An Investigation into Teacher and Student Teacher Confidence in their own Understanding and Abilities to teach Science and Technology effectively in Primary Schools in Northern Ireland

by

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A dissertation submitted as part of the requirements for the Degree of Master of Education from the Queen's University of Belfast.

October 2000

Abstract

There is strong evidence in the literature of a correlation between teacher competence and knowledge of a subject and the subsequent quality of the learning experience. Effective teaching requires knowledge and understanding about the content of teaching, how pupils learn and how to manage the process of learning. The National Curriculum brought into sharp focus the role of subject knowledge. It challenged teachers to provide access to science for all children. The teacher requires 'curricular expertise' - subject knowledge, the understanding of how children learn and the skills to teach the subject successfully.

The aim of this study was to investigate teacher and student teacher confidence in their own understanding and abilities to teach science and technology. Data was collected relating to teachers' confidence in science and technology relative to that in other subjects of the curriculum. Teacher and student teacher confidence in the knowledge areas of science and in their abilities to develop science process skills in pupils was explored. Data was gathered on their confidence in the professional skills related to teaching the subject.

The study found there was a growing confidence in the knowledge areas of 'Living Things' and 'Materials'. Inadequacies were reported in teacher confidence in areas of 'Physical Processes'. Male teachers were more confident than female teachers in these areas. The need for support in developing science process skills and technology skills in pupils was reported. Teachers and student teachers reported low levels of confidence in some aspects of pedagogy.

This study suggests that the key to improvement in confidence would involve school based support with a focus on experiences to increase competence in physical sciences, skills development and pedagogy related to science teaching.

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Acknowledgements

I wish to express my personal thanks

to my supervisor Dr. John Sweeney

for his advice and guidance

in completing this study and

to the typist Mrs. Anne Kinnaird

for her dedication, hard work

and expertise.

The Place of Science in the Primary Curriculum

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1.1 The Place of Science in the Primary Curriculum

If education is to fit children for the society in which they will grow up, then a prime reason for giving science a place in the curriculum from the start is the increasingly central part it plays in society (CACE, 1967). Morris (1990) claimed that being 'at ease' with key scientific ideas is as necessary to functioning in society as being 'at ease' with numbers, with percentages, with rates of change or with various forms of language.

However, in spite of many similar views expressed over the last sixty years, the position of science in the primary curriculum has usually been somewhat contested.

As far back as the Hadow Report (1931) through to the Plowden Report and the Nuffield Junior Science Project (1967), science has been struggling to become an integral part of the primary curriculum. The unsatisfactory state of primary science has been well exposed by HMI Reports (DES, 1978, 1983a, 1985) and the Assessment of Performance Unit surveys (DES, 1981, 1983b, 1984, 1985). A narrow range of science, poor standards of work and low incidence of good practice resulted in the determination of Government to ensure that science changed from being an occasional part of the curriculum to a designated core subject. Its introduction through the Education Reform Act of 1988 in England and Wales and the Education Reform Order of 1989 in Northern Ireland represented the first statutory requirement for science to be included in the primary curriculum as a subject in the newly designated Key Stages 1 and 2.

However, the government's imposition of science on the primary curriculum was not supported by sustained or systematic training. In Northern Ireland various piecemeal initiatives were resourced by individual Education and Library Boards (ELBs) but they were very much dependent on each ELBs expertise in science. Consequently the Northern Ireland Science Curriculum which came into effect in September 1990 amounted to a major new challenge to many teachers whose training in science and previous experience of teaching science were limited.

The Department of Education for Northern Ireland (DENI) issued a Draft Order in 1989 which designated science as a 'compulsory' contributory subject in which all pupils were to be assessed and for which programmes of study and attainment targets were to be specified for each of the four Key Stages of compulsory education (ages 4 - 16 in Northern Ireland). Despite formal standardised assessment at Key Stages 1 and 2 being statutory in England and Wales, pupils in Northern Ireland are not formally assessed in science in the primary sector. However, science assessment does occur as an integral part of the transfer procedure, a selection process for pupils entering secondary education.

The Curriculum Order for Science (DENI, 1990) contained fifteen attainment targets grouped into two profile components. Profile component 1 addressed exploring and investigation in science, communication and the applications of science. Profile component 2 focused on knowledge and understanding of science. The Northern Ireland Curriculum Council (NICC) which had then the responsibility for developing the Northern Ireland Curriculum stated in 1990:

‘The implication of the programmes of study in the Northern Ireland Curriculum for Key Stages 1 and 2 should not be too daunting a task for those schools which already have developed a school science policy document or for those schools familiar with the NICED Primary Guidelines”.

This assertion, however, probably underestimated the difficulties involved, teachers’ insufficient scientific knowledge and expertise, poor resourcing, limited INSET training and manageability in terms of practical experiences. Teachers in England found similar difficulties following the introduction of the National Curriculum in 1989. These have been noted by authors such as Harlen (1998) who claimed that the National Curriculum has produced tension for teachers between the process of working from children’s ideas and the need to cover the content. Similarly the dispiriting effects of the ever-increasing rate of change and the development of new agencies and terminology have been well documented by educationalists (Fullan and Hargreaves, 1991; Alexander, 1992; Johnston, 1992; Hargreaves, 1994).

In May 1992, the Northern Ireland Department of Education issued a circular to schools informing them of a change to the science curriculum. The number of attainment targets in the subject was reduced from fifteen to five. While the programmes of study were restructured in line with the new attainment targets the content of the curriculum remained unchanged, a fact acknowledged by DENI (1992, p.1). This meant that the concerns expressed by many teachers at the time over the amount of content were not in fact addressed. As these concerns became more vociferous, NICC set up a working party to suggest revision of the range and content of the science curriculum. The council acknowledged content overload and the emphasis placed on scientific knowledge at the expense of the acquisition of skills and understanding. The view was expressed strongly that the focus should be on process (NICC, 1993). The fact that this review was undertaken only for science was a reflection of the concerns felt in particular about this subject area.

However, these proposals for a revised science curriculum were overtaken by the decision of Government to implement a full revision of the entire Northern Ireland Curriculum in line with a re-evaluation of the National Curriculum in England and Wales under the chairmanship of Sir Ron Dearing (DFE,1995). This review by the Northern Ireland Council for the Curriculum, Examinations and Assessment (CCEA 1995) resulted in revised programmes of study and attainment targets for the compulsory subjects of the Northern Ireland Curriculum. Science was to be referred to as 'Science and Technology'. The programme of study for science was set out in two attainment targets, Investigating and Making and Knowledge and Understanding. The changes which came into effect in September 1996 included a reduction in content and were a tacit admission by Government that the primary curriculum had been overburdened.

Several reports published in the mid to late 1990s examined the state of science teaching in primary schools in Northern Ireland. In 1996 the DENI Inspectorate carried out an investigation into the quality of teaching and learning in English, Mathematics and Science in a sample of primary schools. The main purpose of the report (DENI, 1996) arising from this investigation was to summarise the Inspectorate's findings in the quality of teaching and learning in the core subjects, identify some of the main trends, including particular strengths and weaknesses and outline examples of good practice. The report also highlighted issues for consideration by the schools and by CASS and other support agencies. With regard to primary science the Inspectorate reported as follows:

1. Almost all children showed enthusiasm for science but the more able did not achieve their full potential due to ‘insufficient opportunities to apply acquired skills, devise their own tests or interpret tasks, with a range of freedom and independence’ (ibid p.3).
2. At Key Stage 1, most children benefited from a broad range of scientific experiences. However, at Key Stage 2, too great an emphasis was placed on ‘information to be acquired rather than on the development of skills’ (ibid p.18).
3. In-service training has had some impact on classroom practice but within Key Stage 2 a significant number of teachers were still insecure in their own knowledge of science and needed continued support to develop further their confidence and competence in the subject.
4. The teaching of science was effective when teachers adopted a wide range of teaching strategies which provided an appropriate balance between instruction and participation by the children. Other important features included ‘the teacher’s positive attitude to the subject and their competence and understanding of the science programme of study’.

The report concluded with the identification of issues to be addressed by both teachers and support agencies. These included the need for a clearer understanding of the processes in science and the need for a significant number of teachers to gain confidence in teaching science.

A further report ‘Children and their Learning’ was subsequently published by DENI (1999). This report drew on evidence from inspections carried out in primary schools during the period 1992-1998 when almost nine hundred primary schools and preparatory departments were inspected. This investigation was an attempt to give both a picture of the quality of provision in primary education in Northern Ireland and to inform the process of continuous improvement.

Observed deficiencies in the planning of science included the use of ‘broad topic headings with only superficial reference to conceptual understanding and skills which children need’ (ibid p.14). The Inspectorate judged that the children’s knowledge and understanding of science and technology were significantly better than their attainment in investigating and making. In over 90% of the schools the children displayed satisfactory or better standards in knowledge and understanding. In 55% of the schools they achieved appropriately in investigating and making. In over 50% of the schools inspected there was little progress in the area of assessment. The report stated that ‘in most schools much remains to be done to ensure consistent progression in children’s learning and development of skills in technology’.

A report from the Northern Ireland Curriculum Cohort Study, ‘The Real Curriculum’ examined the evidence on pupils’ experiences of the curriculum in the final years of primary schooling (NFER 1999).

In the area of science just over half of the total sample of sixty primary school pupils acknowledged continuity and progression in science - a notably lower figure than for

English and Mathematics. Over a third said there was no follow-on in science whilst a few girls said it happened ''sometimes''. In comparison with English and Mathematics, the responses of the children showed no reference to an increase in difficulty in any affirmation of continuity and progression in their science curriculum. Any progression was rather the acquisition of more related information. Equally there was no account which suggested the learning aim of practising for understanding. Indeed, the idea of science process was also notably absent, with no pupil mentioning scientific skills and approaches such as hypothesising, fair testing or experimentation.

By 1999, in a further attempt to help teachers integrate technology into the science curriculum, CCEA designed materials for Key Stages 1 and 2. The programme included progression grids outlining science and technology skills. Focused statements indicating what children should be able to do, know or understand were specified and activities, investigations and technology ideas were suggested.
Whilst the resource did not constitute a scheme of work it perhaps could be seen as an attempt by Government through one of its agencies to provide primary teachers with the support to enable them to translate the statutory science curriculum into effective and workable classroom practice.

1.2 The Nature of Science

The way we teach science should be influenced by two important factors: how we understand the nature of what we are teaching and how we understand the nature of learning. The nature of science has been thought of in two ways - as a body of facts and as a method of exploring and investigating. The teaching of science as facts leads to teaching dominated by ensuring that the wisdom of the past is received by new generations; it is objective with a defined and unique subject matter. When science is seen as developing understanding through testing ideas against evidence, then it is portrayed as a human endeavour to understand the physical world. It provides knowledge which is tentative, it builds upon previous knowledge and understanding using a wide range of methods of inquiry and it becomes a social enterprise whose conclusions are often subject to social acceptability.

Exploration of the philosophy of science is needed by all teachers of science to ensure that they can articulate a clear perspective of their own. Too often because we lack an explanation of the nature of science in our own education, our view of the nature of science, and therefore its translation into school science, are underdeveloped (Ratcliff, 1998). We do not have to go deeply into the philosophy of science to have a ‘feel for it’ according to Harlen (1992) but a brief dip into the question of ‘what is science’ is enough to lay foundations for building a framework for teaching science. Like any other foundation it will support all that comes after.

The Science National Curriculum orders in England and Wales (DFE 1995b) currently lack a clearly stated rationale, both in terms of the nature of the discipline and of the purposes of science education. However, the original non-statutory guidance gives some indication of an underlying view of science.

'*Scientists are curious; they seek explanations. -------scientists formulate hypotheses, design and carry out experiments, make observations and record results. There is also an important place for imagination, for inspirational thinking and the receptive mind -------. A scientist's work can result in the formulation of a new idea or lead to the solution of a problem or the development of a new product. Scientific endeavour produces progressively more powerful ways of understanding the natural world'* (NCC, 1989, p.44).

Similar views about the distinctive characteristics of science have been expressed by ASE (1983), Science Working Group in Northern Ireland (University of Ulster, 1989) and the New Zealand Curriculum (1999). All descriptions address the personal development of pupils, their ability and confidence to approach problems systematically and an awareness of the way science impinges on our lives and culture.

The introduction of the National Curriculum into schools in the United Kingdom has brought into sharp focus the role of subject knowledge. The challenge for teachers of the National Curriculum is to provide access to science for all children. It requires that teachers recognise the needs of children and are able to translate the curriculum into such a manner that access is facilitated. There is, however, an intimate relationship between the teacher's personal subject knowledge and the ability to implement the science curriculum. Teachers will define the curriculum and match it to the children's needs on the basis of their own subject expertise. In terms of the science curriculum this creates problems (Feasey, 1994). For many years it has been recognised that insufficient subject knowledge in science has led to low teacher confidence and expertise. Alexander, Rose and Woodhead (1992) referred to 'curricular expertise'.

"We use the phrase 'curricular expertise' to mean the subject knowledge, the understanding of how children learn and the skills needed to teach subjects successfully. Effective teaching depends on the successful combination of these understandings and skills ----------. Our view is that subject knowledge is a critical factor at every point in the teaching process, in planning, assessing and diagnosing, task setting, questioning, explaining and giving feedback" (ibid p.25).

The authors recommended the introduction of semi-specialist and specialist teaching into primary schools.

NCC (1993) and OFSTED (1993) publications confirmed and re-emphasised that a proper knowledge of subject matter across the curriculum and the suitable deployment of subject expertise, through whatever combination of generalist, semi-specialist and specialist teaching or subject consultation, is fundamental to effective instruction. If a high level of confidence and subject expertise is required to teach science effectively then expectations that teachers will be able to implement a content driven science national curriculum are unrealistic.

Research interest in the 1960s and 1970s in general featured classroom processes and teacher effectiveness (Hargreaves, 1975; Delamont, 1976). The 1980s focused on more detailed and qualitative analyses of curriculum topics, even individual lessons, which took account of teachers' own goals and intentions, as well as children's existing understanding, explanations and problems, strategies, their errors and misconceptions (Glover, 1985; Osborne, 1985). It was Shulman (1987) who noted that subject knowledge was missing from research on teaching and called for attention to this area. Shulman suggested the notion of pedagogical content knowledge and provided a list of kinds of knowledge required to teach science. It is a reminder that teachers need to know about pupils' thinking and reasoning, what kinds of perceptions they are likely to have formed and what teacher interventions might bring about change towards a more scientific view. However, it is significant that Shulman put content knowledge first in this list since several of the subsequent items depend on it. What he emphasised was an understanding of what it is that identifies science, what are its boundaries, its limitations and the different ways in which it can be conceived.

