the group for longer and more profitably, and that this process was dependent on members of the group *not* having authoritative roles which would mean that their contributions took priority over others. Rather, contributions were made 'accenting the individual nature of an utterance while at the same time inviting another's view' (p. 161). However, Barnes and Todd were working with small groups, often talking without the interaction of the teacher. Since the teacher is bound to be associated with an authoritative stance, it begs the question as to whether any discourse in which the teacher is involved must be an authoritative discourse. One solution to this is for the teacher to withdraw from the discourse as far as possible, and in chapter 5 this is what Heather was seen to be doing on some occasions. By carefully not revealing her own response to an answer she was able to keep the question alive, allowing the tentativeness to remain and thereby encouraging children to continue to consider the issue as stake. A second solution is for the teacher not to withdraw, but to make explicit to the children that her role is to remain disengaged from the discourse and that she expects the children to assume control of the reasoning taking place. Skidmore (2000) provides further examples of such strategies and uses the contrasting ideas of a 'pedagogical dialogue' (in which the teacher adopts an authoritative stance in the discourse) and 'dialogical pedagogy' (in which the teacher draws back and allows children to control the discourse). However, whilst this is in no way straightforward even with small groups of children, in the whole class setting, where issues of management are much more prevalent, finding the right balance between maintaining a presence in the discourse and stepping back from it presents a considerable challenge.

Together with tentativeness came *mutual support* for the ideas, even where participants disagreed. Again, all these features of discourse seem difficult in the teacher directed, public, whole class interactive teaching scenario, particularly where the teacher's dominant role is set *a priori* by the nature of school as an institution and where the freedom of contributions to a discussion tends to be severely limited.

Finally, Barnes and Todd identify the importance of *lack of closure*. In their study, they noticed that groups would return repeatedly to an issue in a cyclical way, keeping the topic open for debate and creating 'an openness to further inquiry, further examination, which was what took the groups forward into new conceptual territory'. This is the notion of negotiation and the 'indeterminacy' of language (Mercer, 2000) in action, and Barnes and Todd comment that,

> The absence of a final word - inconclusiveness - is also what opens up the very possibility of a future. What is concluded has no present and therefore no future, only a past. Equally, what is complete cannot adjust itself to, or respond to, another speaker – 'what is complete is hopelessly ready made'

> (Bakhtin, 1981, p. 34). For that reason it is ill-suited to the process of creating new meaning.
>
> (1995, p. 163)

Again, this seems crucial, and where whole class interactive teaching is pre-planned and aimed at particular endpoints it would appear easy for teachers to 'close' topics at moments at which *they* think it appropriate; as Frances did, in telling the children that they must wait for 'her lesson' to finish and in stopping at answers which she judged incorrect whilst moving on over those that were correct (chapter 5). This, indeed, appeared to be how the children in this study understood the situation, 'waiting' for a solution to come along and relying on the teacher to identify it for them as the 'right' one – at which point the discourse was closed by the teacher.

Alternatives are open to teachers. Fielker (1997), for example, suggests that teachers need to maintain an element of 'vagueness' in their examples presented to children so that the problem under discussion is not bounded too closely and remains open to different avenues of exploration. Claxton (1999) notes the need for 'resilience' and for 'persistence' in learners if they are to engage in these open forms of discourse, since they require them to feel comfortable with the notion of not understanding as a necessary pre-requisite for reasoning to take place.

All this, though, is in opposition to the view of teaching promoted by the NNS in which objectives are there to be reached each lesson and the teacher's job is to ensure that children reach them. Balancing these competing imperatives lies at the heart of the tension for teachers in adopting the practices and the philosophy of the National Numeracy Strategy.

Discussion

At the start of this chapter, the National Numeracy Strategy was examined critically in terms of the extent to which structural changes to teachers' practice had been matched by attempts to address deeper changes related to views on how learning takes place through discourses. Two claims were substantiated: first, that teachers were asked to work in new ways by the Strategy without significant access to a theoretical basis; and second, that discourse is, in fact, a valuable tool for learning in a whole class context.

It seems clear that discourse, and especially talk, has a clear role in effective learning, but that this requires teachers and learners to view it in sophisticated ways and to create learning environments that encourage conjecture, tentativeness and lack of closure. Furthermore, Pimm (1987) points to the potential usefulness of viewing the use of mathematical language as metaphorically like foreign language learning and of making the need to communicate through language the driving force for communication and understanding.

Barnes and Todd observed that 'what is learned by discussion in a group of peers will be different in kind as well as content from what is learned from teachers'. Essentially, this difference will be based on the fact that teachers are highly prone – as a result of their position in the classroom structure – to engage in (Bakhtin's) authoritative discourses with children, rather than internally persuasive discourses. The fact that the resultant learning is different is not, in itself, a problem, indeed it may well be an advantage in that different forms of learning are likely to be a good thing if considered carefully by teachers. For example, it may well be appropriate for learners to be asked to accept an idea on the strength of the teacher's authority *before* it can be fully understood (Sfard, 1991).

What is potentially problematic, however, is that teachers may well be unaware of the differences in the discursive forms of learning in which children are engaged and

therefore unable to make appropriate decisions about how and when to use whole class discourse. Given the strength of the National Numeracy Strategy's recommendations to increase 'the opportunity for the teacher to interact with the pupils' (DfEE, 1998b, p. 14), it is also clear that a good understanding of the theoretical ideas behind the recommended pedagogy would appear essential. Such an understanding may not yet be in place, as Earl et al (2003) have pointed out.

Just as it is not the case that discourse is the only way in which whole class teaching may be of value, so it is not the case either that effective discourse is impossible in a whole class situation (e.g. Fielker, 1997), even if the discussion above has identified significant challenges for teachers in managing it. Similarly, it seems reasonable, considering Mason's analysis of the inter-related use of individual and collective work, that the three-part lesson structure recommended by the NNS is indeed an effective format for many (though perhaps not all) lessons.

However, Alexander (1994, 2000) has argued that modern day English classrooms still reflect the structures and values of their origins in elementary schooling, and that these values are deeply embedded in our culture and are hard to alter. In addition, the current, degree of managerialism in education has encouraged an approach to classroom planning which focuses on small, identifiable 'pieces' of the curriculum and a belief that learning these pieces together will be sufficient – that the sum of the pieces *is* the whole. This approach allows for the kind of accountability required of teachers in demonstrating that the curriculum has been 'properly taught' – regardless of whether it is 'properly' learnt.

What is being suggested here is that the implicit values of elementary education and the effects of managerialism have created a *systemic* tension in the Strategy. Despite changes to classroom practice involving greater communication between individuals and, potentially at least, a more communicative discourse, the goal of the learning process remains the individual acquisition of *particular* knowledge objectives, regulated by the teacher. In terms of Pimm's (1987) metaphor relating mathematics and foreign language learning this is similar to the acquisition of only the vocabulary and grammatical 'rules' of a language. This aim persists in the Strategy; indeed the Strategy exacerbates it because of the fragmented, compartmentalised structure of the curriculum as laid out in the framework for teaching and the tightly controlled, objectives-led approach to lesson structures that it recommends. This approach has become *the* official version of 'good practice' and is tightly policed by the inspection system.

In contrast lies the process of developing ideas socially through interactive contribution to a discourse in which pupils stake a claim. This seems to be what the descriptions of 'good' interactive teaching recommend and Pimm noted that this could be seen as metaphorically similar to a foreign language being learnt through the need to communicate. However, it lies in opposition to the former model since such interaction, if engaged in genuinely, is not controllable, as Voigt's (1994) description of it as 'a river that produces its own bed' reminds us. Ultimately, the dilemma reduces to a single idea. In a system that focuses so exclusively on *particular* learning objectives tied to individual lessons, with learning seen as individual, linear and uniform for all children in the group, the teacher must control the interaction of the group very closely. For children therefore, even given the apparent opportunity to 'discuss' and share good ideas, the strategic approach is to do so in a way that remains focused on acquisition of the particular learning objectives in question – even where this leads to learning that is disconnected and inert.

This rather pessimistic view begs the question of whether or not effective interactive practices are possible at all. In using the word 'dilemma' above I am suggesting that they are, since what has been described here is a spectrum, not two absolutes. In practice, teachers can adopt teaching approaches, and more importantly create learning contexts, which promote the kind of 'conjecturing atmosphere' that Mason recommends (Sfard et al, 1998). The observations and interviews undertaken in this study

have themselves been littered with examples of such practice and, more generally, I have (Pratt, 2002, p. 37 – see appendix 11) suggested the following as examples.

> Where the emphasis is on mathematics *as* thinking [as opposed to the more common notion of *mathematical thinking*], however, it is more likely that children will be given time and space to make their own sense and, potentially, to learn more as a result – even if it is not the learning that the teacher had in mind at the start. ... Some strategies for achieving this [are to]:
>
> - Understand and value silence – as teachers we seem to fear it, but there are different kinds of silence and we need to understand the cause and potential value of each kind.
> - Provide the opportunity to receive more than one answer – ask 'what does everyone else think?'. This will mean there are several things to think *about.*
> - Add your own, potentially false, ideas so that children have to jointly argue them away – does the diagonal on a quadrilateral *have* to be straight? Sometimes these lead to interesting new insights.
> - Receive answers neutrally (which is very hard to do) – everyone stops thinking when they think they see the answer.
> - Ask 'can you tell me *anything* about ....?', not 'what is ...?' or 'how does...?' – it makes a huge difference since it values partial answers contributing to making sense jointly.
> - When children give half answers and then say 'D'yuh see what I mean?', do not always reinterpret it for them. Instead, say 'no' – then sensitively explain that they need to tell you more about it, or ask everyone else if they understand.
> - Give praise to the whole group for understanding other peoples' (joint) explanations – understanding is about a collective, two way process, not just an individual's ability to explain.
> - Finally, remind children that *not* understanding is the natural and necessary starting point for mathematicians and use this as the starting point for seeing thinking as the core element of mathematical work.

Crucially, however, it will not be *practices themselves* that matter in this, but rather the meaning associated with the implicit values that such practices carry with them, and the forms of engagement with the mathematics that these encourage in the children. Such approaches demand not just 'training' in 'effective teaching', but a deeper understanding of effective learning. It also requires an understanding of the nature of mathematics itself, and it is greatly ironic that it should appear so hard for teachers in the

current climate, with the existing curriculum, to generate a genuinely inquisitive discourse in a subject which is, by its very nature, intrinsically about investigating inter-relationships. As Stewart (1996, p. 2, emphasis in original) makes clear,

> Mathematics is about *ideas*. In particular it is about the way that different ideas relate to each other. If certain information is known, what else must necessarily follow? The aim of mathematics is to understand such questions by stripping away the inessentials and penetrating to the core of the problem. It is not just a question of getting a right answer; more a matter of understanding why an answer is possible at all, and why it takes the form that it does.

The final chapter takes up the interrelated themes of how mathematics as a subject, and teaching and learning as a practice, are understood. The discussion is framed in a number of different ways in an attempt to understand the problem multi-dimensionally, and thereby, it is hoped, more fully.

Chapter 8 – Concluding discussion

Summary of themes through the thesis

This thesis has explored the tensions faced by teachers in attempting to implement the directives of the National Numeracy Strategy in relation to whole class interactive teaching. It took as its starting point an assumption that teaching/learning was an essentially social activity based on interactions between individuals in social settings. From this perspective, two potential, opposing views of the Strategy were delineated and the empirical study then explored practice in relation to these two perspectives. The findings have pointed to a number of tensions for teachers, reflected in the thoughts and actions of children. Central to these is the tension generated in attempting to teach to specific objectives yet, at the same time, engaging children in discourse about the ideas involved; actions that epitomise the two contrasting ideal types developed in chapter 2.

Chapter 4 identified whole class interactive teaching, and the greater emphasis on the development of mental mathematics through the increased use of mental/oral activity, as two 'new' ingredients of teachers' work, considering them as being innovative and central to the National Numeracy Strategy (though Galton et al, (1999) have shown that whole class teaching generally had been on the increase since the introduction of the National Curriculum in 1989). It also noted that teachers felt relatively free to control their own teaching approaches and not bound by the Strategy in terms of classroom action. Indeed, a feature of the interview responses given by teachers was their positive reception of the Strategy, largely because it appeared to match the kinds of approaches they wanted to use anyway.

This observation needs to be seen in light of the increasing pressure on both teachers and children in the last ten years (for example, Connor, 2001, 2003; General

Teaching Council for England, 2001; more generally, Woods et al, 1997; Hargreaves, 1994). Within this professional environment, the literacy and numeracy strategies, and the model of teaching that each is built on, appear to be here to stay. The same is true of the testing mechanism, at least at Key Stage 2, which appears to have a major effect at the macro-level on the actions of teachers, the ways in which schools go about planning and implementing the curriculum (Earl et al, 2003) and the perceptions of children in terms of what their learning is for (Pollard et al, 2001).

Chapter 5 noted that an objectives-led curriculum, in which children's learning is planned tightly *a priori*, leads to a double tension for teachers: how to narrow the gap between the 'intended' and the 'realised' curricula (Voigt, 1994) and how to manage the tension between pupil creativity (often in the form of unwanted ideas or behaviours) and teacher direction in moment-by-moment classroom interactions. Furthermore, it was suggested that the latter is driven by the former, since the need to control children's contributions arises predominantly as a result of the need to 'manage' the learning that is taking place.

The term *tension*, it was noted, is used here in the sense identified by Woods et al (1997, p. 21) to mean the 'product of trying to accommodate two or more opposing courses of action where choice is limited or circumscribed' and 'where factors beyond the teacher's control impede decision making'. Such tensions are more than simply dilemmas, resolvable through 'professional action'. Particular instances of these tensions in practice were explored, gaining detailed insights into the sources of the tension in terms of the teachers' interaction with pupils. In summary, the question of who controlled the interaction between teacher and children appeared crucial, since slight changes in emphasis on the part of the teacher appeared to have marked effects in terms of children sustaining their interaction. In particular, the question of whether the teacher genuinely sought the child's view, or simply manipulated it for her own teaching ends, seemed highly important.

These observations could be understood in several ways: Bakhtin's (1981) notion of authoritative and internally persuasive discourses; the reading of symbols in the interaction between participants (Woods, 1996); or, different forms of working practice (Boaler, 2002). These are but different ways of viewing the same tension inherent in the teacher's role in the National Numeracy Strategy.

