14

Primary Science:

An analysis of changing policy, policy text and practice

by

Sandra Lesley Eady

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TABLE OF CONTENTS

Page

LIST OF TABLES

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DECLARATION

I declare that the thesis presented here is my own work. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

I declare that this work has not previously been submitted for a degree or diploma in any university.

Sandra Eady .... 27 January 2007 ....

Sandra Lesley Eady Date

ABSTRACT

This thesis sets out to examine the extent to which primary science is a complex interplay between educational and political perspectives which in turn has influenced and shaped the way primary schools interpret, reconstruct and implement science in practice.

This study uses a policy trajectory to consider the changing conceptions of primary science within the arenas of policy influence, policy text and practice in relation to its curriculum content, related pedagogy and assessment. In addition, it examines the nature and impact of professional development to support the implementation of primary science in practice. Evidence was collected through a series of interviews with elite figures in education, a regional survey of primary schools, along with in-depth cases studies in order to develop a deeper understanding primary science within the policy to practice context.

The findings would indicate that despite a succession of top down science education policy reforms, there are still concerns about the extent to which teachers have sufficient science subject knowledge to develop conceptual understanding, a clear idea of the purpose of science investigations and how to use formative assessment as an effective way of diagnosing pupil understanding. Furthermore, the evidence would suggest that the emphasis placed on summative assessment and accountability has narrowed teachers' conceptions of primary science.

The implications are that science policy reform needs to acknowledge existing practice and support a wider definition of science that includes an appreciation of the historical and cultural aspects of science together with an understanding of technological applications. In addition, a more robust infrastructure of professional development needs to be in place which places more emphasis on the science co-ordinator to support teaching and learning in order to provide teachers with access to a changing knowledge base and opportunities to update skills in primary science. Unless these implications are given serious consideration the unrelenting focus on performativity and accountability will prevent any real development of creativity and innovation in the primary science curriculum.

LIST OF ABBREVIATIONS

Assessment for Learning	AfL
ASE/Kings Science Investigations	AKSIS
Assessment Performance Unit	APU
Association for Science Education	ASE
Attainment Target	AT
Cognitive Acceleration through Science Education	CASE
Children's Learning in Science	CLIS
Continuing Professional Development	CPD
Centre for Research in Primary Science and Technology	CRIPSAT
Class Teachers	CTs
Department for Education and Science	DES
Department for Education and Employment	DfEE
Education Reform Act	ERA
Education Support Grants	ESG
Grants for Education Support and Training	GEST
Head Teachers	HTs
Her Majesty's Inspectorate	HMI
Information and Communication Technology	ICT
Initiatives in Primary Science Evaluation	IPSE
Initial Teacher Education	ITE
Key Stage One and Two	KS1&2

Local Education Authorities	LEAs
National Curriculum Science Working Party	NCSWP
National Foundation for Educational Research	NFER
National Curriculum	NC
National Curriculum Council	NCC
National Numeracy and Literacy Strategies	NNLS
Newly Qualified Teacher	NQT
Office for Standards in Education	OFSTED
Primary National Strategy	PNS
Primary Science National Curriculum	PSNC
Primary Science Scheme of Work	PSSW
Qualifications and Curriculum Authority	QCA
Standard Assessment Tasks	SATs
Science Co-ordinators	SCs
School Education and Assessment Council	SEAC
Solids, Liquids and Gases	SLG
Science Processes and Concept Exploration	SPACE
Statistical Package for the Social Sciences	SPSS
Science Teaching and Action Research	STAR
Teacher Training Agency	TTA
Task Group on Assessment and Testing	TGAT

CHAPTER ONE: INTRODUCTION

1.1 OVERVIEW OF THE STUDY

When we look back at the curriculum in English Primary schools prior to the Education Reform Act (ERA) (DES1988a), 'science' was not a significant part of the primary school curriculum. HMI (DES 1978) had argued earlier that the progress of science teaching in primary schools had been disappointing. Yet by 1991 science was a key component of every child's primary education with approximately 10% of curriculum time spent on science (Ofsted 1999a). Furthermore, international comparisons suggested that year five (Y5) pupils in England were performing at the highest levels in science, with only two countries showing better results (Ofsted 2005a). Whilst political interests viewed the 'success' of primary science in terms of national and international comparability (Martin, Mullis, Gonzalez and Chrostowski 2004), educators perhaps perceived 'primary science' and 'success' in a different way. For example, promoting teaching that recognised the importance of pupils' existing ideas and the interaction of processes and concepts to develop scientific understanding together with fostering positive attitudes to science, provided quite a different perspective of 'success' (Harlen 1993). Furthermore, to develop an understanding of the historical origins of scientific ideas, along with an appreciation of the technological applications, enabling children to feel confident and competent enough to engage with a range of scientific issues within a global dimension, provides perhaps another view of 'success' (Millar and Osborne 1998).

Such differing perspectives serve to illustrate the complexity behind the present conceptions of primary science and point to the fact that in order to make sense of the current practices it is necessary to 'deconstruct' such terms as 'primary science', and examine possible factors which over time have influenced and shaped our understanding. Whilst we might turn to philosophy or cognitive psychology to understand the origins of 'primary science' from an educational perspective, the increased political interest in education since ERA (DES1988a) would suggest that it was equally important to examine the influences originating from the educational policy context (Ball 1994, Ball 1999). Furthermore, it is how this is understood and interpreted by teachers in order to construct learning experiences for pupils which really enables us to understand what constitutes primary science in practice. In fact Pollard, Broadfoot, Croll, Osborn, and Abbott, (1994) argued that teachers appear to mediate the external pressures upon them through the filter of their own professionalism and practice and as a result they effectively become 'makers' as well as 'implementers' of policy in their own classrooms (Pollard et al. 1994 p.78-79). Finally how pupils, with their own beliefs and ideas, interact and make sense of such learning experiences will provide yet another perspective of 'primary science'.

In order to make sense of current conceptions it is necessary to take account of related historical and current notions of what is understood by 'primary science' and how the related strands of 'curriculum', 'pedagogy' and 'assessment' which Ball (1994) refers to as the 'message systems of education' and to acknowledge how these are influenced and even shaped by the wider policy agenda. Thus, debate and discourse about the nature of science and its rationale as a curriculum subject in primary schools needs to be considered alongside conceptions of learning and knowledge bases for teaching. Likewise the debate about the place and purpose of assessment has also contributed to the notion of science in primary schools, which in turn have been influenced by political ideologies of market forces and the needs of a 'high skills economy' (Ball 1999).

1.2 PRIMARY SCIENCE

Cognitive psychology (influenced by the ideas of Ausubel, Bruner, Piaget and Vygotsky) and philosophy (in particular the ideas of Popper and Kuhn) have influenced the development of science education resulting in a large body of research (often referred to as constructivist approaches to learning) that has given a great insight into our understanding of how pupils learn science. As a result there has been a steady growth of research giving us a better understanding of how learners use existing ideas to assimilate new knowledge, the kinds of ideas they have about particular concepts and of the interplay between formal and informal ideas (Driver 1983, Osborne and Freyberg 1985 and Harlen 1993). This has, over time, provided a sound basis for ascertaining what might be appropriate 'content' for primary science, based on what is known about children as learners and the likely progression of conceptual knowledge. It has also provided evidence of the links between process skills and conceptual understanding along with the significance of thinking and reasoning of ideas and findings (Harlen 1993). The research has also begun to illuminate the role of the teacher in that process, raising issues about the importance of teacher subject knowledge within the teaching and learning process including capabilities to conduct formative rather than summative assessments as well as the extent to which constructivist ways of learning may translate into constructivist approaches to teaching.

However it was only since the introduction of a Science National Curriculum (1989b) for Key Stages One and Two (KS1&2) referred to in this study as the Primary Science National Curriculum (PSNC) that a detailed, 'knowledge based' science curriculum had been outlined for primary schools. Prior to this 'science' as a subject to be studied was not apparent or clearly defined and it often formed part of a learning experience through 'topic' work. Conceptions of primary science focused predominantly on process skills rather than content knowledge. Outdoor or nature study was perhaps the closest aspect of the primary curriculum to science and related practical work and involved observational drawing, collections or a stimulus for creative writing and poetry, with a focus on 'discovery' in order to develop generic process skills such as observation and measurement (Russell, Bell, McGuigan, Qualter, Quinn and Schilling 1992). In fact the Assessment Performance Unit (APU) survey (1988) suggested that teachers focused predominately on generic rather than science process skills at this time. The notion of 'scientific enquiry' was not a clearly defined aspect of the primary science curriculum until the PNSC (1989b). Likewise early curriculum materials such as Nuffield Junior Science Project (1967) assumed that what children investigated was unimportant, it was how they investigated and even the main aim of Science 5/13 (1972-1975) was to 'develop an enquiring mind and a scientific approach to problems'.

Thus the emphasis of the science curriculum at this time was on the learner and providing an enriching environment in which he or she was invited to explore, with any notional content reflecting the interests of the pupils or teachers and as such was often in the form of everyday observable objects or phenomena linked to the senses. Moreover, because many primary school teachers lacked a science background, they were unlikely to have any depth of understanding or expertise in elementary science. The advent of the PSNC (DES1989b) not only specified a body of scientific content but also defined scientific enquiry for primary schools, thus providing a very different conception of 'primary science' and one, which demanded a structured and more rigorous approach to learning. The PSNC (DES1989b) broadened the definition of primary science to include physical and material sciences as well as a basic knowledge of the scientific method. In addition it introduced the notion of a progression of understanding within each strand of the programmes of study which could be assessed.

1.3 POLICY TRAJECTORY MODEL

Whilst it may be possible to gain an insight into differing perspectives and constructions of 'primary science' over time, it is also important to understand that such perspectives are constructed at different levels and in varying contexts as well as constantly changing. On a micro scale, the way teachers understand, interpret and re-construct primary science will be intrinsically linked to their beliefs, knowledge and experience of science curriculum, learning theories and assessment, as well as the contextual factors in which they operate. On a macro level different local and national pressure groups and political parties will compete to influence educational policy in relation to global and national interests.

In order to understand the dynamic and complex relationship between discourse, policy and practice in relation to primary science in this study, a policy trajectory was used (Bowe, Ball and Gold 1992). This suggested that competing ideologies and interests struggle to influence policy and practice at three levels. Within the context of influence, Bowe et al. (1992) argued different interest groups compete to influence the definitions and purpose of education. Increasingly the people that form part of this group are drawn more from a ministerial group, with educationalists, including teachers being increasingly absent from the context of influence.

In the context of policy text production Bowe et al. (1992) suggested that the production of formal and informal policy texts reflected a compromise of views, struggles and influences of the policy writers in the same way as arenas of influence represent competing views. Furthermore, they argued that whilst policy texts were written in a language that was understood and acceptable to the public and appealed to common sense, they were not necessarily coherent in practice in that they tended to apply to an ideal world rather than to specific contexts. Thus, policy texts need to be read in relation to others produced at the time otherwise they can appear contradictory and do not take account that policy has evolved or moved on.

However, Bowe et al. (1992) suggested that the policy text has real consequences only when it is enacted within the context of practice. Ultimately the policy writers cannot control how their texts will be interpreted, and there is no guarantee that stakeholders will digest policy and implement it as effectively as they can. Instead they interpret and recreate it in relation to their contexts, existing beliefs, views and practices and in relation to the resources they have available. Before policy is implemented it has first to be understood and an interpretation agreed amongst stakeholders of what it will look like in their context. In addition, stakeholders may pick out bits of policy that they agree with and deliberately 'misinterpret' or ignore other aspects that they do not like for whatever reason. In this sense it could be argued that the balance of power shifts from the policy makers to the policy implementers. Thus Ball (1994) suggested that it was impossible for policy writers to control how policy will be carried out in practice as policy received in schools was not just implemented but was subject to individual interpretation and was recreated by individuals and groups. However government and policy writers are dependant on schools to implement policy and either 'praise' teachers for their efforts, commitments and skills or put measures in place to 'enforce and monitor' implementation (Bowe et al. 1992, Ball 1994).

Galton (1995) argued that the imposition of policy and legislation, without much consultation resulted in much confusion and resentment among teachers who were required to implement it in their classrooms. In addition, Black (1995) suggested that often teachers have been treated with remarkable insensitivity and have been seen as part of the problem. This he argued was counter-productive, as it must be recognised that teachers are the key to educational improvement. If they do not share the aims, reflected in policy text then they will be reluctant to make it work in practice (Black 1995 p.180). More recently Alexander (1997) argued that in many instances teachers who have to make policy work in practice do not really change their teaching methods but look for ways of accommodating or integrating new initiatives within existing practice. However, Richardson (1998) claimed that teachers only resist change when it is statutory or suggested by others; where teachers are involved in the change process it can be effective.

Longitudinal studies carried out by Galton, Simon, and Croll (1980); Galton, Hargreaves, Comber, Wall and Pell (1999); Pollard et al. (1994); Pollard and Triggs, (2000) and Osborn, McNess and Broadfoot

(2000) have mapped the trend started by the Conservative government (1992) and continued under New Labour to stamp out the distinctive progressive child centred ideologies with a significant shift toward whole class single subject teaching (Brehony 2005). These studies question whether the subsequent legislation that followed the introduction of the NC did really provide a centralised curriculum to ensure breath, balance, continuity and progression or whether the focus to make schools more responsive and accountable to parents and wider society became more important.

In order to make sense of the interplay between educational and political discourse, policy and practice, this study will use the policy trajectory (Bowe et al. 1992) as a framework to examine the political and educational conceptions of primary science within policy and policy text prior to and after the introduction of the PSNC (DES1989b). In addition, it will analyse how teachers in turn interpret and reconstruct primary science in their classrooms.

In order to explore the underlying ideas the research attempts to address the following research questions

1. To what extent is primary science a product of conflicting influences, views and perspectives?

2. In what ways have recent policy, policy text and discourse contributed to the debate and development of the primary science curriculum?

3. How do schools, Head Teachers (HTs), Science Co-ordinators (SCs) and Class Teachers (CTs) interpret, reconstruct and implement primary science in practice?

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

Using the policy trajectory (Bowe et al. 1992) outlined in the previous chapter, this review will report emerging and conflicting conceptions of primary science through research literature and policy documentation as it relates to the changing policy to practice context.

2.2 THE CONTEXT OF POLICY INFLUENCE.

2.2.1 Philosophical and Cognitive influences

The way in which the creation of scientific knowledge is perceived and how learning takes place in schools has been influenced by philosophical views of scientific knowledge (Warwick and Stephenson 2002). Nussbaum (1989) suggested that much of the science education research in 1980s advocated a social view of constructing knowledge, which particularly showed signs of influences from philosophers such as Kuhn (1970), Toulmin (1972) and Lakatos (1970). As a result, much of the research in science education in the last twenty years has been based on the assumption that knowledge is not 'discovered' but is 'constructed', it does not proceed by an accumulation of more and more facts to confirm existing theories, but by a rigorous testing of existing ideas in order to refute rather than verify them (Popper 1972). Thus, when anomalies in one tradition of scientific practice become so great there is then a need to move to a new basis of scientific practice, which Kuhn (1970) termed a 'paradigm shift', or a scientific revolution.

In the 1960s and 1970s, cognitive learning theories also had a strong influence on the prevailing educational ideology of 'action' and 'doing' and learning though 'discovery' in primary science (Osborne and Simon 1996). For example, Dewey's (1859-1953) emphasis on 'hands-on' experience influenced thinking about the way that natural, spontaneous activities could be directed towards educational ends, whilst Piaget's stages of learning and in particular, concrete experiential learning, provided evidence that young children learned most effectively in this way, often with teachers providing stimulating activities, encouraging children to reflect on their experiences, although not necessarily correcting 'wrong' ideas. Driver, Asoko, Leach, Mortimer and Scott (1994) argued that Piaget's ideas about how children constructed meaning symbolised what has now become known as personal or cognitive constructivism.

However, towards the end of the 1970s there were growing concerns about primary science perceived just as 'process'. The work from the

APU in the 1970s and 1980s provided evidence that although 'processes' were ranked highly by teachers they were not always 'scientific processes', whilst 'process objectives' which were specifically 'scientific' had a low ranking (Osborne et al. 1996). At about the same time further debate about the importance of both content and process skills in primary science was reflected in Harlen's (1978) seminal paper. Also of importance was a concern that science should be for all and that in addition to knowledge and process a science curriculum should include the study of the social and cultural value of science (Black and Ogborn in White, Black, Ogborn, Crick, Aspin and Lawton 1981). In addition, a dissatisfaction with learning theories based solely on Piaget's stages of development had led to a growing interest in the way children's existing ideas influenced learning (Ausubel 1968). This led to the emergence of constructivist research which saw the elicitation of children's prior knowledge or preconceptions, as a vital part in the construction and reconstruction of knowledge. Equally interaction through discussion and reasoning was necessary in order to encourage 'meaningful learning' (Ausubel 1968). Furthermore, Millar and Driver (1987) provided a powerful argument as to why learning science was more than just mastering process skills which they saw as no more than characteristics of logical thought (Millar and Driver 1987), providing further evidence that some notion of 'content' was important.

Theories of how children's initial ideas might be challenged or extended by the support of knowledgeable adults added to the growing interest in the role of the teacher as an active participant guiding and supporting learning in advance of a child's development and therefore playing a crucial part in supporting conceptual change in science (Vygotsky 1962, 1978). Vygotsky emphasised the importance of the social context and the role of others in the process of constructing and reconstructing knowledge (Vygotsky 1962, 1978). In addition, Bruner's (1960) notion that the teacher should become knowledgeable about the structure of subject matter they want to teach by knowing the key ideas and concepts and sequence rather than letting pupils discover everything for themselves was also an important influence on primary science. These ideas led to the growing interest in science that knowledge was socially constructed. Driver et al. (1994) argued that scientific understandings were constructed when individuals engage socially in talk about shared problems and tasks in order to develop common knowledge. In this way the teacher acts as a 'bridge' between pupils existing ideas and those of the scientific community. Thus it is vital that teachers have a thorough understanding of the science subject matter as well as children's alternative frameworks in order to inform their teaching (Driver 1989). In addition Vygotsky (1978) emphasised the use of language as an important part of the process of learning along with interaction with the social world in order to develop cognitive and communication skills, because '*children solve practical tasks with the help of speech as well as their eyes and hands*' (Vygotsky 1978 p.26). Thus, the importance of the social environment and interaction with peers and teachers, especially when encouraging children to articulate their ideas in relation to those of others has influenced the way science has been construed in the primary school. However Windschitl (2002) argued that distinctions between 'discovery' and 'constructivist' ways of learning are easily blurred and have been confused in the past. He suggested that essentially constructivist learning was based on a 'pedagogy that is learner centred but teacher controlled'; whereas with discovery learning the teacher does no more than set up the learning environment and the learner is left to construct meaning by himself.

Perhaps some of the most influential and powerful ideas originating from the emergence of constructivist ideologies came from the Children's Learning in Science (CLIS) Project (Driver 1983) and the Learning in Science Project in New Zealand (Osborne and Freyberg 1985). It could be argued that both have had a significant and long lasting impact on developing so called 'constructivist' approaches to learning in both primary and secondary science education. Drawing from both philosophical and cognitive theories CLIS (Driver 1983), provided evidence to suggest that within education science should be presented as a coherent system of ideas rather than facts and that the aim should be to help pupils make links and connections with these 'big ideas', rather than accumulating a body of knowledge. Both Driver (1983), and Osborne and Freyberg (1985) advocated that from an early age children were developing sets of beliefs and ideas about a range of natural phenomena and that these often varied widely from the accepted theories in science education. Driver (1983) argued that children's 'alternative frameworks' could either be poorly articulated versions of scientific ideas, which with careful teaching, could be developed, or they could be very different or opposing accounts to accepted scientific ideas. She proposed a model of teaching and learning which first involved orientation and eliciting children's ideas, followed by intervention, leading eventually to a restructuring and application of these to new contexts and finally a review of change in pupils' ideas. However Driver et al. (1994) warned that different aspects of science involved different kinds of teaching. Furthermore, not only do pupils' ideas evolve over time but they may hold a range of alternative frameworks at any one time ranging from personalised or shared common sense every day explanations as well as 'scientific' views (Driver et al.1994 p.7). More recently Johnson and Gott (1996) have suggested that eliciting children's ideas is not a straightforward process.

Driver (1983) suggested that the teaching materials and the kind of practical work seen in schools were often based on the traditional 'inductive' view of science and the 'scientific method'. Even early texts such as Nuffield Junior Science (1967) and Science 5-13 (1973), although emphasising practical experiences and discovery learning (in line with Dewey, Piaget and Bruner), assumed that young children did not have existing ideas worth considering. So although pupils were supposed to 'act like scientists', pupils' limited experiences often meant that despite being placed in rich and stimulating environments they did not know what they should observe or what relevance it might have to their existing understanding. As a consequence pupils were often unable to make the same links or see the connections in the way scientists do and in the ways their teachers had planned, particularly in practical work.

Driver (1983) and Driver et al. (1994) have argued that even if teachers do to take account of children's 'alternative frameworks' these could still be very difficult to change and may even involve some 'unlearning'. Others (Osborne and Freyberg 1985, Solomon 1994) came to similar conclusions. Solomon (1994) suggested that rather than dismiss their own ideas; pupils might hold more than one definition, an everyday explanation as well as a more scientific one for classroom or exam purposes.

Whilst the APU Surveys and the seminal work of Driver (1983) had provided an evidence base about children's ideas predominantly in secondary school, little was known about the understanding and capabilities of younger children. Science processes and concept exploration (SPACE) (1986-1990) provided a comprehensive picture of young children's knowledge and understanding of science, heavily influenced by the constructivist learning theory (Osborne and Simon 1996). It advocated a constructivist approach not just for eliciting children's ideas but also provided evidence of the interrelationship between concepts and process skills in order to test in a scientific way (Black and Harlen in Black and Lucas 1993). It aimed to develop an understanding of:

- children's ideas about aspects of the world around them:
- how they came to form these ideas:
- the possibilities of helping children modify their ideas to bring them closer to more useful, scientific ones

(Nuffield 1993 p.6)

Another important aspect of this project was the development of 'concept probes', which could promote formative assessment as an integral part of teaching. The outcome from this research was a series of published research reports (1990-1998) and teaching materials (Nuffield 1993).