1.3. The Effective Teaching of Primary Science

'The intention of all teaching activities is that of bringing about learning' (Hirst, 1974, p.109). Hirst made this statement in his considerations of what characterises teaching. He goes on to say that this is a simple but critical idea, it involves the claim that the concept of teaching is in fact totally unintelligible without a grasp of the concept of learning.

MacGilcrhist et al (1997) have developed this idea further by defining what it is that constitutes effective teaching. They suggest knowledge and understanding of the content of teaching, knowledge and understanding of how pupils learn and knowledge and understanding of how to manage the process of learning. Each involves knowledge and understanding and skill on the part of the teacher and each is dependent for its success on the other two.

These comments are all the more pertinent when considered in conjunction with Shulman's writing in 1987 in relation to science teaching. Shulman addressed the kinds of knowledge required by the teacher to teach science effectively. He emphasised content knowledge, about science and of science, pedagogical knowledge and knowledge of learners and their characteristics. It is worth noting that this focus on content knowledge has been highlighted by other educationalists and government agencies (Bruner, 1960; Alexander, Rose and Woodhead, 1992; NCC,1993; OFSTED, 1993; DENI, 1996; Harlen, 1999). The view is that understanding is needed not so that teachers can convey factual information to pupils, rather so that they can ask questions that lead children to reveal and reflect on their ideas, provide relevant sources of information, identify progress and plan subsequent learning. The aim is not to enable teachers to know all the answers to all the questions children may ask but to allow teachers to have access to strategies for handling children's questions and turning them into opportunities for investigative science.

Extensive research into teacher understanding of Science concepts has identified significant gaps in teachers' knowledge (Kruger and Summers, 1989. Wragg et al, 1989; Carre and Carter, 1990; Mant and Summers, 1993; Harlen, Holyroyd and Byrne, 1995). The impact of teachers' understanding on pupils' learning has also been well established by research (Aubusson and Webb, 1992; Harlen et al, 1995; Osborne and Simon, 1996). Low levels of confidence and understanding have been associated with restricted classroom activities, to following instructions, inhibiting creativity and questioning. Shulman (1991) argued that it is only with a sound grasp of science content that teachers can then develop pedagogical knowledge which he characterised as building *'bridges between their own understanding of the subject matter and the understanding that grows and is constructed in the minds of students'.*

Whilst content knowledge is a key factor in the effective teaching and learning of science, pedagogical knowledge is of equal importance. Key aspects of pedagogy include planning, classroom management and organisation, questioning and assessment.

Pupils' learning is supported most effectively when teachers have planned carefully towards the development of identified skills and understanding. DENI (1999) considered planning to be effective when it took full account of both attainment targets as defined in the Northern Ireland Curriculum for Science and Technology.

The report identified successful planning when teachers chose methods and provided activities which involved children in developing science process skills. It was also important that the intended outcomes were clearly defined, relevant and built on children's previous work and experience.

When planning is completed and learning outcomes identified, organisational issues must be addressed. If classroom organisation has to serve the purpose of facilitating the development of science process skills then organisational procedures must be established and varied. Key features of well organised classes identified by OFSTED (1993) included carefully planned and appropriate grouping of pupils for tasks, to include a mixture of individual, group and whole-class teaching. The report focused on a manageable number of teaching groups and learning activities, with due attention to the use of teacher's time for giving instructions, teaching the whole class, individuals and groups and moving between groups to instruct, question, explain and assess. The report emphasised the need for clearly established routines and systems.

An important aspect of science teaching is practical work. Various authors have claimed that practical work has a central place in science education (NCC, 1993; Harlen, 1998; Reiss, 1998; ASE, 1999). It enables pupils to see a phenomenon or effect for themselves, to decide what to change and then try it in order to test a theory. Practical activity allows students to conduct open-ended investigations and to gain some understanding of the nature and limitations of scientific knowledge and procedures. Research, however, has indicated that practical work often fails to serve a useful purpose and sometimes inhibits understanding (Gunston and Champagne, 1990; Gardner and Gauld, 1990; Hodson, 1993). Effective science teaching therefore requires teachers to use practical work selectively and where it is best suited to the purpose. It is one way of assisting the crucial process of enabling pupils to explore their own and others' ideas.

The organisation of the science and technology curriculum must also take account of the various needs and abilities of the children. Russell (1994) stated:

> *'Differentiated practice represents a view of what 'good science teaching' might be - the provision of appropriate teaching/learning experiences for all pupils'.*

The purpose therefore of differentiation is to make a difference to the pupils learning. This matching of the level of difficulty of an activity to the pupils' capability is not easy to achieve. In science there are problems in identifying how progression in understanding of specific science concepts develops and defining the level of difficulty of activities in advance may not be possible. The way pupils' existing ideas affect their learning in science is an added complication. Naylor and Keogh (1995) suggested a list of strategies which would enable teachers to build a degree of differentiation into their teaching. They proposed using a range of learning styles, adjusting the level of scientific, linguistic and mathematical skills required in an activity and varying the amount and nature of teacher intervention. They considered targeting particular questions to individual pupils and varying the response expected, the pace of learning and the method of recording. They suggested a range of resources to provide additional support for some pupils. The challenge, therefore, is for teachers to become more aware of the range of strategies available, to make more conscious decisions about when to differentiate and make differentiation more explicit in their planning.

Also essential to effective teaching is the role of questioning in primary science. Feasey (1997) suggested that to develop a scientifically literate individual, questioning needs to be at the centre of teaching and learning from the earliest part of schooling. Several studies have considered the quality and purpose of teachers' questions (Galton, Simon and Croll, 1980; Stiggins et al, 1989; Wragg, 1992; Shapiro, 1998). They found that questioning at all levels was dominated by recall questions and pupils were marginalised in terms of opportunities to question. Research also indicated that the quality of teachers' questions was also related to teachers' knowledge of the subject matter (Carlsen, 1989; Feasey, 1997). The authors indicated that when a teacher had a sound personal knowledge and understanding of scientific concepts, he or she was better able to ask probing questions and make higher cognitive demands of children through the use of effective questions. According to the Scottish Council for Research in Education (SCRE 1995) the types of questions which promote learning are, in form, open and person-centred and, in content, require reasoning skills, prediction, interpretation and argument.

It has been widely argued that the formative use of assessment is invariably found in effective teaching and it has a potentially large impact on achievement. Black (1993, p.76) argued for methods of assessment which satisfied the conditions of feasibility, reliability, validity, absence of bias, attention to motivational and affective as well as cognitive development and ways to develop pupil self-assessment. Current practice, however, lacks many of these features. DENI (1998) reported that over fifty per cent of schools had made little progress in the area of science assessment. ASE (1997) provided useful guidance in relation to the assessment of science. The association suggested a focus on what is taught and learnt so that it can influence subsequent teaching and learning. It argued that assessment should match the needs of the learner, be flexible and responsive to changing needs and ultimately involve a wide range of methods and celebrate achievement.

A knowledge of content and pedagogy is not sufficient on its own for the effective teaching of science and technology. A knowledge of learners and their characteristics is another vital aspect of the relationship. There are many theories about how we learn. Commonly used terms include *calibration* (Cooper and McIntyre, 1996), *zone of proximal development* (Vygotsky, 1987), *metacognition* (Gipps and Murphy, 1994) and *accelerated learning* (Smith, 1996). Recent attention has been directed to the theory of multiple intelligences (Gardner, 1983) and the expectation that with the right motivation and teaching all learners can reach a level of achievement which previously may have seemed beyond them. *Constructivism* is a widely used term with a particular perspective on the teaching and learning of science. It is characterised by the view that children are not without ideas about the events and phenomena in the world around them. They have formed ideas in making sense of everyday experiences but these ideas often conflict with the scientific view. The role of the teacher is therefore to develop approaches to encourage conceptual change. Harlen (1998) suggested one of the main ways of doing this was to involve pupils in devising and carrying out investigations, to provide a greater range of evidence and to encourage reflection and communication. A skilled teacher, aware of the theories about learning, will know which are appropriate for pupils and how to maximise the potential for learning.

A further consideration is the nature of learners. Several researchers, including Gilligan (1982), Belenky et al, (1986), Tannen (1992) and Gipps and Murphy (1994), have argued that males and females tend to respond differently to the same stimuli or situation. They did not suggest that girls and boys have different abilities but that they have different ways of using their abilities, that is, different cognitive styles. Johnston et al (1999) examined aspects of the teaching and learning of science in primary schools in Northern Ireland. Specifically, the research investigated the fit between preferred learning strategies and children's experience of learning science in the classroom setting. The study also focused on teacher awareness of children's learning dispositions and the extent of which teachers accommodate such differences in their planning for and in their teaching of science.

The study found that boys and girls have identifiably different dispositions as learners which they bring to the science classroom. A general pattern of precise/sequential processing among girls and stronger preferences for technical and confluent processing among boys was sustained. Boys' avoidance of precise/sequential processing, together with their strong disposition for technical processes was likely to run counter to the predominant classroom ethos where precision and sequence were emphasised.

The report concluded that teachers' own learning preferences together with the effects of the Transfer Test on teaching practice may result in some children being subjected to school experiences which leave them uninterested and demotivated and indeed also misunderstood as learners.

The study recommended (p.103)

‘the need for pupil learning disposition to be known, understood and taken into account in the classroom’.

1.4 Teacher Confidence and Understanding in Teaching Primary Science

There has been considerable research into teachers' understanding and confidence in teaching science, prompted by explicit statements in various national guidelines, curricula and media reports. Many studies have focused on a specific concept area, such as force (Kruger et al, 1990), energy (Summers and Kruger, 1992), changes in materials (Kruger and Summers, 1989), gravity on the moon (Noce et al, 1988), gravity and air resistance (Smith and Peacock, 1992), electric current (Webb, 1992) and the greenhouse effect (Boyes and Stanisstreet, 1993). In general it has been found that the explanations which primary teachers gave of the concepts were at best incomplete and in many cases showed the same misconceptions that were found to be held by secondary school students. Teachers are products of primary and secondary schools with a strong emphasis on text book learning, formal testing and the implicit message that science is complicated and difficult.

This is reflected in the views of Harlen (1999) that primary teachers are recruited, by and large, from those for whom science was not a strength in their own achievement at school and whose experience in the intervening time has done little to increase their achievement in this area. Additionally Harlen argued that the methods used to assess teachers' knowledge of science were similar to those used with school students, complete with their own association with previous failure and frustration.

The research of Bennett, Wragg, Carre and Carter at the University of Exeter underlined the view that the issue of background knowledge in primary teaching is more complex than whether or not teachers have certain concepts (Wragg et al, 1989). Their particular interest was to ascertain primary teachers' perceptions of competence and needs with respect to the new National Curriculum in the UK. In response to the ten subjects prescribed in the National Curriculum only thirty four percent of the sample felt independently competent to help children achieve in science. Overall, science was rated eighth out of the ten foundation subjects according to their perceived difficulty. Technology was rated tenth. (rating 1: most confident, rating 10: least confident). Twenty eight percent indicated they were in need of in-service help in science. This picture of a depressingly low percentage of teacher competence may have been attributed in part to personal anxiety and concern associated with management and organisation of change induced by the National Curriculum. The authors noted, however, that the perceived difficulty of science was reduced when individuals considered their competence to deal with such topics as the 'water cycle' or 'recycling'.

Differences between male and female respondents were also addressed. Men rated themselves as more competent in items relating to forces, electric circuits, sound, light, using simple power sources and night and day. Women rated themselves more highly on items associated with living things, reproduction in mammals, heredity, recycling of waste and in grouping materials according to their characteristics. The data strongly supported the sex-stereotypic masculine image of science previously reported by Kelly (1987).

In discussing the implications, Wragg et al argued for in-service support not of the ‘hit and run’ variety but flexible models based on self-diagnosis of specific need and individual self-study appropriately sequenced over the professional continuum from graduation to retirement.

In a follow-up survey in 1991 of over four hundred teachers, technology remained tenth but science had risen to third place after English and Mathematics in teachers’ rating of their choices. The researchers ascribed the significant position change in the teachers’ perceptions of their own competence in science to the allocation of resources, both human and material, to science teaching, together with the comprehensive map of the subject set out in the statutory orders (Bennet et al, 1992; Carre and Carter, 1993). Thus it seems plausible that gains in curriculum knowledge, pedagogic content knowledge and knowledge of goals may have been responsible for the increase in confidence rather than increased personal understanding of science. The authors emphasised that the research instrument was eliciting teachers’ perceptions of their conceptual understanding and at no stage was there verification of their actual degree of scientific understanding.

Research into primary teachers’ understanding of concepts in science and technology by Harlen, Holroyd and Byrne in 1995 found that there were teachers with no science in their background who were confident about teaching science, but whose understanding was limited. At the same time there were teachers with no science in their background, but who had achieved understanding of key science ideas and whose confidence was low. Finally there were teachers with no science, low confidence and little understanding. What emerged according to the researchers was a series of strategies that teachers used to cope with low confidence in their ability to teach science. These included, avoidance, stressing process outcomes rather than conceptual outcomes, reliance on book or prescriptive work and emphasising expository teaching and underplaying questioning and discussion.

Teaching characterised by these features may enable teachers to include science in their planning and practice without constantly being faced with their own limitations in this area. Within this restricted practice then, it is possible that teachers may claim not to find teaching science particularly difficult.

The research carried out in Scotland by Harlen et al (1995) addressed the nature of teachers' misunderstandings of the concepts they are expected to develop in pupils. The types of misunderstandings included using a name for a phenomenon as if it were an explanation of it, giving an inappropriate analogy and attributing properties that do not correspond with reality. Also, it was common for teachers to equate everyday language with scientific language and propose a mechanism for which there was no evidence. The results confirmed findings of the previous survey in England by Wragg et al (1989), that primary teachers have much less confidence that they have the knowledge and skills required to teach science and technology than to teach English and Mathematics. Forty one percent gave the lowest rating in confidence to teach science and one percent gave the lowest confidence rating to Mathematics and English.