Chapter 6 sought the perspective of a group of children on such issues. Their views mirrored many of the findings of the previous chapter, suggesting that children learn early on what is expected of them and how classroom interactions really 'work'. In general terms, such findings come as no surprise and the ability, indeed the need, for children to learn such strategies for classroom survival at an early age is well documented (for example Pollard et al, 2000; Measer and Woods, 1984; Holt 1984; Woods, 1983). Explored in more detail, however, within this broadly familiar scenario, two results stand out as making a new contribution to research in this area. First, other studies have demonstrated that the introduction of the National *Literacy* Strategy (Hargreaves et al, 2003; Hardman et al, 2003a; Mroz et al, 2000; English et al, 2002) and more generally the National Curriculum (Alexander et al, 1995), appear to have made little impact at any deep level on teachers' observed interactive behaviour in the classroom; this despite the massive investment in teachers' continuing professional development relating to whole class interactive teaching. For example,

> Far from encouraging and extending pupil contributions to promote higher levels of interaction and cognitive engagement, the majority of time teachers' questions are closed and often require convergent factual answers and pupil display of (presumably) known information. .... Only rarely are teachers' questions used to assist pupils to more complete or elaborated ideas.
>
> (Hardman et al, 2003a, p. 212)

The work undertaken in this thesis suggests that the same may be true of teachers' interaction in Numeracy lessons too. This claim is consistent with other, larger, studies, for example Hardman et al (2003b) in a quantitative study (n=72 teachers) and Brown et al (2003), the latter challenging not only the lack of deep change in teachers' actions, but also the claim that the NNS has significantly raised children's attainment. All of this is in line with previous research into teachers' practices and the difficulty of bringing about significant change (e.g. Askew, 1999, p. 102).

More importantly, the thesis has explored in some depth the possible reasons *why* teachers find it challenging to extend their interaction in more sophisticated ways – reasons that do not emerge so clearly in the bigger, quantitative studies above – and goes some way, therefore, towards answering Hardman et al's call for

> further research into ways of effectively supporting teachers in their professional development in order to promote more reciprocal forms of teaching to increase the opportunities for extended interactions with pupils. (p. 214).

It was seen that these reasons are centred on very subtle shifts of emphasis on the part of the teacher during interaction with the class.

The second major contribution made by the thesis is the observation that the children and teachers appeared to hold views of the role of talking and listening in interactive situations that may not be useful in understanding how learning takes place as a result of classroom discourse. Despite apparently viewing talk as crucial, it was listening that was seen as the *way* in which new ideas would be learnt. The model was one of 'aural acquisition' of ideas *from* other people; not the joint construction of ideas *with* other people and talking was therefore seen essentially as a vehicle for generating information to be heard (and thereby learnt by means of memory). Such an observation goes some way towards explaining why teachers may be finding more extended interactions difficult to

engineer and to manage, as well as accounting for the lack of progress in effecting deep change to children's understanding of mathematics.

In light of the observations about discourse made in chapter 6, chapter 7 reviewed the evidence for the effectiveness of classroom discourse as a means of learning mathematics and drew the conclusion that it was the encouragement of conjecture, tentativeness and lack of closure – Mason's 'conjecturing atmosphere' (Sfard et al, 1998) – that was crucial in the use of discourse in conceptual development. What is needed, it seems, is a re-emphasis on the *quality* of discourse – talk in particular – in classrooms, with an associated, more sophisticated, understanding of its role in the creation of meaning between people. Such a move relies on the complex, sociocultural view of teaching/learning outlined at the start of this thesis.

The root of systemic tensions in the National Numeracy Strategy

The claim being made, then, is that the tensions described in the preceding paragraphs are *systemic*, and result from the documentation and the training that underpinned the National Numeracy Strategy's implementation. These did not adequately articulate the principles of both teaching and learning on which the suggested pedagogy is based. What teachers had access to was a set of descriptions of *what*, in outline, to do, but little in the way of *why* such approaches might be useful, and thus they did not have access to what the *essence* of these practices were. Such an approach to changing teaching practices is founded on the assumption that 'effective' practice can be identified and acquired by others unproblematically. In chapter 2 it was observed that there are three objections to this: first, that factors associated with effectiveness can be identified and that they are causal; second, that they are transferable and therefore not contextually dependent; and third, that 'effectiveness' has a shared meaning in the first place. Such systemic problems with the Strategy in terms of translating intended policy into policy-in-practice can be illuminated in a number of different ways.

First, in chapter 5 it was noted that Leach (in Alexander, 2000) identifies the strong distinction between descriptive and prescriptive accounts of action: the former needing to be kept brief in order to allow people to capture the entirety of the notion in question; the latter needing to be extensive and detailed if people are to use it in action. What the National Numeracy Strategy presents is a descriptive account of action, but for prescriptive purposes. That is, the invention of the notion of 'best practice', decontextualised and sanitised for use in whatever context teachers find themselves, leads to an idealised form of teaching which teachers are meant to 'deliver'. In the event, classroom practice has been distilled into advice that it is too condensed to be of real value in helping teachers to understand the subtlety of their actions – *why* what they are doing might be of value and, more crucially, what it is *about* the action that is most significant in bringing about changes in children's learning. Furthermore, this distillation has taken place against a backdrop of ever more centralised control of the profession and a reduction in the confidence of many teachers to reflect critically on their practice and to question the assumptions on which it is founded (Woods et al, 1997).

This distillation of advice about teaching, from intended policy to practice, can be better understood in a second way; through the notion of *didactic tension* (after Brousseau in Mason, 1988). As Mason (ibid., p. 168) points out,

> The teacher's task is to foster learning, but it is the pupil who must do the learning. The pupil's task is to learn, or at least to get through the system. … But what does it mean to learn, and how is it best assisted? The teacher looks for certain tell-tale behaviour, as does the examiner. The pupil seeks to provide that behaviour. Soon the focus is on the behaviour, not on the inner state which gives rise to behaviour.

In terms of the implementation of the National Numeracy Strategy, policy developers want teachers to make changes to their practice which are associated with what they see as more effective teaching and learning. However, all that is accessible to them in the NNS are the 'tell-tale behaviours' of this teaching practice and soon the focus is on these as procedures.

But the beauty of Mason's insight is that the process of didactic tension can be seen at a number of other levels throughout the National Numeracy Strategy too. Above the level of schools, internationally, governments look to other countries to try to seek out 'what works' and then encapsulate these practices in behaviours that pay insufficient heed to cultural differences (Alexander, 2000). Additionally, I might argue that governments look for the wrong kinds of behaviours in general by using, as their measure of success, test results which measure only a very limited range of learning (Claxton, 1999; van den Heuvel-Panhuizen, 1999). What is more, these measures do not even translate directly into the kinds of product the governments desire, namely applicable skills that can be used to the benefit of the economy. Meanwhile, below the school level, in the classroom, the systemic pressure faced by teachers and children in choosing between discourse and control, as described in detail in chapters 5 and 6 of this thesis, is itself another example of didactic tension. The teachers aim to teach children strategies for (say) calculating mentally, and look for behaviours such as listening carefully and 'sharing' their ideas, which they believe signify this learning. For their part, children can be seen seeking out these behaviours, which soon become the focus of attention. These layers of didactic tension throughout the Strategy appear to weigh down on each other, so that the tension at one level imposes itself on the next level down.

Of course, the description of didactic tensions above is stereotypical and in no way reflects the individual case of every teacher, each of whom will be finding his or her own way to deal with the issues under discussion. It does, nevertheless, describe a possible line of development from intended policy, through actual policy and thence to policy-in-practice, and the particular cases of this study, combined with the observations in other studies such as those by Hardman et al (2003a; 2003b), Mroz et al (2000) and English (2002), suggest that it may be representative of a more generalisable effect on teachers.

One issue at stake here, therefore, is that of 'professionalism'. Much has been written about the meaning and nature of the teacher as professional (see Woods et al, 1997, p. 16 for a summary) and no attempt is made here to develop this ground any further. However, it is important to note that if teachers are to make deep changes to their use of classroom interaction they will need to adopt a form of professionalism that encourages them to move beyond simple competencies. Rather, they will need to make the basis of their professional activity the resolution of dilemmas, which 'serve as a language of inquiry for describing schooling and exploring systematically the origins and consequences of the schooling process upon children' (Berlak and Berlak, 1981, p. 135). One key question that remains open in light of this study is whether the political and social environment in which teachers now work still allows teachers to take on this form of professionalism, despite increasing intensification and a resultant separation from the decision making process in respect of teaching activity (Hargreaves, 1994).

In the case of the issues facing teachers in this study, the danger is that it may not be dilemmas that are involved but, rather, tensions that are so strongly controlled centrally that they have become irresolvable by individuals. The evidence suggests that, even if teachers do manage to adopt the necessary reflexive stance, the resolution of the tensions apparently systemically inherent in their work still represents a considerable challenge.

Having reviewed these tensions in overview, they are now reconsidered in detail in order to understand them more fully and to bring together the sense of what the challenge facing such teachers really is.

The challenge of interactive mathematics teaching

It is being argued here that the challenge inherent in teaching interactively boils down to the resolution of a tension between the arrival at particular endpoints (lesson objectives) and the simultaneous engagement in interactive discourse which, by its very nature, is unpredictable. However, this tension is made up of a number of intertwined strands, since all classrooms are dominated by the complex relationships that exist within them. At their heart are the classroom interactions of teachers and children, but these are just part of the much wider 'epistemic milieux' and the many cultures and histories of the participants (Claxton, 2002).

In the following sections, therefore, the classroom culture, the nature of knowledge and of learning in English schools, the nature of mathematics as a discipline, alongside our cultural beliefs about this, and the curriculum structure, content and assessment are all considered as strands in the tension experienced by teachers and children.

Strand 1 – the effect of the cultural climate of the classroom and the nature of knowledge and learning

The model of teaching implied by the discourse surrounding the Strategy, and schooling more generally, is based on a model of learning as individual. This individuality is two-fold: first, it discourages any sense of the importance of the social in learning; second, it implies that learning is a fixed, characteristic of the person and that the learner cannot therefore improve his or her capacity to learn more effectively (Claxton, 1999). So, for example, schools' success is measured by league tables of SAT results which, from 2003, include the 'value-added' by the school across Key Stage 2 to individual children's learning. Such measurable outcomes of education have become a political necessity in an age of accountability where the measures need to be comprehensible to the general public if they are to serve a political purpose. This need mitigates against the use of more complex measures and leads to the maintenance of the status quo vis-à-vis models of learning. However, Lerman (2001, p. 89) has pointed out that as far back as the late nineteenth century 'Durkheim and Marx challenged the image of the individual as the source of sense making and as the autonomous builder of her or his own subjectivity' and hence, with it, the assumption that a teacher can be in control of the child's learning and that this learning is linear, smooth and measurable.

Claxton (1999) delineates several of the culturally inherited assumptions about learning that predominate in Western societies, noting that 'it turns out that many of these assumptions are the exact opposite of what the new science of learning [sic] ... is telling us' (p. 22). Amongst these, according to Claxton (ibid., p. 22ff.), are the popular assumptions that:

1. 'Learning is the acquisition of knowledge' – learning is seen as the end product rather than the activity inherent in the process.
2. 'Knowledge is true' – with the related assumption that the teacher 'holds' this truth prior to it being 'revealed' to the learner.
3. 'Learning is simple' – in the sense that it is just one thing: the building of pieces of knowledge one on the other.
4. 'Learning involves teaching [per se]' – and hence no learning can take place without the teacher's active intervention.
5. 'Learning proceeds calmly' – and hence that any learning that is not linear or which stirs strong emotional feelings is not taking place 'properly'.
6. 'Proper learning involves understanding' – and that therefore anything not understood has not, in any sense, been learnt.

The implications of these assumptions for teaching within the National Numeracy Strategy framework are important and, I believe, readily apparent in the analysis of data presented in the previous chapters. Assumption 1, that learning is knowledge acquisition, leads to the knowledge based structure of the numeracy framework itself and the belief in the target-orientated approach to 'lesson objectives'. In other words, what counts is only *what* is learnt, not *how* it is learnt; nor indeed *where* it is learnt, since transfer is considered unproblematic. Such an assumption, when combined with the suppositions that the teacher holds the truth [2] and that s/he is essential to the task of learning [4] each serve to make the teacher appear 'indispensable', and leads to the perceived imperative that the teacher must take control of the children's learning.

Assumption 3 (simplicity) legitimises this control in that it implies that learning *is* controllable in the first instance. However, as has been seen, in practice, when children are genuinely able to become part of a mathematical discourse, learning inevitably shows itself to be complex [3]. It also arouses strong emotions [5], including *not* understanding in the first instance, and at this point the culturally tuned reaction is to assume that learning is not therefore proceeding 'properly' [6].

None of this is to deny the role that teachers play in their pupils' learning of course, or to suggest that pupils would somehow be better off without them. What it does serve to show, however, is how the systemic tension which the numeracy strategy seems to create is rooted in a culturally inherited sets of values about schooling and about education more widely. It also suggests why changing practice at any deep level appears to have presented such a challenge over the years, since, what may seem only to be changes of action on the part of the teacher, in fact require major shifts in what are likely to be strongly, and implicitly, held cultural conceptions of the very nature of learning itself.

What has been said above is generic to all teaching undertaken in a climate in which strongly focused, knowledge based objectives are seen as an essential requirement

for teaching. However, for mathematics teaching the situation appears to be compounded by the culturally transmitted view of the subject itself, as the next section makes clear.

Strand 2 – the effect of cultural conceptions of the nature of mathematics

Evidence from my personal experiences of teaching mathematics education suggests that few adults can respond clearly to the question 'What *is* mathematics?', despite having studied the subject for at least 2000 hours during their schooling. Typically, students point to conceptual elements of the subject (such as 'addition', 'shape' etc.) and to some surface level process features ('investigating', 'reasoning' etc.), but can rarely go beyond these to talk in any coherent way about what might constitute its essential and defining features. Stewart (1996, p. 1) makes a similar observation, noting that,

> The technical trappings of the subject, its symbolism and formality, its baffling terminology, its apparent delight in lengthy calculations: these tend to obscure its real nature.