Whilst these had considerable influences on the way the educational community perceived primary science it was debatable as to how much it has been able to influence practice in schools. The summary of research *'Teaching science at key stages 1 and 2'* (NCC 1993) which reported on science investigations at Durham, Driver's work at Leeds on conceptual progression and Solomon's work at Oxford on the teaching of the nature of science seemed to have little influence on schools despite the aim to identify good practice in implementing the NC and publishing the implications for teaching science in schools.

Despite the growth of constructivist explanations of learning science caution as to whether 'constructivism' could be construed as a theory of learning had been called into question (Osborne 1996), Richardson 1996). Driver (1989) also argued that constructivism and science education had to acknowledge that, while learning might occur naturally in the context of every day experience, the learning of science does have to be organised, and children cannot be expected to know what to observe or what the significance of their observations might be in relation to an abstract concept such as 'force' or 'motion', they need to be ‘initiated into ways of seeing’ (Driver 1989 p.482; Hodson and Hodson (1989, Harlen 1993). Richardson (1997) suggested there remains limited understanding among teachers of constructivism in relation to teaching and learning, whilst Hausfather (2001) has called for teachers to have a deeper understanding of the role of content in constructivist teaching in order to improve pupil learning. Constructivism is often equated with making learning ‘fun’ usually though physical activities; whereas Hausfather (2001) argued that it is mental activity that is of primary importance. Because pupils construct meaning just as much by listening as by doing, subsequently teaching approaches need not necessarily be constructivist (Hausfather 2001).

Whilst debates about teacher's subject knowledge have helped to influence our understanding of the knowledge bases needed to teach science they have also illustrated the conflicts and tensions which arose when teachers who were trained within the context of one ideology were suddenly expected to adapt and teach a curriculum that represented a shift in ideology and discourse (Turner-Bissett 1999). For example, the changing conceptions and aims for primary science from a largely ‘process’ based curriculum prior to the PSNC (1989b) to a predominantly ‘content’ based one had huge implications in terms of the subject knowledge necessary to deliver the PSNC (Osborne and Simon 1996). In this sense research on the importance of subject knowledge of primary science (Bennett and Carré 1993) cannot be underestimated and has in turn influenced many of the subsequent evaluations of teacher's capabilities to teach primary science.

Shulman's (1986) seminal work identified the importance of subject knowledge, pedagogic content knowledge and knowledge of curriculum materials (Shulman 1986, Grossman, Wilson and Shulman 1989) with pedagogical content knowledge often overlooked. Since this work there has been a number of studies identifying and analysing different kinds of subject knowledge necessary for teaching. Within the broader theory of the construction of knowledge (Mintzes and Arnaudin 1984 in Cazden 1990) made the distinction between 'formal' and 'informal' knowledge; the former being knowledge learned in a formal setting like school and the latter being the knowledge generated by individuals making sense of the world around them. In addition, Ernest (1989) looked at attitudes in relation to pedagogical subject knowledge along with Tamir (1988) and Smith and Neale's work in Brophy (1991). Much of Fenstermacher's work in Darling-Hammond (1994) made a distinction between teacher's knowledge and belief and built upon earlier research on 'propositional' and 'procedural' knowledge. More recently Turner-Bissett (1999) provided a comprehensive range of categories of knowledge encompassed by pedagogic content knowledge, in response to the ITE standards (1998), which she believed to be important for the 'expert' teacher. She suggested, rather than supporting the development of teacher subject knowledge, these 'standards' provided a narrow rather impoverished definition of the knowledge bases needed for teaching (Turner-Bissett 1999).

2.2.2 Political and policy influences

Emerging political debates and discourse, signified by a variety of discussion papers, reports and government White Papers, have also helped to shape conceptions of and aims for science in the primary curriculum. Prior to the NC the Primary Survey (DES 1978) had reported concern about science within the primary curriculum and stated that,

> *...insufficient attention was given to ensuring proper coverage of key scientific notions; the teaching of processes and skills such as observing, the formulating of hypotheses, experimenting and recording was often superficial.*
>
> (DES 1978 p.58)

In addition, the report suggested that support at the local level was seen as having little effect, indicating that primary teachers' poor subject knowledge was a possible cause. Further suggestions of ways in which pupils might learn science were reported in *Science in primary schools* (DES 1983b) which a few years later appeared to have a significant impact on *Science 5-16 a statement of policy* (DES 1985a) where ten principles considered for a science curriculum were outlined. It also stated that all pupils should be taught science whilst highlighting the lack of teacher subject knowledge as a main obstacle to this happening in primary schools. Issues around teacher subject knowledge had also been raised in the White Paper *Quality Teaching* (DES 1983a).

The Association of Science Education (ASE) also prepared the groundwork for defining primary science during the 1980s and raising its status in schools by publishing a series of discussion papers (1974, 1976, 1979 and 1981) and in 1986 launched Primary Science Review, which was aimed at disseminating research and good practice from advisory teachers and classroom practitioners.

Thus arguments for the importance of starting science in the primary school, were gathering strength and there was a greater clarity about its purpose, goals and content, (DES 1983b, DES/WO 1985a, DES 1985b and ERA 1988a). The consequence of these significant influencers of discourse from both private and public arenas of influence at the time was to deepen the understanding of the relationship between subject knowledge and science process skills, recognising there was a place for this within the primary curriculum yet revealing the fact that most of the existing primary teachers were generalists and not science specialists and, as such lacked a firm science background and subsequently expertise and confidence to teach science (Harlen 2004). Ball (1999) argued that much of the orientation within science pedagogy at this time seemed to be directed toward educating for a high skills economy with an emphasis on group work and problem solving.

At the same time as establishing a curriculum to be taught in every school, ERA (1988a) also introduced in England statutory assessment of students at ages seven, eleven and fourteen. Prior to the NC, assessment in primary schools had a low profile (Pollard et al. 1994). Black (1995) argued that the political ideologies prior to ERA influenced the need for a NC which would focus on the basics yet provide parental choice by viewing schools as competing organisations.

Three years after the introduction of the PSNC, many of the recommendations of the discussion paper *Curriculum Organisation and Classroom Practice in Primary Schools* (Alexander, Rose and Woodhead 1992), commonly known as the '*Three Wise Men Report*', had a significant influence on the organisation of science in the classroom, particularly in terms of the shift to methods of whole class teaching. This was perhaps most notable where the emphasis had been on the use of a thematic approach to integrate primary science

> *...much topic work has led to fragmentary and superficial teaching and learning. There is also ample evidence to show*

> *that teaching focused on single subjects benefit primary pupils, (Alexander et al. 1992 para. 3.4).*

Furthermore, the balance between direct and indirect teaching was questioned, with a suggestion that a greater emphasis should be placed on '*teacher explanation of ideas and instructions*' and less on '*indirect teaching through work cards'* (Alexander et al. 1992 para. 102-106). The report also stated that the level of cognitive challenge provided by a teacher was a significant factor in performance and highlighted the importance of subject knowledge and the need for specialist and semi specialist teachers *(*Alexander et al. 1992 para. 4.2*)*. It also suggested that the acquisition and strengthening of subject expertise along with a '*broader range of classroom organisational strategies, including whole class teaching'* should be a priority for Initial Teacher Education (ITE) (Alexander et al. 1992 para. 5.2).

Shortly after this report, the publication of the White Paper *Choice and diversity*, (DES 1992b) helped to further embed political discourse around quality, diversity, parental choice and accountability in light of the government's Standards agenda through the introduction of Standard Assessment Tasks (SATs) and the Office for Standards in Education (Ofsted). 1991-1995 saw the phasing in of national tests and the initial concerns over the science SATs in KS1 resulted in a more traditional (and cheaper) adoption of pencil and paper tests in science at KS1 and Key stage Two (KS2) which in many ways enabled the government to strengthen their agenda of accountability and comparability, rather than invest in formative assessment (Black 1995). In order to monitor and enforce changes; measures were put in place to ensure schools conformed and made every effort to implement the PSNC (DES1991b). From 1993, Ofsted monitored the implementation of NC and standards in schools, making inspections every four years. By 1996 the first publication of performance tables were available enabling national comparison of schools by test results.

Teacher subject knowledge, which prior to the NC had begun to emerge as an issue was now held up as a key factor in the standards and quality debate and needed to be addressed if schools were going to improve teaching (Ofsted 1993 para. 32). By 1994 the Teacher Training Agency (TTA) had been set up to oversee a national curriculum and standards for ITE with an emphasis on subject specialism in the primary phase. The National Curriculum Council (NCC) (1993) also recommended the greater use of single subject teaching and of subject teachers in primary schools. Thus, whilst the White Paper *Quality in Schools* (DES 1985c) had stated the government had no intention to introduce legislation to centralise and increase government control and responsibility for the curriculum, the developments after the implementation of the NC outlined above suggested otherwise. This was of particular importance in relation to primary science, as the conception of 'science' in the primary school since the NC had undergone a complete transformation not only in terms of content, pedagogy and assessment but also in terms of expectations of teacher subject knowledge.

The key ideas reflected by the White Paper (1992b) became further strengthened by New Labour with *Excellence in Schools* (DfEE1997) which continued the accountability and performativity agenda. Ball 1999 has argued that Labour's policies were 'local manifestations of global policy paradigms', whilst Brehony (2005) has suggested that concern for literacy and numeracy was based on the assertion that in terms of the three 'R's we were a long way behind our competitors. Further justification for whole class teaching strategies were based on 'evidence' from countries like Taiwan (DfEE 1997), which resulted in the publication of the National Numeracy and Literacy Strategies (NNLS) in 1998 and 1999 respectively. Conceptions of primary science continued to be influenced by international comparisons and an increasing shift from 'professional' to 'corporate accountability' (Ranson 2003) which put pressure on schools to maintain and raise standards in KS2 tests. Whilst this ensured a consistent teaching of primary science, it also encouraged a focus on content at the expense of scientific enquiry (Black 1995). This had become a particular concern for the science education community who continued to argue that an understanding of the relationship between process skills and concepts was necessary to further learning.

However the report *Beyond 2000* (Millar and Osborne 1998) argued for the need for a wider perception of science education in terms of its definition and purpose with an emphasis on 'science for public understanding'. Ironically despite fifteen years of primary science education pupils were no more science literate or likely to opt for science in secondary school as they had been previously before the PSNC. In fact evidence had shown that pupils were being turned off science before they transferred to secondary school (Osborne 2002). The White Paper (2001) *Schools achieving success* marked a significant shift away from primary to secondary schools and the launch of the KS3 Strategy. Brehony (2005) argued that the growing concern about standards reaching a plateau in numeracy and literacy (although not in science) marked a shift in policy away from a continuous drive for standards towards a drive for creativity and a wider range of skills for a 'new knowledge economy'.

This shift in policy discourse was reflected in the publication of the Primary National Strategy (PNS) (DES 2003) along with Charles Clarke's announcement that the PNS promised more autonomy for teachers with schools being able to set their own targets in future

(Brehony 2005). Alexander (2004) argued that the messages given by the PNS were in conflict with current policies of standards and assessment as schools were unlikely to be 'creative' with the curriculum when too much was at stake with the next round of national targets. In fact the most recent review of the PNS had reported that so far schools had been slow to extend the teaching of literacy and numeracy through other subjects (Ofsted 2005b). Furthermore the concern over teachers' subject knowledge lessened evidenced by the publication of the ITE Standards (2002) which placed an emphasis on professional skills. Most recently an emphasis on 'speaking and listening' and the importance of pupils having an opportunity to express their ideas and clarify understanding which, although has always been seen as an important element of PSNC (Harlen 1993); was now gaining interest from a political perspective.

2.3 THE CONTEXT OF POLICY TEXT PRODUCTION.

The way in which discourse has become embedded in policy text provides an insight into the way policy and education compete to embody particular conceptions of primary science, with little consideration of the implications for practice (Black 1994). The emerging and changing aims and rationale for primary science can be traced through four versions of PSNC (DES1989b, 1991b, 1995 and 1999). These show how the views, struggles and influences of the policy writers have helped to change conceptions of primary science (Bowe et al. 1992).

2.3.1 Implementation of National Curriculum (1989)

The PSNC (DES1989b) marked the first centralised, structured policy text for primary science in England and clearly defined what primary aged pupils should know, understand and be able to do through some seventeen Attainment Targets (ATs). This conception of primary science as a 'knowledge-based' curriculum was in stark contrast to the 'process' approach adopted before the NC. Whilst Donnelly, Buchan, Jenkins, Laws and Welford (1996) argued that within the National Curriculum Science Working Party's (NCSWP) final model for science the emphasis had been on the learner, the importance of contexts and skills, as well as the attitudes and progression and development of key ideas in science, Galton (2002) still considered it to be far removed from primary curriculum philosophy. This was because the make up of the NCSWP meant that primary perspectives on teaching and learning science were largely over looked, including the discrepancy between what was being recommended and a primary teacher's ability to deliver it (Galton 2002). It was also debatable to what extent the SPACE research (1986-1990), had formed the basis for the content, despite the fact that members of the research team had sat on appropriate committees and panels (Russell, Qualter and McGuigan 1995).

However, Osborne and Simon (1996) suggest that much of the evidence about children's learning in science had influenced the early versions of the PSNC (DES1989b and 1991b) in the way it provided evidence of what primary aged pupils knew about scientific concepts.

The HMI survey (1989a), noted widespread evidence of compliance and implementation of the PNSC (DES1989b), but pointed out future challenges in relation to the organisation of science as a subject to ensure conceptual understanding and progression. For example, it expressed concern about the content as well as highlighting issues about the nature and manageability of assessment (DES 1989a p.25), whilst the report (DES1991a) identified the lack of guidance on assessment as a key issue.

Black (1995) and Donnelly et al. (1996) have suggested that the written format of the NC (1989b) was unhelpful to teachers as it encouraged a focus on ATs rather than programmes of study. In addition, primary teachers had to take on board the notion that science was not just about 'process' but about developing conceptual understanding. Furthermore, they were expected to know how to employ methods of formative and summative assessment in relation to the ATs. Although the Schools Examinations and Assessment Council (SEAC 1990) had published assessment guidance materials the report

(1991a) suggested that many HTs had held these back from staff because there were too many changes to cope with.

Thus, the clear message at the end of the report (DES1991a) was that key issues were the support primary teachers needed to make the link between assessment and learning, the need for teachers to apply common assessment standards to ensure consistency of reported assessment and for schools to be clear on the purposes of assessment, that is to evaluate the quality of learning but also to evaluate the quality of teaching programmes (DES1991a p.29).

2.3.2 National Curriculum revision (1991)

The original ERA (1988a) brief had apparently stated that all ATs within the NC should be assessed and it was evident that this was not feasible with the current seventeen ATs in science (Black 1995). This resulted in a rapid 'reconstruction' of the PSNC (1989b) primarily to make assessment more manageable. The proposed revisions outlined in *Science for all ages 5-16* (DES 1991c) with further consultation of their viability by NCC with SEAC (1991) led to a significant reorganisation of the policy text with minimal involvement of the NCSWP, resulting in a final proposal to reduce the science ATs from seventeen to four. The co-directors of the SPACE project (1986-1990) seemed to think that the implications of the research were lost in the rapid revision of the PSNC (DES1991b), as the wording implied that all that was required in primary science was 'knowledge of the specifics' rather than explicitly developing conceptual understanding due to the writers of the PSNC (DES1991b) not able to express the intentions behind the 'know that' and 'know how' statements (Black and Harlen in Black and Lucas 1993 p.226).

Rather than address the underlying issues about progression in concepts and strengthening the relationship between process skills and content, the 1991 revisions of the PSNC instead resulted in a far more traditional science curriculum, strongly resembling the secondary single science format (Donnelly et al. 1996), and it could be argued had widened the gap between a constructivist view of learning and the PSNC even further. In fact it was debatable as to how much if any influence the large-scale research project on investigations at the time had on the 1991 revised PSNC orders (Foulds, Gott and Feasey 1992). This report had warned that teachers in KS1 had little understanding of investigations and that it was important for them to recognise the purpose and scientific value of such activities. Instead the 1991 revision gave out strong messages about assessment rather than how to teach science and integrate process and content (Sharp and Grace 2004, Brehony 2005).

Although the revised PSNC (DES1991) did simplify the operation of external assessment procedures, it also reduced the importance of TA in favour of national assessment and in doing so did not lead to any strengthening of the link for teachers between assessment and learning (Black 1995, Donnelly et al. 1996). In fact it would appear that the 1991 revision encouraged a greater emphasis on summative assessment despite the earlier evidence from APU (1988) about the importance of linking assessment and learning, together with the recommendations from the TGAT report (DES1988b).

> *The assessment process itself should not determine what is to be taught and learned. It should be the servant, not the master, of the curriculum. Yet it should not simply be a bolt-on addition at the end. Rather it should be an integral part of the educational process, continually providing both 'feedback' and 'feed forward (DES 1988b para. 4)*

Furthermore, teachers within primary schools were enraged at having to reorganise science in light of the revised curriculum orders (1991) after having already restructured their planning in order to make sense of the PSNC (DES1989b), (Pollard et al. 1994, Black 1995). It would seem that the government agenda for standards and accountability were influencing the organisation of the science NC so that the focus in primary school was not only on science content but also on assessment. It would appear that the link between knowledge and process skills in primary science which had not been clear to primary teachers before the NC was now even less clear from the revised curriculum orders (DES1991) as content knowledge formed the dominant aspect of assessment. However, *Assessment, Recording and Reporting. A Report by HM Inspectorate on the Second Year, 1990-91* (DES 1992a) noted an improvement in assessment although for many year two (Y2) teachers the SAT period was a particularly stressful time' (DES1992a p.19). Rather than provide additional support and funding for teachers, the recommendation was for SATs to be 'simplified' (DES1992a p.20). The report (1992a) also indicated a possibility that teachers were already thinking about how they could teach to the test (DES 1992a p.22). At the same time McCallum, McAlister, Brown and Gipps (1993) suggested that teachers responded to assessment in three ways, some genuinely engaged in formative assessment; others became 'assessment magpies' whilst others did little to change practice.

The report (DES1992a) also noted that compared with 1989-90, teachers were seen to have a better understanding of assessment of the NC *(DES 1992a p.14).* It warned that where schools integrated subjects within topics, assessment was more challenging. Thus, it seemed that the effect and organisation of NC was forcing schools to adopt a more traditional approach to teaching subjects in isolation, thus making it easier to conduct assessment (DES 1992a p.15).

With the advent of the PSNC (DES1989) primary teachers perceived their assessment role more in terms of summative rather than formative assessment (Black 1993). Moreover, there was evidence to suggest that after the initial introduction of SATs and TA teachers did not perceive the latter as part of their every day practice but were conducting additional TA tasks thus increasing their workload (Harlen and Qualter 1991, Bennett et al. 1992). Black (1995) suggested that part of the problem with the original practical SATs in science was that most teachers complained about the unmanageability of the process because they were unfamiliar with such practice and were not used to linking assessment with learning in this way. Black (1993) argued that because the government had emphasised summative assessment this was now reflected in teacher's practice in school and was having an adverse affect on teaching. Furthermore, he claimed that the apparent lack of public and political confidence in TA, resulted in a reluctance by the assessment council to invest in the development of assessment training or moderating procedures (DES 1991a). In addition, Black (1993) pointed to an unfounded confidence in external tests despite ignorance of their limited reliability and claimed that there needed to be a considerable investment in the retraining of teachers to establish the practice of formative assessment (Black 1993, 1995). Thus it would seem that the writers of the of the NC policy text (DES1991b) helped to steer the primary science curriculum away from educational values to those aligned more with competition and market forces, rather than address the underlying issues of teaching and learning through formative assessment practice.

The report (DES1989a) suggested that the issue of teacher subject knowledge had been addressed to a certain extent by the introduction of Educational Support Grants (ESGs) (DES 1984), with evidence of greater confidence and competence in the teaching of primary science with more physical science than previously reported. However, because attention was now focused on subject knowledge, there was no suggestion that further support should also be in defining appropriate pedagogic practice to support conceptual learning (Feasey in Aubrey 1994 p.73) or that continuing professional development (CPD) also needed to address the link between assessment and learning. This might suggest that many of the recommendations were only designed to address the issue of subject knowledge in the science curriculum rather than develop strategies for assessment and learning. The report (1989a) also stated that the number of SCs had increased although they were not having a great deal of impact on the practice throughout the school. However they suggested that in-service programmes set up by LEAs and funded by ESGs would need to continue with a clear focus on the PSNC. In addition there was a need for ITE to provide more in depth training in teaching science (1989a).

As a consequence, the demands on teacher subject knowledge led to a change in the training of primary teachers from generalists who had specialised in children's learning, towards subject specialists with a new emphasis on teaching (Brehony 2005).

2.3.3 National Curriculum revision (1995)

The 1995 revision was designed to address the increasing debate and dissatisfaction regarding curriculum overload, an issue pertinent particularly to primary science and made even more urgent by the widespread boycott of national tests (1993) which were felt to be unrealistic and unmanageable (Black 1995). Lawton (1996) argued that the real value of the Dearing Review (1993) was that teachers were consulted and listened to, resulting in a complete revision of the orders and a reduction of testing with the removal of science SATs at the end of KS1. Although the Review (1993) had reduced the time allocated to the NC in order for schools to address the 'gaps' in curriculum, the PSNC was still considered by teachers to be overloaded with subject knowledge. Black (1995) argued that although more appropriately programmes of study rather than ATs, were now identified as the basis for content, the latest revision of PSNC (DES1995) had left the progression of some science concepts ambiguous, indicating that the now substantial constructivist research on children's ideas was even further fragmented in the way it was presented by policy writers. For example Sharp and Grace (2004) track the changing emphasis placed on 'astronomy' in each revision of the PSNC (1989b, 1991b, 1995 and 1999).