Harlen (1999) believed an optimistic outcome of this research was the relative ease with which understanding of some key scientific concepts was developed by teachers in the interview setting. She suggested that there was a latent understanding waiting to be awakened and that what held back teachers' understanding was not the ability to grasp ideas but the opportunity to discuss and develop them.

In Johnston's study in Northern Ireland in 1999 entitled 'What Science Engenders', a particular objective was to examine teachers' subject knowledge, organisation for teaching the subject and levels of confidence in science. It was found that, inter alia, limited subject knowledge was a constraint on teaching primary science and led to feelings of inadequacy. This is further evidence highlighting the complexity of the interrelationship between teacher subject knowledge and teacher confidence. Additionally the study revealed that four out of five teachers had never studied science as a main academic subject at A-level or beyond. A substantial proportion of teachers reported that they had attended neither school-based nor non-school-based in-service training courses in science in the 1997-98 school year. Whilst teachers indicated a strongly positive disposition towards teaching science, only seventeen percent reported science as a first preference with regard to teachers' preferences among the core subjects. It was, however, cited to be the second preference of over half the respondents.

Evidence from the study suggested that science had a secondary status in terms of timetabling. In more than half of the Primary 6 classes surveyed, science was taught less than twice a week. The researchers examined organisation for teaching the subject and reported that teachers perceived group work in science as contributing primarily to the development of co-operation and the acquisition of skills, rather than to the development of scientific knowledge and process.

The report concluded that because of the extent of the content to be covered in science and the nature of the selection procedure for entry to grammar school, teachers had to resort to what they saw as primarily transmission teaching where factual knowledge is heavily emphasised. The report confirmed that experimental or investigative activity is sometimes unduly tightly organised and pre-ordained. It may be inferred from these results that the emphasis on structure and advanced planning may be seen as consistent with the existence of a degree of insecurity in a subject with which teachers may not feel entirely confident.

Research in the United States of America appears to be in agreement with the findings of research in the United Kingdom. At a time when national reform in America focused on science for all children (American Association for the Advancement of Science, 1989) and the implementation of national standards (National Academy of Sciences, 1996) very little science is taught in many elementary school classrooms (Silvertsen, 1993). Many teachers are neither interested in science nor confident in teaching it.

A 1993 survey of elementary teachers carried out by the U.S. Government indicated that 76% felt competent to teach reading/language arts while only 28% felt competent to teach science (Weiss, 1994). Although 99% of the respondents asserted that hands on/manipulative activities should be an important aspect of science instruction, about 25% felt “less than well prepared to use textbooks as a resource rather than as the primary instructional tool”.

Research on the aspects of science methods courses which motivate teachers and increase their confidence is an important part of the reform movement in the United States. Jarrett (1999) studied the development of interest in science and confidence in teaching science in two master's programmes which employed different interpretations of constructivist learning. Both courses, taught by the same professor were very hands-on and focused on capturing the students' interests and helping them build their own understanding of scientific phenomena and modelling methods appropriate for the elementary school classroom. Both courses were cohort-based and involved choices in how science was to be implemented in the classroom. The underlying assumption was that the course members and their elementary school students build their own understanding through doing and reflecting. However, the structures and philosophies of the programmes were different.

Students in programme 'A' were inexperienced in the classroom. Their course was taught as consisting of discrete entities, with little attempt to integrate. The course was designed to provide participants with content information on science topics relevant to their teaching, to model developmentally appropriate inquiry teaching methods and procedures for integrating science with other areas of the curriculum and to introduce students to the materials and resources of science.
This course was constructivist in its focus on the development of understanding through hands-on science experiences and reflection on those experiences. Most of the class time was spent investigating various phenomena such as making electric circuits, designing paper helicopters, dissecting owl pellets, studying meal worms and mixing coloured light to make white light. These activities introduced content and science process skills while modelling constructivist teaching methods. Field trips,

science fair projects, dialogue journals and design-technology activities were included.

Students in programme 'B' were experienced teachers. This course emphasised democratic classrooms, learning communities and teacher empowerment. The content was spread over the year and the number of sessions in each content area was determined by the students. Each student was expected to decide on a focus area and join a group with a professor having expertise in the subject. The students were given a list of possible ways in which they could enhance their science learning, including readings, use of technology, lab sessions, journaling and faculty visits to their classrooms. The professor's assumption was that students, upon concluding that science was an area of weakness, would choose to work on improving their science teaching. Owing to the democratic nature of the programme, students were allowed to choose where they would focus and were free to implement or not implement science lessons. As a result students in programme 'B' received approximately 15-16 hours of science spread over the year compared to 45 hours in programme 'A'. Whilst science sessions included discovery lessons, a mini-project and dialogue journals, there were no requirements on students to implement science assignments in their classrooms. The results indicated students in programme 'A' increased in interest and confidence but students in programme 'B' did not.

The author suggested that blocks of time in which students build their understanding of science content and assignments in which students apply inquiry science in the classroom may be necessary if teachers are to increase in interest and confidence. According to the author a three-fold difference in the number of hours of science instruction influenced the outcome, especially in confidence.

Jarrett concluded that interest and confidence are affected by early personal experiences rather than by prior teaching experiences. She argues for weekly meetings rather than a loose series of encounters, to provide the concentration and continuity needed for interest and confidence. 'One-shot' sessions do not stimulate interest (ibid, p.7). Jarrett's conclusions are reinforced by other research on interest which suggested that

'interest is a phenomenon that emerges from an individual's interaction with his or her environment' (Krapp, Hidi and Renniger, 1992, p.5), *'interest is an enduring disposition'* (Krapp et al 1992, p7) and *'interest motivates behaviour'* (Deci, 1992).

Indeed if one refers back to Piaget the *'law of interest … controls the intellectual functioning of both children and adults'* (Piaget 1970, p.159). If these connections are accurate, Jarret argued, science interest can be developed through interaction with fascinating phenomena. Once an interest in science is developed, people make the effort to seek out additional scientific information and science-related experiences, thus further deepening science interest. Teachers who enjoy and appreciate science are motivated to do hands-on science with their children. A key to effective science education is, therefore, to ensure that those who teach science are interested in it. Marlow and Stevens (1999) examined science teachers' attitudes about Inquiry-Based Science. The study claimed that whilst teachers stated that students learn best when they are building on their previous knowledge, asking questions and making connections with things they have already learned, observations told a slightly different story. 'Hands-on' activities were consistently used but open-ended inquiry was not evident, the teacher controlled a great deal of what went on through lecture and testing, the textbook and worksheets pre-determined activities and practice did not match perception. The authors argued that we are dealing with an entrenched prior theory of practice which will be difficult to change.

The concerns over teaching science in primary or elementary schools is also felt in other countries. A recurring theme in much of literature about elementary science education in Australia has been the degree of preparedness and apparent reluctance of many teachers to teach science (Abell and Roth, 1992; Department of Employment, Education and Training, 1989; Harlen, 1997; Mellado, Blanco and Ruiz, 1998; Smith and Neale, 1991). The essence of these and other reports is that significant numbers of elementary teachers avoid teaching science, are not knowledgeable about science and lack the confidence to teach it.

Since the introduction of science (as opposed to 'nature study') to the elementary curriculum in Australia thirty to forty years ago, surveys of science teaching have revealed that many elementary teachers do not teach science and frequently when it is taught, strategies used tend to be teacher discussions, explanation, watching science television shows, library research and teacher demonstrations (Australian Science, Technology and Engineering Council, 1997; Department of Employment, Education and Training, 1989; Symington, 1974; Varley, 1975). A major contributing factor was the tendency for elementary teachers to have poor science background knowledge and to lack confidence in teaching science.

Hope and Townsend (1983) found that pre-service teachers tend to hold similar misconceptions in science to their students and Symington and Hayes (1989) noted how pre-service teachers avoided acquiring the science background knowledge when preparing science lessons. When teachers lack confidence to teach science, they tend to use teaching strategies which allow them to maintain control of the classroom knowledge flow but which are not appropriate ways of engaging students in science.

Appleton and Kindt (1999) suggested that the natural reaction for teachers with low self- confidence is to avoid teaching science altogether or use various avoidance stratagems. These included a series of largely unrelated activities which contribute little to progressive conceptual development in pupils. This, the authors claimed, is *'antithetical to constructivist views of learning'* which permeate much of the science education literature (ibid, p.8). The authors concluded that it seemed
to be the case that the teaching profession appears to self-select people for elementary teaching who tend to fear science rather than those who love it (ibid, p.11). The researchers noted that for those teachers who adopt a set of activities that work, some science learning is provided for pupils. Often this is achieved with little support from their school, school system or from their teacher education programme.

'It behoves us as science educators to recognise the difficulties they experience and try to find ways of enhancing their efforts to teach science more effectively' (ibid p.11).

Recently in Britain the Council for Science and Technology (2000) commissioned a survey to obtain a robust up-to-date picture of the quality of science teaching in primary and secondary schools. The report revealed that despite ten years of compulsory science education, primary teachers were generally less confident about teaching science than about Mathematics or English.

The Council addressed the question of *'what would make a material difference in helping science teachers in primary and secondary schools develop and improve their professional practice, individually and collectively?'*

Their answer was that young people gain their first substantive experience of science from their schools and science teachers. Both their schools and their teachers have profound effects on their attitudes and interests in science and technology generally and on the levels of attainment they reach in science by the end of their compulsory schooling. In all these respects the report claims, the knowledge, confidence and competence of their science teachers are critically important factors.

The Council identified the *'Hallmarks of Top Quality Science Teaching'* . It confirmed the common sense view that the personal attributes, knowledge, skills and competencies of teachers are critically important and influential. The effectiveness of teachers stems mainly from their attitude, their confidence, their knowledge of the subject and how to teach it.

'Truly inspirational science teaching occurs when a teacher is not only enthusiastic about the science topic being taught but also understands that topic fully in order to present it in a comprehensible and meaningful way to each pupil' (p.9).

What needs, therefore, to be emphasised is that good subject knowledge and understanding of the substance, content, structure and organisation of the science subject itself is essential for the teacher to explain not only the facts of science but, more importantly, the arguments for the scientific picture. When it is weak, many teachers find it difficult to deal with the pupils' questions and resort to teaching from a text book to avoid having their lack of knowledge exposed.

This focus substantiated the findings of Timmins and Fraser (1990) who indicated that science teachers need to possess good subject knowledge, in order to develop the subject related pedagogical knowledge, skills and competence that is so necessary to present a science topic to pupils in comprehensible and stimulating ways.
The report concluded:

'There is considerable scope for securing a step change in teachers' performance and hence in the science education of their pupils, by creating a pro-continuous professional development culture, one in which a life time of professional learning is very much the norm and is assisted by modern, effective arrangements' (ibid. p.4).

The consensus in the literature is that the knowledge, understanding and confidence of teachers with regard to the teaching of science might be implicated in the performance of their pupils. Conclusive evidence identified teachers' own understanding as a key factor in improving the quality of teaching and learning in science but there are strong arguments to support the view that understanding is needed not to convey factual information but so teachers can ask questions that lead children to reveal and reflect on their ideas. The aim is not to enable teachers to know all the answers but to empower them with the strategies for handling children's questions and turning them into investigative learning.

1.5 Conclusion

This chapter has attempted to give an overview of primary science education in Northern Ireland. It has discussed the place of science in the primary curriculum and the effects of the implementation of science as a designated core subject. It has argued for a clear understanding of the nature of science by all primary teachers so that teaching will inevitably involve learners in the process of developing understanding where ideas will be explored rather than tested and views will be examined in terms of supporting evidence. Approaches and techniques which have proved effective in the teaching of primary science and technology have been identified. The level of knowledge and understanding required by teachers to teach science effectively has been considered.

The literature reviewed has identified themes pertinent to this study. They have included, inter alia, teachers' and student teachers' understanding in specific concept areas and the nature of their misunderstandings, differences in perceived confidence between male and female teachers, the effects of in-service training on teachers' confidence and the content and design of science courses. The consensus in the literature was that the knowledge, understanding and confidence of teachers and student teachers were key factors in improving the quality of teaching and learning in science.

This study examines teachers' confidence in their own understanding and abilities to teach science and technology in primary schools in Northern Ireland. The hypothesis is that teachers' perceived confidence in their knowledge and understanding of primary science is low and this in turn affects the quality of the pupils' learning experience.

Chapter 2

METHODOLOGY

Methodology

'By methods, we mean that range of approaches used in educational research to gather data which are to be used as a basis for inference and interpretation, for explanation and prediction' Cohen and Manion, 1994; p.38).

This study is set against a background of limited research in Northern Ireland into primary teachers' confidence and understanding in teaching science and technology. Additionally, in my role as Key Stage 2 co-ordinator and mentoring tutor for newly qualified teachers I have been alerted to teachers' insecurity in their own knowledge of science. Within my own school, reliance of teachers on detailed levels of development in areas of content has resulted in an imbalance between instruction and participation by pupils. Colleagues' poor understanding of the processes of science triggered initial concern and helped generate the eventual specific research focus.

The research was designed to address the following areas of enquiry.

- To ascertain teachers' feelings of confidence in teaching science relative to other subjects of the Northern Ireland Curriculum.
- To discover the extent to which teachers are confident in their own knowledge of the science and technology required to teach the Northern Ireland Curriculum.
- To explore primary teachers' perceptions of their confidence in helping children to develop the appropriate science process skills.
- To discover the aspects of pedagogy relating to teaching science that primary teachers find more and less difficult.

- To reveal any association between teachers' background of science in their own education and perceived confidence in teaching science and technology.
- To identify forms of help likely to improve teachers' knowledge, confidence and practice.

To address the research questions it was felt appropriate to gather information from final year B.Ed. students, teachers and support personnel from ELBs. The primary objective was to generate data from both quantitative and qualitative research methods. The quantitative instrument used was a questionnaire. The qualitiative method was the semi-structured interview. This multi-method approach or 'triangular' technique (Open University, 1988) was an attempt to gather data from a number of informants and a number of sources and subsequently compare and contrast in order to provide as full and balanced a study as possible. Triangulation, according to Cohen and Manion (1994) helps to explain more fully the richness and complexity of the issue and is suitable when a more holistic view is sought.