In fact, the students' struggle in responding points to one of the central dilemmas in trying to define the work of a mathematician, namely that 'mathematics is both an object of understanding and a means of understanding' (Burton, 2001, p. 595). Furthermore, Burton notes that professional research mathematicians typically see mathematics as objective, but describe their coming to know it, contradictorily, both 'more personally and more lyrically' (ibid.). Thus, despite the popular conception of mathematics as a precise, impersonal, unambiguous subject, for real mathematicians there is a strong emotional element to their work. The distinction between the object of understanding and the process of coming to understand, reflects the students' (albeit implicit and incoherent) claims about both the 'doing' of mathematics and the conceptual knowledge it involves – though the emotional element has been largely missing for all but a very few, it seems. On the one hand mathematics involves 'content' – conceptual knowledge to *be* understood – on the other, it is a vehicle *for* understanding. Thus, in chapter 5 it was seen that teachers switched their intentions from one moment to the next between seeking responses from children as a means of making sense with them and as a means of checking their understanding. In turn, children's attention was seen to vary according to their perception of the teacher's true intention at any one moment.

To complicate the matter further, though it is the application of this conceptual knowledge that provides the means for understanding the world as we experience it, mathematics is, crucially, also about understanding the essential nature of this knowledge itself in its own terms, as Huckstep (1999; 2000) reminds us. Again, Stewart (1997, p. 1) observes that,

> A mathematician is more than someone who just *does* mathematics. Think of it this way: what is a businessman? Someone who does business? Yes, but not just that. A businessman is someone who see an *opportunity* for doing business where the rest of us see nothing ..... Similarly, a mathematician is someone who sees opportunities for doing mathematics that the rest of us miss.

All this leads Burton (1999, p. 138) to ask the question: 'Why do the stories of mathematics told in classrooms differ so fundamentally from those which were being recounted to me by [these] research mathematicians?'

To summarise, if one is willing to adopt this view of mathematics it implies three, simultaneous, desired outcomes of mathematics learning:

1. The acquisition of knowledge of mathematical ideas – which includes small identifiable units (such as knowledge of multiplication tables), broader conceptual units (such as an understanding of multiplication more widely) and procedures (such as how to compute the product of two numbers).

2. The ability and willingness to understand the essential properties of these ideas in relation to each other (*why*, for example, the product of two negatives produces a positive).
3. The ability to see the opportunity to make use of mathematical knowledge in problems situations and to do so successfully.

Furthermore, Burton's work with research mathematicians implies a fourth outcome, namely:

4. A desire to be engaged in mathematical work and a sense of the personal fulfilment that it can provide, as well as the adoption of certain essential mathematical dispositions (resilience, resourcefulness, intuition etc.).

It is apparent that one of the issues facing teachers which complicates their attempts to teach to particular knowledge focused objectives is the multi-dimensional nature of learning the subject and this is particularly relevant where conceptions of the subject may be limited in the first place (chapters 2 and 4). It is also worth returning to the definition of numeracy adopted by the National Numeracy Strategy, discussed in chapter 2. This definition, to remind the reader, was as follows:

> Numeracy is a proficiency that involves a confidence and competence with numbers and measures. It requires an understanding of the number system, a repertoire of computational skills and an inclination and ability to solve number problems in a variety of contexts. Numeracy also demands practical understanding of the ways in which information is gathered by counting and measuring, and is presented in graphs, diagrams, charts and tables.
>
> (DfEE, 1999a, p. 1:4)

It will be remembered too that chapter 2 noted the opportunity presented, *in theory*, by the NNS definition of numeracy to explore the interconnectedness of mathematical ideas in addition to simply acquiring knowledge of the ideas. In fact, this definition appears, at least, to imply all four of the points above, relating to what it means to learn mathematics. However, in practice, there appeared to be a very utilitarian understanding of the subject (in the sense of Andrews and Hatch's (1999) *economic* and *life tools*) adopted by the Numeracy Task Force. This understanding involved a limited view of the nature of mathematical problems, reflected to a large extent in the training materials produced for teachers. Similarly, a distinction appeared to be being drawn between *numeracy*, carried out at primary school, and *mathematics*, carried out at secondary school and beyond.

Besides simply complicating the teacher's task, the multi-dimensional nature of the subject raises an epistemological dilemma too. As Lerman (1990, p. 54) writes, the many different philosophies of mathematics,

> Can be identified as two competing programmes ... [Those which] attempt to base all of mathematics on universal absolute foundations [and one which] sees the growth of mathematical knowledge as a process of conjectures, proofs and refutations, and accepts the uncertainty of mathematical knowledge as part of the nature of mathematics.

Adopting the former, *absolutist*, view implies seeing mathematics as 'the discovery of timeless truths' whereas 'the alternative is to adopt a *fallibilist* view of mathematical knowledge' in which the results of mathematics are 'relative to time and place, and subject to revolutionary change as much as other forms of knowledge' (ibid.).

The former, objective, view of mathematical knowledge leads to two implications for the classroom (Burton, 2001). First, it tends to hide the reality of the personal and emotional aspects of learning so that 'learners tend to encounter mathematical knowledge without the exciting experiences of making personal and sociocultural connections through

their very varied styles of coming to know that mathematics' (ibid., p. 596). Second, 'not only is the personness [sic] of the discipline removed, but hierarchy of knowledge and elitism of knowers construes an antagonistic cultural climate in classrooms' (ibid.). In other words, learners are taught that mathematical knowledge is owned by experts and that their job is to receive this as a given, rather than to reconstruct it in personally meaningful ways. This results in diminishment of the potential excitement of learning mathematics. Burton notes that by taking the opposing, fallibilist, view one can,

> Site learning into a connected context where the fuel for the search is provided by the challenge and excitement of making new connections. Whether these connections are new to the individual learner and/or new to the discipline does not radically affect the motivation to search since, in every case, 'Understanding is constructed, reflected on, and articulated by the learner and the knowledge that results is his or her own' (Fennema *et* al, 1998; p. 187).
>
> (2001, p. 596, reference in original).

I have been arguing in this thesis that it is possible to interpret the kinds of personal generation of mathematical meaning promoted by the National Numeracy Strategy as just those kinds that are being described here by Burton. Certainly, personal enthusiasm, excitement and sociocultural connections, as well as knowledge and application of number, are all at least implicit, and often explicit, in the materials that were used to support teachers in training to teach the Strategy. However, it has also been argued that such elements are always mixed with competing imperatives which, in practice, appear to make other interpretations more common. Importantly though, in this respect, what Lerman and Burton demonstrate is that for children to be able to engage in this kind of creative discourse their teachers need to work in ways which reflect fallibilist perspectives on mathematics. Opposing, absolutist perspectives are unlikely to promote classroom action in which anything other than the direct recreation of the teacher's own conception of the

mathematical idea is desirable. Such action is likely to be more heavily controlled by the teacher, perhaps through the use of the appropriating strategies identified in chapter 5.

One point of clarification here is that, in referring to a fallibilist approach, it is not implied that the teacher cannot 'teach' ideas to children and that ideas somehow all have to be 'discovered' by them – a common misinterpretation. Whilst ideas may be 'constructed, reflected on and articulated by the learner' (Burton, 2001, p. 596), this does not prevent the teacher from presenting the ideas directly, nor from being an important part of the interaction that constitutes such construction and reflection. The key issue is that, however direct the presentation, intellectual and temporal space are still provided for children to both offer and receive critical thinking about the nature of the idea and there is no *imposition* of the teacher's point of view on the children.

The analysis of both the documentary and field study data in this study suggests that the National Numeracy Strategy has gone some way towards developing the possibility of both fallibilist perspectives of mathematics and the multi-dimensional nature of the subject, at least in as far as actual policy is concerned. In terms of the documentation, chapter 2 identified the possibility of interpreting the NNS in terms of a *complex sociocultural activity* which reflects the kinds of approach to mathematics teaching unpicked here. In terms of the field study, at one level children referred to their attempts to make sense together and of the challenge associated with seeing new ideas. Similarly, teachers seemed concerned with interconnections between mathematical ideas and with application. However, in practice, it has been seen that the deeper level processes seemed less convincing. For example, teachers actually held on to tight control of children's discourse and children themselves had views of their roles in discourse which implied limited forms of learning. Ultimately, children's references to, for example, 'best' solutions, the need to 'remember' and their model of learning through 'overhearing' talk, all seemed to point to a mathematical identity in which the central purpose of their learning

was to acquire particular knowledge in the form that the teacher was bringing to the lesson. Moreover, this form of knowledge was that detailed in the National Numeracy Strategy's Framework for Teaching which in turn leads to the last of the three intertwined strands of complexity for the teacher: the content, structure and assessment of the curriculum.

Strand 3 – the effect of the content, structure and assessment of the mathematics curriculum

Whilst the current version of the National Curriculum (DfEE, 1999) reflects a view of school learning that includes both affective elements of learning and processes of learning, in addition to conceptual content and skill development, the Framework for Teaching of the National Numeracy Strategy takes a much narrower line in this respect. Although the paragraphs in the previous section noted again the possibility of interpreting the Strategy in complex ways, it noted too that a much narrower *technicist* interpretation in terms of both structural and organisational aspects was likely. It is also an interpretation which views the curriculum itself as being based on concepts, skills and mathematical 'facts' to be learnt, an idea reinforced by the 'key objectives' in the front of the document which focus teachers' and children's attention almost exclusively on knowledge rather than process.

In effect, the document which has become the working curriculum for teachers – despite its non-statutory status – may be experienced in daily practice, by many, as a list of knowledge to be acquired. Such experiences are unlikely to encourage the fallibilist position that meaningful discourse appears to require, and the direct recreation of this knowledge base is likely to be the most likely outcome.

Of course, from the point of view of the teacher in the school, such teaching behaviours may indeed lead to success, depending on how this is being measured. It needs to be remembered that the introduction of the National Numeracy Strategy was a direct result of a political imperative to raise test scores, since, as was noted above, these were the measure of success for a government which was being asked to be judged by its electorate on education. Thus, from the political point of view, 'real' gains in mathematical understanding are not the issue. Inevitably, the same can become true for teachers, as political imperatives are transferred, via new performance management mechanisms and inspection regimes, down to the level of the classroom. What becomes the major source of concern is that children perform better in the standard tests for mathematics, since this, by definition, is what *improvement* has come to mean.

Brown et al (2003) mount a significant challenge to this notion of improvement based solely on SAT scores. They have demonstrated that, using a different test of children's numeracy from that used in SATs, the average score for children from two large, national cohorts of Year 4 children, two years before and two years after the introduction of the National Numeracy Strategy, increased by just three percentage points. Given the increased focus on numeracy of the Strategy, and the likelihood that understanding in other areas of mathematics (especially shape and space and data handling) might have reduced, the overall effect of the Strategy is seriously questioned by the study. As Brown and her colleagues argue,

> The way that the percentages grow and then plateau for both subjects [maths and science], with the mathematics results improving less dramatically than those for science even though, significantly, there was no national science strategy, strongly suggests that increasingly careful test preparation was the salient factor in improvement and the NNS had an insignificant effect.
> (ibid., p.669)

Furthermore, their findings corroborate those presented here in that whilst teachers have been 'overwhelmingly positive about the NNS ... their teaching in the classroom seems to have changed mainly in superficial ways' (p. 668).

The paragraphs above noted the way in which the nature of mathematics has been established through the structure of the NNS Framework, reflecting an absolutist version of mathematical knowledge. This, of course, is supportive of the testing regime since the particular assessment mechanism in question, with little in the way of application of mathematical knowledge beyond simple word problems, is most successfully negotiated through just the kind of direct recreation of the teacher's ideas that an absolutist perspective encourages. In short, a testing mechanism that focuses on a very narrow range of mainly knowledge-based objectives will best be supported by an absolutist curriculum, reproduced 'absolutely' by both teachers and, subsequently, children. Such a state of affairs is likely to minimise the gap between the intended and the realised curricula (Voigt, 1994 – see chapter 5).

Again, one must be careful in making such sweeping statements. Clearly the claims being made here are assertions in as far as the data in this study alone are not sufficient to support them as they stand, but the other studies referred to above provide a more convincing backdrop to the claims. The current study, however, gains its originality from the way in which it has shed light on the detail regarding possible mechanisms of, and motivations for, the actions of teachers and children. Nevertheless, if one accepts the argument above, one obvious question requiring an answer is what an alternative might look like. The answer is in both theoretical writing relating to the issue of teaching and learning mathematics and in the observations and interviews reported here. Both these sources have identified the same thing – that the *opportunity* for a very different form of pedagogy is already in place in terms of the National Curriculum, and its embodiment via the National Numeracy Strategy. Taking up this opportunity, though, is seen to require a significant shift in the conceptual understanding of both the nature of the subject of mathematics and in teachers' understanding of the desired outcomes of learning. In turn, these might then lead to a more profitable understanding of the purpose of current teaching

practices – in particular the role of discourse in the classroom, embodied, in part, through whole class discussion. As Claxton (2002, p. 32) asserts,

> This [change in understanding and practice] involves not the design of new programmes of study, nor even, in the main, the adoption of new forms of pedagogy, but an attention to the implicit values and assumptions of the culture, and to making sure that its objects, its tasks, its non-verbal signals and so on are consonant with the dispositions that the culture wishes to develop. It is the beliefs and priorities that are dissolved in the micro-'how' of the school that matter; not glitzy new packages of 'what'.

Such changes in the micro-'how' are represented here by the ideas articulated in previous chapters.

Concluding remarks

The observational data in this study support Claxton's view, above, that it is a change of emphasis and attention that is required if children are to develop deeper mathematical understanding. Teachers feel supported by the National Numeracy Strategy which provides a clear structure for their teaching – both its content and its implementation. Children appear to enjoy the lessons in which they are engaged and share the teachers' expectations, to a large extent, regarding what is significant. However, although this structure supports these classroom 'performers' in the act of 'getting on' with mathematical work in the daily routine of the classroom, below its surface lies a fatal tension resulting from a mismatch between the various discourses inherent in the Strategy itself. This tension revolves around the issue of whether the performers' essential purpose is to replicate the content of the curriculum as objective knowledge, or to become mathematicians creating their own knowledge, along with the necessary dispositions that such legitimate participation in the mathematical process encourages (Lave and Wenger, 1991).

The National Numeracy Strategy is structured in terms of the former, yet simultaneously appears to promote the latter. The tension was seen most clearly when the participating teachers were interacting with the class, where frequent and subtle changes of emphasis were used by the teachers to appropriate children's involvement in the discourse for their own ends. The result of such practices is teaching that, though perhaps different in structural terms (and even this has been seen to be questionable) differs little from that which has preceded it in terms of the form and depth of children's engagement with the mathematics.

Having pointed to the difficulty for teachers of engaging in practices which are likely to result in deep changes to children's mathematical understanding, the preceding sections of this final chapter have sought to delineate the various elements of the teaching-learning process that seem most significant. Three interrelated issues have emerged and these are shown diagrammatically in figure 5.