At this time ESG courses run by science advisors drew on the SPACE reports (1990-1998) as a basis for making the links between content and process skills more explicit. In this sense advisors acted as interpreters of programmes of study and whilst building science subject knowledge, tried to encourage a focus on investigations particularly fair testing despite new arrangements in SATs at KS2 focusing on content. As a result, teachers in primary schools were faced with a 'dual' curriculum as whilst they understood the need to link scientific enquiry to content they were under increasing pressure to assess and prepare pupils for national tests which focused on knowledge. Consequently teachers continued to find progression in science problematic and seemed to be less confident in planning and teaching science compared with the other curriculum subjects (Holroyd and Harlen 1996).

Boyle and Bragg (2005) show that from 1998 onwards there was a significant increase in time spent on NNLS at the expense of science. For example, in 1997 the average percentage teaching time for science was 10.1% but by 2002 it had decreased to 8.5%. In comparison English teaching time had increased from 26.6% in 1997 to 29.2% in 2002, with similar increases for mathematics. At about the same time the publication of the non statutory guidance materials, the Primary Science Scheme of Work (PSSW) (QCA 1998) attempted to address the remaining tensions between planning science, progression and teacher subject knowledge. However, due to the timing of its publication, it could be argued that the main aim was to free up teachers' time to focus on implementing the NNLS which the government saw as vital to meet their targets in raising literacy and numeracy standards.

The PSSW (1998) helped to address teacher concerns about planning and progression in science and through the exemplary scheme of work suggested how scientific enquiry and content knowledge could be combined to provide meaningful learning experiences in science. The handbook provided guidance on how schools could individually structure a scheme of work for science, and in an indirect way, it also helped to support teacher subject knowledge. The timing of the publication of the PSSW (1998) to coincide with pressure on schools to implement the NNLS (1998), together with Ofsted inspections condoning its use, resulted in the PSSW (1998) becoming a powerful 'user friendly' interpretation of the PSNC (1995). As a consequence, other published science schemes, including the Nuffield (1993) teacher materials which had emerged directly from SPACE research (1986-1990), declined in popularity.

2.3.4 National Curriculum revision (1999)

The most recent revision of the PSNC (1999) represented the greatest consultation with teachers although resulted in few changes in primary science. In relation to primary science this period marked a distinct reduction in discussion papers and policy documents as attention had been focused elsewhere. However this was not to say that the PSNC (1999) had addressed previous issues around process skills and content and the relationship between assessment and learning and ultimately the relationship between teachers ' subject and pedagogic content knowledge. Instead it would suggest that teachers were left to deal with these issues, whilst education policy changed direction. Furthermore, it would seem that the emphasis on summative assessment had increased (Ofsted 1999a). Whilst Ofsted (1993) suggested that SATs were being used as models for TA it would appear that there was still little focus on diagnostic assessment with a tendency for schools to teach in a more formal way and spend more time on revision in science (Russell et al. 1995, Ofsted 1999b). Although primary teachers now frequently monitored progress towards targets and informed parents (Ofsted 1999b), it cannot be assumed there has been an improvement in teaching for learning. The writers of the PSNC (DfEE1999) had done little to exemplify research findings on children's learning in science and assessment of those ideas, and had failed to address the professional development needs of teachers in relation to understanding the relationship between the PSNC, learning and assessment.

2.4 CONTEXT OF POLICY PRACTICE.

2.4.1 Teacher subject knowledge

The changing conceptions of primary science marked by the revisions of the PSNC (DES1991b, 1995, DfEE1999) meant that teachers now had to adopt a new conception of science as a subject with a distinct content of concepts and skills. Much of the content knowledge of PSNC (DES1989b) was unfamiliar to most primary school teachers who perceived science in terms of practical 'discovery' due to their previous experience and training (Osborne and Simon 1996, Turner-Bissett 1998). Furthermore, the notion of scientific investigation and specific science process skills were also unfamiliar territory (Foulds et al. 1992). The difficulties faced by primary teachers to adopt, adapt and cope to what amounted to a complete 'paradigm shift' in thinking about primary science has been well documented by Wragg, Bennett and Carré (1989), Kruger, Summers and Palacio (1990), Harlen and Qualter (1991), Bennett, Wragg, Carré and Carter (1992), Russell, et al. (1992), Black (1993) among others. All of which point to an underestimation of the support needed for teachers to implement the PSNC (DES1989b), not just in terms of developing teacher subject knowledge but also for conducting TA.

Prior to the NC, primary teachers had taught to their strengths reflecting the ideology of the time (Galton, Simon and Croll 1980) arguably covering up deficiencies particularly in science subject knowledge (Osborne and Simon 1996). Within primary science much of debate has centred on the depth of science subject knowledge needed in primary science as well as the importance of pedagogic content knowledge along with knowledge of appropriate curriculum materials (Shulman 1986, Grossman et al. 1989) in order to implement the PSNC. Since the introduction of the NC (DES1989b), several studies have identified links between teacher confidence and ability and willingness to teach science Wragg, et al. (1989), Bennett et al. (1992), Holroyd and Harlen (1996). Other research has shown how weaknesses in science subject knowledge may influence the quality of teaching (Bennett and Carré 1993) as well as little knowledge of the underlying principles of learning science (Qualter 1999). Studies exploring effective teachers of literacy and numeracy have identified connections between the kinds of knowledge and effective ways of teaching, and questioned the need for teachers to have extensive subject content knowledge (Askew, Brown, Rhodes, Johnson and

William (1997) and Medwell, Wray, Poulson and Fox (1998). Ernest (1989) suggested that epistemological beliefs appear to play a major role in the organisation and interpretation of individual knowledge, as it was possible for two teachers possessing similar science knowledge to present distinctly different interpretations of content as a result of their teaching (Ernest 1989). Carré and Ovens (1994) and Carré in Desforges (1995) also suggest that teachers' differing views or 'orientations' of teaching and learning science would lead to different teaching and learning opportunities within the classroom.

All these studies have highlighted the importance that science subject knowledge can play in teacher's differing approaches to develop, challenge and extend pupils ideas. More importantly they have shown that it is the interrelationship between subject, pedagogic content knowledge, and knowledge of curriculum materials which is most effective in the reconstruction of meaningful learning experiences.

Thus over the last two decades, how primary school teachers have interpreted, reconstructed and implemented education policy in practice has been of great interest (Galton et al. 1980, Galton et al. 1999, Alexander 1992, 1995, 1997, Pollard et al. 1994, Pollard, and Triggs 2000 and Osborn et al. 2000). These studies have would suggest that the introduction of new educational policy initiatives do not replace existing ones but merely add another layer of complexity. Moreover, Pollard et al.(1994 p.232) claimed that whilst teachers supported the NC in terms of its egalitarian values of a broad structured experience, they opposed it in terms of its assessment procedures linked with competitiveness and curriculum differentiation.

Although ESGs (1984), were available to support the teaching of science it would appear from the Initiatives in Primary Science; an Evaluation (IPSE) (ASE 1988) and Science Teaching and Action Research (STAR) (Cavendish, Galton, Hargreaves and Harlen 1990, Russell et al. 1992, and Schilling, Atkinson, Boyes, Qualter and Russell 1992) that these did little more than raise teachers' awareness of the need to teach science. In fact because advisory teachers initially adopted a predominantly 'skills' approach, the issue of teachers' science subject knowledge was not fully addressed (Osborne and Simon 1996). In and around 1992 several studies pointed to the growing concern about teachers' confidence and perceived competence of teaching NC science (Wragg et al. 1989, Bennett et al. 1992 and Summers and Kruger 1994). More recently Harlen and Holroyd (1997) suggested this was still an issue but teachers with low confidence had adopted coping strategies. In addition there were signs that as practical science was diminishing teachers were adopting a more directed approach to teaching which Hacker and Rowe (1997) in a repetition of Eggleston, Galton and Jones' (1976) study had shown to be the least effective way of teaching science.

Even before the PSNC not only had the need for greater support for the 'generalist' teacher to manage the needs of an increasing primary curriculum been identified, but so too a need for greater clarity around the role of subject co-ordinators (Webb and Vulliamy 1995). It would appear that at this stage the subject role was not perceived to be much more than providing support in school when teachers needed it and in fact few subject co-ordinators seemed to take on a developmental pedagogic role (Edwards 1993). This was seen as partially due to a lack of expertise not only in subject knowledge but also in people management skills and status and in addition access to limited or no 'non-contact' time which often resulted in co-ordinators doing little more than provide and maintain curriculum resources (Kinder and Harland 1991, Web and Vulliamy 1995). Although SCs could have provided a clear role in supporting the development of subject knowledge in schools, their own lack of experience and skills as well as time available meant they were unable to have much impact in this way. Although the publication of standards for subject leaders (1998) clarified the role, it did not result in any more time or training for subject co-ordinators to develop an understanding of their responsibilities. However, more recently it would appear that the role of SC has been influential in maintaining science standards in primary schools and monitoring and working alongside teachers (Ofsted 1999b).

Summers (1992), and Summers and Kruger's (1994) research suggested that if CPD was going to have a long lasting impact on subject knowledge and classroom practice then it needed to be long term. This was particularly crucial if, as Feasey in Aubrey (1994) argued, the 'deep-seated child-centred legacy' had strongly influenced primary teachers' conceptions of science resulting in a need for a higher level of personal subject knowledge. She argued that until teacher understanding of the nature of science and associated concepts was sufficient, then it would be difficult to meet the demands of the PSNC. Russell et al. (1995) from their national evaluation of science curriculum policy found that although teachers welcomed the centrally defined PSNC as it promised progression and continuity, there were areas of science that were neglected in primary schools which they also attributed to a lack of teacher subject knowledge as well as knowledge of the most appropriate teaching methods. Some aspects such as 'earth in space' were rarely covered either because it could not be taught by practical work and therefore thought inappropriate, or they felt the conceptual demand too great for young children. The evaluation also came to the same conclusion as Black (1993) that diagnostic and formative assessment had been neglected in favour of summative assessment. The findings from this evaluation led to two official initiatives the publication of distance learning materials to support subject knowledge (Schilling et al. 1992) and the setting up of Grants for Education Support and Training (GEST) twenty-day courses to support the development of teacher subject knowledge.

It would appear that GEST courses went some way to bridge the gap between teacher's previous training and the current requirements, as they were relatively long-term and designed to specifically address knowledge resulting in a significant impact on practice (Turner-Bissett 1998). However, opportunities to continue to improve practice in this way diminished, as New Labour appeared to direct funds towards literacy and numeracy. The demise of these courses reduced the vital support teachers needed (Osborne and Simon 1996). However, Jarvis, Pell, McKeon (2003), have shown that there is still a need for CPD to develop science subject knowledge and pedagogic content knowledge, whilst Osborne and Simon (1996) and Watt and Simon (1999) have provided evidence that teachers need clear guidance in order to use curriculum materials in ways that provide more productive and effective learning experiences for pupils. More recently, research funded by the Wellcome Trust (Murphy and Beggs 2005) reported that in the United

Kingdom teachers still perceived the biggest issue in primary science to be a lack of subject knowledge.

2.4.2 Scientific investigations

Foulds et al. (1992) and Jenkins (1995) claimed that the conception of scientific investigations as envisaged by PSNC went way beyond classroom practice. Although teachers in primary schools appeared to equate science with practical work prior to the NC, it did not resemble the 'scientific method' outlined in the PSNC, as there was little evidence of investigations where children were required to collect and interpret evidence. Moreover, the APU and subsequent studies of teacher CPD for science had shown that on the whole teachers emphasised generic process skills rather than scientific ones (Kruger et al. 1990, Russell et al. 1992, Russell et al. 1995, Harlen and Holroyd 1997). Foulds, et al. (1992) suggested that a clear rationale for investigations were missing from NC and consequently teachers were not able to see the link between investigations and conceptual understanding. Moreover, they claimed that because too much emphasis had been put on science in terms of understanding and teaching scientific concepts; not enough emphasis had been placed on understanding evidence (Foulds et al 1992). Furthermore, it was found that teachers had a very narrow view of science investigations, with many using them as a way of illustrating and reinforcing concepts rather than testing ideas or focusing on 'consumer type' investigations as a result of limited subject knowledge. (Millar and Driver 1987, Swatton 1990, Foulds et al. 1992, Donnelly 1994 and Carré 1995). Foulds et al. (1992) argued that science should be about developing transferable skills to make sense of science in wider society.

The findings from the ASE/Kings Science investigations (AKSIS) research project (Watson et al.1998) found that teachers still had a narrow view of investigations with the majority of practical work centred around 'fair testing' This resulted in a significant widening of the definition of scientific enquiry to include a wider range of investigations in the revised NC (DfEE1999). However, it is debatable, given the pressure to focus on literacy and numeracy, as to how widely CPD has been available to support teachers to develop skills to embrace a wider definition of science investigation and embed this into practice. Furthermore, the current demise of investigational work particularly in year six (Y6) has been linked to the additional pressures for SATs revision and has continued to cause great concern (Black 1995) and Harlen 2004).

2.4.3 Teaching strategies and conceptual understanding

Research throughout the 1980s and 1990s had consistently shown that if science was really about extending children's ideas and understanding, then knowledge of the most appropriate strategies, curriculum tools as well as secure conceptual understanding was required by teachers (Russell et al. 1992, Holroyd and Harlen 1996, Jarvis et al. 2003). Carr et al. in Fensham (1994) said teachers with insecure knowledge found transmission methods of concepts less intimidating whilst Carré in Desforges (1995), suggested that teachers with a good science background have a better view of how to develop conceptual understanding and are best positioned to respond to pupil's questions and to plan investigative work using open questions with a clear purpose in mind. However, it could be argued that even if teachers do have secure subject knowledge in science, the process of constructing and reconstructing new meaning by pupils in light of new experiences encountered or presented by teachers could be a lengthy process. How to reduce the gap between pupil's existing or alternative knowledge, ideas or explanations and widely accepted scientific ideas is thought to be problematic and time consuming (Driver 1983, Osborne and Freyberg 1985) or may not be possible (Millar 1989, Driver et al. 1994 and Solomon 1994). This problem is even more compounded when teachers are not able to recognise when children's ideas are unscientific or for example, are unaware of the complexities or confusions surrounding a simple activity of 'floating and sinking' (Carr in Fensham et al. 1994). Osborne (1996) puts a case for some aspects of science to be taught in a didactic way as a constructivist approach may not always appropriate, a point also reiterated by Millar and Osborne (1998) and Windshitl (2002).

Critics of constructivism have argued that constructivist approaches to teaching have been problematic (Solomon 1994). If, as Solomon suggested children hold more than one explanation of every day phenomena depending on the context they are in then, it is difficult to know what they really believe and therefore which view to change. Johnson and Gott (1996) have warned we must be careful not to interpret a child's words within our own frame of reference, but from a child's perspective, otherwise we cannot know if what children say represents what they really know, understand or mean. Furthermore, there is a danger of over interpretation and to ask a question from a scientific perspective which pupils may answer from their every day understanding rather than from a scientific understanding assumed by the teacher (Johnson and Gott 1996). The problem is how to get children to believe and understand scientific ideas, which are often contradictory to their experience (Matthews, 1994). Millar (1989) argued that active learning, (the construction and reconstruction of ideas) takes place in the learner's head and only when they feel motivated to do so. Likewise Foulds et al. (1992) suggested that acquisition of knowledge and concepts were not necessarily best developed though investigations.

Therefore it could be argued that the mode of instruction in science is, to a certain extent, immaterial as long as it gets the learner to engage in the kind of learning which leads to changes in how they view or explain natural phenomena. Millar (1989) claimed that the so called 'constructivist' approaches to teaching should be used sparingly as they are often time consuming and may not always be the most productive way to get children to consider the usefulness of alternative ideas in relation to the existing ones they hold (Millar 1989). Driver et al. (1994) argued that the fundamental issue was that the teaching approach should take account of the learner' existing conceptions together with the aspect of science to be taught. Wing-Mui So's (2002) three year longitudinal study concluded that because constructivist teaching practices require more time than traditional ones and learning experiences place high cognitive demands on learners, pressure from over loaded curriculum and parents, along with the diversity of learners leads to teachers using more direct teaching strategies in practice. Thus it could be argued that the pressure to cover all aspects in the PSNC also puts demands on constructivist approaches in science.

The work of Shayer and Adey (1981) Cognitive Acceleration through Science Education (CASE) has focused on the process of cognitive conflict as a way of challenging existing views. It assumed that pupils come to the task with their own ideas which they then apply when faced with cognitive conflict. In order to develop and defend their ideas or reject or modify them there is a necessity to communicate with others about possible solutions to the problem in hand. As a result this approach provides pupils with opportunities to develop process and communication skills in the form of thinking and reasoning which are necessary to build an understanding of knowledge in the wider world (Shayer and Adey 1981). Furthermore Shayer and Adey claimed that CASE is not specific to learning science but is a reflection of the wider process of learning and as such is not subject specific.

A considerable amount of research has now examined and evaluated effective teaching strategies, particularly in relation to creating conceptual change Naylor and Keogh (1999), Asoko in Millar, Leach and Osborne (2000), among others. However, these and other studies have also shown that within the context of practice there is increasingly limited time in which to cover a considerable number of concepts Ogborn, Kress, Martins and McGillicuddy (1996), Ogborn (1997), Newton and Newton (2000) and Asoko (2002) have shown that the role of the teacher is vital in developing conceptual understanding and where ideas are particularly abstract there is a need for teachers to 'talk ideas into existence' (Ogborn et al 1996, Asoko 2002).

Ogborn suggested that for conceptual development to take place it was important for pupils to be active in thinking and this included a respect for the pupil and their ideas. Thus, the way teaching was organised should predominantly capitalise on what pupils know, and use this to address difficulties.

Naylor and Keogh (1999) found that by representing scientific concepts in a visual format helped provide a valuable stimulus for scientific investigation as well as encouraging the elicitation of children's ideas. As a result they suggested that 'concept cartoons' were seen as a possible way of extending the range of pedagogical strategies available to primary teachers by presenting learners with a set of alternative ideas about a scientific concept in a visual form. They argued that this approach supported learning by generating discussion and stimulating investigation. The concept cartoons have also been used within ITE and CPD in order to develop science subject knowledge and conceptual understanding and to model practice. The fact that teaching in primary schools represents the move away from every day ideas to more scientific ways of thinking requires a greater understanding of pupils' cognitive abilities and greater expertise by teachers on ways to use activities to present and explore ideas (Asoko 2000). Furthermore, current thinking suggests there is a need to consider the language of science and build time into understanding this in relation to its culture and wider society (Osborne 2002).

Despite CPD programmes supporting teaching development particularly in conceptual understanding, there was evidence to suggest that not all teachers would reach an adequate stage of scientific understanding in order to prevent their own misunderstandings interfering with children's learning (Jarvis et al. 2003). In fact gaps in teachers' subject knowledge has often resulted in a perception that some aspects of causal understanding in PSNC are inappropriate for the age group, even although cognitive studies have shown otherwise (Harlen et al. 1997, Sharp et al. 2004). Newton and Newton (2000) have found that within primary science lessons, there were low levels of teacher discourse that related explicitly to 'causes and reasons', whilst discourse that related to developing 'vocabulary, facts and descriptions' was far more common. Furthermore, they suggested that the evidence from their research pointed to a link between low levels of teacher/pupil interaction and low achievement. However they also considered that one reason for teachers spending less time on causal understanding could be because test success in SATs does not place enough emphasis on this (Newton and Newton 2000).

Whilst the way in which primary teachers have interpreted policy into practice has been an expression of accumulated subject experiences, values and beliefs; it would appear that external pressures particularly in relation to assessment and performativity have also affected the way science is perceived and taught. Research documenting the way science assessments have been conducted suggest little understanding of the purpose of assessment with a far greater emphasis on summative assessment (Harlen and Qualter 1991, Black 1993, 1995). In fact it is only relatively recently that teachers have begun to develop a clearer understanding of the link between assessment and learning, however an evaluation of PNS has suggested this as still having little impact on practice (Ofsted 2005b). One reason for this is because government policy over the last fifteen years has resulted in a rapid increase and emphasis on external testing, not just in science but in all subjects (Black 1995, Harlen 2004). Furthermore, the use of summative assessments in the form of national tests to monitor schools against national standards has given SATs in primary science, a 'high stakes' status in England and would seem to adversely affect teaching (Black 1993, 1995, Harlen 2004).

> *Schools and individual classes are set targets in terms of raising the number of students at the higher levels of attainment and there are implications for the status of schools and the position of teachers and head teachers if targets are not met. This pressure has certainly meant that science is taught but we have to ask 'what kind of science? (Harlen 2004 p.4).*

Whilst early research after the implementation of the NC focused on how teachers coped with PSNC, the current conception of primary science suggests recent research is appearing to adopt broader perspectives which although still promotes an understanding and progression of scientific concepts, acknowledges a need for a much greater range of teaching strategies, which place an emphasis on oral reasoning and explanation. In other words, the centrality of scientific literacy and its connection to other areas of learning is now seen as paramount in science education (Millar and Osborne 1998), Osborne 2002). Equally, the application of technology and mathematical skills is also relevant within a scientific context, however such integration would make assessment of single subjects far more challenging if not impossible, a point made in the HMI survey (1989a) and more recently by Alexander (2004). It could be argued that a shift towards the non practical elements of science have been as a result of restricted time within the NC, but also due to the increased focus on formative assessment which places a great deal of emphasis on discussion and reasoning as evidence for understanding.

Thus the introduction of the PSNC and subsequent policies has helped to promote the discourse around Standards rather than around learning and teaching in science (Ball 1994). Whilst it has provided a body of content for primary science it has confused perhaps, rather than clarified the relationship between the learner, scientific enquiry and conceptual understanding in primary school and has encouraged teachers to focus summative forms of assessment rather than assessment for learning (AfL). Since 1989 debate and discourse has been on the content and progression of ideas suitable for primary science and also on the interpretation of scientific enquiry, its role in the primary science curriculum and it relationship with the other programmes of study. Debate has also centred on assessment of scientific knowledge and understanding and particularly on content (Black 1995). The initial PSNC (DES1989b) and its revision (DES1991b) exposed the nature of the knowledge expected by teachers and thus the amount of support needed. It also encouraged schools to place growing emphasis on standards and assessment with limited and often inconsistent CPD to ensure that teachers were prepared and supported to manage such change. The subsequent revisions of the PSNC have helped to increase manageability of assessment and to some extent content but have also showed that the conceptions of science envisaged by the scientific community and by government were far removed from the previous practice in primary science. The PSNC has provided little guidance on how to teach primary science, and as a result it could be argued that teachers have drawn largely on their existing knowledge and expertise of science in order to implement it in practice.