According to Davidson (1970) an ideal questionnaire is:

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

Cohen and Manion (1994) argued that frequently the postal questionnaire is the best form of enquiry in an educational survey. (p.94)

Munn and Driver (1999) highlighted the advantages of using a questionnaire. These included the efficient use of time, anonymity for the respondent, the possibility of a high return rate and the advantage of standardised questions strictly controlling the stimulus presented to all respondents.

Teacher and Student Teachers' Questionnaires

The questionnaires were designed to provide information about teachers' and student teachers' background and experience. They were also designed to enquire into how teachers and student teachers perceived their confidence and understanding in teaching various subjects of the curriculum and, within science and technology, the level of confidence in helping pupils to achieve certain skills, knowledge and understanding.

The design closely reflected that of the questionnaire used by Harlen, Holroyd and Byrne in their research into 'Primary Teachers Understanding of Concepts in Science and Technology' in 1995. The reason for similarity of questionnaire design was to make as valid a comparison as possible with their findings.

Questionnaire for Teachers of Pupils in

Primary Schools in Northern Ireland (Appendix 1)

Piloting

Bell (1993) states:

‘*All data gathering instruments should be piloted to test how long it takes recipients to complete them, to check that all questions and instructions are clear and to enable you to remove any items which do not yield usable data’* (p.127).

Similarly Cohen and Manion (1994) warned that clarity of wording and simplicity of design are of paramount importance.

The questionnaire, therefore, was piloted with three primary school teachers, sympathetic to the research but willing to give forthright comments and sharp criticism. After piloting, a number of questions were adjusted to remove ambiguity and misleading phrases and superfluous questions were abandoned. Adjustment to layout and design was also essential.

The six page questionnaire contained five main sections:

1. Background Information
2. Teaching across the curriculum
3. Knowledge and Understanding of key concepts
4. Process skills
5. Pedagogical knowledge

1. Teachers were asked to provide information on their sex, the key stage taught, any particular responsibility allowance in science, their teaching qualification and when it was obtained and qualifications in science (pre-service and in-service).

2. Teachers were asked to rate their confidence in their knowledge and teaching skills in different subject areas of the Northern Ireland primary curriculum. Each of the areas was rated on a four point scale from ‘fully confident’ to ‘I need help to develop my knowledge and skills’.

3. In the third section teachers were asked to rate their confidence in their own scientific knowledge to enable them to help pupils develop understanding of the key features of the Northern Ireland Science and Technology Curriculum. Seven statements were included from ‘Living Things’, ten from ‘Materials’ and fourteen from ‘Physical Processes’ (Rating as for section 2).

4. Teachers were asked about their confidence in helping pupils to develop certain science process skills (Rating as for section 2).

5. Section five referred to pedagogical skills involved in teaching science and technology. Each skill was rated on a three-point scale from ‘not at all difficult’ to ‘very difficult’.

The final question was open-ended, seeking information on the help that teachers felt they needed in relation to science and technology.

The Sample

The sample for the study comprised one hundred and thirty teachers in a selection of primary schools in Northern Ireland. The schools varied in size, geographical location and were drawn from controlled, maintained and preparatory sectors. Given the small- scale nature of the project a truly random sample was not achieved. Opportunity sampling was employed. This was acceptable as the researcher did not intend to generalise findings beyond the sample in question. Personal contact was made with the principal and science co-ordinator of all the schools involved. The purpose of the study was explained and confidentiality was assured. An offer to send an abstract of the major findings when the analysis is completed was included. The level of response was high. One hundred and seventeen questionnaires were returned (90%).

Questionnaire for Final Year B.Ed. Students

(Appendix 2)

The research instrument administered to final year B.Ed. students was similar to that distributed to primary teachers (see Appendix 2). The aims were to explore matters relating to student teachers' perceived confidence and understanding in teaching science and technology and to identify any changes that are needed in the education of student teachers. As previously stated, the questionnaire contained five sections. Section One, 'Background Information' was revised to accommodate those students taking science as a main subject. Questions relating to teaching qualification, responsibility allowance for science and key stages taught were omitted. The four remaining sections remained unchanged. As redrafting of questions and adjustment to format had already occurred, it was felt that piloting was unnecessary.

The Sample

One hundred questionnaires were administered to all final year primary designated B.Ed. students at a teacher training institution in Northern Ireland. Eighty-one completed the survey, giving a high return rate (81%).

Semi-Structured Interview/Questionnaire with ELB Support Staff

Aware of the limitations of using a questionnaire, the tendency to describe rather than explain, the risk of superficiality and the limited value in exploring hypothesis, the semi-structured interview was used to generate qualitative data.

Bell (1993) recognises that a major advantage of the interview is its adaptability. (p.135)

Tuckman (1972) claims:

'It provides access to what is inside a person's head, it makes it possible to measure what a person knows (knowledge or information), what a person likes or dislikes (values and preferences), and what a person thinks (attitudes and beliefs)'.

Additionally Cohen and Manion (1994) argue it may be used to test hypotheses or to suggest new ones or as an explanatory device to help identify variables and relationships. Kerlinger (1970) suggests that it may be used to follow up unexpected results or to validate other methods.

The shortcomings of this method of research include the danger of bias creeping into the interview and leading the respondent by tone of voice. Also emphasising certain aspects may produce different responses. Similarly Borg (1981) drew attention to additional problems that may occur, eagerness of the respondent to please the interviewer or a vague antagonism that sometimes arises between interviewer and respondent. According to Bell (1993), *'Complete objectivity is the aim'* (p.140). Conscious of the inherent dangers, integrity in the conduct and reporting of the interview was paramount and this was maintained throughout.

The Interview Schedule (Appendix 3)

The interview schedule consisted of a mixture of open and closed questions. The general aim was to encourage the respondents to talk at some length about their opinions, experiences, motivations and reasoning.

The interview focused on the respondents' opinions on:

- Primary teachers' perceived competence in teaching science and technology.
- Reasons for low competence - if apparent.
- Aspects of pedagogy that primary teachers find difficult.
- In-service support and training.
- Differentiation in primary science and technology.

- The status of primary science and technology since the School Improvement Initiative.
- Assessment in primary science.

A tape recorder was used to record information.

Due to the small number of support personnel for primary science currently employed by the ELBs, piloting did not occur. Questions were discussed with an experienced colleague, some leading questions were deleted and the order of questions was reconsidered.

The Sample

Science and Technology Advisors from the five Education and Library Boards in Northern Ireland were approached. Requests were made to two former primary science field officers and a primary science advisor. Altogether there were eight intended interviewees. Initial contact was made by letter, outlining details, focus of the study and the relevance of the person's expertise to the research. A follow up telephone call was made ten days later.

Owing to workload and pressure of time, representatives from Belfast Education & Library Board, North Eastern Education & Library Board, Southern Education & Library Board and South Eastern Education & Library Board returned postal responses. (Appendices 3a, 3b, 3c, 3d). The Assistant Advisory Officer for Primary Science and Technology, Western Education & Library Board, agreed to a telephone interview (Appendix 3e). A former primary science field officer and a primary science advisor took part in the semi-structured interview (Appendices 3f, 3g). One former primary science field officer gave a postal response (Appendix 3h). All respondents/interviewees requested a preview of the general structure and main questions to be asked. In the case of postal responses it was recognised that answers could not be developed which obviously limited their effectiveness.

Bell (1993) suggested that whatever procedure for collecting data is selected, it should always be examined critically to assess to what extent it is likely to be reliable and valid. A check for reliability occurred at the stage of question wording and piloting of the instrument. Validity, however, according to Bell is a more complex issue. Belson (1986) stated that the validity of postal questionnaires can be seen from two viewpoints; firstly whether the respondents who complete the questionnaire do so accurately and secondly whether those who fail to return their questionnaires would have given the same distribution of answers as did the returnees. As a high return rate was secured, this concern was of little significance. Validity in interviews, as previously stated, was achieved by minimising the amount of bias.

In conclusion, it was the aim of the research to obtain a fairly representative range of responses to fulfil the objectives of the study and to provide answers to key questions. A case study was omitted because it lacked quantifiable measures and would not have allowed for generalisation and objectivity. Similarly action research was rejected because it would have focused on a restricted sample and therefore would have been unrepresentative. Findings would have been of the situational-specific nature. Cohen and Manion claimed, *"it is lacking in scientific rigour"* (1994).

The most appropriate methodology for the task in hand was selected, the questionnaire and semi-structured interview, to produce as full and balanced a study as possible.

Chapter 3

RESULTS

Bell (1993, p.173) stated:

'Raw data taken from questionnaires….. need to be recorded, analysed and interpreted. A hundred separate pieces of interesting information will mean nothing to a researcher or a reader unless they have been placed into categories. We are constantly looking for similarities and differences, for groupings, patterns and items of significance'.

The overall aim of the study was to ascertain the degree of perceived teacher and student teacher confidence and understanding in primary science. Therefore analysis of data should attempt to find the presence or absence of any trends in responses and how these can be related to:

- Gender
- Teaching experience
- Key stages taught
- In-service training
- Science background

3.1 Teacher Survey - Confidence in teaching science and technology

One hundred and thirty questionnaires were distributed. One hundred and eighteen responses were received (90%). A copy of the questionnaire is included in Appendix 1. The responses given in the teacher questionnaire were analysed and the results are summarised below.

3.1.1 Confidence in teaching different subjects

The preamble to this part was 'some teachers are more confident in their knowledge and teaching skills in some areas of the curriculum than in others. Please give an honest estimate of how you feel in general about teaching the following……' In this section teachers had to respond by ticking one of the four boxes. They were given the following interpretations:

Category 1:	Fully confident
Category 2:	Confident with a little guidance
Category 3:	I can manage but depend on advice
Category 4:	I need help to develop my knowledge and skills

Table 3.1 Teacher Survey: Confidence in teaching different subjects - Subject rank comparison

Subject	Rank	Cat 1: % Fully Confident
Mathematics	1	58
Religious Education	1	58
English	3	52
History	4	45
Geography	5	34
Art	6	26
P.E.	7	24
Science & Technology	8	23
Music	9	14

Results indicated that if the criterion of 'fully confident' was used, the teachers surveyed placed science and technology lower than most other subjects of the Northern Ireland Curriculum.

Table 3.2 Teacher Survey: Confidence in teaching different subjects - conflation of Categories 1 and 2.

Subject	Rank	Cat. 1 & Cat.2 %
English	1	97
Mathematics	2	94
Religious Education	2	94
History	4	91
Geography	5	86
Science & Technology	6	77
Art	7	70
P.E.	8	70
Music	9	41

If you conflate categories 1 and 2 as shown in Table 3.2, 77% of teachers were reasonably confident in their knowledge and teaching skills in science and technology. Science and technology moved from position 8 to position 6. It remained, however, below the other core subjects of English and Mathematics. Figures in Table 3.2 show there was a tendency for teachers to feel more confident in Religious Education, History and Geography than they do in Science and Technology. The percentage admitting to dependence on advice from others and to needing help in Science and Technology is 23%, which compares with only 3% in English and 6% in Mathematics.

3.1.2 Confidence in Teaching Different Knowledge Areas

The preamble to this section was 'How confident do you feel that you have the knowledge needed to help pupils develop understanding of each of the following…' quoted from the Northern Ireland Science and Technology Curriculum. The rating criteria remained the same.

Table 3.3 Teacher Survey: Confidence in knowledge areas

Area	Aspect	Cat. 1 %	Cat.2 %	Cat. 3 %	Cat. 4 %
Living Things	organs	57	33	7	3
	health	69	25	4	2
	life processes	51	28	18	3
	flowering plants	40	34	20	6
Materials	properties	44	35	17	4
	solids, liquids, gases	39	29	22	10
	desirable/undesirable change	43	31	17	9
	permanent/temporary change	46	28	18	8
	rusting	38	28	23	11
	decay	42	33	22	3
Physical Processes	energy sources	27	29	37	7
	movement and shape	22	32	36	10
	friction	27	31	28	14
	renewable sources	31	30	28	11
	insulators/conductors	42	26	22	10
	varying currents in circuits	29	30	24	17
	sound	35	30	27	8
	reflection of light	36	30	25	9

In the area of Living Things, teachers' expressions of confidence in their knowledge were generally high. Conflating categories 1 and 2 and categories 3 and 4, showed about three-quarters or more of the sample reported a fair degree of confidence (i.e. categories 1 & 2). 26%, however, appeared to need support in their knowledge of the main features of a flowering plant.

The figures reported in the area of Materials again indicated that primary teachers were reasonably confident, although lower levels were found in the aspects of 'solids, liquids and gases' and 'rusting'. Low levels of confidence were recorded by 32% and 34% of the respondents in these areas respectively.

In the area of Physical Processes teachers' perceived confidence was generally lower than in Living Things or Materials. The findings revealed that a substantial number of respondents need advice in this area of science.

3.1.3 Confidence in Developing Process Skills - The Results from Question 7

The preamble to this section was 'Please rate in the same way, how confident you feel in helping pupils to develop science process skills'.

The results are shown in Table 3.4'

Table 3.4 Teacher Survey: Confidence in teaching process skills

Area	Skill	Cat.1 %	Cat. 2 %	Cat. 3 %	Cat. 4 %
Science	solving problems	29	50	18	3
	investigating	36	45	17	2
	observing	42	46	8	4
	fair testing	34	46	15	5
	interpreting	29	44	22	5
	relating to prediction	31	52	13	4
	evaluating	29	49	17	5
	suggest improvements	31	47	15	7
	communication skills	38	36	20	6
	identifying patterns	33	38	23	6
Technology	choosing materials	26	41	30	3
	planning	27	47	22	4
	manipulative skills	15	45	31	9
	constructing models	10	40	37	13

Results indicated that if the criterion of 'fully confident' was used the teachers surveyed recorded low levels of confidence, similar to their perceived confidence in their knowledge of physical science. However, when categories 1 and 2 were combined teachers claimed a confidence about developing science process skills in their pupils roughly similar to confidence in their knowledge of 'Materials' and 'Living Things'. Teachers were less confident in their ability to help pupils develop technology skills, for example 40% of the respondents recorded low levels of confidence in manipulative skills and 50% admitted to needing support in constructing models.