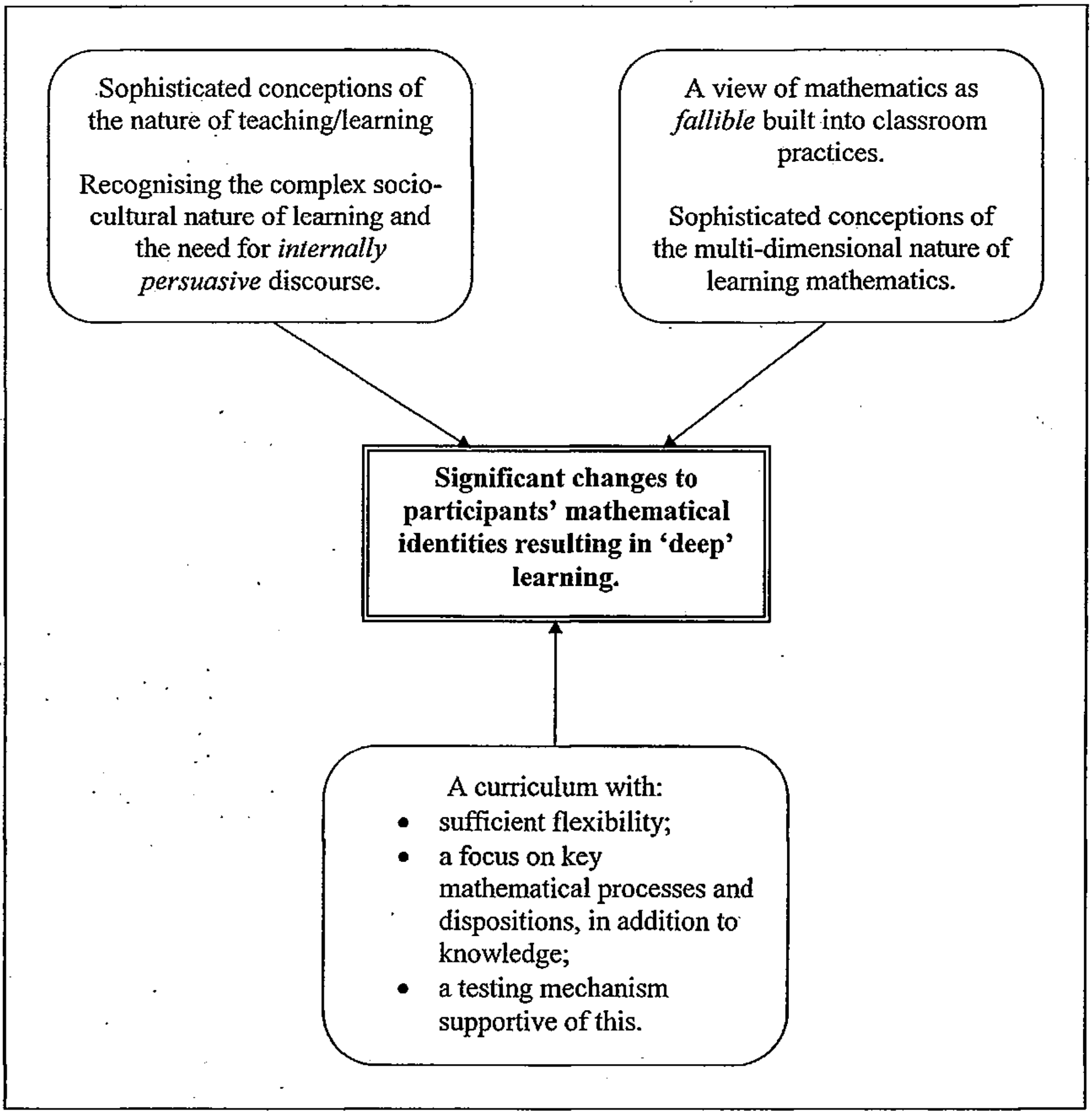


Figure 5 - Interrelated issues for 'deep' mathematical learning.

It would appear that *all three* of these elements need to be in place together if teachers are not to be caught in the gap between rhetoric and reality that results in the kind of tensions illuminated here. Where even one of them is not in line with the others, the result will be teachers who are caught between the desire to empower their children in being part of the process of the cultural transmission and transformation of knowledge, whilst having, in practice, to ensure that particular knowledge is learnt as if objectified by

the curriculum. The result will be children who lack, like the generations that have gone before them, the essential dispositions and the particular forms of knowledge required to be able to make use of their learning in mathematical and non-mathematical environments.

Meanwhile, for the teachers themselves, without a national strategy for mathematics that reflects the indispensable need for indeterminacy – both in the outcome of children's learning, in the language that forms the discourse between them and in the nature of the subject itself – they will be stuck, inevitably, with the didactic tension that permeates much of current practice, in which the discourses of the teacher and the child conflict in the attempt to reach particular end-goals.

Opportunities for future research

The observations of this study, and the conclusions drawn above, imply several potential avenues for future research.

First, the interviews with teachers reported in chapter 4 form the basis of a longitudinal study of their changing views of the National Numeracy Strategy. Ways in which the same teachers now view the Strategy may say a great deal about changing forms of professionalism and, more particularly, about how they view their role as mathematics teachers after five years of the NNS.

Second, the same study might explore teachers' developing conceptions of mathematics itself and relate these to the imperatives that they experience in their role as mathematics teachers. In other words, it might explore how the demands of the current professional climate and the form of mathematics understood by the teachers, interrelate.

Third, a study might investigate the effect of teachers' own learning about class interaction on their practice in the classroom and, subsequently, on their pupils' performance.

Fourth, this study has made one major assumption, namely that a more discursive form of teaching/learning will lead to deeper, more effective, learning. Though other studies support this view (Boaler, 1997, 2002; Jones and Tanner, 2002) it has not been demonstrated empirically here. This leaves open the possibility of exploring ways in which different forms of teaching affect children's learning. More generally, it offers scope for investigating the interrelationship between *knowledge*, *identity* and *practices* in mathematics classrooms. Possible avenues for research here include:

- Comparing the forms of knowledge that children draw on in different kinds of mathematics practice.
- Finding ways to map identities and comparing the positions children take during different forms of mathematics practice.
- Investigating ways in which children might learn to be mindful of these positions in order to help solve problems more effectively.

In these ways, we might explore how the National Numeracy Strategy can offer a supportive framework for developing the *breadth* and *depth* of children's mathematical thinking.

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Appendix 1: Semi-structured interview schedule – phase 1

A. Introductory questions / past experience

A1. Can you just start by saying something about your role in the school? Where do you teach and what other responsibilities do you have?

A2. What about your teaching background? Can you give me a quick potted history of your teaching career to date?

B. Exploring understanding of the NNS

B1. I'm interested, as you know, in the NNS. We have some American exchange students in the college with us at the moment who are going to be working in our local schools knowing nothing at all about the Strategy. If they were to come to work here, how would you explain it to them?

B2. Could you summarise, or maybe add to, what you've said by saying what you think are the 'big ideas' in the Strategy; the things that stand out as being the essential features of it?

B3. Have you begun to form any opinion about it yet?

B5. Clearly there is a responsibility on your part to deal with the Strategy, but how do you feel about it yourself?

probe - as a professional and as an individual; support or imposition

C. Changes to practice

C1. •I know that you've begun to think about it already in the school......
•I don't know whether you've begun to think about it here in the school yet, but..
.... could you describe the / any ways in which you've begun to prepare for it?
probe - individually and as a school

C2. Thinking ahead to the last part of this year and then into next September, what do you think will be the implications of the NNS coming in for you?

probe - as a teacher

as a coordinator

big changes or not?

D. Conceptions of mathematics

D1. We've been talking about the NNS specifically. I'd like to think about maths teaching more generally now. How do you feel about teaching maths?

D2. Are you able to identify any key ideas or features of your maths teaching which you feel underpin it; things that you feel are central to what you are trying to do?

probe - examples in practice?

D3. Would you call your children mathematicians?

probe - in what ways?

what about yourself?

what makes someone a mathematician?

D4. Can you extend this into a definition of what maths is?

D5. Relating this back to the Numeracy Strategy, can you see any particular mathematical philosophy in it ?

Appendix 2: Example of conceptual labels from open coding – phase 1

Matches previous advice	HE	Yes, and before that really because I'd seen [adviser name] a few times doing, you know, he'd done courses at Tiverton and he'd been in to [school] and talked to me and he'd, you know, be talking. And also [adviser name], of course he came and did our inspection at [school] and quite a lot of my coordinators interview was about division and how to approach division. So there were lots of times when people had spoken to me about things like that and even right back to my training really. It wasn't quite so much the case then that people were talking, you know, about those kind of methods but I certainly came across it.
	NP	Did you work with [name] at [institution name]?
Matches previous advice	HE	Yes, so it's gonna be, that's gonna be more of a development, but I do agree that its awkward in very much as part of the numeracy project that that's the approach that they're encouraging.
	NP	You've kind of picked out some of the things there that you see as major elements, features. Are there any other kind of big idea that you see? You have picked out the objectives and you've said a few things about the teaching.
Approach to calculating Origin of ideas Approach to calculating Mental facility	HE	Well I suppose the major [thing] would be the approach to calculating and that um it brings more into the fore with all teachers. | I know with my experience with literacy, I suppose the English coordinator would have been much as I am with maths, [have] come across a lot of the ideas that are included. I only perhaps came across them when I actually got the literacy training. | So yes I suppose the approach to calculating would be one of the major things, | um, and the mental facilities, you know the idea that children develop their methods from mental.
	NP	In their heads?
NNS valuable= Successful	HE	Yes, and they do, I mean there's no [doubt], I've seen it in my own classroom so many times.
	NP	Right. Do you think you'd seen that prior to the Strategy, or have you seen it since you kind of started thinking because of the Strategy?
Focusing attention NNN valuable= Confidence	HE	Um, I suppose the Strategy has really made me concentrate on it more. I probably did see it before, but its given me the confidence to say yes we can do it this way and we can do it that way, and it doesn't matter which way we do it in. If we get to the answer, if that's the way that suits that particular child that's great.
	NP	And was that a way you wanted to work before?
NNN valuable= Confidence	HE	Probably, probably I did but as I say it's given me the confidence. I certainly think I'm a better teacher now for doing it that way.
	NP	You mentioned the literacy strategy a few times in talking about the numeracy strategy. Are you drawing parallels between the two?
Comparison with the NLS	HE	I'm um. I suppose you have to because of the way they're introduced. They've both come from, it seems like, the same direction from a, you know, a wish to improve standards and,

		you know, this is the way to do [it]. But I have certain misgivings I have to say about them being too associated because I found the literacy training not particularly helpful in a lot of places. I mean there have been things I've found useful, but I don't feel I've learnt a huge amount.
	NP	Have to have a sense of tact…
		.. [laugh]..
Comparison with the NLS NLS=negative Association with NLS Valuable= philosophy Comparison with the NLS	HE	But its not been um a wonderful experience, the introduction of the literacy hour I mean and I'm hoping that maths will be better, | but when you see it come in an almost identical box [laugh] and the covers look almost the same. You think, oh dear. And I have this worry that we're, you know, will they perhaps be too similar, because I do feel that the maths should be better. I just think its based on something that really works whereas for the literacy, I'm yet to be completely convinced. I think there are parts of it that, yes, it's improved my English teaching, but there are parts I find very difficult.
	NP	I just noticed, you said there, the maths was based on something that really works. Do you have, I think you begun to say something about what that is. I'm just wondering if we can get more into what it is that actually works? Do you have a sense of kind of where its coming from the thing that is what makes it work?
Formality of methods Mental vs Written methods Valuable= memory/ Success	HE	I think it's that it takes it away from the very formal methods which some children, well, I think *all* children, at some stage have been taught. I mean I think most teachers have the experience of, right we're going to do some subtraction and you give a child a sum and they do something. I mean they very often make very similar mistakes, they try to do things, decomposition, that they haven't quite remembered. And I just think, well, if you get away from that it's not something that's working for a lot of children and my experience of the things that you do with them, with mental methods and using things that they already know and building up, you can come back to it in a term's time. And they, OK, they don't perhaps, they haven't, they aren't still at the stage they were at a term ago on that particular [thing], but they remember so much of it and they can apply so much of it. Whereas, you know, decomposition is the obvious one, you end up teaching it to them all over again and then the following term they've forgotten it again.
	NP	So they kind of remember it if but they don't understand it
Mental vs Written methods Valuable= success/ understanding	HE	That's right, yeh. The real understanding isn't there, whereas I think I can think of lots of examples where some of the other methods that I've been using recently, the understanding is there and then they take it on a step further and you can see the real evidence that they've understood what you're doing and what you're saying. And you know I think that's the big difference really.

Appendix 3: Examples of developing rules for inclusion for categories from interview data – phase 1

First draft:

Category name and code	Rule for inclusion
HOW IS THE NNS UNDERSTOOD?	
Comparison with NLS (cfnls)	The NNS is compared to the NLS either as being similar or different, better or worse and this comparison is used to make a point about the NNS.
Origins of knowledge of NNS (no)	The interviewees come to know about the NNS in many different ways and from many different sources. They also had received information about approaches to teaching numeracy before the NNS and these may or may not have been the same.
NNS *as* (nas)	The NNS is seen as *being* something in particular. This is either a physical thing or a conceptual thing (such as 'being about raising standards'. The point is that the interviewee uses this 'thing' as his/her image of what the Strategy actually is.
NNS is valuable (nv)	The strategy is seen as being valuable in some way. There are many different ways in which this may be the case (which will be filtered at a later stage) but they are all functional things, i.e. they relate to the facility and usefulness of its implementation.
NNS is problematic (np)	The strategy is seen as being problematic in some way. There are many different ways in which this may be the case (which will be filtered at a later stage) but they are all functional things, i.e. they relate to the facility and usefulness of its implementation.
Feelings about NNS (nf)	The interviewees have feelings about the NNS which may be positive or negative, strong or weak. These relate to a personal feeling as opposed to NVP which relates to the facility of the use of NNS.
WHAT CONSTITUTES EFFECTIVE TEACHING AND LEARNING OF MATHEMATICS?	
Compulsion-Compliance (cc__)	The strategy is view in terms of the two spectra; as a choice or a compulsion and as something to which one is either compliant or non-compliant. There may be elements of the Strategy about which teachers feel differently.