CHAPTER THREE: METHODOLOGY

3.1 INTRODUCTION

Using the three policy contexts (Bowe, et al. 1992), the previous chapter has reviewed educational and political literature in order to provide an overview of the development and often conflicting conceptions of primary science. This chapter will now outline the research methodology.

3.2 AIMS

The focus of this study is the changing policy to practice context of primary science. The research is located mainly within an interpretive paradigm as it seeks to explore meanings given to and interpretations of the conception of primary science. The research questions outlined below are aimed to explore the policy to practice context and have arisen from the literature reviewed.

1. To what extent is primary science a product of conflicting influences, views and perspectives?

2. In what ways have recent policy, policy text and discourse contributed to the debate and development of the primary science curriculum?

3. How do schools, (head teachers, science coordinators and class teachers) interpret, reconstruct and implement primary science in practice?

A mixed methodology (Denzin and Lincoln 1998, Ritchie and Lewis 2003), encompassing a macro to micro approach to constructing understanding (Layder 1993), with survey and follow up case studies, along with semi structured interviews was used to explore the research questions in more depth. Overall this was framed in Ball's policy to practice trajectory (Bowe et al. 1992).

3.3 RESEARCH DESIGN

The research questions were addressed by a mixed methods approach. This resulted in a series of semi-structured interviews with key national figures (elites) in education and primary science, providing the data for the context of influence and policy production. Then the research was set in a wider policy context by conducting a regional survey of schools with primary aged pupils, across two LEAs, using a questionnaire. This enabled a large amount of information to be gathered over a relatively short period of time providing data on a wide range of issues. Four case study primary schools were selected following the maximum variation principle and over a year, a series of in depth interviews and lesson observations were conducted with various stakeholders in order to provide data for the context of policy practice. Table 3.1 provides an overview of the data collection process.

Table 3.1 The data collection process

POLICY TO PRACTICE CONTEXT		
ELITE INTERVIEWS	REGIONAL SURVEY	CASE STUDY SCHOOLS
SIX ELITES	TWO LOCAL EDUCATIONAL AUTHORITIES	FOUR PRIMARY SCHOOLS
DATA COLLECTION METHODS		
SEMI-STRUCTURED INTERVIEWS	QUESTIONNAIRE	SEMI-STRUCTURED & GROUP INTERVIEWS LESSON OBSERVATIONS

This approach enabled the researcher to build a rich and vivid description of primary science at all levels, from different perspectives and in different settings, within the policy to practice context framework.

3.3.1 Role of researcher

A central part of this research was to explore meanings and actions (Denzin and Lincoln 1998) by collecting generated and naturally occurring data. By adopting an interpretive stance it was acknowledged that the researcher would have a significant influence on the research process at all stages, and in the sense that there is a need to understand that the research process is shaped just as much by the researcher's personal history as it is by participants in the study (Denzin and Lincoln 1998). For example, the role and professional position of the researcher as teacher educator, has been an important factor in terms of not only gaining access to the schools, influencing what participants might say in interviews and how they may act in observed lessons; but also in terms of the interpretation of data. Nevertheless, despite attempts to maximise objectivity by using multiple methods of data collection, the researcher's interpretation of the natural and generated data collected from each of the settings can only be a reflection of the researcher's perception of social reality, filtered by her own experiences and understandings of science and educational practices within primary schools (Ritchie and Lewis 2000).

3.3.2 Ethical issues

In order to conduct the research, strict ethical guidelines in line with those produced by the British Educational Research Association (1992) were adhered to throughout the research process. Within an interpretive paradigm it is recognised that ethical issues affect all aspects of the research including the extent to which participants shape and direct the research as well as the extent to which they have ownership of it. Scott and Usher (1999) argue that whilst open democratic research might be desirable it may not feasible on the grounds that participants do not always have adequate knowledge of the research process in order to enter into equal negotiations, or expertise to know what should be released into the public domain. Furthermore, the researcher may not always be in a position to ensure that every participant is not subject to coercion or pressure to partake. As a result 'open autocratic' research may be preferable (Scott and Usher 1999).

Elite national figures were contacted and asked if they would agree to be interviewed in relation to the research. Those that agreed were then given further details about how the interviews would be used and the right to view the transcript before being used in the doctoral thesis. In relation to the survey questionnaire, explanatory letters accompanied offering anonymity if the questionnaire was completed and returned. With regards to the case studies, the researcher sought permission from HTs, to work within the school setting, clearly outlining the context of the research and what would be involved. It was made clear that at all times the schools, teachers and pupils would remain anonymous and any data collected would only be seen by the researcher, supervisor and external assessors. The researcher only approached teachers who wanted to be involved and provided them with further detail about the research design. It was explained that at any point during the research process, individual teachers or schools could opt out of the study if they did not feel comfortable with the situation or felt it was detrimental to the children's learning. However it cannot be known the extent to which participants were coerced to participate by HTs (Scott and Usher 1999).

Once schools had agreed to participate, the researcher asked that permission would be sought from parents and carers for interviews with groups of pupils to be carried out and provided a draft letter to each school for this purpose. Prior to the start of the research, the researcher also met with individual teachers who had agreed to participate and re-stated the aims of the research to ensure that each teacher fully understood the timescale, design and purpose of the research and the role of the researcher.

3.3.3 Trustworthiness, issues of validity and reliability

It is hoped that greater objectivity has been achieved through the use of both quantitative and qualitative techniques where the various accounts from participants with differing roles and perspectives have been collected and combined with the researcher's own perceptions and understandings. In this way the interplay between quantitative and qualitative data seeks to provide a broader and deeper understanding of the policy to practice context (Strauss and Corbin 1998). Robson (1996) argued that 'objectivity' in qualitative research cannot be understood in the same way that it is for quantitative research, which is typified by the experimental approach. In this context the criteria for evaluating qualitative research was more in terms of trustworthiness and authenticity (Denzin and Lincoln 1998), and in this sense triangulation was not viewed as a tool of validation but as an alternative to which it can add breadth, depth and rigour to the research.

3.3.3.1 Survey

Although surveys through the use of a questionnaire are effective ways of gathering large amounts of information relatively quickly, the reliability and validity of the data can be questionable. Oppenheim (1999) pointed to many pitfalls when using questionnaires, particularly when attempting to gather information on attitudes. Much of this is due to the wording of questions as well as the mood and circumstances of those responding. He suggested that using sets of questions to measure the same attitude may help to over come this to a certain extent, however he concluded that the '*problem of attitudinal validity remains one of the most difficult in social research' to resolve* (Oppenheim 1999 p.149).

Oppenheim (1999) thought that the issue of 'non-return' was an important consideration when conducting a survey, as those that decide not to respond form a significant group who may, by the very nature of not responding, have different views than those that choose to do so. He suggested that non-response could be a particular problem with postal questionnaires and that some steps should be made to try to increase response by adding an incentive or sending out reminders with further questionnaires. However financial constraints and the importance placed on anonymity can make this difficult to achieve in practice. Similarly incomplete or wrongly completed questionnaires again can reduce the original sample size (Gorard 2001). Although non-response could lead to further bias in the sample, the aim of the survey was to provide a broad description of primary science by drawing upon schools varying in size, locality and socio-economic status. However it cannot be overlooked that those who chose not to return the questionnaire might well have very different views about science in their primary schools.

In order to maximise the validity and reliability of the survey, the questionnaire was carefully constructed using sets of questions designed to collect opinions and attitudes about science in primary schools and about the role of the SC. These questions were influenced by policy documents and recent findings from funded published research. In addition, a great deal of consideration was given to the wording of the questionnaire which was piloted with SCs representing eighteen primary schools. The results of the pilot study, along with discussion with the primary science team, a senior statistician and the researcher's supervisor showed that the number of questions needed to be significantly reduced and so an initial principle components analysis of this questionnaire-using Minitab was carried out. This was designed to reduce the data to two dimensions to see what combination gave the biggest spread. For each question two variants were used for the data, covariance and correlation. Such analysis helped to inform the selection of a minimum number of questions needed in order to give the maximum information, which resulted in the final questionnaire (appendix 5.1).

3.3.3.2 Case study

Robson (1996) suggested that case study was a strategy for doing research rather than a method and it was focused on phenomena in context. Thus it draws upon multiple methods of data collection. Bassey (1999) warned that there was no overarching framework, which clearly defined case study research and highlighted the complexity surrounding this approach to research. Nevertheless in order to provide an in depth understanding of policy to practice context, a case study approach was considered the most appropriate way to generate data as it is naturally suited to an interpretive and subjective paradigm where the researcher was seeking to understand and interpret the world within a real life context (Yin 1994). In addition, it was felt to be the best means of following up in more depth the broad issues emerging from the survey, drawing upon both naturally occurring and generated data in the form of lesson observations and interviews.

The case study research here in many ways resembled Stenhouse's (1978) ethnographic case study in that it comprised several cases (rather than a single one) studied in depth which although drawing upon non-participant rather than participant observation, was supported by interviews. In this sense collective case studies were undertaken to provide a fuller picture (Stake 1995). Whilst they focus on the understanding of individual actors in terms of their conceptions of primary science, they also seek to provide explanations that in Stenhouse's words, 'emphasise causal or structural patterns and as a result 'develop' rather than 'test' theory (Stenhouse 1978).

The approach adopted here was also similar to Stake's (1995) view of 'instrumental' case study research as it draws upon more than one context in order to try and understand an 'outside concern' and gain a deeper understanding of issues surrounding the interpretation and integration of policy into practice. Stake (1995) defined 'instrumental' case study as issues dominant with the case only playing a supportive role, and, as such, it differs from an 'intrinsic' case study where the case is dominant (Stake 1995 p17). He argued that by using 'issues' as the conceptual structure it forces our attention on 'complexity' and 'contextuality' surrounding the issue and therefore draws us towards observing and teasing out the problems of the case (Stake 1995 p16). Thus, the 'cases' selected here are indicative of Stakes' instrumental case study, extended to several cases in order to gain a better understanding of the issues surrounding primary science.

Stake in Denzin and Lincoln (1998) advocates that it is the researcher who decides on how the case should be reported, based on which method s/he feels will maximise understanding of the issues in question. Therefore, in order to report the findings from the case study schools, the decision was taken to focus on a number of individuals/cases (HTs, SC, CTs and pupils) with features in common in order to tease out the dominant issues in relation to primary science at differing levels within the schools.

This allowed the analysis to uncover issues of a political, social or historical nature, for example issues that were policy driven such as teaching for SATS as well as issues which were individualised, for example experience of CPD or length of teaching experience (Stake 1995). If time and wordage had permitted, then a further phase would have considered these issues by reporting each school as a case study.

Whilst the case studies reported here are partially descriptive in terms of describing what primary science is like, they are also explanatory in an attempt to identify which causes produced which effects (Yin 1994). However instead of being similar, they are purposively as diverse as possible, in order to provide a greater example of interpretation into practice.

Thus, exploring the conceptions of primary science through case study will, in the words of Cohen, Manion and Morrison (2000) enable an observation of effects in naturalistic settings by considering the complex and dynamic interactions between individuals and other external factors relating not just to primary science, but also to education in the primary school in general. Whilst a survey can provide the overall picture, a case study approach can explore understandings and interpretations of particular policy and practice... *'they can penetrate situations in ways that are not always susceptible to numerical analysis'* (Cohen et al. 2000 p.181).

Bassey (1999) pointed out that the problem of generalisation from case study was viewed in different ways. Yin (1994) suggested that only 'analytic', not 'statistic generalisation' was appropriate and this view would also fit with Stenhouse's (1978) notion of 'retrospective generalisation', which arises from the analysis of case studies. In relation to this case study approach, 'generalisation from the instance studied to the class it represents' best describes this research Bassey (1999) in that it is concerned to explore and analyse similarities and differences in views, beliefs and practices from four diverse schools in terms of socio economic status, size and standards as reported by Ofsted (1996-2000) and SATs (2000-1).

Whilst a series of interviews and observations over a period of time may increase reliability within the four schools, however generalisation from these studies must be done with a certain amount of caution (Stake 1995). Simons (1996) suggested we should acknowledge the paradoxes and tensions that case study presents, as this is how we develop a deeper understanding. Thus it cannot be assumed that the 'findings' from the case studies presented here, are necessarily representative of views, beliefs and practices in other primary schools.

Oppenheim (1999) stressed that in order to identify unforeseen problems and minimise these for the main case studies, it is necessary to attempt some form of pilot. However Robinson (1996) argued that as a case study is a unique entity there are no comparable equivalents, which makes this problematic. With this in mind, a range of data collecting techniques was trialled and modified, including semi-structured and group interview, and lesson observations before conducting case studies.

Prior to conducting pilot interviews each interview schedule was discussed at length with the researcher's supervisor and senior academic educations from the science education department at the local ITE institution. Then, in order to ensure validity and appropriateness of interview questions and to refine and perfect interview techniques, the questions and the interview process itself were piloted in a range of contexts. Elite interviews were piloted with three 'pseudo elites' with various roles within an ITE college and pilot interviews with HTs, SCs and CTs were conducted within a primary school that would not be part of the study. As a result of the pilot interviews, the questions were modified accordingly and final interview schedules prepared (see appendices 4.1, 6.1, 7.1 and 8.1).

3.3.3.3 Group interviews

In order to gain a wider understanding of primary science within the case study schools it was felt important to elicit the pupils' views. Ruddock (2005) suggested that pupils were 'active players' in the education system and therefore it was important to listen to what they had to say about how they learn. She identified four key arguments in support of pupil voice, including the influence of the children's rights movement that said children should have their say on matters that concern them. Lewis and Lindsay (2000) advocated that children's perspectives on teaching and learning were unique to themselves and therefore it was important for researchers to conduct research ethically, but in a way that maximised opportunities for children's perspectives to be listened to.

Brooker in Mac Naughton, Rolfe and Siraj-Blatchford (2001, p 163) suggested that current thinking perceived children as fully formed and complete individuals who had rights of their own, including the right to voice opinions and influence decisions in matters relating to their own lives. Furthermore, she argued that there were important insights to be gained by listening to children's view points which particularly in combination with other evidence could enable us to see and discover aspects of their lives which no other research method could reveal (Brooker in Mac Naughton et al 2001 p177). Lastly by engaging in shared dialogue with each other about teaching in and learning, (in this case primary science) pupils may have the opportunity to develop meta-cognitive skills which Brooker suggests may be more worthwhile in the long-term than the research itself.

Ruddock (2005) argued that because teachers were predominantly concerned with covering the curriculum and preparing for tests, they had little time to provide pupils with a voice about teaching and learning in school. Consequently it was the researcher who was best placed to do this Therefore the aim of the 'group' interviews was to provide a broader perspective of practice by providing pupils with an opportunity to articulate their views of the importance of science in everyday life and how this related to the teaching and learning of primary science school.

It was felt to be important to distinguish between interviewing 'groups' and 'focus groups', where the main aim is to 'brainstorm ideas prior to the construction of a survey questionnaire (Krueger 1994). However the strengths and weaknesses of group interviews are similar to those found with focus groups, in that if set up correctly they can be a powerful way of gaining ideas and feelings about a particular issue. In a similar way to focus groups they allow people to interact with others within naturalistic settings and enable the 'interviewer' to probe unanticipated issues. Disadvantages include having less control over the group and generating data which is more difficult to analyse. Furthermore, Krueger (1994) advised that comments should be interpreted within the context of the social environment as people may modify or reverse their views after interacting with others. He also warned that each group has unique characteristics and thus in the context of this research it was felt to be important to conduct at least two group interviews with pupils from each class in order to see if their views were comparable and therefore possibly representative of the class.

Thus, the reasons for interviewing children in groups rather than individually were based on the assumptions that this approach would boost confidence and provide a context where one child's idea could trigger thoughts and ideas in others. Groups of six were seen as the optimal number, enabling a range of views to be shared, and opportunities for quieter pupils to contribute to the discussion (Krueger 1994). Other important considerations taken into account were the choice and dynamics of the groups and the nature and sequence of questions asked. In this sense it was felt that the use of group interviews with children would not only enable the researcher to gain an insight into children's understanding and views about science within each school but would also enable the pupils to have a voice by articulating their views about science, and science education (Rudduck 2005).

The piloting process was felt to be particularly important with young children and initially the aim of the research was to draw upon ideas from pupils in KS1&2. However, it is well documented that interviewing young children can be quite a difficult process and therefore it was felt necessary to trial questions with young children beforehand (Lewis 1992). Piloting the same questions with pupils in different year groups illustrated that it would be problematic to use the same interview questions with all ages. Whilst 'warm up' questions such as '*what do you like to do at school?*' seemed to be a good way of putting all pupils at ease before asking questions specifically about science; questions that asked the children to think about 'science' within school in terms of its relevance to the world were quite difficult to phrase without becoming leading questions. In addition, whilst questions could be simplified for younger pupils it was questionable whether the responses given would then be comparable with those from older pupils responding to a modified question. Furthermore, the use of the word 'science' with very young pupils also proved to be meaningless. Other problems encountered when piloting group interview techniques included pupils giving the answer they felt the researcher wanted, or any answer, irrespective of the question asked, or repeating the response given by another pupil (Lewis 1992). These issues were exemplified with pupils in KS1.

Thus, the questions compiled for group interviews were piloted before hand with groups of four to six children from Y1 to Y6. From this the most informative questions judged by the researcher and most appropriate vocabulary used and understood by the pupils provided the basis for the group interviews within the case studies. Responses from KS1 pupils were more descriptive, unpredictable and idiosyncratic and did not illuminate the research questions. This resulted in the decision that the group interviews reported in the case studies would focus on pupils within KS2 only (appendix 9.1).

3.3.3.4 Observations

Data collection through methods of observation can become quite complex and problematic. In terms of objectivity and trustworthiness of data it is important to bear in mind that the observation in whatever form is only one view of what is happening, as the complexities of the classroom situation make it impossible to observe all that is taking place. Non-participant observation was felt to be appropriate for gathering evidence in this study, so that the researcher was still in a position to stand back from the observations and retain some objectivity, albeit from one perspective.

Again the importance of conducting pilot studies (Oppenheim 1999) and of piloting observation techniques cannot be underestimated in terms of deciding on the most appropriate observational strategy and in terms of perfecting this in order to minimise disruption and bias in data. Thus, prior to carrying out observations in the main study, a range of observation techniques were tried. This included the use of video tape and teacher reflection on the lesson, taking field notes of observations and writing them up afterwards and using a science lesson observation schedule adapted from Coates, Vause, Jarvis and McKeon (1998).

The outcome and evaluations of these methods with the researcher's supervisor and other colleagues of the primary science department of the local ITE, led to the decision to use field observation notes together with the observation schedule (Coates et al. 1998), in order to minimalise the amount of disruption and intrusion into the science lesson. It was decided that observational notes would be recorded as quickly as possible and in enough detail in order to sum up the described event (Lofland 1971 in Cohen et al 2000) whilst the observation schedule (Coates et al. 1998) would focus on specific scientific discourse and interaction (appendix 10.1).

3.3.4 Sampling strategy

Careful consideration was given to the sampling strategy at all stages throughout the research and the discussion here briefly outlines the employment of theoretical or purposive sampling (Silverman 2000) in relation to survey and case study. With regards to elite figures in science education, those that were felt by the researcher to have had some significant influence, insight or experience of the policy context were considered. Out of the eight contacted, six agreed to an in depth interview in relation to the policy to practice context of primary science.

Another important consideration was the selection of a representative sample for the survey (Oppenheim 1999). Mujis (2004) observed that much education research draws upon methods of 'convenience sampling' and although this may be advantageous for financial and time reasons, it can lead to serious problems in terms of sample bias (Mujis 2004, p.40-1). For the researcher in this instance, attempts have been made to minimalise sample bias by, in Oppenheim's (1999) words, opting for 'cluster' and 'quota' sampling techniques in order to provide a representative sample of schools with pupils aged between five and eleven (KS1&2).

Schools were selected from two neighbouring LEAs, in the south east of England, and as it was not financially viable to send questionnaires to all schools a sub-sample was selected by targeting those with pupils aged between five and eleven that were in partnership with the local ITE College. This amounted to a survey total of three hundred and forty nine of a possible five hundred and eighty eight schools, approximately 60% of state funded schools containing pupils aged between five and eleven within the two LEAs. This included some first and middle, but mostly primary schools and was felt to be representative of the diversity of schools in terms of size and socio – economic mix within these LEAs. However it has to be acknowledged that being in partnership with a local ITE College may have influenced in the way in which schools responded to the survey.

Theoretical and purposive sampling (Silverman 2000) was used to select the case study schools in the hope that they would provide theoretically meaningful data in relation to the research questions (Mason in Silverman 2000). The case study schools were purposively selected so that they represented a wide range of schools that followed the PSNC (1999). This was to see if interpretation and understanding of science and subsequent teaching was dependent on the context teachers worked within in terms of size of school, urban/rural settings and socio-economic status of the school's catchment area. Initially ten schools which had been involved in the regional survey and who had expressed an interest in further participation in the study were approached. From this four agreed to participate and this was felt to be the optimum number for the researcher to manage given the constraints of time. Table 3.2 provides an overview of interview data collected within the case study schools.