3.1.4 Confidence in areas of pedagogy

The preamble to this section included 'Teaching science and technology involves many professional skills, some of which you may find more difficult than others.

Please give your estimate of how difficult in general the following are for you in terms of the following criteria.

1. Not at all difficult
2. Sometimes a little difficult
3. Very difficult'

Results are shown in Table 3.5. The aspects are grouped into three areas, content focused, skill focused and assessing.

Table 3.5 Teacher Survey : Confidence in areas of pedagogy

Area	**Aspect**	**no diff. %**	**some diff. %**	**very diff. %**
Content focused	questioning	52	44	4
	introducing new topics	51	48	1
	responding to questions	41	53	6
	explaining ideas	35	62	3
	gender equality	30	62	8
	deciding concepts	25	72	3
Skill focused	organising practical	29	60	11
	deciding skills	15	75	10
Assessing	assessing content	14	69	17
	assessing skills	9	70	21

With the exception of questioning and introducing a new topic, at least half of the primary teachers questioned and sometimes as many as 85% found aspects of science and technology pedagogy difficult to some degree.

3.1.5 Areas in which help is desired

This open-ended question asked teachers to indicate ‘What help, if any, you need in relation to your understanding in science and technology and what form might this take?’ From the one hundred and eighteen completed questionnaires, sixty seven primary teachers responded (56%). An overview of the teachers suggestions allowed for six areas to be identified. They were grouped as follows, skills, pedagogy, knowledge, knowledge and skills, resources and in-service support.

Table 3.6 Teachers Survey: areas in which help is desired

Area	**% desiring help**
Skills	49
Pedagogy	15
Knowledge	6
Knowledge & skills	12
Resources	9
In-service support	9

Results indicated teachers mainly felt a need for support in the development of process skills.

3.2 Teacher Survey - Analysis by sub-groups

Further statistical analysis was carried out to see if there were any significant differences in the patterns of response to the structured questions from different sub-groups within the total number of primary teachers who responded.

3.2.1 Gender

26% of the respondents were male, 74% were female (statistics provided by DENI in March 2000 indicated the gender of teachers in the primary sector of Northern Ireland to be 23% male and 77% female).

Table 3.7 Teacher Survey: Confidence in teaching science and technology by gender

Gender	Cat. 1 %	Cat. 2 %	Cat. 3 %	Cat. 4 %
Male	32	42	23	3
Female	20	59	18	3

In responses to question 6, asking teachers to rate their confidence in teaching the subject, more male than female teachers were fully confident. When categories 1 and 2 and categories 3 and 4 were conflated the differences between male and female were much less.

The breakdown of responses to question 7 (Confidence in knowledge areas) by gender was then considered. When categories 1 and 2 were combined the results shown in tables 3.8, 3.9 and 3.10 were obtained.

Table 3.8 Teacher Survey: Confidence in knowledge areas by gender

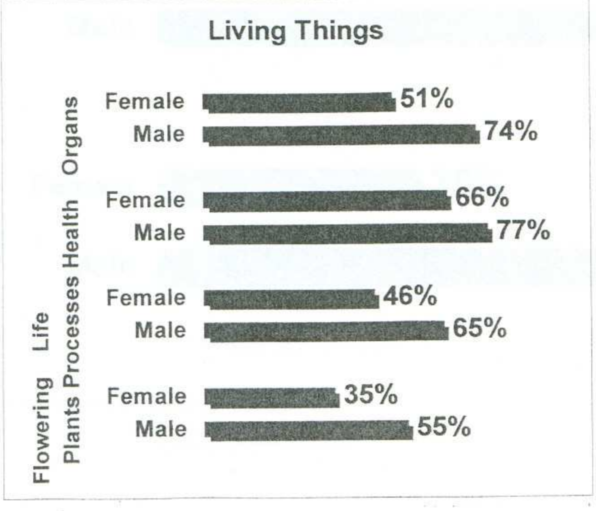


Table 3.9 **Teacher Survey: Confidence in knowledge areas by gender**

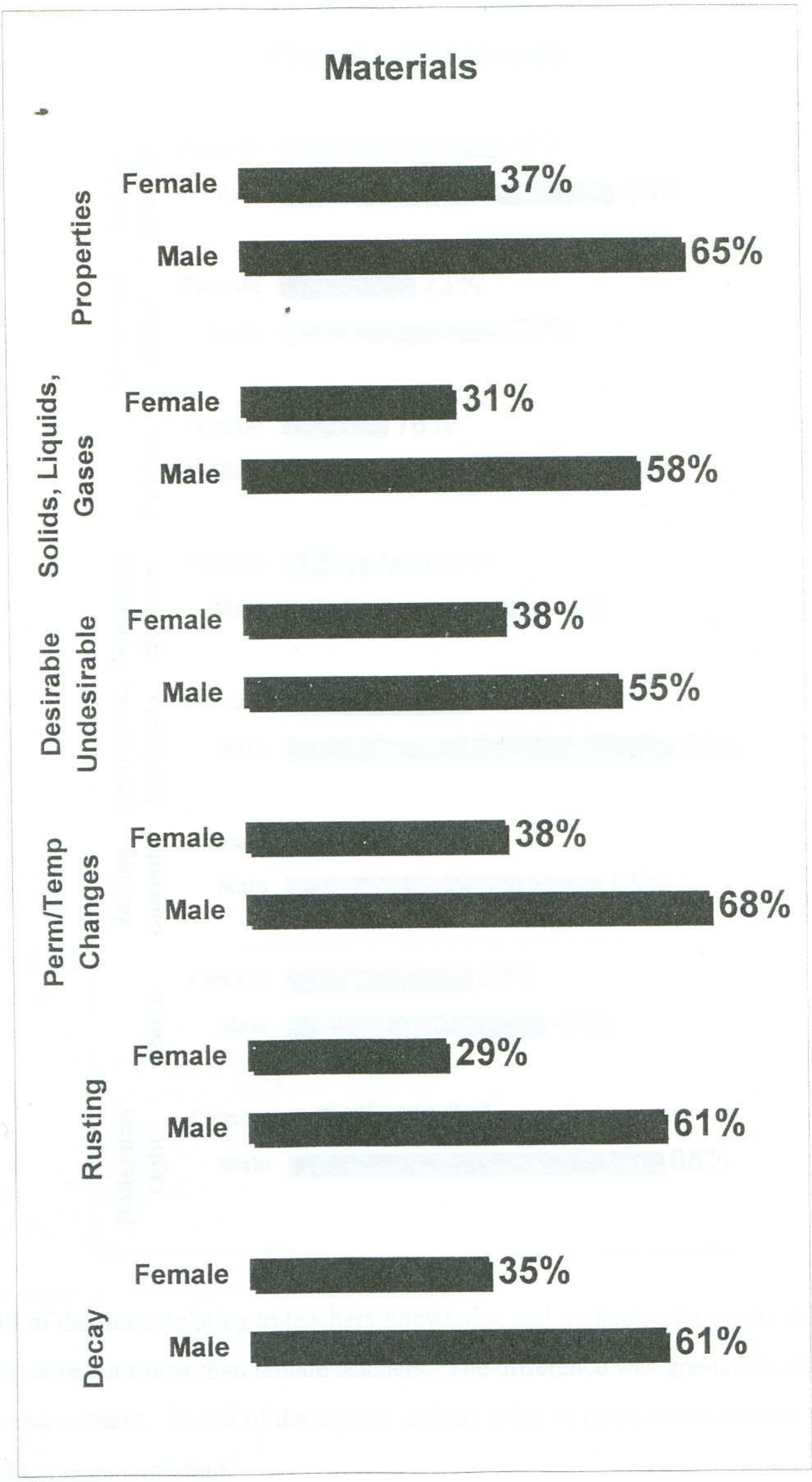
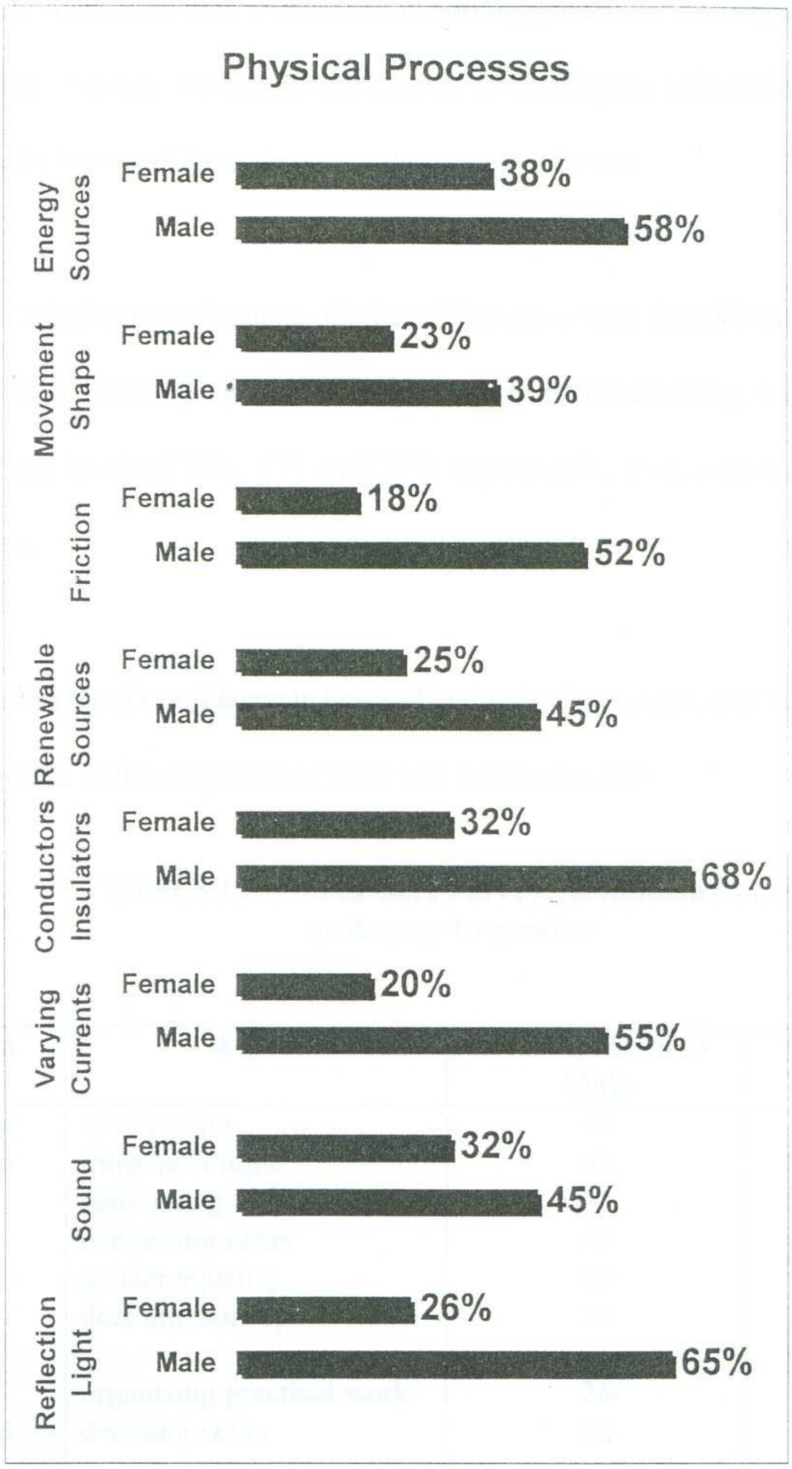


Table 3.10 Teacher Survey: Confidence in knowledge areas by gender



In all of the items relating to teachers' knowledge and understanding male teachers were more confident than female teachers. The difference was greatest in the physical processes strand. In half of the aspects at least twice as many male teachers as female teachers were confident.

In science process skills there were no substantial differences between male and female in relation to their confidence in solving problems, investigating and observing. Female teachers found it easier to develop the skill of fair testing but recorded a low confidence level in interpreting evidence.

In skills relating to technology, distinct differences were found between male and female respondents. In planning, manipulating and constructing, women recorded low confidence levels of 30%, 47% and 57% respectively. Men were significantly more confident.

In the analysis of confidence in areas of pedagogy by gender, overall there appeared to be a balance in the responses of male and female teachers.

Table 3.11 Teachers Survey: Confidence in areas of pedagogy by gender

Area	Aspect	% no difficulties Male	% no difficulties Female
Content focused	questioning	48	54
	intro. new topic	58	48
	responding to questions	52	37
	explaining ideas	45	31
	gender equality	33	28
	deciding concepts	32	22
Skill focused	organising practical work	26	30
	deciding skills	26	11
Assessing	assessing content	13	15
	assessing skills	13	8

Women were slightly more confident than men in questioning skills and organising practical work. However, in responding to questions, explaining ideas, deciding the concepts and skills to be developed in an activity and assessment in relation to process skills, they reported lower levels of confidence than their male colleagues. As reported in Table 3.11 both male and female teachers in the sample experienced considerable difficulties in the professional skills required to teach science and technology.

3.2.2 Teaching Experience

It should be noted that 35% of the total sample had been teaching for more than twenty one years. 19% of the cohort who replied had less than four years' service in the primary sector. (This reflected the age profile shown in statistics provided by DENI in March 2000. The age profile of primary teachers in Northern Ireland included 54% over forty years old and 16% under thirty years).

Table 3.12 Teacher Survey: Confidence in teaching science and technology - teaching experience

	- Number of Teachers -				
When did you qualify?	**Cat. 1**	**Cat. 2**	**Cat. 3**	**Cat. 4**	**Total**
0 - 4 years	6	11	5	1	23
5 - 10 years	8	16	5	-	29
11 - 20 years	3	15	4	2	24
21+ years	10	22	9	1	42
Total					**118**

When Table 3.12 was converted to percentages and degrees of confidence were analysed (i.e. categories 1 and 2 were conflated), more recently qualified teachers appeared more confident than those with longer teaching experience. Results are detailed in Table 3.13.