Changes to teaching practice (cp)	Teachers have either already changed their practice as a result of the NNS or perceive that they will do so in some way. It may be that they also perceive the need for their colleagues or teachers in general to change their practice too.
View of Effective Teaching (et)	Teachers express opinions about what makes their, or others', teaching effective or ineffective.
View of Effective Learning (el)	Teachers hold views about the ways in which children learn and how these relate to their own teaching. These views can be expressed as opinions about how to make learning effective.
HOW DO TEACHERS PERCEIVE THE PURPOSE, STRUCTURE AND NATURE OF MATHEMATICS?	
The Nature and Structure of mathematics. (mns)	Even if they cannot make them explicit, teachers perceive the nature of structure implicitly and provide clues about these ideas in what they say about the subject.
Purpose of Mathematics (mp)	Teachers mainly view mathematics as being a functional utilitarian subject, learnt in order to help in one's life experiences but there may be other views about it which differ from this.

Final Draft:

Category name and code	Rule for inclusion
HOW IS THE NNS UNDERSTOOD?	
Comparison with NLS (cfnls)	The NLS has a major influence on teachers' perceptions of the NNS and they tend to use comparisons between the two in making judgements about the latter.
Origins of knowledge of NNS (ok)	The interviewees come to know about the NNS in many different ways and from many different sources. They have also received information about approaches to teaching numeracy before the NNS and these may or may not have been the same.
NNS *as* (nas)	The NNS is seen as *being* something, or being *about* something, in particular. This is either a physical thing or a conceptual thing (such as 'being about raising standards'). However, the important point is that the interviewee uses this 'thing' as his/her image of what the Strategy actually *is* or *is about*.
Power from above - control / constraint (pfac)	The NNS is seen by some teachers as being a controlling power, originating from somewhere not necessarily made clear, but generally with the feeling that the power is 'above' me (in the sense of more important than me and remote from my influence). This power will "ensure" that things happen and "force' people to do certain things which may be a good or a bad thing. The use of the word 'they' without any clear explanation of who this refers to is often a signal of this happening.
Power from above - validation / affirmation (pfav)	As above in that the NNS is a controlling power, but this power helps teachers to be confident in their practice or beliefs because it is approving of them and provides the justification for these ideas.
NNS is valuable (nv)	The strategy, or something in it, is seen as being valuable in some way. There are many different ways in which this may be the case (which will be filtered at a later stage) but they are all functional things, i.e. they relate to the facility and usefulness of its implementation.
NNS is problematic (np)	The strategy, or something in it, is seen as being problematic in some way. There are many different ways in which this may be the case (which will be filtered at a later stage) but they are all functional things, i.e. they relate to the facility and usefulness of its

	implementation.
WHAT CONSTITUTES EFFECTIVE TEACHING AND LEARNING OF MATHEMATICS?	
Validation (v)	Some teachers feel positive about the NNS because it validates a way of working that they have chosen. The NNS is seen as justification for their chosen approach to teaching.
Changes to teaching practice (cp)	Teachers have either already changed their practice as a result of the NNS or perceive that they will do so in some way. They may also perceive the need for their colleagues or teachers in general to change their practice too. It is the description *of* change that is vital here though, not what has *driven* that change.
NNS practice (nprac)	Teachers hold definite views of what the NNS suggest that they might do in terms of teaching practice.
View of effective teaching and learning (et)	Teachers express opinions about what makes their, or others', teaching effective or ineffective and about the ways in which children learn most effectively. These may or may not be inter-related.
Resources (r)	Teachers have views about the resources that are either most effective and/or that they need to work with the NNS.
HOW DO TEACHERS PERCEIVE THE PURPOSE, STRUCTURE AND NATURE OF MATHEMATICS?	
The Nature and Structure of mathematics. (mns)	Even if they cannot make them explicit, teachers perceive the nature or structure implicitly and provide clues about these ideas in what they say about the subject and particularly in terms of the way in which they describe what it is to be a mathematician.
Purpose of Mathematics (mp)	Teachers mainly view mathematics as being a functional utilitarian subject, learnt in order to help in one's life experiences but there may be other views about it which differ from this.
Feelings about mathematics (mf)	Teachers have feelings about the subject and their teaching of it which affect the way they teach it. These feelings often stem from past experiences as a learner themselves.

Appendix 4: Post observation interview schedule for phase 2 observations

1	The NNS is essentially....	
	... a set of objectives for teachers to teach to.	Yes ← No →
	... a set of teaching procedures to follow.	Yes ← No →
	... a 'blueprint' for the most effective way of developing children's mathematics.	Yes ← No →
	... a means of achieving an overall aim, which might be political or personal to you and the school.	Yes ← No →
2	To what extent does the NNS support the way you want to work anyway?	
	It completely justifies what I want to do anyway. ←→	It completely undermines the way I'd like to work.
3	To what extent are you controlled by the NNS?	
	I'm completely free to do what I want. ←→	I have to do exactly what I'm told.

4	To what extent do you agree with each of these aspects of the NNS?							
	Objectives are clear	1	2	3	4	5	6
	The approach to calculation is right	1	2	3	4	5	6
	There are helpful examples to follow	1	2	3	4	5	6
	It has meant more work for us	1	2	3	4	5	6
	It ensures that no gaps are left in the children's development	1	2	3	4	5	6
	Children never get round to finishing	1	2	3	4	5	6
	It shows the standard to achieve	1	2	3	4	5	6
	It's based on good research	1	2	3	4	5	6
	It's made our job simpler	1	2	3	4	5	6
	We don't have the right resources	1	2	3	4	5	6

	It's very hard to differentiate well	1	2	3	4	5	6
	It contains lots of good ideas	1	2	3	4	5	6
	The less able one get left behind	1	2	3	4	5	6
	The NNS and the NLS are squeezing out other things	1	2	3	4	5	6
	Other things?						

6	Maths is essentially abstract but can be applied in different situations.	⟷	Maths is essentially practical but can be abstracted from these situations.
7	'Maths' means the *concepts* involved, with processes being the way in which these are then used.	⟷	'Maths' is essentially a *process*, but there are concepts which come out of this.
8	Concepts have to be learnt by children before they can be used in contexts.	⟷	Children can only learn concepts as a result of them being seen in contexts.
9	Because they are abstract, mathematical concepts can be easily transferred	⟷	Children's understanding of a concept is different depending on the

	to new contexts.		context in which it was learnt.
10	Practical tasks are essential for learning mathematical concepts.	↔	Practical tasks play little part in children's mathematical learning.
11	All children are mathematicians, though of varying skill.	↔ Some children are mathematicians, others are not.	No child can be a mathematician.
12	School maths should be about learning to cope with everyday situations because this is most useful.	↔	School maths should be about learning the subject in its abstract form because it is simply enjoyable.
13	The above depends on the child.	↔	The above is true for all children.
14	Maths is my favourite subject to teach.	↔	Maths is my least favourite subject to teach.

Appendix 5: Example of an analytical memo – phase 2

Frances - Lesson observation: analytical memo - 8.6.00

The children started today doing a 'tables practice' sheet where they were asked to fill in the answers to a set of randomized questions relating to different tables. Frances had told me at the beginning that they were still struggling to learn these and had asked whether I had any ideas for this. I noticed that most of the children were counting on on their fingers in twos, threes etc. and it seemed obvious to me that they needed to be encouraged to find ways of learning them orally so that they didn't need this counting strategy. This is an illustration of the difference between Frances's mathematics pedagogical subject knowledge and that of say Heather, who is such more able to identify the things that the children need.

Working on the shapes activity it is clear that Frances (again) believes in the idea of 'discovery' learning (though whether this is just for me and whether she does it differently when I'm not there I don't know). The task is to 'find the relationship between the number of lines of symmetry and the sides of a regular polygon' and the worksheet is set up to 'explore' five shapes recording their number of sides and lines of reflective symmetry next to each shape (in order to see that they are the same). Frances twice said that she wanted them to discover this for themselves. What is interesting here is that there is, in practice, little sense of discovery because the fact that *she* wants them to discover it drives the lesson towards this single point alone and so the children are consequently not *free* to 'discover' anything -the point being that to genuinely 'discover' something you need to have been free to chose the direction of your exploration in the first place and not simply guided along towards it. So, for example, two of the children near me identified that the

sides and symmetries would be the same after doing just the first one because of the structure of the worksheet which so obviously had them side by side. Thus the discovery was related to the layout of the sheet and not to any mathematics that they were doing.

Appropriation of children's answers was, again, a major feature of Frances's interaction, characterised by the desire to finish off their responses for them when they had only given partial answers to the questions or to repeat the answer but in her own words. For example:

FH: Can anyone hold up an irregular pentagon?

Ch: (holds up correct shape from selection on desk)

FH: Why is it an irregular one?

Ch: (child gives a correct but not complete nor succinct answers).

FH: Yes. All the sides are different lengths and all the angles are different (note that this is not necessarily true of irregular polygons since only one of the sides *or* one of the angles is sufficient for it to be irregular, with these two things being dependent on each other).

and...

FH: This is a regular pentagon. Why is it regular?

Ch: Same length

FH: Yes, all its sides are the same length and all its angles are the same.

[and this is followed by a request to hold up examples of irregular and then regular shapes with the question "why is it irregular/regular?" each time. Each child's answer is followed by Frances stating that it's irregular because the sides and angles are different or regular because the sides and angles are the same.]

What seems crucial in all this is that Frances's practice is not matching the philosophy that might underpin her beliefs. In other words she believes in discovery but is not acting in a way that allows the children to truly discover anything. Examples of behaviour that might indicate this genuine discover might be:

- children choosing what to look for;
- children choosing how to organise their data;
- children being given freedom to explain what they've found to others;
- children being able to follow up leads on their own.

None of these are happening in Frances's classroom.

It's worth noting that Frances is working with some of the least able children in Y5 (and even a few from Y6). This, I suspect, strongly influences her approach in the way identified by Askew et al (1997 EToN):

"A view of working within levels that would not challenge the children [not necessarily true of Frances] was held by both transmission and discovery orientated teachers and appeared to have at least two effects. First lower attaining pupils in particular would seem to require a different approach to teaching and learning. There was little sense that these children were expected to achieve a sense of satisfaction through being challenged [again, not necessarily true of Frances] ...... Second, in order to reduce demands on pupils, the mathematics had to be presented in small, fragmented steps. Because this breaking down and structuring had to be done by the teacher, it appeared that this in turn fostered a classroom culture where some pupils became heavily dependent on the teacher and a style of learning mathematics characterised by lack of deep understanding. Thus a cycle of dependency and low attainment may be set up."

The second of these issues seems particularly relevant to Frances's approach. There is a very strong feeling that she is teaching 'separate ideas' in her lessons She talked before the lesson, as she had before, of getting 'these children' to understand some of the basic things (my words, but her meaning I think). This is driven by SATs I'm sure and recall how concerned she was to get her struggling children to 'learn some of the basic things for the test'. D's discussion with me at the Curriculum Links meeting was typical of this too (and no doubt drives Frances), with a very heavy emphasis on "identifying what the children can and cannot do" and "identifying the strategies that they use and the ones that they don't use yet". Here is the thing that Threlfall describes where the NNS becomes a series of targets to achieve without thought about the underlying structure and philosophy that underpins the teaching and the learning.

Final section of the observation notes demonstrates Frances focusing on the way to find all the lines of symmetry by trying to get one child to explain how he did it. She asks the other children to stop talking "because this is very important" and then gets the child to explain how managed to ensure that he found all the lines of symmetry. the children listen well to this 'child-explanation'. At the end, with time run out, she struggles to get the children focused on the 'crucial relationship' of lines and sides being the same.

Appendix 6: Child interview schedule – phase 2:2

The following questions are in the context of the clips from the video to be viewed with the children.

General introduction – show introductory clip:

1. Do you remember the lesson?
2. Can you describe what was happening?

Then, for each clip, ask the following:

3. How did you feel?
4. What sort of things do you think about in this part of the lesson?
5. What do you think [teacher] is trying to do here?

Here are some things that [teacher] might do:

[Each of these is written on a list in front of the child]

- asking questions
- repeating your answers back to you
- writing on the board
- listening to you talking
- telling you things
- encouraging each other to talk and listen

Ask: Which of these does [teacher] do?

Are there any other things he/she does? [add these to the list]

Do they help you? – Probe response in terms of how/why not

Why do you think that [teacher] does them?

Appendix 7: Child interviews: rules for category inclusion – phase 2:2

	Category	Rule for inclusion
	Collaboration....	
		...Sharing Ideas
SIsg	sense of group	The child refers to a situation which identifies the extent to which they are part of a group and/or the function of that group. One end of this dimensionally is individual work; the other is whole class work with pairs and groups in the middle.
SIftl	focus on listening	Children state or imply that listening is the key to learning and an important part of their behaviour. It is seen as more important than talking in talking-listening situations.
SIvtl	value of talking and listening	Describes children's perceptions of why and how it is of use to talk and listen to each other.
SIpe	peer evaluation	Children are asked to evaluate each other's work in some way and to make a judgement and or a suggestion.
SIf	features of sharing	Describes any features that characterise the act of sharing ideas in the classroom (but not views of the use or efficacy of these sharing acts), for example finding it hard or easy to hear, to understand etc. or identifying individuals in the class who are particularly helpful.
		...Freedom and Control
Cc	compulsion	Describes situations where children are, or feel, compelled to act in ways specified by others, usually the teacher.
Cs	selection	Describes teacher's acts which are designed to, or result in, choices being made about what to acknowledge and/or make public.
Caj	assessment /judgement	Describes acts in which the teacher assesses and/or judges children's ideas or results from their work.
F	...Feelings	Any unit of data which refers to the way somebody feels in the school environment.
E	...Explaining	Describes features of explanation by the teacher
		View of Learning...
VLml	meta-learning	Describes situations in which children comment on their own learning in some way and/or make judgements about the effectiveness of what they have done.

VLqa	using questions for assessment	Describes situation where children are aware that questions are being used by the teacher to assess their understanding / knowledge.
VLwc	working out from clues	Children refer to being asked to make sense of an idea from clues given by the teacher, who does not refer to the whole idea.
VLmr	memory & recall	Any unit of data which refers to the need to remember or to the value of recall/memory in learning. Also refers to any unit which relates to notions of 'getting the *right* answer' where this implies that the purpose of 'right' is that it may then be remembered.
VLp	progression	Referring to a sense of progression in learning as children move through the school or across a year and/or their own ability and success in relation to such a progression.
VLv	value of approaches	Refers to descriptions of approaches to teaching that are seen as valuable, or otherwise, by the describer.
VLre	refined efficiency	Refers to the development of increasingly useful or efficient techniques for calculating (not just getting questions right) or to issues to do with this development, including children's views on the value of this.
VLc	correcting	Describes the teacher's act of making explicit what is wrong and ensuring that the learner(s) know what is right (usually in order that they may then remember it.
VLts	teacher as support	Describes situations in which the children perceive the teacher as a 'supporter' of their learning in ways other than simply 'correcting' their answers.
	Procedures...	
P		Refers to all descriptions of 'procedure' in the classroom.
Psp	speed	Refers to occasions when children note aspects of speed in having to respond or calculate etc.