Within each school the same sampling strategy was applied. Semi structured interviews were carried out with HTs, SCs and CTs (at least one from each key stage). In each school the HT was asked to select teachers from each key stage, where possible based on variation in gender, length of teaching experience, and a willingness to take part. In the two smaller schools some CTs had mixed-age classes, although none of the CTs had a class with pupils from both KS1&2. Group interviews were conducted with a sample of pupils from each of the KS2 teacher classes. In all cases, the CT was asked to select the

Table 3.2 Interview data collected from case study schools

SCHOOL 1 (urban)	SCHOOL 2 (semi-urban)	SCHOOL 3 (rural)	SCHOOL 4 (semi-rural)
HEAD TEACHER INTERVIEWS (HT)			
HT1	HT2	HT3	HT4
SCIENCE CO-ORDINATOR INTERVIEWS (SC) AND YEAR GROUP (Y)			
SC1 (Y4)	SC2 (Y3)	SC3 (Y5/6)	SC4 (YR)
CLASS TEACHER INTERVIEWS (CT) AND YEAR GROUP (Y)			
CT1A (Y1)	CT2A (Y2)	CT3A (Y1/2)	CT4A (Y1/2)
CT1B (Y5)	CT2B (Y4)	CT3B (Y3/4)	CT4B (Y4/5)
CT1C (Y6)	CT2C (Y6)		
PUPIL GROUP INTERVIEWS (G) AND YEAR GROUP (Y)			
G1A[1*] G1A[2] (Y1)	G2A[1] G2A[2] (Y2)	G3A[1] G3A[2] (Y1/2)	G4A[1] G3A[2](Y1/2)
G1B[1] G1B[2] (Y5)	G2B[1] G2B[2] (Y4)	G3B[1] G3B[2] (Y3/4)	G4B[1] G4B[2] (Y4/5)
G1C[1] G1C[2] (Y6)	G2C[1] G2C[2] (Y6)		
G1SC[1] G1SC[2] (Y4)	G2SC[1] G2SC[2] (Y3)	G3SC[1] G3SC[2] (Y5/6)	GSC[1] GSC[2] (YR)

** Denotes first and second group interview*

groups so as to ensure there were a balance of boys and girls and a range of ability including special educational needs. The number of children in each group interview was a percentage of the class, for example between 20-30%.

Other important aspects to consider in terms of maximising trustworthiness were the timing of interviews. The researcher needed to take account of the busy life of the school, particularly interviews with HTs fitting in with their schedule. Consideration was given to whether interviews should be conducted before or after school, on the same or different days of observation as this might have some bearing as to how receptive and willing teachers might be to partake. Whilst it was acknowledged that it was impossible to know how much the presence of an observer affected the general routine of science lessons, nevertheless it was also important to decide on the total number of interviews to be conducted and number of lessons to be observed in order to maximise the trustworthiness of data. Thus it was agreed that each teacher who gave an interview would be observed teaching three science lessons throughout the year and permission would be sought to interview a minimum of two groups of children from that class.

Careful consideration was needed when arranging to observe science lessons, within each term and throughout the year in order to avoid situations where the class and teacher are unable to continue 'normal' routine and work pattern. However the busy life of a primary school can mean that no time during the school year can be considered 'normal' and 'free from disruption'. Nevertheless the researcher tried to maximise the trustworthiness of data by avoiding lessons right at the beginning or end of term and during the, period of SATs in KS2. However, some situations were unforeseen, such as ITE students on placement or teacher absences through illness. In such cases the lesson observation data could not be used for that class. However when considering what is 'normality' in terms of science in primary schools it is worth noting that the elimination of all 'disruptions' would perhaps provide an 'artificial' picture.

Lesson observations took place at termly intervals in each school. In most cases three lessons were observed, one during each term so as to identify variation or continuity in the way the teacher taught science throughout the academic year. In some cases it was only possible to observe two lessons due to teacher absence or the presence of a trainee teacher on school placement.

3.4 METHODS OF DATA COLLECTION

3.4.1 Questionnaire

The aim of the survey was to build a regional overview of the conception of science in schools with primary aged pupils. A questionnaire was felt to be the most appropriate way of collecting general information about science and was addressed to the SC as it was felt that they would have an interest in, and be best placed to comment on science policy and practice in their school. Once modified, the questionnaire was sent out with a covering letter and stamped addressed envelope to encourage return.

The final questionnaire contained fourteen questions and was divided into two sections relating to:

- teaching and learning science, including beliefs around how children learn, strategies used for teaching and the role of assessment;
- the role of the SC including their educational background and experience, as well as perceptions of their role and professional development priorities for themselves and for the school.

3.4.2 Individual Interviews

Semi structured interviews with elite figures in science education and selected participants from the case study schools were conducted at various stages during the research in order to ascertain their views and understanding of primary science. Interviews were considered an appropriate method of collecting in depth information about opinions and practice relating to primary science. In all cases the questions on the interview schedules were framed so as to be open-ended and not 'leading' or biased in any way, yet specific enough to avoid ambiguity. The interviews were designed to gather data on perceptions of:

- what primary science should be about;
- perceived significant influences on the past, present and future of the primary science curriculum;
- conflicts and tensions since the advent of the PSNC and how these have/have not been resolved.

3.4.3 Group Interviews

Two groups of pupils were interviewed in each class in an attempt to give a wide spread of views. Each group consisted of six boys and girls of mixed ability and were chosen by the teacher. However for the purposes of analysis, only the first interview from each class was used and where discrepancies emerged, the second interview was referred to. Each group interview lasted no more than twenty minutes and was designed to gather information about:

- interest and motivation in school science and science in the wider context;
- definitions of science including their understanding of the scientific process and content in relation to other subjects;
- purpose of learning science including its relevance to other aspects of their lives and others.

3.4.4 Observation

Lesson observations focused on the interaction between pupils and teachers, in terms of the nature of 'talk', and planned activities within the science lessons. Lesson observations were conducted once a term across KS1&2 and provided data from which a comparison could be made in relation to the PSSW (1998) and PSNC (1999) for teaching science. Finally it enabled a comparison of what teachers said they did in their science lessons and what from the researcher's perspective actually happened.

During the lessons the researcher made observations by using the observation schedule (Coates et al 1998) and recording extensive field notes about the structure and organisation of the lesson, its objectives and subject matter, teaching and learning strategies employed. This also included the purpose and quality of talk, in particular, the kinds of questions used by the teacher and pupil responses, recorded word for word where possible (see appendix 10.3), the range of practical activities pupils engaged in at various times during the lesson. Notes were also recorded in relation to the quantity and purpose of written work, and examples of assessment. Field notes were written up immediately after each lesson so as to capture as accurately as possible the researcher's interpretation of events.

3.5 DATA ANALYSIS

3.5.1 Quantitative data

A Statistical Package for the Social Sciences (SSPS) programme has been used to aid the analysis of data generated by the questionnaire. This was used to provide a broad description of science in primary schools across two LEAs, in terms of describing the perceived influences on planning, teaching and assessing science along with descriptions of the typical role of the SC. An analysis of the questions was conducted, taking account of measures of central tendency and measures of spread in order to generate descriptions of:

- the overall profile of the sample,
- science in terms of curriculum, pedagogy and assessment,
- role of the SC in relation to needs and support.

Where appropriate cross tabs were conducted to enable comparison of responses between KS1&2. A description of each question was then generated in terms of the range of responses and where relevant, a table was created to illustrate findings, together with exemplary comments.

3.5.2 Qualitative data

Silverman (2000) suggested that qualitative researchers should be concerned about issues of validity and reliability not only in research design and in the collection of data but also in its analysis. He suggested five ways in which the careful analysis of qualitative data can provide more valid findings (Silverman 2000 p.188). Data analysis of qualitative research should be carried out in a rigorous and robust manner in order to increase the credibility and trustworthiness of the findings. Comprehensive data treatment through constant comparison and deviant case analysis (Silverman 2000) was applied at all levels of data analysis.

3.5.2.1 Interview data

In all instances a similar strategy was used to analyse the interview data (from both elite and case study interviews), with theory arising out of the data collected (Strauss and Corbin 1998). Whilst the policy contexts were used to frame the research design, the broad themes that emerged from the elite interviews (which spanned all three policy texts) were used to structure the analysis throughout. For example, an analysis of the elite data was conducted in the following way. Starting from the initial interview transcripts, speech mannerisms such as word repetition, thinking words (um, ur etc) that added nothing to the meaning of the text were removed. Then each question was taken in turn and responses were assembled and presented side by side on a spreadsheet and cross-referenced to the original transcripts so that the texts could be examined for processes, actions, assumptions, consequences, metaphors and conflicts. A description of how each elite answered each question was then written, along with exemplary comments. Then further analysis was carried out by placing those responses that related specifically to each of the three contexts (Bowe et al. 1992) into a summary grid which enabled the identification of connecting themes.

Throughout the process code notes were made so that main themes, issues and surprises for each topic along with contrasting views could be identified. Operational notes were also made during data collection in case practical matters had any bearing on the overall process. Finally, theory notes were made in an attempt to build a conceptual model (Strauss and Corbin 1998), which is presented in the discussion section of each data chapters. The same systematic analysis was repeated for HTs, SCs, CTs and pupils within the case study settings. However, because these interviews related only to the context of practice the broad themes of curriculum, pedagogy, assessment/accountability and teacher development and subject knowledge were reflected in the summary grids and in relation to the pupils' data, only the first three of these themes were applicable. In addition, for each school, the two group interview transcripts were compared by taking each key question in turn and assembling each group's responses side by side to see if there was significant variation in responses. In each case these were found to be minimal so the first interview carried out in each class formed the basis of the analysis, leaving the second for reference where necessary.

Finally the summary grids enabled layers of interview data to be compared across and within case study schools. Exemplary comments taken from the summary grids have been used to illustrate the analysis in the discussion of each data chapter.

3.5.2.2 Observation data

An initial analysis of all observed lessons was carried out starting with the field notes made during each observed lesson. Each text and observation schedule was examined in much the same way described for the interviews above. The broad themes of curriculum, pedagogy, assessment/accountability and teacher development and subject knowledge that emerged from the analysis of the elite interviews were used as a basis for the initial analysis of all observed lessons. In addition the responses teachers made to the interview questions *'How do you plan, teach and assess science* were also used in the initial analysis in order to identify key influences in the way lessons were orchestrated and evidence of conflicting views, ideologies and policies in action. This allowed main themes, issues and surprises from each cluster of lessons for each teacher to emerge and enable comparison with another teacher's cluster of lessons either in the same school or between schools and key stages (Strauss and Corbin 1998).

Then six exemplar lessons broadly based on the theme of solids, liquids and gases (SLG) were drawn upon to illustrate main themes and any other outstanding issues and were examined in depth. In relation to the broad themes outlined above, the following dimensions emerged from observed pedagogic practice:

- the nature of practical activity;
- the quality and purpose of 'talk';
- the purpose of written tasks.

In addition, learning objectives, planned activities and learning outcomes were analysed in relation to teachers' lesson plans, the appropriate unit of work in the PSSW (1998) document and school science policy.

CHAPTER FOUR: THE ELITES

4.1 INTRODUCTION

The views of the elites represent a broad but important overview derived from their contrasting roles within an educational context and their links to science education. From their differing perspectives, it was hoped that they might provide significant viewpoints on the way key events, opinions and ideologies have shaped national policies, which in turn have been recreated in practice.

4.2 AIMS

This chapter will consider the past and present policy to practice context by reporting the views of elite figures and themes that emerged. The findings from this chapter reflect current perspectives on science education in 2003.

4.3 METHODS

4.3.1 Participants

The elites were selected in the manner described in the methodology chapter with the aim to provide a diversity of opinion and interpretation of events and ideologies, which may have been significant in the development of primary science. The elites varied in terms of their backgrounds and were chosen because of their present roles within science education.

Elite 1 (E1) was Principal Science Consultant within the Qualifications and Curriculum Authority (QCA) and had been involved in the revision and publication of the current Primary PSNC (1999) and the *Assessing Progress in Science* (2003) guidance materials. Prior to this he had worked within ITE secondary science programmes. Most recently he had been involved in the QCA *Future's Thinking Project* (2002). Elite 2 (E2) had been involved in nationally funded science research projects including SPACE (1986-1990) and recently had co authored the report *Beyond 2000* (1998) which has informed the latest review of the NC (1999). He also acted as a science advisor to QCA/NFER on an annual basis regarding the scientific content of the SATs. Elite 3 (E3) had had a long involvement in primary education as a HMI and Ofsted inspector and had also produced several publications on primary science and primary education. He currently worked as a Professor in Education at an ITE College. Elite 4 (E4) had been a key figure in science and assessment nationally funded research projects, most notably joint director of the APU prior to the introduction of the NC and joint director of SPACE project. She was one of the original members of the NCSWP, whose Interim Report (DES1987) informed the science

NC. She had been the Director of Scottish Education Research. She was also currently a member of the Assessment Reform Group and had also published many books on primary science and assessment. Elite (E5) worked as an independent consultant for primary science supporting CPD within LEAs and Schools and producing a number of related publications. Prior to this she was involved in a major research project that explored the teaching of science investigations (Foulds et al. 1992). She was also Chair of ASE from 1998-1999 at the time of the publication of the PSSW (QCA 1999). Elite 6 (E6) is currently Chief Executive of ASE. He had also been chair of ASE 2000-2001 and prior to this had worked in science ITE.

4.3.2 Materials

An interview schedule was designed to gather information from the elites (see appendix 4.1). The content of the interview schedule was determined by the key research questions of the study and outlined in more detail in the methodology chapter.

4.3.3 Procedure

Each key figure was sent a letter via email requesting an interview and stating how it related to the research. When they had agreed, a date was set and an interview schedule (appendix 4.1) sent to enable them to consider the questions beforehand. The key figures selected a time and venue for the interview, which lasted approximately an hour. Responses were audiotape recorded with permission from the individuals and transcripts were sent to each elite to comment on in terms of accuracy of content and to modify accordingly to ensure that the transcript reflected their responses to the questions.

4.3.4 Analysis

A data trail was kept, starting from the initial interview transcripts and analysed in the way described in the methodology chapter. Then those responses that related specifically to each of the three policy contexts (Bowe et al. 1992) were placed in a summary grid to enable further analysis and identification of connecting themes. Further examination of the summary grid enabled four broad underlying themes to emerge. A description of what each elite said in relation to these themes within each context was then recorded. In addition to this, the responses from each elite figure was examined in light of his or her past and present roles within science education.

4.4 RESULTS

Within the three contexts the broad themes of curriculum, pedagogy, assessment/accountability and teacher development and subject knowledge were used as an organisational framework for reporting the elite views about the development of primary science. The discussion section, which follows, develops the broader, analytical story around these themes. Exemplary comments taken from the summary grids have been used to illustrate the analysis in the discussion section.

4.4.1 Context of influence

4.4.1.1 Curriculum

E1 stated that in the 1960s and 1970s, Schools Council Projects, and Nuffield Science had influenced the primary science curriculum, however, leading up to the PSNC (DES1989b), he felt that politicians became quite influential, by forming a 'coalition' with scientists and educators. E2 felt that Harlen had argued strongly for science to have a place in the primary curriculum and through the NCSWP helped to shape the PSNC (DES1989b). E3 also thought that Harlen's seminal paper '*Does content matter?*' (1978) had raised the debate about 'content' rather than just 'process' in primary science. However because the NCSWP mostly consisted of science specialists and enthusiasts, E3 thought primary science took on the inappropriate format of a secondary science curriculum. Although he had formed part of a working party to look into the manageability at what was being proposed for the three core subjects for primary schools a report was never published. E4 suggested her work in the APU had an indirect influence on primary science in that it raised the notion for the need to have some 'content' on which to base the assessment. As a member of the science NCSWP, she argued that the original version of the PSNC (DES1989b) had been viewed as mostly process based with some core content, although the DFES after reading the report had added more detail and filled in gaps left out by the working party (E1, E2, E3 and E4).

E5 felt that the government's own education agenda resulted in science becoming a core subject but argued that other bodies such as ASE and Industry had also influenced the curriculum content, whilst E6 suggested that earlier the HMI document *'A Statement of Policy'* (1985) had also raised the debate about primary science (E5 and E6).

E4 thought that more recently the *Dearing Report* (1993) had been a key influence on reducing the complexity of the NC (DES1995). E3 felt the lack of any significant change to the curriculum content of the current PSNC (DfEE1999) was largely due to the enhanced importance given to other policy initiatives such as the NNLS. E1, E2 and E5 thought that AKSIS (1998) had a big impact on the current version of the PSNC (DfEE1999) in relation to scientific enquiry as the findings had shown that pupils were generally poor at data handling. E5 also felt the ASE had influenced the current content of PSNC (DfEE1999) because it met regularly with DfEE, Ofsted and QCA feeding in views and responses to changes in the curriculum (E1, E2 and E5).

E6 stated that political influences had led to the most recent revision of the NC (1999) along with the suggestion (from teachers) that it was still too overcrowded. He felt that the revision was not due to wanting to have a fresh look at what educationalists wanted from a science curriculum but was a reaction to what was already there. Nevertheless, he suggested that within the science community there was broad agreement about what was to be achieved for science and this was due to having the right people in the right jobs at the right time, particularly in Ofsted and QCA.

4.4.1.2 Pedagogy

E3 suggested that a strong influence on science pedagogy had been the work of Nathan Isaacs and The National Froebel Foundation, which in turn had influenced the Plowden Report and had given a rationale for a 'process' approach to primary science. E4 thought that the work of Piaget had been influential, as it had shown children were able to explore and make sense of the world. E4 stated that in the 1980s the research by herself and Driver into children's own ideas, along with Osborne and Freyberg's work in New Zealand had been a key influence on primary science pedagogy. It had led to the realisation that children already had their own ideas and these should be taken into account when making assessments. This had influenced thinking about the interaction between scientific process and concepts. Thus, E4 felt that research on the constructivist philosophy had been a major catalyst as now most teachers realised the importance of starting with children's ideas. E5 also thought CLIS and SPACE, promoted by inspectors and advisors had influenced science pedagogy and pushed the constructivist approach in schools because ASE had been proactive in reporting science research when lobbying government.

4.4.1.3 Assessment/accountability

The *Primary Survey*, (DES1978) was cited by E2 and E3 as significant as it identified science as very patchy in primary schools. E3 also stated that the HMI discussion paper in the early 1980s *Science in Primary Schools* (1983) had influenced debate about the notional content, particularly leading up to the PSNC (DES1989b). E3 thought that the HMI had been influential between 1978 and 1988 and also during the period 1992 to 1996, when inspections were very much concerned with 'compliance' with NC. However since 1998 he felt science although regarded as important by the government had become less of a curriculum focus due to the more recent emphasis on NNLS. However, the place of science in the NC had been made more secure by the fact it was tested at KS2.

E4 felt that the government's wish to move to a national system of testing in order to ensure greater accountability and parental choice had prevented the APU having a greater influence on assessment in terms of providing teachers with diagnostic points about where they were going wrong in science. This had now resulted in a tension within the current context of influence between the government's determination to keep summative tests, yet also wanting AfL. E4 argued that the two forms of assessment could not go together as they involved different teaching and learning methods.

E2 stated that the government's policy of national testing had and continued to be a major influence on the development of primary science, both in terms of curriculum and pedagogy. He felt the tests asked for too much recall and even although he advised the test producers of this they did not take it on board. E6 felt there was a tendency for SATs to dictate the content of science, whilst E5 reported that the findings of AKSIS (1998) had resulted in more scientific enquiry questions, particularly on data handling in the SATs. E6 said that the wide uptake of the PSSW (1998) had been fuelled by Ofsted's approach, in that those schools that followed it received a 'tick in the right box'.

4.4.1.4 Teacher development and subject knowledge

E3 thought the early HMI primary science courses had been a major influence in defining primary science particularly as they operated then with enthusiasts like Wastnage and Stockdale who E3 argued had '*been major proselytisers for primary science'*, but also because they resulted in the appointment of advisory teachers who in turn ran the courses. He felt HMI district advisors influenced LEAs to appoint people with 'specialisms' in science in order to support primary science. E2 also viewed courses funded by ESGs as influential in developing teacher subject knowledge and understanding, whilst E4 felt the very fact that primary science was made compulsory, meant more attention had been given to ITE and resources.

E1 stated that there had been a tension between how much 'science' a primary trained teacher needed to know in order to teach effectively, and whilst the NC implied you needed to know a lot, he thought that good science teaching was just as much about how teachers interacted with pupils rather than how much they knew. E1 argued that in the recent PSNC (DfEE1999) the issue of how much a primary teacher should know in order to teach science was too detailed, instead the main aim should be to encourage primary teachers to concentrate on things they could do well, and not to go into too much detail. E3 thought that teacher's subject knowledge had only become an issue after the mid 1990s.

4.4.2 Context of policy text production

4.4.2.1 Curriculum

E3 stated that the PSNC (DES1989b) was the first attempt to bring together 'process' and 'content'. However he felt that as a result there had been too much emphasis on content although subsequent revisions had meant the balance was perhaps better now. However E2 argued that due to the way the original PSNC (DES1989b) was written, primary science was now defined in conceptual terms, and as such; scientific enquiry was not explicit, whilst E1 thought that the present PSNC (DfEE1999) reflected the current definition of primary science and in many ways could be viewed as a 'foundation' curriculum. E3 also stated that there had never been any clear guidance as to how much time should be spent on science and thus how much time would be needed to cover the PSNC. E2 thought that primary science was now undervalued and did not get as much time spent on it as some other subjects, whilst E4 said the tensions were in terms of overloading the curriculum and this had not been resolved.

E1 stated that the current PSNC (DfEE1999) could be cut down even more but felt there would not be a chance to do this with the current emphasis on testing. However he thought there was plenty of scope for science process skills to be applied across other subjects as all subjects through their skills had a common root and in this sense science was not so different. E1 felt that the PSSW (1998) had now built upon the foundation of the NC and thus it was reasonable to expect schools to work from this.

E1 thought there had been a big tension between scientific enquiry and content before and after the PSNC (1989b). The PSNC (DES1989b, 1991b and 1995) meant that teachers began to lose sight of what scientific enquiry was and relied on the formulaic versions from the NC. E1 thought that was not what was envisaged pre PSNC (DES1989b). E1 felt that there was a tension between NNLS and producing the science equivalent with skills carrying the same importance. He thought that science and finding out about the world could be a great context for learning literacy and numeracy, as he felt the way one learned basic skills was important. E3 argued that although science was a clear vehicle for promoting literacy and numeracy, the government had done little to encourage this. E6 felt that literacy and numeracy skills were a prerequisite for science learning and thus science could not expect to have as much time devoted to it as the other core subjects. Nevertheless he was of the opinion that it provided access to other subjects and to underlying culture.