Table 3.13 Teacher Survey: Confidence in teaching science and technology - teaching experience

When did you qualify	Cat. 1 & 2
0 - 4 years	73%
5 - 10 years	82%
11 - 20 years	75%
21+ years	52%

3.2.3 Key Stage Analysis

The number of respondents in Key Stage 1 was forty nine (42%). An equal number of teachers had experience in Key Stage 2 (42%). Twenty respondents had experience across both Key Stages. 45% and 39% of Key Stage 1 and Key Stage 2 teachers respectively had no pre-service awards in science subjects. 8% of Key Stage 2 teachers had a recognised qualification in science (B.Sc/PGCE & Science). No one in Key Stage 1 had a similar qualification.

Table 3.14 Teacher Survey: Confidence in teaching knowledge areas - Key Stage analysis

Area	Aspect	Key Stage 1 Cat. 1 & Cat. 2%	Key Stage 2 Cat. 1 & Cat. 2%
Living Things	organs	83	94
	health	93	94
	life processes	63	92
	flowering plants	67	84
Materials	properties	75	88
	solids, liquids, gases	48	88
	desirable/undesirable change	67	84
	rusting	46	90
	decay	67	86
Physical Processes	energy sources	84	90
	movement and shape	43	70
	friction	43	78
	renewable sources	43	80
	insulators/conductors	51	82
	varying currents in circuits	43	74
	sound	57	74
	reflection of light	53	84

Teachers in Key Stage 2 were more confident about their possession of the necessary knowledge to help pupils develop understanding of the Northern Ireland Science and Technology Curriculum as can be seen in Table 3.14.

Differences between Key Stages in science process skills were less marked. 18% of Key Stage1 teachers and 22% of Key Stage 2 teachers reported low levels of confidence in investigative skills. Similar findings were reported in helping pupils to solve problems. Teachers in both key stages claimed they were fairly confident in the skills of observation. Teachers in Key Stage 2 identified fair testing as an area in which considerable support was needed (27%). Only 12% of Key Stage 1 teachers felt that they needed advice to recognise, design and carry out a fair test.

Key Stage 2 teachers were more confident in helping pupils to develop technology skills. Substantial differences were reported in confidence in the areas of planning, manipulating and constructing.

The key stage factor did not appear to influence confidence in areas of pedagogy. Findings were similar to that reported in Table 4.5. Teachers in both key stages experienced degrees of difficulty in almost all of the items described.

In considering these findings it should be noted that within the Key Stage 1 cohort 2% of teachers were male. Within the respondents in Key Stage 2, 55% were male.

3.2.4 In-Service Training

Question 5b in section one of the questionnaire asked teachers to indicate whether or not in the last ten years they had attended an in-service course of more than one day's duration concerned with teaching science. 29% reported that they had.

Analysis of the data revealed that 45% of teachers who had attended science courses were fully confident in their ability to teach science and technology compared with 13% of respondents who had received no in-service training. However, in-service training did not appear to influence confidence in the development of science process skills or technology skills. 17% of those who attended science courses and 21% of those with no in-service training depended on advice to help pupils develop the skill of fair testing. 47% of those who responded to the open-ended question asked for support in skills acquisition. Professional skills in teaching science and technology were not affected by in-service support.

3.2.5 Science Background

An analysis was carried out to compare those teachers who had 'no science' qualifications against those teachers who had 'some science'. Some science was interpreted as possessing at least a single award in science at GCSE level. 58% of the sample had some science in their background, 38% had no recognised science qualification.

In confidence to teach the different knowledge areas a science qualification had impact on one category of response, namely that more teachers who had such a qualification felt fully confident than those without a pre-service science award. When category 2 (confident with a little guidance) was considered no substantial differences were observed.

In all of the science process skills (Question 8) more teachers with some science were fully confident. However, when a reasonable degree of confidence was examined, the possession of a science background made little difference.

In only three of the listed professional skills (Question 9) were those teachers without a science background more confident. Teachers with some science found it easier to decide on the concepts to be developed, introduce a new topic, respond to pupils' questions about content and explain ideas.

3.3 Final Year B.Ed. Student Survey

One hundred questionnaires were distributed to all final year primary designated B.Ed. students in a teacher training institution in Northern Ireland. Eighty-one were returned (81%). As previously stated in Chapter 3, the design, layout, question categories and interpretations replicated those used in the questionnaire for primary teachers. The results are summarised below.

3.3.1 Confidence in teaching different subjects

Table 3.15 B.Ed. 4 Survey: Confidence in teaching different subjects - Subject rank comparison

Subject	Rank	% fully confident
Religious Education	1	64
P.E.	2	23
Art	3	21
History	3	21
Geography	5	18
Mathematics	6	17
Music	7	15
English	8	11
Science & Technology	9	7

The confidence of final year B.Ed. students to teach science and technology was less than in all other areas of the curriculum.

Table 3.16 B.Ed. 4 Survey: Confidence in teaching different subjects - Subject rank comparison.

Subject	Rank	Cat. 1 & 2 %
Religious Education	1	99
History	2	81
Geography	3	78
Mathematics	4	75
English	5	75
Science & Technology	6	69
P.E.	7	64
Art	8	62
Music	9	42

When the total of ‘fully confident’ and ‘confident with a little guidance’ was considered, science and technology moved from position 9 to position 6. What became apparent was that there were no substantial differences between science and technology and the other core subjects of English and Mathematics. From the students’ perspective confidence was stronger in teaching Religious Education and Environmental Studies (History and Geography) than in the three core subjects of the Northern Ireland Curriculum.

3.3.2 Confidence in different knowledge ageas

Table 3.17 B.Ed. 4 Survey: Confidence in teaching different knowledge areas

Area	Aspect	Cat. 1 & Cat 2 %
Living Things	organs	84
	health	95
	life processes	74
	flowering plants	74
Materials	properties	86
	solids/liquids, gases	69
	desirable/undesirable change	61
	permanent/temporary change	72
	rusting	44
	decay	79
Physical Processes	energy sources	84
	movement and shape	58
	friction	62
	renewable energy sources	80
	insulators/conductors	80
	varying currents in circuits	73
	sound	64
	reflection of light	74

In the area of Living Things student teachers' expressions of confidence in their knowledge were generally high.

The figures reported in the area of Materials again indicated that student teachers were reasonably confident. Only in the aspect of rusting was confidence reported to be weak.

High levels of confidence were reported in many of the aspects of physical processes. Confidence was strong in student teachers' knowledge of renewable energy sources, insulators and conductors, the effects of varying current in a circuit and reflection of light. Only in their knowledge of how forces affect the movement and shape of objects was confidence deemed to be weak (42% needing help).

3.3.3 Confidence in developing process skills

Table 3.18 B.Ed. Survey: Confidence in teaching process skills

Area	Skills	% Confidence with a little guidance
Science	solving problems	89
	investigating	87
	observing	97
	fair testing	93
	interpreting	82
	relating to prediction	90
	evaluating	88
	suggesting improvements	91
	communication skills	85
	identifying patterns	85
Technology	choosing materials	75
	planning	78
	manipulative skills	67
	constructing models	57

The high levels of confidence reported by student teachers in the knowledge areas of science and technology were reflected in the perceptions of their ability to develop the science process skills in pupils. Only in technology skills was there an indication of the need for support. Advice was sought in choosing materials (25%), planning (22%), manipulative skills (33%) and constructing working models (43%).

3.3.4 Confidence in areas of pedagogy

Table 3.19 B.Ed. Survey: Confidence in areas of pedagogy

Area	Skills	% No difficulties
Content focused	questioning	56
	introducing new topic	59
	responding to questions	36
	explaining ideas	37
	gender equality	59
	deciding concepts	9
Skill focused	organising practical work	33
	deciding skills	7
Assessing	assessing content	17
	assessing skills	9

The perceived confidence of final year B.Ed. students in the professional skills associated with teaching science and technology was significantly lower than their reported confidence in subject knowledge and science process skills. Only 9% and 7% respectively claimed to have no difficulty in deciding the concepts and skills to be developed in an activity. Almost two-thirds of the sample were experiencing degrees of difficulty in responding to questions and explaining ideas. The majority of respondents admitted to depending on support and advice in relation to content and skills assessment.

3.4 The Semi-Structured Interview/Questionnaire with ELB Support Personnel

Cannell and Kahn (1968) defined the research interview as a

'two person conversation initiated by the interviewer for the specific purpose of obtaining research relevant information and focused by him on content specified by research objectives of systematic description, prediction or explanation'.

In this study it was used to gather information which could complement and extend the data provided by the questionnaire with regard to teachers' perspectives on content knowledge, science process skills and pedagogical knowledge. In addition, the interviews were used as an opportunity to explore the interviewees' personal views of primary teachers' confidence and understanding in teaching the Northern Ireland Science and Technology Curriculum. Eight ELB support staff with experience and expertise in the field of primary science were selected. Two semi-structured interviews were conducted and one telephone interview was secured. Five postal responses to interview questions were returned.

The interview schedule consisted of thirteen questions identifying the precise areas of investigation. The interviews were transcribed and are included in the appendices. The responses were analysed and the results are summarised below.

Data From Interviews

Question 1:

To what extent do primary teachers understand the key features of the programmes of study for science and technology (NIC, 1996) i.e. is teachers' understanding sufficient for the areas they are expected to teach?

The consensus of opinion was that teachers were not well versed in their knowledge of the key features of the Northern Ireland Science and Technology Curriculum. Comments included:

'Teachers limited their knowledge to factual recall'.

'Greater understanding is required in physical processes'.

One respondent felt teachers had a sound knowledge at attainment target level, another claimed that if an organised and structured primary science programme was available at school level, then teachers would find it sufficient for the areas they are expected to teach.

Question 2:

How do primary teachers perceive their competence in helping children to achieve the attainment outcomes in science and technology?

There was general agreement that low competence existed in skills development and investigative science. Respondents referred to teachers feeling *'apprehensive'* and '*uneasy*'. It was suggested that *'teachers rely considerably on question and answer technique* --- *they do not have the confidence or competence to set up an hypothesis'*.

However, in one response a high level of competence was mentioned and in another the interviewee claimed teachers underestimated their confidence.

Question 3:

If low competence is apparent - what are the reasons for it and what remedial steps are seen as being required to improve competence?

Respondents claimed low competence was influenced by:

- inadequate initial training
- little in-service provision
- lack of scientific background
- negative attitude towards science
- lack of funding

Four respondents suggested that low competence was directly associated with Attainment Target 1 and development of process skills. A contributory factor included *'lack of support in a system which values recall'*.

Remedial steps suggested were:

- INSET and classroom support
- observation of good practice
- workshop sessions within schools
- self reflection on methodology
- removal of level 5 from the primary science and technology curriculum
- teacher release for further training

Question 4:

> What aspects of pedagogy relating to teaching science and technology do teachers find difficult?

Most agreed that the accessing of skills and how to develop them through content presented teachers with considerable difficulty. Some focused on classroom management and organisation with specific reference to practical work and differentiation. One respondent questioned whether teachers' scientific knowledge would be adequate to facilitate conceptual development in pupils. One person concluded that *'teachers tend to experience difficulty when there is a process involved'*.

Question 5:

> What help do teachers receive from in-service training courses in developing appropriate pedagogical skills? (Do the courses concentrate on content or pedagogy and why)?

Two support personnel admitted to inadequate in-service support. Four field officers agreed there was a concentration on both content and pedagogy. Four believed the sole focus was on content, 'schemes of work, knowledge areas and outcomes which were content based'. This was justified by the fact that it was what teachers demanded; 'skills were not given precedence because schools and teachers had not voiced pedagogy as a concern'.

Question 6:

> As advisers/field officers do not have the right to sit in on classes (as opposed to inspectors who do have the statutory right), on what evidence do advisers/field officers decide on what to include in their in-service courses?

All respondents/interviewees considered the Curriculum Advice and Support Service (CASS) school survey of needs as a determining factor in the provision of in-service courses. Three advisory staff reflected on their roles within the school situation as providing insight into teachers' needs and concerns. One former field officer believed that working in a team-teaching capacity gave her 'a fair claim to teachers' knowledge and understanding and this subsequently informed future planning'. One respondent stated that judgement on the content of in-service courses was based on consultation with co-ordinators. Another reported that 'often what the co-ordinator claimed, wasn't what the school in effect needed'. She explained that many co-ordinators called for schemes of work and lesson plans. However, 'from anecdotal evidence and visits to actual classrooms you become aware of the fact that this isn't really the issue'. There was general acknowledgement of reports by the Education and Training Inspectorate (ETI), feedback from science cluster groups, evaluation from previous INSET courses, school audits and inter-personal discussion. One officer reflected on his experience of the primary science and technology challenge:

> '*I am aware of pupils' lack of independence in planning, manipulating materials and tools, explaining and constructing'.*

He concluded that this must inform the content of future courses.

Question 7:

Is there any objective evaluation of the training the ELBs. provide apart from teacher questionnaires?

Three respondents were unaware of any specific evaluation of INSET provision. They relied on informal remarks from colleagues and other support personnel and follow-up visits to schools. Five of the advisory staff commented on ETI reports and the overall monitoring role of DENI in ELB provision. One former primary adviser claimed that although ‘nothing was measured as such’ in the past, *‘there is currently an attempt with the introduction of action plans and success criteria to evaluate more fruitfully the training provided’.*

Question 8:

What changes in pre-service and in-service training are likely to improve primary teachers’ knowledge, confidence and practice in teaching science and technology?

The need for assistance in Attainment Target 1, enquiry and investigative skills, was raised by four respondents. The attraction of accreditation was supported by two interviewees. Courses in which practice is school-based and where ‘teachers design to best fit their situation’ were promoted. Other proposals included:

- INSET which is all-inclusive (principal, senior management team, co-ordinator and teachers).
- Class-based support (team-teaching)
- Non-contact time for planning
- Term release
- Promotion of science through literacy and numeracy.

A former field officer suggested that within Initial Teacher Education there must be an element that looks at primary science and the range of programme that teachers are expected to deliver. He believed the Induction Programme should be directed not only at content but at teachers' ability to develop investigative skills. He argued that the correct implementation of School Development and Performance Review (SDPR) could improve teachers' knowledge, confidence and practice in teaching science and technology. He admitted that currently science is 'an also ran' in terms of in-service training.

Question 9:

> Is there the same need for differentiation in primary science as there is in literacy and numeracy?