Appendix 8: Ethics protocol for interviewees – phase 1

Ethical Principles Relating to Research into Teachers' Perceptions of the National Numeracy Strategy

Introduction

The project aims to gain access to ideas held by teachers regarding the nature of mathematics and its teaching and learning and to explore the two-way relationship between these and their practice in implementing the National Numeracy Strategy. Whilst this will involve making observations of teaching in action and considering the effect of actions on the children's behaviour, it does not seek to make judgments about the *merit* of teachers' conceptions; nor does it set out to *judge* teachers' practice in terms of its effectiveness; indeed, teachers will be involved in validating their own positions in this respect as part of the methodology. Similarly, it is envisioned that participation in the research may well lead teachers to develop their thinking in terms of both their conceptions and pedagogy of mathematics.

Within this broad framework, the following ethical principles will apply:

1. Informed Consent

   I will undertake to gain the consent of participants in advance and to inform them of any aspects of the work that may reasonably be expected to influence their willingness to participate in the study. As clear a picture as possible regarding the nature and purpose of the work will be given in advance of any participation.

2. Openness and Honesty

   I undertake to be open and honest about the purpose, application and results of the research with all those participating in it, except in circumstances where knowledge in advance of what I am examining might cause the participants to behave in an abnormal way. An example of this might be that, in interviewing participants regarding "their conception of mathematics" I might refrain from detailing too precisely what is meant by this statement in order not to influence their ideas in advance. Where this is the case, I will endeavour to ensure that participants are made aware of any findings in debriefing the event.

3. Confidentiality

   I undertake to ensure that data collected during the course of the study safeguards confidentiality, except where given permission to do otherwise in advance by the participant concerned. In order to do so, recordings - audio, video, written - will only be viewed by the researcher and the person involved and any transcripts used in public writing will be coded to prevent identities becoming known. Where identities might be guessed at anyway (for example where the nature of the context suggests the identity), explicit permission will be sought from the person/people involved before using the data. However, since development in mathematics, and the NNS in particular, is fundamental to the project, I will endeavour to give

periodic feedback to the headteacher and/or the senior management of the schools involved regarding issues which relate to a school as a whole. In carrying out this feedback I undertake to seek the opinion of any participants whose confidentiality might be put in jeopardy in advance of such feedback and to seek their subsequent permission in using the data. Each participant is thus a 'gatekeeper' in relation to data regarding themselves.

4. <u>Briefing and Debriefing</u>
I undertake to provide participants with an account of the purpose of, and expected methodology for, the study and to ensure that any findings from it are explained in full either during, or at the end of, it if they so wish.

5. <u>Right to Withdrawal and Ownership of Data</u>
I undertake to ensure that participants are aware, in advance, of their right to withdraw from all, or any part, of the research study at any time. In addition data collected in note and/or tape form (including subsequent transcripts), whilst usually held by myself, remain the property of the participant and s/he may choose to withdraw these at any point.

6. <u>Protection From Harm</u>
I undertake to ensure that all participants are, to the best of my ability, protected from any psychological or physical harm. The study should involve no activities that are dangerous in this respect.

Signed .... (Researcher) Date............................

Signed.. (Supervisor) Date............................

Appendix 9: Ethics protocol for participating teachers – phase 2

Ethical Principles Relating to Research into Interactive Whole Class Teaching

Introduction

The project aims to gain access to ideas held by teachers and children regarding the purpose and effectiveness of 'interactive whole class teaching'. Whilst this will involve making observations of teaching in action and considering the effect of actions on the children's behaviour, it does not seek to make judgements about the *merit* of teachers' or children's conceptions, nor does it set out to *judge* teachers' practice in terms of its effectiveness; indeed, it is expected that teachers will be involved in validating their own positions in this respect as part of their involvement.

Within this broad framework, the following ethical principles will apply:

1. Informed Consent

   I will undertake to gain the consent of participants in advance and to inform them of any aspects of the work that may reasonably be expected to influence their willingness to participate in the study. As clear a picture as possible regarding the nature and purpose of the work will be given in advance of any participation. Where children are involved, since the activities in which I am involved are part of the everyday purpose of the class or, in the case of interviews, are related to discussing this purpose, I shall assume that the permission of the head teacher and the teacher is sufficient.

2. Openness and Honesty

   I undertake to be open and honest about the purpose, application and results of the research with all those participating in it, except in circumstances where knowledge in advance of what I am examining might cause the participants to behave in an abnormal way. It might therefore, from time to time, be necessary to limit the information given to participants regarding the purpose of parts of the study. Where this is the case I undertake to make this clear to the participant in retrospect and to check that they give their permission for this data to be included.

3. Confidentiality

   I undertake to ensure that data collected during the course of the study safeguards confidentiality, except where given permission to do otherwise in advance by the participant(s) concerned. This will include data relating to children's views of their lessons. In order to do so, recordings - audio, video, written - will only be viewed by the researcher and the person involved, except where agreement has been given in advance to share it with others, and any transcripts used in public writing will be coded to prevent identities becoming known. Where identities might be guessed at anyway (for example where the nature of the context suggests the identity), explicit permission will be sought from the person/people involved before using the data. However, since development in mathematics, and the NNS in particular, is an implicit part of the project, I will endeavour to give periodic feedback. In carrying

out this feedback I undertake to seek the opinion of any participants whose confidentiality might be put in jeopardy in advance of such feedback and to seek their subsequent permission in using the data. Each participant is thus a 'gatekeeper' in relation to data regarding themselves.

4. <u>Briefing and Debriefing</u>
   I undertake to provide participants with an account of the purpose of, and expected methods for, the study and to ensure that any findings from it are explained in full either during, or at the end of, it if they so wish.

5. <u>Right to Withdrawal and Ownership of Data</u>
   I undertake to ensure that participants are aware, in advance, of their right to withdraw from all, or any part, of the research study at any time. In addition data collected in note and/or tape form (including subsequent transcripts), whilst usually held by myself, remain the property of the participant and s/he may choose to withdraw these at any point or ask that data be deleted.

6. <u>Protection From Harm</u>
   I undertake to ensure that all participants are, to the best of my ability, protected from any psychological or physical harm. The study should involve no activities that are dangerous in this respect.

Signed .... (Researcher) Date............................

Signed.. (Supervisor) Date............................

Appendix 10: Additional data relating to teachers' views of mathematics

The categories identified in chapter 4 which aimed to make clear teachers' views of the subject are reconsidered here with additional data presented in order to help the reader to ascertain the extent of the trustworthiness of each categorisation.

Nature and structure of mathematics

1. *A strong distinction made between the content of the subject – seen as the conceptual ideas of addition, counting, shape etc. – and the process aspects of it – such as problem solving, reasoning etc.*

2. *The related implication that mathematical 'stuff' needed first to be 'understood' before children could then 'make use' of it.*

In terms of pedagogy, this distinction between content and process – 'stuff' and 'understanding' – was visible in many teachers as a separation of content to be *learnt* (and hence to be *taught about*) and its *application*. For example:

> [Maths is] An understanding of number, being able to work with number confidently, an understanding of measurement and an understanding of shape so that when these situations arise they'll be able to use number in every day situations.
>
> (Mary, 20.5.99)

> Overall it's [the NNS] there to make children numerate [so] that they are confident to deal with, um, problems, different styles of calculations, so there we have a bank of ways to … a bag of strategies, to actually go out and use them, and I think the biggest thing is that, yes you can give children the strategies, but it's, you've got to enable them to actually select the appropriate ones to do.
>
> (Adrian, 17.6.99)

3. *Despite the separation between content and process, a commonly held view that mathematical knowledge is highly interconnected with great emphasis placed on the need for children both to be shown these connections and to establish them for themselves.*

The separation of content and process tended to be associated with a sense that mathematics was 'transmitted' by teachers; that teachers first taught it and children then learnt it and used it. However, this was complicated by a strong sense that there was also a need for the interconnected nature of the subject to come through, for example:

> It's lovely to see the children, you know, when the parts of the jigsaw start to come together and they can make links and use those……
> ……they start to link these, as I say, put these parts of the jigsaw together and they can actually start to use things they know to help them solve new calculations and find easier routes into doing, and find an easier way to do it.
> (Adrian, 17.6.99)

The process of developing this connected knowledge, relied on the children seeing interrelationships between ideas (but within the mathematics itself). The use of analogies similar to a 'jigsaw', with pieces of knowledge 'fitting together' was common, as was the notion that those who are good at mathematics can more readily 'see' these connections. A number of teachers referred to the need for opportunities to 'play' with numbers and for the sharing of their ideas between children in order to widen their knowledge. Thus, whilst aspects of their thinking tended towards technicism, in other ways it showed signs of complexity, with the need for mathematical ideas to 'make sense' rather than children being reliant simply on procedures. Similarly, teachers saw a need for mathematics to be used in the solution of problem situations; indeed this was very much a focus for them. However, there remained a question as to the way in which these teachers believed that abstracted, interconnected knowledge was related to its application in problem contexts.

Put simply, teachers implied a belief in the conception that, whilst mathematics was useful for solving problems, and whilst children's knowledge of mathematics needed to be interconnected within itself, it could happily lie *unconnected* to anything else, until, that is, required for the solution of some kind of problem.

4. The need for mathematical ideas to 'make sense', rather than children being reliant simply on procedures.

5. The need for both an understanding of abstract interconnections and application in problem contexts in order for this 'sense making' to happen.

For most teachers, children needed both an understanding of abstract interconnections and applicability in order properly to understand:

> Yes, and [understanding is] just seeing a good understanding of numbers and being able to manipulate numbers and play with numbers and make use of numbers really.
>
> (Julian, 15.7.99)

> I suppose it's the ability to make sense of everything around you in a way, make sense *out of things* by linking them to each other, by finding that what you've learnt in school applies to going shopping or reading time tables or working out how much material you need for curtains.
>
> (Avril, 15.7.99, emphasis added)

Sense making in mathematics was, therefore, apparently a case of understanding abstract concepts in relation to each other *and* understanding how these could be used by transferring them directly into contextualised situations. However, as noted in chapter 4, there was little implication that mathematics could be learned *through* problem situations.

Furthermore, there was sometimes a sense that most children were *only* going to be able to understand the contextualised mathematics, and not the abstract form of it.

> I think what we're talking about, it's something, ok it becomes quite esoteric in some aspects, but it's also a very useful thing and for a lot of the children you teach that's what you're aiming for, to make it make sense to them so they can use it. Perhaps for the minority you're then actually trying to enthuse them and perhaps more abstract problems, but its more of a practical thing [for most children].
>
> (Heather, 20.5.99)

> Yes pure maths, group theory. I mean I could **do** it [during her degree], I mean I can't, I haven't got a clue what that's **about** because it was just so totally abstract and that's mathematics at that sort of level. Which is nothing like, I mean what we do at school isn't.
>
> (Catherine, 5.7.99, emphasis in original)

The purpose of mathematics

1. *Practical utility reflecting a perceived need for mathematics in one's everyday life.*
2. *A more 'esoteric' purpose reflecting a view that mathematics could be fun and fulfilling in its own right as an abstract discipline.*

The latter conception here tended to be associated with 'abstractness' and was often seen as more light-hearted and enjoyable as well as being more about children's own ability to 'see' mathematical ideas and connections. The former tended to be associated with the concrete and was seen as serious and important, as well as being something that needed to 'be learnt'. These two views were often held simultaneously.

A separation of the children themselves in terms of those who were likely to be able to access the more abstract, enjoyable curriculum and thus to be working with reasoning and connection making, and those who were unlikely to be able to do this and were thus stuck in the concrete, 'taught' world of the 'necessary'.

Catherine identified that,

> If they're doing the Greeks or Egyptians then maths does come into the sort of history side and so the openings are there for those that are interested. And also sort of just bringing in the little things like, you know, when they do the nine times table looking at the patterns. So that does all come into it, the opening is there for the children that do have that interest, which is nice to sort of give. But there will always be the children that only can take on board the arithmetic and that's really all they need, but they need to have it sort of at their fingertips. So I mean there are two sides to it; it's nice if you can think that you are opening the way to those, you know, that might have the interest.
>
> (Catherine, 5.7.99)

For Amy, the 'basic' requirements involve process skills related to the ability to consider situations critically, as well as knowledge of mathematical concepts:

> A Well I think when we were trying to define what mathematics was that logic, that reasoning, that organisation, I think those are skills that do come into other areas. I mean your personal organisation, files and notes and things for any study, um, more children going in to study maths at a higher level.
>
> NP They'll be......
>
> A Most or many jobs will involve number at some stage even if it involves checking your pay slip; a more, I don't want to say more critical person, but critical can actually be very positive.
>
> (Amy, 14.7.99)

This separation led to a distinction for some teachers (perhaps most, though direct evidence of this was not apparent) regarding *whether the children in their class were 'mathematicians' or not.* Teachers' views regarding this issue tended to be a reflection of the two conceptions of mathematics above: the esoteric and the practical. Thus, children who showed the characteristics of the former conception – making connections, working quickly, particularly in their heads, thinking logically and making this explicit – were acknowledged as 'mathematicians' by their teachers. The others were consigned to 'non-mathematician' status. For some teachers, the idea of mathematician extended to the need

to be 'brilliant', for example Mary, when asked if she considered herself to be a mathematician replied,

> A mathematician? No I don't think so. I always enjoyed maths at school, I did well at maths at school, and, uh, but I wouldn't say I was a mathematician no. I understand quite a lot of it but I wouldn't say I was brilliant at it. I certainly have to relearn what Year 6 learn when we teach Year 6. I'll have to go through a lot of those things again because a lot of it you forget don't you. But at the level I'm at now I probably know quite well what I'm supposed to be doing, but I wouldn't say I was a mathematician.
>
> (Mary, 20.5.99)

In this way, *being a mathematician* seemed to be seen as an end product, something to be achieved, rather than a 'state of being' or a way of working.

Feelings about mathematics

The overall positive feelings about teaching mathematics.