Within the science NC policy text E2 thought there was a tension between primary and secondary science as often the latter did not acknowledge the groundwork of primary school teachers. He thought this resulted in problems with progression when topics were revisited and perceived by pupils to be a repetition of primary school work. E4 argued that in the current PSNC (DfEE1999) it was not clear both in terms of skill or concepts what the next step in learning should be. She felt subsequent revisions had actually resulted in less progression as various elements had been removed. In the original PSNC (DES1989b) she said the science NCSWP found it hard to get away from the traditional Physics, Chemistry and Biology probably because people were comfortable with this. E4 was of the opinion that progression in skills was easier, whereas progression in concepts was quite different attempting to move from small ideas to a big idea, which was more encompassing and more applicable. E4 felt that the underlying problem was that the PSNC (DfEE1999) was not presented in terms of 'big ideas', and the introduction of level descriptors, although looked more manageable, made it more difficult to see progression.

E5 stated that the current version of the NC policy text still tended to be very subject orientated and did not capitalise on cross-curricular links. E6 felt that in the current version of the PSNC (DfEE1999) the definition of a fair test still reflected that of physical science and that the notion of 'model building' was missing. This he felt was a very powerful tool in terms of building conceptual understanding, yet the PSNC (DfEE1999) seemed to ignore it. Although he thought that progression was broadly in the right direction, content was probably too heavy.

4.4.2.2 Pedagogy

E1 said that within the Foundation Curriculum policy text, 'knowledge and understanding of the world' was a good way for children to explore. He said that this could lay foundations for quite complex concepts later on. He felt that primary science pedagogy was a process of enquiry although acknowledged this posed problems in the classroom in terms of ensuring individual progress.

E6 stated that science was more about the way that it was taught, not about the curriculum itself. He argued that the PSSW (1998) had been based on the SPACE research (1986-1990), but that the writers of the PSSW (1998) had missed the point in that children's ideas were seen as important in order to show what they thought rather than as SPACE had intended to show where they were in terms of their conceptual understanding. E2 thought that the PSSW (1998) had become a 'tablet of stone' and that it probably drew upon the 'misconceptions' literature and investigations in primary science by people like E5 and Goldsworthy.

4.4.2.3 Assessment/accountability

E1 suggested that the national tests might place more emphasis on some aspects of the science curriculum, whilst E2 thought it was really unfortunate that testing had focused on the science content, resulting in many Y6 classes revising early for the tests. E4 stated that changes to the NC made by government and the advent of the national tests had placed greater emphasis on science content.

E4 argued that the original intention with the first SATs (1992) was to ensure that the curriculum led the assessment and reflected good practice in the classroom, but there had been a compromise, which unfortunately meant that scientific enquiry, became lost altogether which was now an enormous concern for primary science. E3 did not feel science enquiry could be assessed by written tests but only by a series of real-life problem-solving situations. He felt the early version of SATs although more logical were impracticable. He highlighted the tension between testing to compare children and diagnostic testing to find out what they could do.

E1 felt that the *Assessing Progress in Science* (QCA 2003) units provided a good framework based on findings from *Centre for Research in Primary Science and Technology* (CRIPSAT). However, E4 said that these units illustrated that there was a contradiction between the government's understanding of what was 'AfL' and what the Assessment Reform Group meant. E4 stated that you would not get AfL whilst testing continued.

4.4.2.4 Teacher development and subject knowledge

E1 felt ITE standards were far too detailed and that such prescription had been driven by accountability. E1 was not convinced by the view that primary science teachers were poorer teachers because they did not have a science background. However, E2 felt it was necessary to have some subject knowledge through prior qualification, ITE and CPD. He felt the twenty-day courses in the 1980s had been successful in that sense. E2 felt teachers became more restrictive in their pedagogy, if they had to teach science without subject knowledge.

E1 thought that the PSSW (1998) had been a useful bridge between policies and set out a framework for teachers at all levels, illustrating how it was possible to cover the science curriculum content in a set amount of time. He argued that it was fluid enough in its structure for schools to use it as a basis to plan lessons in relation to their own contexts, it was also a useful way for QCA to influence things, as their reviews had shown that almost 100% of schools made use of it, either in its entirety or modified in some way. He felt that the use of an 'expectation range' enabled greater flexibility in assessment, as pupils would vary in terms of their ability in different units of work, depending on their experiences.

E2 strongly indicated his dislike for the PSSW (1998), arguing that if you were going to show respect and trust for teachers then you should allow them to develop their own scheme of work based on the broad framework of the PSNC (DfEE1999). He felt there was no rationale to suggest that the PSSW (1998) was the best way of approaching primary science and money could be better spent on improving the quality of ITE and CPD.

On the one hand, E4 felt PSSW (1998) provided a good example of whole school planning for science, yet she was skeptical of the quality of science if teachers took it as a prescription as it could lead to dull science teaching with no real ownership, understanding or possible interest by the teacher. She argued it was more effective for teachers to start from their own thinking rather than adopt someone else's. E4 felt that the main aim was to give schools more support in translating the science curriculum.

E5 stated that the PSSW (1998) had a clear government agenda that was on the progression and integration of scientific enquiry. It been developed in order to give teachers more time to concentrate on the NNLS in order to help the government meet targets, this way teachers would not have to worry about planning and progression in science. E5 felt now that there was not a need for the PSSW (1998) and that in many ways it was dull and uninspiring; E5 stated that those who wrote the PSSW (1998) came from a variety of different backgrounds. Some had limited views of science and were not so recent in the classroom. She felt that a different group of people would have produced a very different scheme of work.

E6 said that the whole rationale for the development of the PSSW (1998) stemmed from the subject knowledge debate which suggested that because primary teachers had poor subject knowledge, a scheme of work could provide the support in terms of progression structure and planning. He felt that the unintended consequence was that schools had accepted it as the normal practice, which resulted in science becoming uniform and boring and restricting thinking.

4.4.3 Context of policy practice

4.4.3.1 Curriculum

All elites thought that prior to the NC science had been largely process based and centred on nature studies. Whilst most felt this to be quite a narrow focus, E6 thought it was open ended with an emphasis on children doing in the practical sense. After the introduction of the PSNC (1989b), he felt science became closed in with assessment becoming important.

E5 thought that now schools realised that science had to be taught, and all children had access to science and on the whole it tended to be more practical. E2 stated that the definition of primary science had been broadened, although he felt that the PSNC (DfEE1999) had somewhat obscured this. E2 argued his research showed that teachers tended to spend on average one hour a week on science. He felt this could not provide enough time to engage in scientific or meaningful investigation. However, whilst E4 agreed that confining science to the afternoon was not a good thing, she did not think that having equal time with literacy and numeracy was necessary.

E2 felt that if there was to be any meaningful discussion about the future of primary science it needed to be freed from the assessment debate. However, he thought this would be a difficult within the current government agenda on standards and improvement. For E6 the main success was that all schools were doing science in some form and that there was a lot of good practice.

4.4.3.2 Pedagogy

Within the context of practice, E2 stated that there seemed to be an association between the poor quality of the tests and poor pedagogy, with the emphasis being on rote and recall. However he did feel that a child being educated today did perhaps have a wider range of experiences than twenty-five years ago. E2 argued that within the context of practice it was important for young children to have the experiences and opportunities to investigate and explore and not just to get them to a certain national 'level'. E1 felt that assessing children at five was getting in the way of a need to work on the natural way of learning about the world. E4 was concerned that process skills were being taught through direct instruction, and as a result children did not enjoy science anymore.

Although science had got some teachers thinking about the way they taught, E6 felt that this had been lost to some extent due to the pressure of SATs. However he felt that the Primary Teaching Awards were evidence that there was still some good teaching in schools. E6 felt that the challenge was to recognise the impact teaching had on learning and thus to realise the importance of AfL in order to improve teaching interactions which result in effective learning. Within science, E6 stated that this meant getting a better balance between the teaching of skills and knowledge as neither could be taught effectively in isolation.

4.4.3.3 Assessment/accountability

E3 felt that teachers viewed the PSSW (1998) as an 'official' translation of PSNC (DES1995 and 1999) and this had been fuelled by Ofsted who encouraged schools to feel that they were unlikely to be criticised in inspections if they adopted it. E3 stated that the inspectorial overtones had meant that teachers probably felt obliged to teach science, although thought they were now more confident teaching and assessing science than before.

E1 argued that teachers were now not so worried by changes in the science curriculum but by other things such as assessment, whole school issues and management. However, he did feel that the prominence of the tests had prevented scientific enquiry developing properly in primary schools, possibly because of the link with testing and the league tables. E1 stated that within the context of practice the assessment policy was not helpful and that he was concerned that schools start preparing for the KS2 tests very early in the year.

E2 thought there was a conflict between what people's aspirations were for primary science and what it had turned out to be in terms of the tests. He argued that national assessment had made people teach to the tests and that research, currently being funded by *The Wellcome Trust* showed that a lot of emphasis in science was on revising for tests particularly in Y6. Although there had been a move for current test papers to have a greater emphasis on data handling and fair testing, E2 suggested that it was still possible to prepare for these kinds of questions and ultimately would not lead to a change in practice. E2 thought that a better form of assessment would be a portfolio of evidence, based on TA although the ideal scenario would be to get rid of testing, particularly as the evidence seemed to show that even younger children were being turned off science. E3 stated that there did not seem to be the same pressure in KS1 but he certainly felt science was assessment driven in Y6. E3 felt this could be avoided if the current testing was replaced with TA and diagnostic tests, not unlike those in 1992.

E4 thought that testing had also provided tensions in the way test results were used in that it had narrowed the curriculum and changed teaching methods to predominantly direct teaching. She cited research which suggested that there was a tension between what teachers believe in and what they were forced to do to get children through the tests, despite this; some teachers were still producing good science. E5 thought that the impact of the assessment policy was to make teachers less creative and worry about science. As a result there was an increase in the amount of written work and Y6 had become a revision year.

E4 thought that the assessment policy had been detrimental to primary science, whereas AfL would be much more supportive of good science teaching in terms of tracking pupil progression. Therefore she felt that the biggest challenge for science was to get all teachers involved in AfL so this would improve feedback and make teachers look more closely at pupils' work. E6 stated there was a distinct difference between teacher and national assessment; the latter had constrained the development of science in the classroom focusing teachers on preparing children for tests, whereas the former encouraged teachers to work with pupils.

4.4.3.4 Teacher development and subject knowledge

E2 suggested that the predominantly female teaching population in primary schools tended to have a negative view particularly towards physical science and this needed to be addressed. E5 also argued that historically female teachers were unlikely to have studied science at school so access to CPD was important. Whilst the science curriculum for ITE had provided some support for trainee teachers they rarely saw 'exciting' science in schools, which had a 'knock on' effect for their own development. E5 also felt that experienced staff did not have access to courses due to limited school funding. Her personal experience had been that teachers in one LEA received no science CPD for five to seven years and that generally LEA support for science was far less than for NNLS. E1 and E5 stated that the status of science had slipped as a result of the governmental push on NNLS. E4 said that a teachers' background knowledge was now better than it had been and this was certainly true of new teachers, who were also more confident teaching science.

E6 stated that training requirements for science have to be seen in context of the other subjects and in this sense he felt it was about right. If ITE was part of professional development, then it was important to ensure that there was a systematic approach to provide further and ongoing support for existing CTs in science, E1 thought that the

Science Learning Centres might go some way to boost teacher esteem. E1 said that another challenge was to make CTs more confident to make judgments about what to teach in science, he felt the NC had not really allowed this to happen yet. He stated that the paradox was that because science had been seen as a success, then the assumption was that it did not need any further support.

4.5 DISCUSSION

The discussion will develop the 'analytical stories' of the elite figures as they related to the broad themes within the context of influence, policy text production and practice of primary science.

4.5.1Context of policy influence

4.5.1.1 Curriculum

It would seem that the initial debate about the balance of skills and content within primary science reflected a range of competing influences. E3, who had worked for the Inspectorate prior to the introduction of the PSNC (DES1989) felt although the government had been alerted to serious concerns about the manageability of science in relation to the other core subjects this was never really acknowledged.

> *One of the things that isn't known about the development of the NC is that in 1988 a primary sub-group was established to look at the manageability of what was being suggested in maths, science and English…it only met about 3 or 4 times, and I was the HMI assessor on that…we never published the report but we issued an internal document.*

E3 also attributed significant influence to HMI who he implied, set the foundation for the steady development of primary science, with E1, E2 and E6 expressing similar views. E3's comments would suggest that HMI and Ofsted had a key role not only in ensuring science was taught but that all content was covered;

> *...in the early days (1988-1992) Primary HMI ... were looking for evidence of the introduction of the National Curriculum...with reference to the presence or absence of primary science. Also annual reports produced by...HMI would contain summary observations of how far primary science was or wasn't developed... it's been less of a focus in Ofsted inspections since 1998 where literacy and numeracy have been the focus... (E3).*

This might suggest that such stringent monitoring helped to encourage schools to place a greater emphasis on content knowledge rather than scientific enquiry.

However, E6 as Chief Executive to the ASE argued that the science community and ASE had been key players in the discourse around the balance of skills and content;

> *... I think credit has to go to the science education community itself. Them coming together and working hard and quietly to convince policy makers ...The ASE had to have a role in it and was a catalyst as it brought together the science community* (E6).

E5, as former Chair of ASE felt that whilst the Government;

> *has its own education agenda and they placed science as a core subject in the National Curriculum. ...ASE is a proactive organisation and has lobbied government to raise the profile of science, reported research to them and promoted primary science (*E5).

However E4, a member of the original science NCSWP at the time, suggested that ultimately the working party were not able to influence the balance of skills and content in the science curriculum in the way they had envisaged;

> *...there was a core of content, but we still thought the processes would be an important thing. Once the National Curriculum got into the hands of those people from the DFES, it changed, it became much more elaborate; they filled in gaps that we had left... (E4).*

This might suggest that although the science community and ASE made significant contributions to the debate about the balance between content and skills, ultimately the government determined the curriculum content.

The findings would indicate that the government agenda continued to influence subsequent revisions of the PSNC although there had been some reduction in content and the widening of scientific enquiry, which E6 attributed to having the *'right people in the right place'*. E3 and E5 suggested that science had recently become side lined, whilst E4 widely attributed this to the government's 'wider market forces agenda'. However E3 concluded that at about this time the political agenda had begun to focus specifically on literacy and numeracy;

> *I do think [science] is clearly regarded by the government as important, but nowhere near as important as it probably once was...there's been a moral panic about standards of literacy and numeracy which in my view has been overblown...science has suffered from that... (E3).*

This would suggest that once the government had secured science within the curriculum it was not interested in the finer details regarding the balance of content and skills particularly as science SATs remained high. Despite active lobbying by the science community though ASE and QCA, the current version of the PSNC (DfEE1999) appeared to have been strongly influenced by the political agenda and resulted in a science curriculum still largely dominated by content. E2 seemed unsurprised by this and felt that this was because;

> *the ASE is toothless. It likes to keep in with the Government it doesn't like to challenge ...They need a policy person with ideas, to say 'this is good, this is bad' and keeps talking and working with the academic community* (E2).

4.5.1.2 Pedagogy

E3 thought that the initial discourse around primary science prior to the PSNC (1989b) placed significant importance on the constructivist philosophy, which along with a substantial body of research cited by E4 and E5 should have had a significant influence on the development of primary science.

> *CLIS and SPACE were important research projects into pupils understanding in secondary and primary (respectively) particularly subject knowledge and led to work on a constructivist approach in schools in this country and a push by inspectors / advisers etc (E5)*

Whilst this would appear to be the case at the advent of the PSNC (DES1989b) pedagogic practice based on constructivist philosophy seemed to get lost once the government focused more on raising standards through national tests (E3).

4.5.1.3 Assessment/accountability

Although the scientific education research community supported a constructivist approach to learning science, linked to diagnostic and formative assessment, the government appeared to be far more interested in summative assessment in the form of national tests which enabled a comparison across schools on an annual basis;

> *Well what [the government] wanted to do of course was to use the national test results because with that you've got them for every school. The APU ... was a sample survey so you ... could [not] use [it] for accountability. They wanted to hold schools accountable ...it was structured market economy applied to education which meant they needed a measure and national testing gave that... (E4).*

These competing perspectives on summative and formative assessment would appear to have influenced the debate around the development of the science curriculum in terms of the balance of skills and content and in terms of the approach to teaching. However it would seem that ultimately the government's wish to have greater accountability resulted in the emphasis being placed on summative assessment through a policy of national testing, which in turn influenced both the content and pedagogy in schools.

4.5.1.4 Teacher development and subject knowledge

It would appear that the initial discourse around primary science together with the implementation of PSNC (DES1989b) resulted in a network of teacher support and development based on the assumption that there was a gap between what primary teachers know and what they were required to teach in science. There was also a suggestion that science courses were concerned with developing pedagogic practice and emphasised the constructive approach to teaching science. E3, who felt that subject knowledge became an issue after the introduction of the PSNC (DES1989b) stated;

> *there was a [national] short course programme that HMI ran for years and years...it also resulted in the appointment of advisors for primary science who in turn ran courses...LEAs appointed people with science specialisms to support primary science (E3).*

This would suggest that initially there was a significant concern about the level of primary school teacher expertise particularly in subject knowledge so much so that a whole infrastructure was developed to support the implementation of the PSNC (DES1989b, 1991b and 1995). It could be argued that initially such support was also driven by the government's wish to ensure compliance to teaching science.

More recently however it would appear that there has been a shift in the discourse and debate around the importance of subject knowledge for teaching primary science and as such the need for teacher support and development has declined. E1 stated;

> *Government are not interested. ... They're happy for primary science to just potter along, it's not causing any problems, and they don't have the same expectations of it I guess (E1).*

E5 and E3 implied that one reason why the government was not interested was because the focus on NNLS;

> *... has resulted in enormous redistribution of resources and training towards those two subjects at the expense of all the others...science has suffered from that (E3).*

E1 was not convinced that primary teachers need a good background in science in order to teach it well. Although he went on to say;

> *if you lack confidence in the subject you are supposed to be teaching it is probably quite difficult to remind yourself that what really matters is how you get on with the kids and how they are learning rather than how much subject knowledge you know (E1).*

4.5.2 Context of policy text production

4.5.2.1 Curriculum

Although E3 felt that the PSNC (DfEE1999) text ensured science was consistently taught, he was of the opinion that the production of this policy text had done little to resolve the process/product tension in primary science. Despite the strength of the educational debate about the balance of skills and content it would appear that primary science was largely defined in 'conceptual' terms. Furthermore, E6 argued that teachers were not clear about the distinction between primary and secondary science resulting in a repetition of content rather than any real progression or development in understanding. E2 had a similar view and thought that secondary teachers continued to place little value on pupils' experiences of primary science. E4 was concerned that despite each modification of the PSNC (DES1991b and 1995), the current version seemed less clear about progression in both skills and content. Despite a few relatively minor modifications resulting in slimming down content knowledge it would appear that the current PSNC (DfEE1999) was still concept driven.

Linked to the content debate was the notion of how much time should be spent on science. E2 an active researcher in science education, was particularly concerned about the lack of guidance, around this issue as it had significant implications for curriculum delivery;

> *[Our] study showed that teachers were only spending an hour a week [on science]...and also [science] gets relegated to the afternoon when kids are less engaged, are less attentive and have less energy...what does anyone do in an hour? (E2).*

E3's comments suggested that right from the advent of the PSNC (DES1989b) no one had really considered how much time was needed to deliver science and because 'enthusiasts' designed the science curriculum; little thought had been given as to how primary teachers might actually manage this in relation to the other subjects.

The elites seem to suggest that coverage in terms of time available and depth of knowledge were partially addressed through the publication of the PSSW (1998). However E5, who was Chair of ASE at the time of its publication, also thought that the real reason for the PSSW was so that;

> *...teachers could focus on literacy and numeracy ... so schools did not have to spend additional time on science ... the government at that time had targets to meet in literacy and numeracy... This was seen as a way that would help teachers to meet their targets and therefore government ones (E5).*

Again this would suggest the government's standards agenda influenced the guidance materials, with little interest in their quality as long as they enabled teachers to feel secure enough teaching science as well as focus on NNLS, for example E6 thought that;

> *those that produced it were drawing largely on the understanding we had of SPACE research, but totally missed the point...* (E6).

Whilst E2 voiced even stronger concerns about the credibility of the guidance material;

> *You don't give out stupid 'recipe' [QCA] schemes of work which are highly flawed any way, highly questionable, drawn up by people whom, I would argue, are not terribly well informed about the work they were doing...(E2).*

However there was general agreement and concern amongst the elites that although PSSW (1998) had been portrayed as one example of how to plan science, it now had acquired considerable status within the context of practice, '*When you now think about the wide spread use of it, it's a very important document really isn't it? (E4).* E3 suggested that teachers viewed it as the 'official translation of the programmes of study' rather than guidance material.

4.5.2.2 Pedagogy

Unlike the content of PSNC (DfEE1999), evidence from the elites would suggest that there has been little official guidance on pedagogy, which as a result had led to the adoption of 'formulaic versions' of scientific enquiry and a narrow interpretation of investigations. Findings from elite interviews indicate that quality of guidance within the PSSW (1998) was inconsistent and ambiguous in the way it suggested activities should be organised (E6) and as a result had not helped teachers develop a constructivist pedagogy. Whilst E1 felt that '*Assessing Progress in Science*' (2003) had attempted to address some of the underlying issues relating to pedagogy. Other elites thought that there was a need for teachers to understand why it was important to elicit children's initial ideas before they became entrenched, as well as a need to understand the way pedagogy underpinned the development of scientific knowledge and enquiry, for example E6 argued;

> *Whilst the curriculum is important, its not really about the curriculum going on, its what I do with it, how I teach it that matters (E6).*

Furthermore, E2 argued for a stronger link between pedagogy and enquiry;

what matters is the experiences and the opportunities to investigate and to explore, to start a verbal understanding... (E2).

However, the significance of the relationship between teaching, learning and the curriculum content (evidenced by research) appears to have been lost with the publication of PSNC (DfEE1999) and, as a result, E2 thought that the government focus on accountability and the Standards agenda had meant that pedagogic practice became strongly aligned with testing.

E4 felt that teachers were aware of the pedagogic principles of teaching science, although E2 and E6 thought that the policy text and current focus on testing might have prevented teachers from putting these into practice.