Almost all agreed on the need for differentiation in primary science - both by task and outcome. There was a general recognition of the difficulties involved, resource requirements and low teacher confidence in the professional skills associated with differentiation in science. One advisory teacher for primary science gave a negative response; in her opinion there was no need for differentiation.

Question 10:

> How is the transfer test affecting the teaching of primary science?

All interviewees/respondents conceded that the transfer test had resulted in a high concentration on knowledge and factual acquisition at the expense of investigative skills and process development. One primary adviser commented:

> *'It is skewing the delivery of a content-based curriculum'.*

Although it was generally accepted that the transfer test had done ‘irreparable damage in terms of true primary science’ three respondents admitted that the selection procedure had in fact secured the high profile of the subject in the primary curriculum.

Question 11:

Is there the need for more science support teachers in classrooms?

A disparity of opinions was presented. Two respondents agreed. Two emphasised the need for science support teachers in small schools only. One former field officer supported the need in terms of modelling the pedagogical skills required to teach science and technology. One respondent dismissed the need and argued for professional discussion related to the philosophy of primary science education to determine educational priorities. Two former field officers were not in favour. One admitted to a negative response from classroom teachers who were not prepared to participate in a team-teaching situation to promote good practice.

Question 12:

Has science been effectively downgraded as a result of the School Improvement emphasis on Literacy and Numeracy?

The consensus of opinion was that science has most certainly been downgraded as a result of the focus on literacy and numeracy although two respondents believed science and technology had not lost its profile. The need for the development of literacy and numeracy through Science was raised by four of the interviewees.

Question 13:

Should science be assessed at the end of Key Stages in Northern Ireland as it is in England and Wales?

The absolute need for assessment was emphasised by two former field officers and one assistant advisory officer for primary science and technology. It was supported by the following statements:

'It would help to promote investigative science and ensure an equal balance between content and process'.

'An assessment unit which sets the pupil a practical test and hypothesis and allows the teacher to observe the stages the child moves through would be appropriate'.

The belief that assessment would place a considerable burden on teachers in a time of innovation overload was reported by three of the support staff. One respondent was unsure as to whether formal science assessment should be introduced and another believed it to be acceptable only with a commitment to skills assessment.

Chapter 4

DISCUSSION

It is just over a decade since the introduction of science as a core subject in the Northern Ireland Curriculum at Key Stages 1 and 2 and there is no doubt that it has raised the status of science at primary level. It has also, however, had implications for many teachers who had to learn new subject knowledge and acquire new pedagogical skills.

The intention of this study was to explore teacher/student confidence in teaching science and technology in primary schools in Northern Ireland. Specifically it focused on teachers' perceived understanding of knowledge areas, their confidence in helping pupils to develop the appropriate science process skills and their perceived competence in the pedagogical approaches to teaching science and technology. It should be noted that no attempts were made to verify teachers' claims to scientific understanding.

Whether teachers' confidence about science and technology presents a problem is arguable. Jarrett (1999) suggested confidence in the ability to teach science is a self-assuredness that arises out of subject matter, knowledge and practice in 'what works' with children. Harlen et al (1995) described confidence as a positive feeling based on self-appraisal of skills and knowledge processed. The authors claimed that all teachers should approach the task of teaching science confident in their professional effectiveness and then if confidence falls below a certain level the quality of teacher/pupil interaction suffers and so does the quality of pupil learning. This study revealed low levels of confidence in some aspects of teaching science and technology in the group studied.

The research found that if the criterion of fully confident was used, primary teachers studied have much less confidence about teaching science and technology than almost all other curriculum areas. This result would compare with research carried out by Harlen, Holroyd and Byrne in Scotland in 1995. It is, however, in stark contrast to the findings of Bennet et al in England and Wales in 1991, when after only two years of National Curriculum science the subject was ranked third after English and Mathematics in teachers' ratings of self-perceived general competency. It is reasonable to conclude that despite the position of science as a core element in the Northern Ireland curriculum, many teachers do not approach the subject secure in their ability that they can teach it effectively.

Within this broad statement of relatively low confidence in teaching science and technology there were clear differences in confidence to teach different knowledge areas. Many teachers rated themselves reasonably confident in helping children to achieve statements of attainment in 'Living Things' and 'Materials' but a considerable percentage indicated they need advice and support in 'Physical Processes'. 42%, 44% and 46% of the respondents respectively admitted to needing help in the effect of friction on movement, renewable and non-renewable energy sources and how forces affect the movement and shape of objects. This finding confirms other reviews indicating difficulties with physical science (Carrie and Carter, 1990; Kruger et al, 1990; Summers and Kruger, 1992; Harlen, Holroyd and Byrne, 1995).

Evidence from the study suggested confidence in developing science process skills was generally less than in teaching knowledge areas. It is perhaps due to the concentration on content because of the Transfer Procedure or indeed teachers' more traditional approach in Northern Ireland. Teachers' low competence in skills development was also confirmed in interview discussions with support personnel. Although it contradicted the findings of Harlen et al (1995) that Scottish teachers' confidence about developing science skills in their pupils was somewhat higher than their confidence about developing understanding of science content, it is perhaps significant that the issue of skills development has been raised. Current research (Gardner, 1993; Nisbett, 1993; McGuinness, 1999) has emphasised the quality of thinking processes and thinking skills as a means to raise educational standards and to prepare pupils for life long learning. CCEA in their consultation document for proposed changes to the Northern Ireland Curriculum (CCEA, 2000) recommended a Key Stage 1 curriculum with a specific focus on the development of skills. In Key Stage 2 they suggested a reduction in content and skills common to each subject to be highlighted and subject-specific skills to be identified. It is therefore reasonable to conclude that emphasis on scientific skills and the key role science can play in its potential to develop communication, critical thinking, problem solving and the ability to find, use and evaluate evidence will gain prominence as part of a curriculum-wide aim of achieving transferable skills.

In confidence in areas of pedagogy the study confirmed that many teachers experienced some degree of difficulty in the deployment of the professional skills in science and technology teaching. However, cautious interpretation is needed of some of the results. The three categories of interpretation (not at all difficult, sometimes a little difficult, very difficult) did not allow for a balance between those who were reasonably confident and those in need of advice and support. Category 2 simply meant that the skill was difficult on occasion and as Harlen (1995) has argued this feeling of anxiety, stemming from insight into the complex demands of a situation may well be necessary to perform effectively in any new context. Only a small percentage of teachers found explaining ideas to pupils and deciding on the concepts to be developed in an activity very difficult. These figures support the hypothesis that teachers are reasonably confident in their ability to teach science content.

Teachers were less confident, however, in those areas of pedagogy which were skills related. (71% and 85% of the respondents respectively were experiencing degrees of difficulty in organising practical work and deciding on the skills to be developed in an activity). This finding was confirmed by support personnel, the majority of whom agreed that classroom management and organisation, practical work and differentiation presented teachers with considerable difficulty. Similarly only a small percentage reported no difficulty in assessment. Lack of progress in the area of assessment has been identified by DENI (1998) and perhaps reflects the fact that summative assessment in science is not a statutory requirement at the end of Key Stages 1 and 2 in Northern Ireland. Additionally, teachers' pedagogical approaches may have been shaped by the requirements of the Transfer Procedure Tests in that assessment is primarily concerned with recall of factual knowledge.

The responses to the open-ended questioned clearly indicated the need for teacher support in the development of process skills. This would confirm earlier comments about low competence in skills development. Only a small percentage (6%) required help in relation to their understanding of knowledge areas, reiterating again that the primary teachers studied believe that they are reasonably confident in their understanding of science content.

This research strongly supported the view that science has a masculine image with male teachers confidence in the physical sciences higher than that of women. (65% of male teachers and 26% of female teachers were confident in their understanding of the reflection of light. 54% of male respondents and 18% of female respondents were confident in their understanding of the effect of friction on movement). Indeed literature has repeatedly emphasised the link between science lessons and gender bias (GIST, 1982; Koch, 1992). In Northern Ireland, although research was primarily concerned with gender differences and subject choice at A-level, Gallagher et al (1996) concluded that science, mathematics and physical sciences remained disproportionately the preserve of boys. Johnston et al (1999) examined aspects of the teaching and learning of science in primary schools and recommended that in order to counteract the pervasive notion that science is a boys' subject, teachers should be proactive in presenting science as a subject for all and in challenging any stereotyping which children bring to the science classroom.

In the analysis on gender, female teachers were less confident in skills relating to technology. Perhaps this is not at all surprising given that the majority of primary teachers are women and likely to have been affected by some form of gender bias in their own educational background, a view supported by Goddard-Spear (1989) and Sadker and Sadker (in Johnston et al 1999).

The study considered the relationship between teaching experience and teacher confidence in teaching science and technology as a curriculum area. Evidence from the study suggested that more recently qualified teachers tend to have more science in their background. Indeed a further analysis of questionnaire responses revealed a positive correlation between teacher confidence and a pre-service award in science. A science background appeared to give teachers more confidence in aspects of teaching relating to science content, i.e. deciding on the concepts to be developed, responding to pupils questions and explaining ideas. Feelings of inadequacy due to lack of science background is supported by the findings of Harlen et al (1995) and Osborne and Simon (1996).

The research indicated that Key Stage 2 teachers rated themselves considerably more confident in their possession of the necessary knowledge to teach science and technology. Support personnel accredited this to the influence of the Transfer Test and the focus on the transmission of factual knowledge. A determining factor must also include the higher percentage of male teachers in Key Stage 2. The only substantial difference in confidence to develop skills between the Key Stages was the ability to help pupils recognise, design and carry out a fair test. Key Stage 2 teachers admitted to experiencing greater difficulty than their Key Stage 1 colleagues. Given that the skill of fair testing is introduced at level 3 of the Northern Ireland Science Curriculum, teachers in Key Stage 1 generally do not have to concern themselves with the development of this skill. Is it therefore possible for the confidence to be somewhat misplaced?

If their school experience had not provided teachers with confidence, the study attempted to explore if indeed in-service training had a positive effect. It was found that a substantial proportion of teachers had not been involved in INSET of more than one day's duration in the last ten years. It is reasonable to conclude that the in-service education called for by the Science Working Group (1989) and emphasised by NICC

(1993) did not in fact come to fruition. INSET provision was delivered in single days and lacked coherence. This view is consistent with the findings of Carre and Carter (1993) and Jarrett (1999) presented in the literature section.

The study revealed that attending courses had a positive influence on confidence to teach science and technology as a curriculum area. In-service training, however, did not affect confidence in the development of science process skills, technology skills or indeed professional competencies. The study pointed to the need for support in enquiry and investigative science and the pedagogical approaches fundamental to the effective teaching of the subject. The evidence suggested the need for INSET provision in the form of award-bearing courses as a means of improving primary teachers' knowledge, confidence and practice.

Evidence from the B.Ed. 4 Survey suggested low levels of confidence in teaching science and technology as a curriculum area. When the criterion of 'fully confident' was used science and technology was given the lowest rating. When categories 1 and 2 were considered science was rated sixth falling just below the other two core subjects of English and Mathematics. It is only possible to conclude that students' feelings of competency are similar in all three core elements of the Northern Ireland Curriculum. It is pertinent to comment on the high degree of confidence expressed by students in Religious Education. A possible reason is the fact that it is a separately accredited course and an essential requirement for a teaching position in Catholic maintained primary schools in Northern Ireland.

The study found student teacher confidence in teaching different knowledge areas was quite high. Differences in levels of confidence in ‘Living Things’, ‘Materials’ and ‘Physical Processes’ were not very pronounced. Indeed the high levels of confidence reported by student teachers in physical sciences were in contrast to the findings in the teacher survey. It is possible to conclude that this positive correlation can be attributed to the high percentage of students who had attained a pre-service qualification in science (94%). Indeed the positive effects of compulsory school science on scientific literacy have been reported by Murphy et al (2000).

Similarly high levels of confidence were reported in students’ perceived ability to develop science process skills. It perhaps reflects the emphasis in college courses on skills acquisition.

However, it was difficult to reconcile the high levels of confidence reported in scientific concepts with the low levels of competency in the pedagogical skills directly related to science content. Student teachers claimed to be experiencing difficulty in deciding on the concepts and skills to be developed in an activity, responding to pupils’ questions and explaining ideas. It is then, as Harlen et al (1995) argued, desirable to distinguish between understanding a science concept and knowing how to represent that understanding in ways which make it accessible to a variety of learners. It is reasonable to suggest that the development of professional skills is closely linked to the experience of practising in the classroom.

Data gathered from the semi-structured interview/questionnaire suggested teachers were not well versed in their knowledge of the Northern Ireland Science and

Technology Curriculum. There was general agreement that low competence existed in skills development and investigative science. This outcome confirms the findings from the Teacher Survey. The respondents/interviewees claimed low confidence was influenced inter alia by inadequate initial training, little in-service provision and lack of scientific background. There was some agreement that in-service training courses focused on content and that skills were not given precedence. All respondents/interviewees conceded that the Transfer Test had resulted in a high concentration on knowledge and factual acquisition at the expense of investigative skills. A range of proposals likely to improve primary teachers' knowledge, confidence and practice in teaching primary science and technology were suggested by the ELB support staff. They included the need for assistance in enquiry and investigative science, accredited courses, school and class-based support and the correct implementation of School Development and Performance Review.

This chapter has attempted to discuss the important issues emerging from the research and relate the findings to existing evidence about confidence in primary science teaching.

Chapter 5

SUMMARY

&

RECOMMENDATIONS

Summary and Recommendations

The study found that there is a growing confidence among primary teachers in their ability to teach science and technology. Confidence to develop pupils' understanding of knowledge areas was generally high. Inadequacies, however, were reported in teachers' perceived competency in basic physical concepts and there was a marked difference between male and female teachers in this area. Teachers indicated the need for support in developing science process skills. Lack of confidence in technology skills was also reported. Feelings of insecurity in some aspects of pedagogy were revealed. Many teachers did not consider science teaching to be one of their strengths.

It was found that in-service training and having a science background positively influenced confidence. There was some evidence to suggest that gender issues, Key Stages taught and teaching experience affected levels of perceived confidence.

It has to be reiterated that this was a small-scale survey and the knowledge revealed by the research is inevitably incomplete. The recommendations are therefore modest.