Many teachers reported that they had not liked mathematics during their own childhood, and indeed these reports were often accompanied by powerful stories about their experiences:

> And [despite enjoying it now] I don't think I'm particularly logical in my approach to it because as a child I failed at arithmetic, at maths you know I couldn't... I think when I was at junior school one of the teachers said to my parents, you know, 'oh you tell her they're apples and she can add them up you tell her they're oranges and she hasn't got a clue' and I struggled and I did my GCSE maths a year late when I was in the sixth form and I got a pass but only a scrape. And I had such a hang up about it for the whole of my time at school that it actually stopped me doing subjects that I now wish I had done, more science based subjects because I was just so totally convinced that I couldn't do it. I don't know where I'm going on this actually.
>
> (Avril, 15.7.99)

These positive views match my own wider experience as a lecturer visiting schools and talking to teachers, almost all of whom do indeed seem to enjoy teaching the subject, an observation supported by Adrian who stated that,

> It was said, somebody said, the other day [at a meeting] 'oh yes maths is one of those things that nobody likes doing', or 'it's hard to get the children to be enthusiastic towards doing' and a number of teachers who were all present then said 'no, no'.

Thus, whether the enjoyment was a recent discovery of ability since learning to teach ('Oh, I'm quite enthusiastic about it now, but I wasn't for myself' – Avril), or a long held love of the subject itself ('I enjoy maths personally, you know, I just enjoy playing with numbers, I enjoy teaching it as well' – Julian), teachers seemed keen to be involved in it.

In addition to the enjoyment shown by the teachers, they reported a similar enthusiasm in their children:

> Yes, I mean I don't think I've got any children that don't like maths, um we actually have most of primary school children liking maths. It's, um, I'm not quite sure what happens. Somewhere along the line they suddenly decide they don't like it.
>
> (Catherine, 5.7.99)

> M It's a positive thing for the children, and I hate all this thing about, you know, oh if you don't do that properly then we'll do some number work and someone go over there and do that sensibly if you can't do that nicely... I hate all that attitude to it.
>
> NP As a punishment?
>
> M Yes I can't stand that. So I do enjoy maths I do enjoy teaching them number, the kids love it. They really get really enthusiastic about it and that's really worth it.
>
> (Mary, 20.5.99)

Appendix 11: Publications originating from the thesis

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On Martyn Hammersley's Critique of Bassey's Concept of the Fuzzy Generalisation

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ABSTRACT *This article is a further contribution to a critique of Michael Bassey's concept of 'fuzzy generalisations' as a form of dissemination of educational research. Martyn Hammersley has questioned both the uniqueness, and validity, of 'fuzzy' generalisation; the former in terms of a misunderstanding about the nature of generalisation as a whole, and the latter in relation to the potential for circumventing the research community's role in validation. It is argued here that, whilst in agreement with the first of these criticisms, the second depends upon the perspective taken, and that, from the perspective of the practitioner—as opposed to the researcher—(external) validity is a question of 'usefulness' within a particular context rather than generalisability across contexts. Furthermore, generalisations which state what will happen to a practitioner may fail to take account of the fact that he or she is far from being a passive recipient of the research.*

Bassey (1999) proposes the notion of 'fuzzy generalisations' as a means of disseminating the results of case study research. He acknowledges that his proposal is, in part, a reaction against the kind of research outcomes suggested by David Hargreaves (1996) in his lecture to the Teacher Training Agency in which he called for research that

> demonstrates conclusively that if teachers change their practice from x to y there will be a significant and enduring improvement in teaching and learning. (Hargreaves, 1996, quoted in Bassey, 1999, p. 48)

Bassey rejects the notion that this is even possible, stating that 'teaching situations are so varied that it is rarely, if ever, possible to say with certainty "Do x instead of y and your pupils will learn more"' (Bassey, 1999, p. 48). Instead, he suggests that research outcomes from case studies should be phrased in language that provides 'a firm reminder that there are many variables which determine whether learning takes place' and which invite teachers 'to enter into discourse about it' (1999, p. 51). Thus, in place of 'do y instead of x and your pupils will learn more', he suggests a phrase such as 'do y instead of x and your pupils *may* learn more' (1999, p. 51), noting that whilst this is only a slight change in language, it implies a very great change in emphasis.

In stating these ideas, Bassey refers to his (relatively recent) realisation that there are different kinds of generalisation and refers to *scientific* generalisations (those of classical physics) and *statistical* generalisations (those born of survey research, 'studies of samples', which include a statement of the probability that an event will happen). He delineates these generalisations and claims fuzzy generalisations as a third, distinct, form of generalisation; 'a qualified generalisation, carrying the idea of possibility but not certainty' (p. 46).

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In response to Bassey's ideas, Hammersley (2001) has criticised the distinction that is made between these forms of generalisation, claiming that they are all, in fact, of the same kind. Essentially this criticism is on two accounts. First, he rejects the notion that fuzzy generalisations are distinct in the sense that they do not apply to every case. This rejection is based on the premise that *scientific* generalisations too are only 'certain' within the conditions in which the experiment was carried out and, hence,

> outside of the situation where scientific generalisations are being tested, predictions derived from them about future cases should *always* be formulated in terms of what *could* happen. (2001, p. 220, italics in original.)

The same argument is, he claims, valid for statistical generalisations too, since the nature of the sample makes them less than certain in any situation beyond the sample itself. Thus,

> whilst scientific laws should be formulated in terms of what causes them (always or in x% of cases), predictions derived from these laws about future cases ought to be formulated in terms of what *could* happen. (2001, p. 223, italics in original)

His second rejection of the difference between fuzzy generalisations and scientific and statistical generalisations is based on the way in which each is produced. He notes that, in claiming that a fuzzy generalisation can be formulated when a case study suggests a causal relationship between variables and that the fuzzy generalisation suggests that the same causal relationship 'may' exist in other cases, Bassey

> neglects a crucial feature of causal attribution; that it is intrinsically general in character. To say that a causal relationship operates in one case is necessarily to imply that the same relation *will* (not that it *may*) hold in other similar cases (even if we cannot be sure what 'similar' means in exact and reliable terms). (2001, p. 221)

The corollary of this, he points out, is that the problem becomes that of determining what 'sufficient support' implies in the case of a fuzzy generalisation and that, whereas scientific research relies on validation by the research community, Bassey seems to be implying that 'all educational research reports should present fuzzy generalisations designed for use and accompanied by best estimates of trustworthiness' and, hence, that this 'circumvents the role of the research community in validating findings' (p. 221). In summary, Hammersley claims that:

> What is faulty about the use of natural science as a paradigm by social scientists and educational researchers is not the conception of generalisation which this involves but the model – supposedly derived from science – of the relationship between the knowledge produced by the research and practical action. (2001, p. 223)

Thus, the problem is not that case study (or social research in general) cannot create laws that will predict outcomes in all cases, but that, in fact, *any* type of research fails to be able to do this, so that even if educational research could produce scientific laws these would only tell us what *could* happen and not what *will* happen.

> In other words, 'fuzziness' is not a feature of a particular type of generalisation but rather a mode of formulation that ought to be characteristic of all

> generalisations, *including those produced by scientific research*, when they are intended to guide future action in the world. (2001, p. 223, italics in original)

Hammersley, despite his criticisms of Bassey's differentiation between different kinds of generalisation, still acknowledges the usefulness of the notion of fuzzy generalisations, particularly in 'suggesting that we can have theoretical knowledge of causal relationships before we can produce precisely and fully formulated scientific laws—indeed, perhaps even when such precision and completeness are unobtainable' (p. 223).

I wish here to pick up on this sense of utility and to take it on a stage further, for whilst I accept Hammersley's rejection of 'fuzziness' as a unique form of generalisation I agree with him regarding the usefulness of the idea of 'fuzzy generalisation' as a form of dissemination for educational research, but believe that there are implications for it which are not identified in his critique. In essence, this is that he does not take full account of a central aspect of generalisations in influencing practice; namely that the practitioner is not a *passive* recipient of the research in the way in which formulations of generalisations (of any sort) seem to suggest. Thus, they are suggested in the form 'do x instead of y and something positive *will* happen *to* your practice as a result', whilst their 'fuzzy' equivalents suggest 'do x instead of y and something positive *may* happen *to* your practice as a result'. However, both these formulations imply that the changes in practice happen *to* practitioners rather than that practitioners *make* changes happen within their practice.

The important aspect here is the function of research and the role of researcher and practitioner within it. From the point of view of the researcher, the aim of the research is to analyse a situation in order to understand it better and then to disseminate this new understanding in order that others might share in it. From the point of view of the practitioner however, the aim of the research is to *make use* of the fresh insight in *effecting change* in his or her own context. Note that, in the first of these, the aim is the *formulation* of understanding, whilst in the latter, the aim is the *utilisation* of understanding (and note too, that 'researcher' and 'practitioner' may be the same person operating in different modes at the different times). If research merely aims to describe a studied case then an analysis of what happened *to* the practitioner suffices. However, if it aims to offer the opportunity for practitioners to *change* their practice as a result of understanding the studied case (or to try to persuade them to do so), then it seems sensible for the research to present the analysis in a form that emphasises the action that *may* be taken to facilitate that change. Indeed, this is what Bassey seems really to be proposing.

> A fuzzy generalisation carries an element of uncertainty. It reports that something has happened in one place and that it may also happen elsewhere. There is a possibility but no surety. There is an invitation to 'try it and see if the same thing happens for you'. (1999, p. 52)

I would suggest, however, that fuzzy generalisations might be taken a stage further. Instead of stating that 'doing x rather than y may *result in* a positive change to your practice' we might state that 'you may be able *to facilitate* change z in your practice by considering doing x instead of y in your particular context'. One might claim that this may simply be seen as semantics. However, in the same way that Bassey himself suggests that a small change in wording from 'will' to 'may' produces a significant change in meaning, so I make the same claim here. What is important is not—as

Hammersley rightly argues—the *form* of the generalisation, but nor should it be simply an 'invitation to try it and see'—as Bassey proposes. Rather fuzzy generalisations should be seen as a way in which researchers may share with practitioners their understanding of how the latter *might* reconsider their practice in order, *proactively*, to *make* change happen in their own context. That is, the research outcome needs to say to the reader 'this is what happened in this case, these are what appeared to be the significant aspects of it, now you could consider how they *might* (note, the uncertainty remains) apply to your situation in order to help you *make* change happen'. Furthermore, the invitation remains open for the practitioner to report back on the process of trying to effect the change, to describe whether or not it worked, and to analyse the aspects of the practice which facilitated this. It thus maintains, as Bassey suggests (1999, p. 52), the opportunity for case study to become cumulative as individual practitioners identify those features of their practice which seemed to be significant in effecting the change.

In addition to the change in emphasis outlined above, the delineation of the perspectives of researcher and of practitioner allow us to reconsider Hammersley's second objection to the idea of fuzzy generalisations; the circumvention of the research community in validating the outcomes of the research. He points out that validation of case studies through accumulation of cases relies on comparison of cases which are of the 'same putative kind selected to provide comparative leverage' (footnote, p. 224). Once again, this is based on the premise that research should result in knowledge which generalises in a particular way; namely that, given a specified set of conditions, an action of the form x will produce (by causal relationship) a result, z, in practice. However, this again relies on an understanding of the recipient of the research as passive. If fuzzy generalisations are seen as opportunities to understand a situation in order *to effect* change, then their (external) validity may be seen not as a function of whether the 'same thing *happens*' in other situations with comparable conditions but, instead, of the extent to which practitioners can *make use* of them in effecting change proactively in their own situation.

Again, the distinction here is to do with the different perspectives of the researcher and the practitioner. What Hammersley seeks is the creation of academic knowledge, for which (external) validity means the extent to which there is 'substantial agreement' within the research community that the findings are 'sufficiently likely' to generalise to other cases, given the available evidence. On this basis, he thus claims that

> the fundamental problem is that, on his [Bassey's] account, it is not clear what precautions are to be taken by case study researchers to make sure that what is proposed as a fuzzy generalisation has a reasonable chance of general validity based on causality; given the case study does not employ experimental manipulation. (Hammersley, 2001, p. 222)

However, this 'problem' is dependent upon a desire for the outcome of the research to be knowledge in an academic form, where the central tenant of validity is as a measure of generalisation *in terms of causality*. My claim is that (1) this relies on the notion of the practitioner as a passive variable in this causal relationship, and that (2) it takes the perspective of the researcher as being dominant over that of the practitioner, with the result that academic knowledge is seen as superior to practitioners' 'craft' knowledge. When this situation is reversed, and the perspective of the practitioner is placed first, what matters is not whether the result generalises to *all* cases (with the same conditions), but whether it can be *made* to generalise to the practitioner's *own* case. This is, of course, a function, in part, of the *active* ability of the practitioner to do so, not simply

to 'let it happen' to her. Seen in this light, from the practitioner's perspective, external validity becomes more a matter of the *usefulness* of the case in supporting change in the practitioner's own context. Cumulative case studies might therefore provide increasing validity in the sense that they are likely to increase the opportunities for the practitioner to identify those aspects of the situation which are 'significant' to her in being able to effect a change in her practice.

In passing, it is worth noting that this may also provide a rationale for seeking alternative forms of presentation of the research such as those discussed by Woods (1997). Where utility becomes the main focus for reporting research, these alternative forms of presentation are, perhaps, more likely to produce the kinds of resonances that allow the practitioner to identify which of the features of the case studied are the most significant.

Finally, but significantly, it should be noted that the above discussion refers to an alternative conception of *external* validity. It is important to note that, whilst it challenges the notion that external validity need be a function of causal generalisation, it does not alleviate the need for *internal* validity. Whilst it is the perspective one chooses to take (researcher or practitioner) which affects the nature of external validity, whichever perspective is chosen, one needs to be sure that the features of the situation identified as 'significant' are arrived at in ways that allow a reasonable degree of confidence in them. Thus, issues such as soundness of reasoning, sufficient triangulation, systematic enquiry etc., as detailed by Bassey under the term 'trustworthiness' (1999, pp. 74–77), remain crucial to the internal validity of the research. In criticising the adequacy of 'professional judgement about trustworthiness', in the sense that it does not sufficiently involve the research community, Hammersley seems not to be making the distinction between internal and external validity.