The constructivist philosophy which I think has taken over now. I mean almost every teacher knows [that] they should at least find out what children's ideas are...(E4).

In fact E4 went on to argue that teachers admitted they taught in a direct way as this helped them get through the tests. Thus, it would appear that despite the strong body of constructivist research, subsequent guidance on pedagogy has been minimal compared to the detailed prescriptions on science content.

4.5.2.3 Assessment/accountability

The elites felt that testing had also contributed to the over emphasis on content knowledge so much so that E4 thought that science investigations had become virtually lost. Nevertheless E5 thought that the current version of PSNC (1989) and more recently SATs had placed a greater emphasis on scientific enquiry;

> *AKSIS was a large ASE Kings College research project into data handling...They also fed back to Ofsted and QCA. As a result QCA have changed the SAT questions to include more scientific enquiry questions, in particular, data handling in an attempt to raise the profile of this with teachers and change their approaches to teaching this aspect and both primary and secondary (E5).*

However, E3 questioned whether scientific investigations could realistically be assessed by pencil and paper tests and E2 doubted that even with recent attempts to focus more on scientific enquiry it would still not change practice;

> *I just had the recent lot [of tests], they tend to be very much data/ graph type of questions because again those are ... easily [assessed]. They tend to be questions about will this be a fair test? Again there is a sense that actually I can prepare you for any kind of test ...even if you change the nature of the questions; people are just going to practice... (E2).*

Thus it would appear that there was a difference of opinion reflecting a deeper debate about the extent tests could assess understanding and application of knowledge as well as recall. Thus if scientific enquiry could be tested in this way it raises the question about the need for practical assessment and even AfL.

However E1 was confident that the QCA's recent assessment guidance and exemplification materials would help address this issue of assessment of scientific enquiry as well as bridge the gap between the government's demand for summative assessment through national testing and the educational wish for a greater emphasis on AfL. In fact he stated;

> *I think it is quite a good combination of fairly obvious activities that you are likely to do anyway and good pedagogic things, like asking the right kind of question, probing what they might have learned. I would be happy to hang [primary science] pedagogy on the process of enquiry... (E1).*

Whilst E4 held similar concerns to E1 about the problem of teaching to the tests, and the importance of engaging teachers with AfL, she did not share the same view that these guidance materials were an appropriate way of doing this;

> *...those QCA things called Assessment in Progress...it was put as ...AfL, but I just don't think it is! They have levels all the way down, I mean their idea is to see what level the child works at, that's summative not formative...in any case the way they've put in those extra statements...so it means that children do something in relation to plants and the next step is to do it in relation to animals, who says? It's a matter of what they've been exposed to...they've got the wrong kind of progression...(E4).*

Despite differences of opinion, it would seem that elites agreed that AfL should be a central part of assessment yet at the same time viewed the political agenda around national assessment and testing as a dominant and a somewhat restrictive influence on the development of the PSNC. For example, from E2's perspective it would seem that the government's unrelenting national testing regime had determined and distorted the nature of primary science, reduced the science curriculum to little more than content knowledge, which as a result had distorted the way science was taught.

4.5.2.4 Teacher development and subject knowledge

In light of PSNC (DfEE1999) and its emphasis on subject knowledge, elites differed in their views regarding the debate around teacher development and the extent of subject knowledge required for teaching science. E1 felt the ITE standards that had been developed to address the subject knowledge issues in training were far too prescriptive and he was of the opinion that;

> *the way the NC has been written implies you need to know a lot...what really matters is how you get on with the kids rather than how much subject knowledge you know (E1).*

Whereas E2 argued;

> *but if you are going to ask them to teach it then its important that they have subject knowledge, either you insist that they have it as a prior qualification, do it on the pre-service training or do it on the job through in-service training...actually I think you have to do all three... (E2).*

Although the PSSW (1998) seemed to be a way of enabling teachers to focus on NNLS (E1), it also seemed to address many of the issues previously raised, namely planning, progression, and integration of scientific enquiry. In fact E6 suggested;

> *...one of the problems we got into was this. Primary teachers don't know much science. They need help teaching National*

Curriculum, therefore provide them with a scheme of work to help them...(E6).

Thus it could be argued that if teacher subject knowledge was now not such a priority as E5 would suggest, then the PSSW (1998) might be one way of ongoing support for teachers without an expensive and labour intensive infrastructure of CPD, particularly when funds were being diverted to NNLS (E3, E1). In addition, there did not seem to be the same concern as to whether teachers have the appropriate pedagogic content knowledge in order to deliver the science curriculum.

Whilst E2, thought the PSSW (1998) was an unacceptable way to provide teacher support in delivering the science curriculum;

...the scheme of work is a profound indication of the lack of trust in the professional capacity of the people you have trained... (E2).

E1 who previously stated '*we can now do things most powerfully at the level of QCA*' would perhaps disagree. Nevertheless E6 felt there should be stronger links between ITE and CPD, although the dubious origins and questionable nature of the PSSW (1998) might raise concerns about the nature of CPD support.

4.5.3 Context of policy practice

4.5.3.1 Curriculum

E3 thought that whilst there were more opportunities to engage in science, there was still too much content to cover. E2 doubted whether attempts to broaden the notion of scientific enquiry had really worked in practice, and hence it would appear that schools focused largely on subject knowledge rather than scientific enquiry. He thought this was mostly because national tests had distorted practice in primary science and it would be impossible to redress the pedagogic and educational issues whilst this was the case. For this reason he was strongly in favour of returning to a greater emphasis on practical enquiry;

> *it needs to go back to a much more common process orientation... because a) I think the teachers would be much more happier about that and if the teachers are happier then it would be taught in a more interesting way and b) the kids would be much more exposed to science as a process of investigating and asking questions about the material world (E2).*

E6 felt that there was still a need to address issues relating to the balance of content and skills;

> *in science the debate about content and process, this needs to have better balance you can't teach knowledge in isolation, equally you can't teach skills on their own... (E6).*

Although E1 also thought that testing would prevent a further reduction of content, there was now a need to move on from the skills versus content debate and work at the level of QCA.

> *...We can do things most powerfully at the level of QCA with those schemes of work and the exemplifications as well... (E1).*

E3 had a different view, although concerned about the amount of content he felt the risk would be greater if science was not tested. Both E1 and E3 implied a more cross curriculular approach should be adopted suggesting that science process skills could be taught through other subjects. In fact E3 argued;

> *Science is obviously a clear vehicle for promoting literacy or numeracy but I don't think enough has been done about that (E3).*

It could be argued that views expressed by E2, E1 and E3 reflect some of the cross curricular aspects of the PNS (QCA2003) on the other hand it could be that their views reflected primary science prior to the PSNC (1999) which was possibly more thematically based, and provided more scope for teachers to focus more on scientific enquiry.

4.5.3.2 Pedagogy

The findings indicated that all elites thought that pedagogy had been adversely affected by the government's emphasis on national testing. For example, E2 stated;

> *...because of the poor quality of the tests it leads to an associated poor quality of pedagogy on which the very emphasis is on rote and recall... (E2).*

Thus regardless of whether teachers are aware of good pedagogic practice, they were not in a position to make much use of it in the current climate of testing;

> *teachers are teaching through direct instruction, even process skills they are doing in this way. ...Children are not enjoying*

science anymore and so it really is disastrous...teachers were saying 'we teach like this because this is the way to get them through the tests...(E4).

Thus it would appear that elites seemed somewhat concerned that testing had high-jacked teaching to such an extent that;

the impact of SATs determines the content of science and what happens in the classroom (E6).

Furthermore E4 claimed that;

children don't actually understand what they are doing but they actually pass the test (E4).

The findings from the elites would suggest that whether or not teachers were aware of constructivist pedagogy it would seem they were compromising this in order to prepare pupils for the tests. In fact because the emphasis had been on curriculum content and summative assessment, rather than on the quality of the teaching and learning experience, constructivist pedagogy appears to have been replaced by far more direct methods of teaching.

4.5.3.3 Assessment/accountability

E4 was of the opinion that initially the aim of assessment had been to support learning

I was working ... to develop some of the very first versions [of the tests]... what we wanted to do was to emulate good practice ...let the curriculum lead the assessment rather than the other way round (E4).

This view was also expressed by (E6), whilst other views from the elites would suggest that testing was the dominant form of assessment and it would appear that the initial APU influence on assessment along with the strong arguments for AfL have had little impact on the science curriculum and pedagogy despite E4's view that;

> *...research shows that using AfL actually does improve standards...understanding...enjoyment (E4).*

E4 thought that teachers relied on 'teaching to the test' not just because they lacked the time, confidence or expertise to focus on AfL but because;

> *the trouble is with the tests that [teaching through direct instruction] can work...at least for a little while...[but] you do get this tapering off as you can only increase [scores] by so much... (E4).*

The evidence from the elite interviews, might then suggest that the publication of SATs test papers (which up until recently have focused on content) have provided an alternative version of the PSNC (DfEE1999) and in may ways appear to have formed the basis for much teacher planning, alongside the science scheme of work particularly in Y6. In fact E6 stated that '*what is taught is dependent on the assessment regime*' and E1 and E2 felt this was evidenced by the fact that revision for tests started very early in the year. Such concerns were also voiced by other elites at various points throughout the interviews. Furthermore, E2, who annually reviewed the tests stated;

> *well people look at the tests and say what do they need to know in order to succeed? Then they teach to the test (E2).*

This would suggest that it was assessment driving the curriculum with the content of the test papers defining what should be taught rather than the PSNC (1999), a view also expressed by all elites. In fact it would seem that testing was placing significant restrictions on any future development of the primary science curriculum, particularly in terms of improving the quality of teaching and learning. E4 argued;

> *they will not accept …that you will not get [AfL] whilst you still have the testing going on…(E4).*

E2 suggested a major challenge was to free the science curriculum from the tests but he felt that politicians would be very reluctant for this to happen. However, E1 thought the way forward was to use the guidance materials to work within the constraints of the tests. Nevertheless all elites agreed that there was certainly a need to develop AfL in order to get teachers to focus more on learning.

4.5.3.4 Teacher development and subject knowledge

Evidence from the elites suggested that current support for CPD was in some cases non-existent contrasting sharply with the support after the implementation of the PSNC (DES1989b);

> *a lot of energy went into primary CPD in science…we've seen that tail away and the infra structure's gone so I think science has suffered quite a lot in the last five to ten years as a result of that (E1).*

E5 expressed similar concerns and felt this was largely due to the government's focus on NNLS;

> *many teachers will complain that there are no longer people in the LEA to support science , whereas there are advisers for literacy and numeracy (E5).*

It could be argued that the government concerns about teacher subject knowledge were no longer sufficient to warrant a comprehensive programme of science CPD and the changing policy context had resulted in the redirection of resources to NNLS (E3).

However evidence from E2 and E5 implied there was still a need for CPD in science, not only because SCs needed it, but because the predominantly large female population in primary schools were less likely to have a science background. Thus many existing teachers could only draw upon their ITE experience (which might be several years ago) and which in E5's opinion may have been compromised;

> *...many student teachers are still ticking boxes and seeing less than exciting science in the classroom, as a model this has consequences for their own development... (E5).*

Furthermore, whilst the PSSW (1998) might have given guidance on how to translate programmes of study into learning experiences, the relationship between concept development and scientific enquiry was neglected or at best underdeveloped possibly contributing to the reasons why teachers were not largely adopting constructivist approaches to teaching and learning. It would appear that whatever purpose the PSSW (1998) served, it was a poor substitute for science CPD;

where are the arguments that this [science scheme of work] is a good way of approaching science, there's no rationale in it whatsoever. Nobody can actually see the research or the experience it's based on its not open to question it's a profoundly anti democratic piece of material (E2).

E5 provided further evidence that CPD had diminished whilst E2 argued there was a need for consistent support before, during and after ITE otherwise he felt that weak science knowledge undermined confidence and restricted pedagogy. However, E4 thought that teachers' background knowledge had improved whilst E1 speculated that;

Science Learning Centres are hopefully going to be very important so that primary teachers get a sense of provision there (E1).

Unfortunately E1 and E3 felt the government would not view science CPD as a priority as long as pupils performed well in science SATs. Thus it would appear that whilst some elites thought primary science a success, E2's view regarding the complacency of the science community was also appropriate;

there needs to be a debate… ' Is primary science a good thing?' … It's been in place now for sixteen years or so. … All the evidence I see suggests that actually it is questionable and wouldn't it be much better if we looked at it harder and asked what's good about [primary science], what's bad about it and I think that's the trouble, people don't look at it very hard… (E2).

4.6 CONCLUSION

The discussion has traced the broadly related themes emerging from the elite interviews and analysed how they have influenced the development of primary science within all three contexts. For example, the balance between skills and content within the curriculum, the questionable pedagogy driven by the assessment agenda and shifting debate around the importance of teacher subject knowledge have exposed conflicting perspectives which have given rise to further tensions.

Whilst the purpose of this chapter has been to provide an analysis of key influences and debates, that have helped to shape and define primary science, the views of the elites reflect their own personal understanding and interpretations of the policy to practice context. It cannot be not known the extent to which their views represent past or current reality at grass roots level, however there is an indication of an ongoing debate about the balance of knowledge and skills that has continued to affect the development of the primary science curriculum which has become increasingly influenced by national testing since 1995.

The elite interviews suggest that the promotion of a 'constructivist pedagogy' to support and develop learning has never been part of the government's policy in relation to primary science. Instead the prescribed PSNC (1999) and a preoccupation with national testing at KS2 has led teachers to adopt a pedagogy that maximises achievement in the tests, largely defined by the government's market forces and standards agenda, framed by national assessment and testing procedures. In this sense pedagogic practice would appear to be driven by the national, measurable outcomes rather than by a development of scientific learning based on individual needs. Thus it might seem that despite the considerable amount of research investigating children's learning in science, little debate at policy level has ever been concerned about the quality of teaching and learning of science, but rather has focused upon the most effective ways to measure performance in primary science through national tests and make schools accountable.

This chapter has addressed the first two research questions through elite interviews to suggest that the current conceptions of primary science curriculum have been much more defined by political policy rather than educational discourse. Influences, although wide ranging, became largely politicised interpretations of current discourse. The four broad themes spanning the three contexts in this chapter will provide a framework for analysing the regional survey and case studies presented in the following chapters.

CHAPTER FIVE: THE REGIONAL SURVEY

5.1 INTRODUCTION

The previous chapter used qualitative data to provide an overview of the policy to practice context drawing upon individual perspectives from elite figures in education. In order to gain a wider understanding of primary science within the context of practice, a regional survey was conducted.

5.2 AIMS

This chapter aims to report the findings from the survey, which addressed the third research question: how primary science policy text was interpreted, reconstructed and implemented within the context of practice. Although the intention was to capture practice across a wide range of schools in order to identify similarities, differences, tensions and conflicts, it was acknowledged that the survey would only provide a 'snapshot' of practice at one point in time. Nevertheless the 'broad sweep' provided a useful overview of opinions, experiences and practice in 2001.

5.3 METHODS

5.3.1 Participants

A semi-structured questionnaire was used to collect data on primary science across two LEAs, sampling urban, rural and mixed regions and representing diversity in type, size and organisation of schools. The schools were selected in the manner reported in the methodology chapter and included primary, first and middle schools. Questionnaires were addressed to SCs as it was assumed that they would have 'expert' and 'recent' knowledge of the requirements of the PSNC (1999) and how this was translated into practice within their school context. They were also likely to have their own views and rationale for the way they supported the implementation of the PSNC (1999), in relation to the size and type of school in which they worked. For example, in a small school the SC might have multiple roles and responsibilities, whilst in a large school they might hold a single role.

5.3.2 Materials

The final questionnaire contained fourteen mostly closed questions which were divided into two sections in order to ease analysis (appendix 5.1). Further details of how the questionnaire was piloted are reported in the methodology chapter.

5.3.3 Procedure

At the beginning of the summer term the questionnaire was sent together with a covering letter explaining its purpose and overall link to the wider research context and invited recipients to add their contact details regarding further participation in the research. In addition, respondents were also requested to return the questionnaires by the end of the summer term and these were then analysed.

5.3.4 Analysis

By the end of the summer term one hundred and forty four questionnaires (42%) had been returned. A data trail was kept by first numbering each questionnaire and inputting the data from each question into SPSS 12.0. Further details are reported in the methodology chapter. Findings which related to the broad themes of curriculum, pedagogy, assessment/accountability and teacher development and subject knowledge are reported below in the form of tables and descriptive comments.

5.4 RESULTS

This section first provides a brief description of the profile of the sample and then findings are presented under the broad themes previously outlined. Questions, which provided evidence and exemplification for these themes, form the basis for the tables and charts that appear. A commentary describing each table in more detail is given underneath.

5.4.1 Profile of the sample

30% of schools in the survey had less than seven classes, with 56% of schools having between seven and fourteen classes. Just 14% of schools had more than fourteen classes. It could be assumed that many of the smaller schools might have mixed-aged groupings, which might influence the way science was taught. Additionally SCs, in smaller schools may hold a number of roles and responsibilities. The sample also contained 36% of the respondents who at the time of the survey, taught KS1 including reception classes, 56% who taught KS2 and 4% who taught in both key stages.

Of the respondents, 27% had less than one year's experience as SC with 44% of the sample having between one to five years co-ordination experience. It would appear that only 5% of respondents had more than ten years of experience. Thus 71% of the sample had been a SC for no more than five years. 30% of the respondents had no additional responsibilities other than SC, whilst 63% had management or other subject responsibilities. In addition, 8% were HTs. However, 54% of the respondents had been teaching for more than ten years, whilst 23% had taught for less than four years.

It would appear that only 32% had studied science at Advanced ('A') level whereas 48% of the sample had qualifications in arts subjects. 21% of the SCs had a mixture of arts and science qualifications at 'A' level; however, 21% did not answer this question.

5.4.2 Curriculum

The majority of respondents, 62%, stated that their school had adopted the PSSW (1998), whereas 37% said they used some of it and only two schools stated they used their own science scheme of work.

Table 5.1 Barriers to teaching science

Barrier	Frequency/percentage
Curriculum pressure	114 (81%)
Time	91 (65%)
Staff confidence	68 (49%)
Paper work	54 (39%
Class size	43 (31%)
Limited of resources	30 (21%)

Table 5.1 shows that curriculum pressure was seen as the greatest barrier to teaching science, followed by lack of time, whilst only 21%

perceived a lack of science resources as a barrier. It was interesting to note that 49% still thought that staff confidence could be a barrier. When comparing responses between those who taught KS1&2, 90% in KS1 felt curriculum pressure a barrier compared to 78% in KS2.

5.4.3 Pedagogy

Table 5.2 presents statements that represent different beliefs about learning science. Whilst statements A, D, E, G, and I broadly reflect a 'constructivist' view of learning, statements B, C, F, H and J represent a more traditional 'transmissionist' view of learning. Statement D was the only constructivist statement that attracted a divided opinion with a total of 43% in agreement and a total of 58% disagreeing. Whilst other constructivist statements reflected agreement, statements B and C reflected a broadly transmissionist conception of science yet were both supported. However, statement H also representing a traditional view of learning science was mostly rejected with a total of 99% in disagreement perhaps reflecting the strength of opinion about the place of practical work in primary science. On the other hand, statement J showed broad agreement but with a total of 37% disagreeing, whilst statement F was supported by only a total of 28% with 72% respondents disagreeing that misconceptions were a result of not understanding what is being taught. Thus it would appear that respondents exhibited both 'constructivist' and 'transmissionist' views of learning science with perhaps a greater agreement with constructivist statements.

Table 5.2 Learning science

	Statement	Strongly agree	Agree	Disagree	Strongly disagree
A	Pupils learn by being challenged to make links between scientific concepts in order to develop understanding	72 (52%)	65 (47%)	2 (1%)	0
B	Pupils learn by being taught existing facts and scientific concepts	18 (14%)	97 71%)	20 (15%)	0
C	Pupils should be encouraged to use scientific vocabulary whenever possible	88 (62%)	52 (37%)	1 (1%)	0
D	It does not matter if scientific vocabulary is not used, it is the understanding that is important	8 (6%)	50 (37%)	66 (49%)	12 (9%)
E	Pupils misconceptions need to be recognised, made explicit and worked on	70 (50%)	70 (50%)	1 (1%)	0
F	Pupils misconceptions are a result of failure to grasp what is being taught	5 (4%)	33 (24%)	88 (63%)	13 (9%)
G	A teacher should let pupils plan and carry out their own investigations and draw their own conclusions	41 (29%)	83 (59%)	16 (11%)	2 (1%)
H	Pupils planning and testing out their own ideas is of little importance	0	2 (1%)	49 (36%)	87 (63%)
I	A teacher's main role is to help pupils reject, shape and extend ideas and to justify why they think the way they do.	29 (22%)	78 (58%)	28 (21%)	0
J	A teacher should plan pupils practical investigations to prevent aimless activity	20 (15%)	65 (48%)	44 (33%)	6 (4%)

Table 5.3 Classroom organisation

Method	Ranked 1	Ranked 2	Ranked 3	Ranked 4	Ranked 5
Whole class doing the same practical task	67 (50%)	35 (26%)	18 (14%)	8 (6%)	5 (4%)
Whole class doing related practical tasks	57 (44%)	53 (41%)	17 (13%)	4 (3%)	0
Circus of related activities	13 (11%)	19 (16%)	30 (26%)	36 (31%)	19 (16%)
One group at a time doing science	8 (7%)	6 (5%)	14 (12%)	27 (24%)	57 (51%)
Teacher demonstration	6 (5%)	14 (11%)	50 (40%)	32 (25%)	24 (19%)

Table 5.3 illustrates how respondents ranked methods of classroom organisation. 50% and 44% of respondents ranked whole class teaching methods as the predominant way of organising science. 11% ranked using a circus of related activities as their preferred method of classroom organisation. However 7% stated that they organised their class so that one group at a time did science and only 5% ranked teacher demonstration as their first method of organising the class for science. Respondents that taught KS1 made greater use of circus related activities (24% ranked it first), compared with KS2 where 3% ranked it first.