SUMMARY

I am aligning myself, in the above discussion, with Hammersley's criticisms of the uniqueness of fuzzy generalisations and agreeing with him about the usefulness of the notion. However, the difference between us is in my own delineation of two perspectives, that of the practitioner and of the researcher, which, I assert, leads to different emphases in terms of what constitutes (external) validity. The latter perspective leads to an emphasis on academic knowledge where the focus is on the legitimacy of the knowledge itself, with an associated emphasis on generalisation between all 'similar' situations. The former perspective, however, leads to an emphasis on craft knowledge—what counts is its applicability to a specific situation; that of the practitioner herself. From this perspective, the practitioner is no passive recipient of the research 'to' whom things happen; rather, she is active in *making* changes to her practice as a result of a consideration of the issues raised by the research.

Research as a contribution to, and stimulus for, professional discourse is in essence the idea that Bassey himself develops and certainly he claims that it

> should contribute to the maelstrom of ideas, theories, facts and judgements about education. It should be something that teachers ... look for, read about, argue over, reflect on and then either reject and forget, or file away in their memory to adapt and adopt later. (1999, p. 51)

However, in addition to looking for, reading about, arguing over and reflecting on research I am suggesting that teachers might also attempt to make it (the fuzzy

generalisation) happen in their own contexts and that, in doing so, they might then contribute to the generalisation itself in the cumulative way that Bassey suggests.

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MATHEMATICS AS THINKING

Nick Pratt

'That's fascinating, but what I want you to see is . . .'

If you have ever found yourself saying these words then it is likely that, like all teachers, you may be stuck between the rock of encouraging children's thinking and the hard place of trying to develop learning in a particular direction. In the context of the national numeracy strategy the tension can be seen as being between instructions for planning teaching on the one hand and the recommendation for carrying this out on the other. In respect of planning, the claim is that, 'better numeracy standards occur when . . . the teaching programme is based on identified learning objectives, and is planned thoroughly, to ensure . . . good progression throughout the school'[1]; regarding implementation, one should use interactive teaching, 'a two-way process in which pupils are expected to play an active part by answering questions, contributing points to discussions, and explaining and demonstrating their methods to the class' [1]. Clearly this represents a potential dilemma, for if one believes that children will learn best when *what* they should learn is detailed in advance, then it becomes problematic when, as it always does, children begin to think about 'something else' as the teaching and learning takes place.

We want children not just to engage *in* mathematical thinking, but to come to view mathematics *as* thinking.

My starting point for considering this dilemma is an assertion: that we want children not just to engage *in* mathematical thinking, but to come to view mathematics *as* thinking. From this perspective, though mathematics of course involves the development of knowledge and practical skills, it is *essentially* about trying to make 'mental sense' of ideas in ways which are coherent and consistent by thinking in particular ways. The numeracy strategy's call for children to contribute to this sense-making is based (presumably – though it is not made explicit) on a belief that we learn most effectively with other people and that *talk* is the primary vehicle for doing so. What I intend to explore here is how, as teachers, we tend to control the flow of children's talk, often to the extent that they cease to be able to become a genuine part of any interaction and how, if we wish to change this, we might profitably reconsider a few of our teaching strategies.

What sort of interaction do we want?

Interaction can, of course, take many forms but I limit myself here to interaction in the form of talk. If we wish to encourage children to make sense of mathematical ideas by thinking and talking, what kinds of thinking and talking do we wish to foster? Mercer [2] proposes three, 'ways of talking and thinking': disputational talk, cumulative talk and exploratory talk. The first of these 'is characterised by disagreement and individualised decision-making'; the second is talk 'in which speakers build positively but uncritically on what the other has said'. However, in exploratory talk people engage in constructive criticism of each others' ideas and,

> *knowledge is made more publicly accountable and reasoning is more visible in the talk. Progress then emerges from the eventual joint agreement reached.* [2]

It is this last form of talk that seems to me to be what the national numeracy strategy is hoping for in its description of 'whole class interaction'. Knowledge which is publicly accountable might also be shared more readily and reasoning which is visible might be more likely to 'make sense' to children. However, in practice, talk is all too often no better than cumulative with the teacher controlling what is acceptable and what he or she thinks should be said in order to accumulate a 'correct' picture of the idea under discussion. This brings us back to the dilemma outlined above: that the national numeracy strategy encourages a view of mathematics as interactive, but simultaneously as a

progressive series of ideas to be acquired under the control of the teacher. In so doing, teachers are recommended to 'involve pupils interactively through carefully planned questioning' and to 'ask pupils to offer their methods and solutions to the whole class for discussion' [2]. Such recommendations are easy enough to make but harder to fulfil. What follows is intended to address this to some extent by both considering the dilemmas involved and offering some simple starting points for resolving them.

What stops exploratory talk?

Exploratory talk implies 'talk which combines challenges and requests for clarification with responses which provide explanations and justifications' and which 'by incorporating both conflict and the open sharing of ideas represents the more 'visible' pursuit of rational consensus through conversation' [3]. Clearly, making the rationality of talking more visible is likely to develop the kind of reasoning upon which mathematics is based.

However, such discursive activity is easily described but is more difficult to achieve in practice (and more difficult still is to be able to stand outside one's own teaching and see how it is being prevented). Consider for example the following dialogue in a Y5 class with Frances (F), their teacher, in which the children are trying to find the complement to 100 of various numbers ({Ch} refers to particular children).

F: 85?
Children hold up cards at varying speeds. Frances waits and those who are waiting with her begin to call out the answer.

F: {Ch1} how did you get 15?
{Ch1} begins to explain his answer. His explanation falters before it is complete and Frances immediately takes over (offering an interpretation of how he might have reached 15).

F: {Ch2}, tell us how *you* did it.
{Ch2} gives an explanation which the others follow.

F: Ok. What about 42?
Children begin to work out the answer [58] and hold up their cards.

F: {Ch3}, tell us how you did it.
The explanation from {Ch3} is long, though apparently accurate in the sense that I could understand it as an 'expert' listener. However, Frances interrupts the explanation part way through and gives her own, different explanation.

When I was watching this interaction the attention of the children at different moments stood out very clearly for me. On the whole, the children appeared very much involved in it, seemingly watching and listening carefully to each other. However, on each occasion that Frances provided an explanation (once in 'support' of a child who stopped and once interrupting a long explanation) many of the children demonstrated a marked drop in their attention and their willingness to 'interact' with the teacher's talk. Such a shift of attention was usually signalled by changes in body language, for example dropping eye focus, turning attention to objects on their desks or turning to talk to another child. (I should note here that such changes in body language are relatively subjective and do not, individually, indicate an unquestionable drop in attention. What is referred to here are occasions on which such expressions were marked amongst significant proportions of the class simultaneously.) Compare the transcript with the one below in which another teacher, Heather, manages to keep the attention of her Y6 children high throughout.

> Clearly, making the rationality of talking more visible is likely to develop the kind of reasoning upon which mathematics is based.

H: What is 200 grams as a fraction of 1 kilogram?

Ch1: One fifth.

H: Everyone agree?
Ok, so what is 200 grams as a fraction of 3 kilograms?

Ch2: A fifteenth.
Heather makes no response here either verbally or physically and allows time for other responses.

Ch3: Three fifths.
General murmur amongst class about each response.

H: A fifteenth? Three fifths? Which one is right, and why?
Children begin to consider this and Heather sits back allowing them to think about it for several minutes. One child then gives an accurate explanation as to which is correct and there is general agreement from the rest of the class.

H: So, what fraction is 600 metres of one kilometre? Show me with your cards.
All the children I can see display three fifths with digit cards.

H: Very good. You all got three fifths.

These two transcripts are open to many interpretations and I am aware that one would want to see many more examples, as I have been lucky enough to, before making the kinds of judgements below. However, they are useful in illustrating one particular issue: the relative focus of each teacher. I began by making a distinction between mathematical thinking and mathematics *as* thinking and this, to me, seems to mark out the distinction between the two teachers here. For Frances, the implicit end product of her teaching is *particular* knowledge that she wants the children to develop. Thinking is

therefore a means of getting to this end point and the kind of talk generated is the cumulative kind where Frances herself is in control of the accumulation; its content and its order. Where points are offered to the whole class they are not for discussion *by* the whole class. Rather, they are meant to be part of the accumulated information that Frances herself considers to be necessary and sufficient for understanding the idea in question, which is why she controls it closely in terms of its accuracy and (perceived) relevance. Interestingly, the children not only know this but suggest through their level of attention that they are less interested in the accumulation of knowledge than in the business of rational discussion about it. For Heather however, thinking itself is the focus – illustrated in the transcript above, but evident throughout her mathematics teaching – and she attempts to create talk of an exploratory kind, with a development in knowledge being the natural result of this. Of course, this does not mean that Heather has no knowledge objectives for her lessons. For Frances though, objectives serve as endpoints, towards which she tries to move continually, essentially in a straight line ('the shortest distance between two points'!). For Heather the objectives are 'centre points' around which the lesson rotates, often moving away from them but always returning eventually. As a result, Heather's children are thinking mathematically because they are encouraged to view mathematics as thinking – and to use talk to explore their ideas, making knowledge more 'publicly accountable' and reasoning 'more visible'. Such thinking is of a particular sort involving, for example, logical reasoning, conjecturing and induction and this is where modelling and careful questioning are so important because they allow the teacher to demonstrate this kind of thinking in action herself and to prompt children to do so.

Any mathematician will tell you that the process of *arriving* at a proof is very different from the *post hoc* production of the formalised proof itself.

Forms of 'thought control'

Twenty-five years ago, when primary teaching was under the influence of a very different set of (Plowdenesque) values than it is today, Edwards and Mercer [4] identified a set of actions which they claimed 'may foster or hinder the development of common (ie, joint) knowledge in the classroom'. My own observations suggest that little seems to have changed despite the changes in values. The list below illustrates some of the teaching actions that, I believe, can potentially hinder thinking in the mathematics classroom, especially where they are done habitually. However, I emphasise that each can also have a positive teaching effect in another context. I invite you therefore to consider them in the light of your own practice and to ask the question *how* each one might affect the way your children think about mathematics.

What happens when you:

- ask a child to explain his or her solution to a problem/calculation without this being an opportunity for other children to explore it in relation to their own; ie the explanation is simply for its own(er's) sake?
- ask more than one child to explain the same problem/calculation without contrasting them?
- support' a child with his or her answer by:
  - interrupting it and/or finishing it off in your own words?
  - reinterpreting what had been said to mean something different?
  - ignoring the whole answer because it does not match the teaching point?
  - ignoring the whole answer for fear that it could not be understood sufficiently by others?
  - ignoring elements of the answer in order to refocus it on something new?
  - repeating the answer, emphasising certain elements of it and thereby changing the meaning?
  - using value judgements ('good', 'I'm not sure about that', quizzical looks etc.) thereby endowing certain aspects of the answer with special significance?

The role of indeterminacy

So often, mathematics is associated with the definite and with truth. The purpose of a proof (or, for young children, at least an argument) is to try to remove any ambiguity; to convince the reader/listener that that is the way it is. However, any mathematician will tell you that the process of *arriving* at a proof is very different from the *post hoc* production of the formalised proof itself. This difference may mirror the distinction between the pleasure derived from the creative view of the subject which most mathematicians would hold and the negative feelings held by many people more generally. But the same distinction may be being reflected in the classroom too if a teacher confuses the *result* of an argument with the process of engagement *in* such an argument. Furthermore, such a confusion is more likely in any initiative which promotes the idea of objectives to be 'achieved' too strongly, since the temptation to hear children saying the right thing (or more usually saying it for them), rather than engaging in

exploratory talk about something, will be very much increased.

One key issue here is in the indeterminacy of language. Words symbolise ideas and where we find ourselves commandeering children's spoken words to 'make the meaning clear' (by the processes outlined above: rephrasing, refocusing, re-emphasising and so on) it is, presumably, due to an implicit sense that the meaning needs to be clear *before* children will understand. Such an approach, though easy to criticise, is understandable in an environment where 'getting done' [5] is paramount and where teachers are under pressure to achieve particular learning at particular times. However, as Mercer (2000, p172) again notes,

> *the same collection of words can never be guaranteed the same interpretation by different listeners. If we think of language as a system for accurately transmitting ideas and information between speakers, this may seem to be a problem. But if we consider language as a medium designed for collective thinking, this feature, the 'necessary indeterminacy' of language . . . is a strength rather than a weakness.*

Thus, it becomes apparent that it is the very indeterminacy of language that drives the process of meaning making in interactive mathematics teaching and one corollary is that, whatever the pressures on us as teachers, we may need to allow children more space and time both to find adequate words in giving explanations and to make sense of the words of others in the context of their own current knowledge.

Summary

The phrase 'thinking skills' is currently common in the teaching profession. One drawback with it is that it can imply that children need somehow to develop the 'skill' of thinking. I would argue that children can already think and that what they need is the opportunity to learn to apply this thinking in a mathematical context – to learn *mathematical* thinking. In doing so they need to use language both to organise their individual thoughts and because meaning is made jointly (even 'individual' ideas arise as a result of joining together the products of previous interactions with others). Though the end product should result in new ideas, where the emphasis is placed too strongly on these endpoints, the result can be that these opportunities tend to get appropriated by the teacher in her effort to ensure that children hear the 'right thing', as we saw above. Where the emphasis is on mathematics *as* thinking, however, it is more likely that children will be given time and space to make their own sense and, potentially, to learn more as a result – even if it is not the learning that the teacher had in mind at the start. To finish, therefore, let me offer some strategies for achieving this which arise, in a sense quite obviously, from the discussion so far:

- Understand and value silence – as teachers we seem to fear it, but there are different kinds of silence and we need to understand the cause and potential value of each kind.
- Provide the opportunity to receive more than one answer – ask 'what does everyone else think?'. This will mean there are several things to think *about*.
- Add your own, potentially false, ideas so that children have to jointly argue them away – does the diagonal on a quadrilateral *have* to be straight? Sometimes these lead to interesting new insights.
- Receive answers neutrally (which is very hard to do) – everyone stops thinking when they think they see the answer;
- Ask 'can you tell me *anything* about . . .?', not 'what is . . .?' or 'how does . . .?' – it makes a huge difference since it values partial answers contributing to making sense jointly.
- When children give half answers and then say 'D'yuh see what I mean?', do not always reinterpret it for them. Instead, say 'no' – then sensitively explain that they need to tell you more about it, or ask everyone else if they understand.
- Give praise to the whole group for understanding other peoples' (joint) explanations – understanding is about a collective, two way process, not just an individual's ability to explain.
- Finally, remind children that *not* understanding is the natural and necessary starting point for mathematicians and use this as the starting point for seeing thinking as the core element of mathematical work.

I would argue that children can already think and that what they need is the opportunity to learn to apply this thinking in a mathematical context.

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