Table 5.4 illustrates how frequently science activities, which were perceived to result in either open-ended or closed outcomes, were used. It would appear that 'discussion' and 'reporting back to the class' was the predominant science activity with 94% of respondents claiming they used this frequently. 89% claimed they used 'classifying or sorting activities' in science, whilst 84% said they had used 'labelling diagrams'. 80% frequently got pupils to 'draw what they mean'.

Table 5.4 Pupil tasks

Task	Frequency/ percentage
Using discussion, reporting back to the class	134 (94%)
Classifying and grouping activities	126 (89%)
Labeling diagrams	121 (85%)
Children to draw what they mean or understand	115 (80%)
Children writing up the whole science investigation	97 (68%)
Carrying out surveys to gather data	89 (62%)
Copying from board or work sheets	84 (59%)
Concept mapping to find out children's ideas	78 (55%)
Completing past SATs papers, mini tests	76 (53%)
Children using spreadsheets and/or databases	53 (37%)

Just over half of the sample (54%) used 'concept maps' as an activity in the last term, yet 53% of respondents claimed to 'practice SATs papers' or use 'mini tests'. 59% said they had used 'work sheets' and board work as an activity during the last term, whilst 68% of the sample of SCs said they got pupils to 'write up' whole investigations. The majority (62%) claimed they had made use of 'surveys to gather data' in science, however only 37% of the sample said they used 'spreadsheets or databases' with their class. Whilst the most frequently used activities would appear to be those that have relatively open-ended outcomes, some more closed tasks such as labeling diagrams and writing up investigations were also used. In addition, SATs papers and mini tests, spreadsheets and databases, full write-ups and worksheets were used far more by KS2 than KS1

5.4.4 Assessment/accountability

Table 5.5 Purpose of assessment

Purpose	Strongly agree	Agree	Disagree	Strongly disagree
Diagnostic purposes	101 (70%)	41 (29%)	2 (1%)	0
Guide future teaching	87 (60%)	55 (38%)	2 (1%)	0
Monitor standards	50 (35%)	87 (61%)	5 (4%)	0
Compare pupil performance in class	31 (22%)	70 (50%)	36 (26%)	2 (1%)
Compare performance with other schools	9 (7%)	69 (50%)	47 (33%)	13 (9%)
Match teaching materials to children's needs	67 (47%)	63 (44%)	12 (8%)	2 (1%)

Table 5.5 presents SCs' attitudes towards assessment. It would appear that the majority thought assessment should be diagnostic and guide future teaching. 35% strongly agreed that it should be used to monitor standards. However, there was less agreement about comparing pupils in class and least agreement (57%) about

assessment for comparing performance with other schools. The spread of views was similar in both KS1&2.

5.4.5 Teacher development and subject knowledge

Table 5.6 Professional needs

Professional need	Rank 1	Rank 2	Rank 3	Rank 4
Monitoring assessing science and setting targets	74 (55%)	40 (30%)	15 (11%)	5 (4%)
Developing a wider range of teaching strategies	25 (20%)	42 (33%)	42 (33%)	19 (15%)
Developing leadership and management skills	25 (20%)	30 (24%)	33 (26%)	38 (30%)
Science subject knowledge	18 (14%)	18 (14%)	33 (26%)	60 (47%)

Table 5.6 shows how SCs ranked their own professional needs. It would appear that 55% of SCs ranked monitoring and assessing science and setting targets as their highest priority. 20% of SCs ranked management as first amongst their professional needs. Development of leadership and management skills together with developing a wider range of teaching skills were ranked as equal in priority. Only 14% ranked science subject knowledge as their main professional need and only 4% put this as a low priority. A comparison between KS1 and KS2 showed that both ranked assessment as their highest priority whilst 26% of KS1 ranked management skills as a

priority compared to 16% of KS2. Similarly 23% of KS1 ranked subject knowledge a priority compared to 6% of KS2.

Table 5.7 School development needs

Needs	Frequency/percentage
Developing investigational skills	102 (71%)
ICT in science	86 (60%)
Assessing science	80 (56%)
Children recording science	53 (37%)
Developing subject knowledge	44 (31%)
Science in the Early years	29 (20%)
Literacy through science	16 (11%)
Numeracy through science	13 (9%)

Table 5.7 shows how SCs prioritised school development needs. 71% of SCs perceived 'developing investigational skills' as the highest priority for science in their schools. 'Information and Communications Technology' (ICT) was also viewed as an essential need by 60% of the respondents and 56% thought 'assessing science' was a professional development need.

Only 20% thought 'science in the Early Years' was a school development issue. However it would appear that whilst 31% of SCs thought 'developing subject knowledge' was important, it was seen as less of a priority than developing 'children's recording' in science. Developing literacy or numeracy through science was seen as the lowest priority. Perceived needs did not differ between KS1&2.

Table 5.8 Professional duties

Duties	Strongly agree	Agree	Disagree	Strongly disagree
Create a climate of positive attitudes to science	116 (83%)	22 (16%)	2 (1%)	0
Ensure curriculum coverage and progression for all pupils in science	115 (81%)	27 (19%)	0	0
Evaluate science teaching in school and use this to inform effective practice and areas of improvement.	79 (56%)	58 (41%)	4 (3%)	0
Provide guidance on teaching and learning methods in science	73 (52%)	67 (48%)	1 (1%)	0
Set expectations, establish targets and evaluate pupil progress and achievement in science	61 (43%)	75 (53%)	5 (4%)	1 (1%)
Analyse and interpret national, local and school data and inspection evidence	39 (28%)	80 (57%)	17 (12%)	3 (2%)
Audit training needs of staff for science	36 (26%)	89 (65%)	12 (9%)	1 (1%)
Ensure effective development of literacy, numeracy and IT skills through science	33 (24%)	87 (63%)	19 (14%)	0

Table 5.8 illustrates SCs' attitudes towards a selection of professional duties outlined from the Subject Leadership Standards (1998), which identified the importance of both support and monitoring aspects of the SC's role. 83% of SCs felt that their main professional duty was to create a climate of positive attitudes to science. 87% strongly agreed with this in KS2 compared with 77% in KS1. 81% strongly agreed they

needed to ensure curriculum coverage and progression for all pupils, with 89% in KS2 compared with 69% in KS1 strongly agreeing. 43% strongly agreed they should establish targets and evaluate pupil progress as part of their role as SC, with 51% at KS2 compared with 28% at KS1. However, 56% strongly agreed they should evaluate science teaching in school in order to inform practice; in fact only 3% disagreed with this. However there was a greater spread of opinion as to whether part of their role should be to analyse and interpret national, local and school data and inspection evidence and only 28% strongly agreed with this. Only 24% saw their role as ensuring effective development of literacy, numeracy and ICT skills through science, whilst only 26% strongly agreed they should audit training needs of staff. Whilst there was general agreement with all the statements, there was greater variation of opinion in relation to the last three statements but no difference between KS1&2.

5.5 DISCUSSION

This section will provide a more in depth discussion of issues relating to the broad themes of curriculum, pedagogy, assessment/accountability and teacher development and subject knowledge.

5.5.1 Curriculum

The findings from the questionnaire suggested the take up of the PSSW (1998) had been considerable, and indicated that central guidance material might have a significant influence on the way science was organised within both key stages. Furthermore, the suggestion that PSSW (1998) was used as a basis for planning implied a greater uniformity of science curriculum across each year group. It would appear that teachers no longer planned directly from the PSNC (1999) in the way they might have done previously in order to ensure that they were covering all aspects of the statutory orders. However if the majority of planning, delivery and assessment of science was now based on just the PSSW (1998), then this might suggest a narrow interpretation of science within the classroom with much uniformity across schools, reflecting an 'outcome' rather than a process-focused curriculum.

There was no strong indication that science should be taught through numeracy or literacy or vice versa, in fact, this had been viewed as a low priority both in terms of school CPD needs and professional duties (tables 5.7, 5.8). Furthermore, there was an implication that the pressure to teach other aspects of the curriculum could be a barrier to teaching science (table 5.1). Therefore it would appear that science was viewed as a separate subject taught in isolation rather than one that was integrated with other curriculum areas. There also seemed to be a preference for learning correct scientific vocabulary where possible rather than developing a conceptual understanding (table 5.2), which might indicate an emphasis on developing short-term learning in preparation for tests rather than developing understanding.

5.5.2 Pedagogy

Statements A and B (table 5.2) provided evidence that schools supported both 'constructivist' and 'transmissionist' models of learning. For example, the majority agreed that pupils learned by being taught existing facts and scientific concepts, suggesting a preference for a transmissionist approach, but also agreed that pupils learned by being challenged to make links between scientific concepts in order to develop understanding. Statements C and D (table 5.2), illustrated similar conflicting views although with less agreement as to whether learning science vocabulary was more important than developing scientific understanding. Although it cannot be deduced from the evidence here why both models of learning were supported, and cross tabs indicated no difference between key stages, it may be that teachers did not have clear understanding of the differences between the statements. Alternatively it could be that although they believed in constructivist approaches to learning, they felt obliged to teach existing facts and concepts in order to prepare pupils for the end of key stage tests, thus representing a real conflict between views about 'learning for understanding' and 'learning for the test'.

The statements G, H, I and J (table 5.2), also reflected contrasting views in relation to learning through investigational work. Whilst all respondents were keen for investigations to take place, there was a difference in opinion regarding the teacher's role, with a significant number agreeing teachers should plan practical investigations to prevent aimless activity. However a large number also thought it important for pupils to plan their own investigations and rejected the idea of pupils testing out ideas as a meaningless activity. Again it perhaps highlighted conflicts and tensions in relation to beliefs about learning science and the realities of getting through the curriculum as well as the problems arising from following prescribed investigative activities from PSSW (1998) rather than allowing children to develop their own investigations. As a consequence, it might be suggested that constraints on time, together with external pressures of accountability may have resulted in a preference for teacher intervention and imposed structure in order to prevent 'aimless activity'.

The disparity in views about investigations would appear to highlight the problems of organisation within a whole class-teaching context both in terms of pressure on resources as well as whole class management issues, possibly avoidable if other classroom organisation methods were being adopted, however the findings suggested that alternative methods of organising science, such as using a circus of activities, or one group doing science at a time (although the former was more frequent in KS1 classes), were in fact hardly used (table 5.3). It could be argued that pressure from 'The Three Wise Men Report' (1992) reinforced by inspection together with influences from NNLS has marked a shift to whole class teaching (table 5.7).

It could be argued that the conflicting views again represent a dilemma faced by schools in that whilst many might agree with a 'constructivist' approach to scientific learning, external pressures in the form of a knowledge-based curriculum whose coverage was measured by pupil performance in national tests forced teachers to take a more dominant role in pupil learning, adopting a more transmissionist approach which was possibly perceived to make the best use of limited time available. Whilst it was not wise to allow complete pupil autonomy and risk the chance of 'aimless activity,' it was feasible for the teacher to plan structured practical activity for pupils to experience.

The findings would suggest that respondents held no strong views about the role of the teacher in the learning process, particularly in relation to scientific investigations, although slightly more felt that teachers might structure learning to prevent aimless activity unlike pre NC where learning was unstructured. Thus it would appear that a lack of guidance on pedagogy and how children learn science within policy texts and through CPD has resulted in schools adopting a range of approaches, some of which appear to be more effective in preparing for tests rather than supporting constructivist approaches to learning.

The findings suggest that science was taught predominantly through whole class teaching methods or with pupils doing the same or related practical activity (table 5.3). In fact 84% ranked whole-class organisation as their first or second preferred method (table 5.3). It could be argued that whole class teaching was more conducive to a traditional pedagogy and thus may provide further evidence that despite holding constructivist views about learning, schools were organising the classes to accommodate more transmissionist approaches. Furthermore, if as the findings indicate, whole class teaching was now the dominant way of delivering the science curriculum, then it could be argued that this might put a strain on resources for practical work possibly limiting the amount of pupil participation and the kinds of activities that could be experienced and achieved by relying on whole class teaching methods. However, the profile of the sample (71% of respondents had been SCs for less than five years), might also suggest that they might not actually be familiar with other ways of classroom organisation given that much of CPD in this time had focused on whole class teaching of literacy and numeracy and therefore, were not in a position to support or model a range of strategies for teaching science due to a lack of knowledge or experience in using these methods. On the other hand, it might suggest whole class teaching methods (influenced by Alexander et al (1992)) was perceived to be the most effective way of delivering an overloaded science curriculum and meeting the demands of the national tests within a limited time framework. Equally, regular monitoring by Ofsted had ensured that whole class teaching approaches had been widely adopted.

Evidence indicated that the sample drew upon a range of activities (table 5.4), organised within a whole class context, although it cannot be known from the findings here if certain year groups used one particular activity rather than others, for example, although it was apparent that SATs revision was more frequently used by KS2, Y6 classes might engage more frequently in SATs revision than other KS2 year groups. The constructivist teaching activities most frequently used were discussion, classifying and sorting, drawing to show understanding, and to a lesser extent concept mapping. The fact that the majority of the sample claimed they used these activities, might suggest that a greater value was placed on an exploratory open-ended approach to learning in science. However, although equal proportions of KS1&2 claimed they used discussion as a way of reporting findings from practical work, it was not clear how such discussion was orchestrated, whether it was teacher-led with a predominance of closed questions to extract information from pupils, or whether there was a greater use of open questions to invite pupils to share and discuss their findings arriving at their own conclusions, based on their evidence.

However the majority of the participants also claimed to use other activities which could be seen as supporting a 'transmissionist', 'behavioural' view of learning, such as board work, labeling diagrams and 68% of the respondents encouraged pupils to write up whole investigations, although these methods were more frequently used by KS2 (table 5.4), perhaps reflecting the fact that teachers felt they needed 'evidence' of pupils having completed an investigation. Again, this raised the question given the time constraints on science, what aspects of investigation should be prioritised, for it could be argued that 'writing up' was more of a literacy activity rather than an approach to develop scientific understanding. Similarly the revision of SATs papers and the use of mini tests could be viewed as a method of summative assessment taking up valuable curriculum time for developing scientific understanding.

Equally of interest were activities which were 'infrequently' reported, for example although a large number (62%) claimed they had made use of surveys to gather data in science only 37% of the sample said they made use of spreadsheets or databases with their class and 49% at KS2 compared with 18% at KS1 (table 5.4). Whilst it would appear that investigational work was seen as important and in need of development, the findings here would suggest that the interpretation of data, possibly generated by pupil investigations warranted further development. In fact it could be argued that full investigations were difficult to achieve with little time being given to the final interpretation of data and drawing conclusions due to barriers of curriculum pressure, time constraints and possibly a partial understanding of constructivism (table 5.1). Furthermore, this could indicate that whilst there might be opportunities to apply skills taught in other subjects, they were not being used. Although there was a belief that children should make links between science concepts (table 5.2), in order to develop understanding, the same belief was not applied across subject areas (table 5.4). In fact it could be argued that stronger links between literacy and numeracy would not only enable pupils to apply key skills in science investigations and specifically in interpreting data, but would also free up time in which to conduct full investigations. However, evidence from the findings would suggest that SCs did not perceive support for developing literacy and numeracy through science as a priority (tables 5.7, 5.8).

5.5.3 Assessment/accountability

The data would appear to indicate that overall schools felt that assessment was for diagnostic purposes and to guide future teaching, suggesting a close link with teaching and learning (table 5.5). However, monitoring science was also viewed as important, yet this seemed at odds with the preference for diagnostic and formative assessment as previously stated. Furthermore, monitoring and setting targets was cited as a key priority for SC's CPD (table 5.6) and also a relatively important need for staff (table 5.7). Whilst there was a strong agreement that assessment should be used to monitor standards (61% agreed and 35% strongly agreed with this statement). There were mixed views about assessment being used to compare pupils in class (although 50% agreed, 26% disagreed with this statement). Moreover, there was least agreement (that is a greater spread of views) about assessment for comparing performance with other schools; this was despite the fact that the publication of SATs results in annual league tables was a significant part of assessment (table 5.5).

Similarly this also reflected the way SCs perceived their professional duties. For example, SCs did not see analysing and interpreting national, local and school data, (which could be seen as part of monitoring and setting targets) as part of their role. It could be argued that on the whole respondents held the view that formative assessment was a key priority for them and their schools. However making use of local and national assessment data could also be important. This might suggest that schools spent increasingly more time monitoring science rather than supporting teachers teaching it effectively, especially science investigations.

5.5.4 Teacher development and subject knowledge

5.5.4.1 External support

The findings suggest that most SCs viewed assessment and target setting as the highest priority for their own CPD (table 5.6). This possibly reflected the increased importance now placed on assessment particularly SATS at KS2, along with the expectations of the SC to monitor science, analyse data and set targets. Equally SCs viewed assessment as an important aspect for staff development, although not the main one, implying that there was an increased focus on assessment and monitoring within schools. Thus it could be argued that many SCs might see their role not just in terms of supporting science, curriculum and pedagogy, but also in terms of monitoring and setting targets.

Although most SCs did not appear to have a strong science background in terms of science related subjects at 'A' level, the development of science subject knowledge was not a main priority for their own professional development or for other members of staff although interestingly KS1 SCs saw this as a slightly higher priority than KS2. This might suggest that schools were generally more confident with the science content and felt that they had adequate background knowledge in order to teach it. However, it could be argued that the perceived need for subject knowledge had diminished with the adoption of PSSW (1998), which provided a 'recipe' approach to science. This may imply that all subject knowledge needed to deliver the PSNC (DfEE1999) was embedded in the PSSW (1998), supporting the view that most teachers could take on the role of SC without a strong subject background or the perceived need to increase their own subject knowledge. However this might also suggest that despite having the role of SC, less than half were able to draw upon a strong background in science to support colleagues interpreting science.

Investigational skills, ICT and assessment were identified as school priorities for CPD although it was not clear from the data why such a high priority should be placed on developing science investigations (table 5.7). On the one hand, this could reflect the fact that CTs spent more time on scientific knowledge rather than investigations. Alternatively it could reflect a concern that despite the support from PSSW (1998), CTs did not have the expertise or confidence to engage in much investigational work.

The use of ICT to support science was also identified by 60% as a CPD priority perhaps indicating an over reliance on traditional methods of teaching science rather than integrating the use of ICT, for example data logging and sensing equipment, perhaps in practical work. Thus it might be assumed that SCs wanted to strengthen the link between ICT and science investigations. It was notable that developing literacy or numeracy through science was not a main priority; possibly reflecting the view that enough school development time had already been spent on these areas (table 5.7). Equally SCs did not consider the promotion of literacy and numeracy through science as one of their professional duties (table 5.8), but seemed more concerned to identify distinctive 'science' time and lessons, rather than an opportunity to emphasise its cross curriculular links. Similarly children's recording and early years science were not perceived to be priorities for school development, even by KS1.

5.5.4.2 Internal support

In terms of the ability for SCs to provide support and development in science, there was a strong sense that they still needed to create positive attitudes to science and ensure curriculum coverage and progression. The fact SCs saw this as their main role may indicate that there was still a certain resistance or reluctance to teach science or certain aspects of it within schools. Equally it could indicate possible issues around the SC's status and confidence to advise on teaching science or model good practice. However this also raised the question as to whether time was readily available to model good practice or whether it was possibly restricted to mostly verbal support, encouragement and a supply of resources. The fact that time was identified as a key barrier to teaching science might also suggest it was difficult for SCs to support other members of staff in the way they wished (table 5.1). There was also recognition of the growing importance of the need to monitor and set targets in science which undoubtedly would put demands on co-ordination time (table 5.8). Whilst most agreed they needed to monitor and evaluate teaching and learning, there was a differing of opinion regarding analysing national, local and school data. Nevertheless the majority of SCs saw this as an important aspect of their role, perhaps reflected in the high priority they attributed to monitoring and target setting in relation to their own professional development.

SCs seemed least sure about their role in terms of aspects of assessment and evaluation. The evidence here would indicate that assessment was perceived in terms of making evaluations based on assessment data and using this to set general targets rather than the assessment of learning of individual pupils in class. This would imply that summative assessment was having a big influence on the SC's role and in turn on restricting the development of science in the schools. Although SCs perceived there to be a balance between support and monitoring it might be argued that whilst they saw the former as a key aspect to their role, increasing pressure to monitor science and set targets meant that more time was spent on assessment.

5.6 CONCLUSION

The findings from the regional survey provide a broad overview of primary science within the context of practice in which schools operate, contributing to the emerging and interrelated 'stories' of curriculum, pedagogy, assessment/accountability and teacher development and subject knowledge. It would appear that the PSSW (1998) largely formed the basis of the primary science curriculum with the development of literacy and numeracy through science as a low priority. Whilst science content appeared to be clearly defined, the findings indicate the use of a wide range of teaching strategies and activities suggesting a preference for both 'constructivist' and 'transmissionist' views of learning organised within a whole class teaching context.

It could be argued that pressures relating to end of key stage tests and the publication of SATs in league tables might have led to a conflict of ideologies in relation to pedagogic practice in science. Equally it would appear that whilst AfL was seen as having greater importance, there was a concern and agreement that science standards should be monitored. However opinions varied in relation to the purpose of monitoring, although a large proportion disagreed that it was to facilitate a comparison of performance with other schools. The importance given to assessment was reflected in professional development needs SCs identified for themselves; although they felt ICT and investigational skills were a priority for school development.

Whilst the purpose has been to provide an overview and broad description of the context of practice, the views reported here can only reflect the school context through the eyes and perceptions of the SC. It cannot be known to what extent their responses were representative of the current reality within their schools, or represent their individual beliefs and practices at a particular point in time. However, a particular suggestion arising from the findings was that the PSSW (1998) provided a structure for much of the primary science curriculum. Although there appeared to be strong support for formative assessment, this was possibly seen as a developmental need within schools along with support for science investigations and ICT, suggesting that a range of methods were used to deliver a prescribed science curriculum. A range of teaching strategies and associated activities, which were both complimentary and contrasting were employed. Some strategies and activities suggested that pedagogy might have been strongly influenced by national testing.

This chapter has addressed the third research question by identifying general trends in relation to curriculum, pedagogy, assessment/accountability, teacher development and subject knowledge. The main intention has been to develop key issues and debates underpinning the development of primary science. These along with conflicts and tensions within the emerging themes will be explored in greater detail and will be used to as a framework to analyse the case studies presented in the following chapters.