The study recommends that:

- Teachers self-reflect on their own practice in relation to science teaching and use the process of School Development and Performance Review (SDPR) to enhance their personal and professional development.

- All teachers, but particularly those in Key Stage 2, attempt to ensure a balance between conceptual and procedural understanding in their teaching of the subject.

- Principals, school management teams and teachers address the issue of formative assessment in science and technology.

- Principals and school management teams dedicate staff development days to effecting change in pedagogical practice.

- Education and Library Boards re-examine the quality and quantity of in-service provision for primary science and facilitate and support training programmes with an emphasis on skills development and experiences to increase teachers' competence in relation to their understanding of ‘Physical Processes’.

- Teacher educators extend their provision of certificate courses which could be integrated into a more comprehensive in-service award.

This study confirms the hypothesis that low levels of confidence about teaching aspects of science and technology exist. Although considerable progress has been made by primary teachers since the introduction of science as a key element in the Northern Ireland Curriculum there remain issues to be addressed and problems to be solved. This review points to need for further research in assessment in primary science and differentiated learning.

This study at best provides a glimpse of the way things are.

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Appendix 1

Questionnaire for Teachers of Pupils in Primary Schools in Northern Ireland

The aims of this study are to explore matters related to primary teachers' understanding and confidence in teaching science and technology and to identify any changes that are needed in the professional development of practising teachers and in the training of student teachers.

The information you provide will be treated in the strictest confidence.
I ask for your name only because I would like to speak to some teachers in the next phase of the study.

Background Information

Name of teacher (optional): ______________________________

1. Please tick: Male ☐ Female ☐ ☐

2. Stages taught: Key Stage 1 ☐ Key Stage 2 ☐ ☐

3. Do you have a responsibility allowance for Science? Yes ☐ No ☐ ☐

   (a) 1 point responsibility allowance ☐

   (b) 2 point responsibility allowance ☐ ☐

   (c) 3 point responsibility allowance ☐

4. About your teaching qualification.

   (a) when did you qualify?

   0-4 years ago ☐ 5-10 years ago ☐ ☐

   11-20 years ago ☐ 21+ years ago ☐

   (b) what was the qualification? (B.Ed., B.A., B.Sc.) ☐
   (If PGCE, please indicate if Science was one of the subjects in your initial degree). .

   ____

5. About your qualifications in Science:

(a) what are your pre-service awards in Science subjects?
(GCSE, Single/Double /Triple Award)
(A Levels, Physics, Chemistry, Biology)

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(b) have you in the last ten years attended an in-service course of more than one day's duration concerned with teaching science?

Yes ☐ No ☐

If yes, please give approximate date, title, duration and location and say whether it resulted in any award (e.g. 1992 - 3 days - College of Education).

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Teaching Across the Curriculum

6. Some teachers are more confident in their knowledge and teaching skills in some areas of the curriculum than others. Please give an honest estimate of how you feel in general about teaching the following, rating each as follows:

1. Fully confident
2. Confident with a little guidance
3. I can manage but depend on advice from others.
4. I need help to develop my knowledge and skills

	1	**2**	**3**	**4**
English	☐	☐	☐	☐
Mathematics	☐	☐	☐	☐
Science/Technology	☐	☐	☐	☐
History	☐	☐	☐	☐
Geography	☐	☐	☐	☐
Art	☐	☐	☐	☐
Music	☐	☐	☐	☐
P.E.	☐	☐	☐	☐
Religion	☐	☐	☐	☐

7. How confident are you that you have the knowledge to develop pupils' understanding of the following? (quoted from the Northern Ireland Science Curriculum) (1996) (rate using the same criteria as in question 6).

    1. Fully confident
    2. Confident with a little guidance
    3. I can manage but depend on advice from others
    4. I need help to develop my knowledge and skills

	1	**2**	**3**	**4**	
The position of the major organs of the body	☐	☐	☐	☐	☐
Factors contributing to good health	☐	☐	☐	☐	☐
Basic Life Processes (circulation, respiration, digestion)	☐	☐	☐	☐	☐
Similarities / differences among plants and animals	☐	☐	☐	☐	☐
Conditions necessary for the growth of familiar plants	☐	☐	☐	☐	☐
Life cycle of a flowering plant (pollen, stamen, stigma, fertilisation, disposal of seeds)	☐	☐	☐	☐	☐
Simple food chains	☐	☐	☐	☐	☐
Properties of materials	☐	☐	☐	☐	☐
Distinctive properties of solids, liquids and gases	☐	☐	☐	☐	☐
Everyday substances which dissolve	☐	☐	☐	☐	☐
Desirable / undesirable change	☐	☐	☐	☐	☐
Knowledge of water cycle	☐	☐	☐	☐	☐
Permanent / temporary change	☐	☐	☐	☐	☐
Control of rusting	☐	☐	☐	☐	☐
Waste created by human activity	☐	☐	☐	☐	☐

	1	2	3	4	
Materials which do / do not decay naturally	☐	☐	☐	☐	☐
Recycling	☐	☐	☐	☐	☐
Energy sources in school / at home	☐	☐	☐	☐	☐
Sources of energy in models / machines	☐	☐	☐	☐	☐
How forces affect the movement and shape of objects	☐	☐	☐	☐	☐
The effect of friction on movement	☐	☐	☐	☐	☐
Renewable, non-renewable energy sources	☐	☐	☐	☐	☐
Safe use of mains electricity	☐	☐	☐	☐	☐
Construction of simple circuits	☐	☐	☐	☐	☐
Insulators and conductors	☐	☐	☐	☐	☐
Investigation of the effects of varying current in a circuit to make bulbs brighter or dimmer	☐	☐	☐	☐	☐
How sounds are produced when objects vibrate	☐	☐	☐	☐	☐
Sound travels through a variety of materials	☐	☐	☐	☐	☐
Light passes through some materials and not others	☐	☐	☐	☐	☐
The formation of shadows	☐	☐	☐	☐	☐
The reflection of light from mirrors and other shiny surfaces	☐	☐	☐	☐	☐

8. Please rate in the same way, how confident you feel in helping pupils to:

Solve problems	☐	☐	☐	☐	☐
Carry out investigations	☐	☐	☐	☐	☐
Make observations	☐	☐	☐	☐	☐
Recognise, design, carry out a fair test	☐	☐	☐	☐	☐
Choose appropriate materials when planning what to make (cartons, doweling, wheels, etc).	☐	☐	☐	☐	☐

	1	2	3	4	
Plan what they are going to make and talk about the materials and components they could use.	☐	☐	☐	☐	☐
Develop manipulative skills using a range of materials and tools (e.g. low temperature glue gun).	☐	☐	☐	☐	☐
Construct working models (using syringes /tubing etc.)	☐	☐	☐	☐	☐
Interpret evidence	☐	☐	☐	☐	☐
Relate what has happened to what they predicted	☐	☐	☐	☐	☐
Evaluate and revise their work	☐	☐	☐	☐	☐
Make suggestions for improvements	☐	☐	☐	☐	☐
Develop oral, written, graphic and communication skills	☐	☐	☐	☐	☐
Use results to identify patterns	☐	☐	☐	☐	☐

9. Teaching Science and Technology involves many professional skills, some of which you may find more difficult than others. Please give your estimate of how difficult in general the following are for you in terms of the following criteria.

    1. Not at all difficult
    2. Sometimes a little difficult
    3. Very difficult

	1	2	3	
Deciding concepts to be developed in an activity.	☐	☐	☐	☐
Deciding process skills to be developed in an activity	☐	☐	☐	☐
Ensuring equal interest of girls and boys	☐	☐	☐	☐
Introducing a new topic	☐	☐	☐	☐
Responding to pupils' questions about content	☐	☐	☐	☐
Explaining ideas to pupils	☐	☐	☐	☐

	1	2	3	
Organising practical work	☐	☐	☐	☐
Using questioning skills to stimulate pupils thinking	☐	☐	☐	☐
Assessment in relation to concept development	☐	☐	☐	☐
Assessment in relation to process skills	☐	☐	☐	☐

10. Please indicate what help, if any, you need in relation to your understanding in Science and Technology and what form this might take.

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Your help in completing this questionnaire is very much appreciated.
Thank you.
<u>Paula Alexander</u>

Appendix 2

Questionnaire for Final Year B.Ed. Students in Teacher Training Colleges in Northern Ireland

The aims of this study are to explore matters related to primary teachers' understanding and confidence in teaching science and technology and to

Only

identify any changes that are needed in the professional development of practising teachers and in the training of student teachers.

The information you provide will be treated in the strictest confidence.

Background Information

1. Please tick: Male ☐ Female ☐ ☐

2. Teaching Practice Key Stage 1 ☐ Key Stage 2 ☐ ☐

3. About your qualifications in Science:
   What are your pre-teacher training awards in Science Subjects? (GCSE, Single/Double/Triple Award) (A Levels, Physics, Chemistry, Biology)?

   ____

Teaching Across the Curriculum

4. Some student teachers are more confident in their knowledge and teaching skills in some areas of the curriculum than others. Please give an honest estimate of how you feel in general about teaching the following, rating each as follows:

   1. Fully confident
   2. Confident with a little guidance
   3. I can manage but depend on advice from others.
   4. I need help to develop my knowledge and skills

	1	2	3	4	
English	☐	☐	☐	☐	☐
Mathematics	☐	☐	☐	☐	☐
Science/Technology	☐	☐	☐	☐	☐

	1	2	3	4	
History	☐	☐	☐	☐	☐
Geography	☐	☐	☐	☐	☐
Art	☐	☐	☐	☐	☐
Music	☐	☐	☐	☐	☐
P.E.	☐	☐	☐	☐	☐
Religion	☐	☐	☐	☐	☐

5. How confident are you that you have the knowledge to develop pupils' understanding of the following? (quoted from the Northern Ireland Science Curriculum) (1996) (rate using the same criteria as in question 6).

1. Fully confident
2. Confident with a little guidance
3. I can manage but depend on advice from others
4. I need help to develop my knowledge and skills

	1	2	3	4	
The position of the major organs of the body	☐	☐	☐	☐	☐
Factors contributing to good health	☐	☐	☐	☐	☐
Basic Life Processes (circulation, respiration, digestion)	☐	☐	☐	☐	☐
Similarities / differences among plants and animals	☐	☐	☐	☐	☐
Conditions necessary for the growth of familiar plants	☐	☐	☐	☐	☐
Life cycle of a flowering plant (pollen, stamen, stigma, fertilisation, disposal of seeds)	☐	☐	☐	☐	☐
Simple food chains	☐	☐	☐	☐	☐
Properties of materials	☐	☐	☐	☐	☐
Distinctive properties of solids, liquids and gases	☐	☐	☐	☐	☐

	1	2	3	4	
Everyday substances which dissolve	☐	☐	☐	☐	☐
Desirable / undesirable change	☐	☐	☐	☐	☐
Knowledge of water cycle	☐	☐	☐	☐	☐
Permanent / temporary change	☐	☐	☐	☐	☐
Control of rusting	☐	☐	☐	☐	☐
Waste created by human activity	☐	☐	☐	☐	☐
Materials which do / do not decay naturally	☐	☐	☐	☐	☐
Recycling	☐	☐	☐	☐	☐
Energy sources in school / at home	☐	☐	☐	☐	☐
Sources of energy in models / machines	☐	☐	☐	☐	☐
How forces affect the movement and shape of objects	☐	☐	☐	☐	☐
The effect of friction on movement	☐	☐	☐	☐	☐
Renewable, non-renewable energy sources	☐	☐	☐	☐	☐
Safe use of mains electricity	☐	☐	☐	☐	☐
Construction of simple circuits	☐	☐	☐	☐	☐
Insulators and conductors	☐	☐	☐	☐	☐
Investigation of the effects of varying current in a circuit to make bulbs brighter or dimmer	☐	☐	☐	☐	☐
How sounds are produced when objects vibrate	☐	☐	☐	☐	☐
Sound travels through a variety of materials	☐	☐	☐	☐	☐
Light passes through some materials and not others	☐	☐	☐	☐	☐
The formation of shadows	☐	☐	☐	☐	☐
The reflection of light from mirrors and other shiny surfaces	☐	☐	☐	☐	☐

6. Please rate in the same way, how confident you feel in helping pupils to:

	1	2	3	4	
Solve problems	☐	☐	☐	☐	☐
-carry out investigations	☐	☐	☐	☐	☐
-make observations	☐	☐	☐	☐	☐
-recognise, design, carry out a fair test	☐	☐	☐	☐	☐
Choose appropriate materials when planning what to make (cartons, doweling, wheels, etc).	☐	☐	☐	☐	☐
Plan what they are going to make and talk about the materials and components they could use.	☐	☐	☐	☐	☐
Develop manipulative skills using a range of materials and tools (e.g. low temperature glue gun).	☐	☐	☐	☐	☐
Construct working models (using syringes /tubing etc.)	☐	☐	☐	☐	☐
Interpret evidence	☐	☐	☐	☐	☐
Relate what has happened to what they predicted	☐	☐	☐	☐	☐
Evaluate and revise their work	☐	☐	☐	☐	☐
Make suggestions for improvements	☐	☐	☐	☐	☐
Develop oral, written, graphic and communication skills	☐	☐	☐	☐	☐
Use results to identify patterns	☐	☐	☐	☐	☐

7. Teaching Science and Technology involves many professional skills, some of which you may find more difficult than others. Please give your estimate of how difficult in general the following are for you in terms of the following criteria.

1. Not at all difficult
2. Sometimes a little difficult
3. Very difficult

	1	2	3	
Deciding concepts to be developed in an activity.	☐	☐	☐	☐
Deciding process skills to be developed in an activity	☐	☐	☐	☐
Ensuring equal interest of girls and boys	☐	☐	☐	☐
Introducing a new topic	☐	☐	☐	☐
Responding to pupils' questions about content	☐	☐	☐	☐
Explaining ideas to pupils	☐	☐	☐	☐
Organising practical work	☐	☐	☐	☐
Using questioning skills to stimulate pupils thinking	☐	☐	☐	☐
Assessment in relation to concept development	☐	☐	☐	☐
Assessment in relation to process skills	☐	☐	☐	☐

10. Please indicate what help, if any, you need in relation to your understanding in Science and Technology and what form this might take.

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Your help in completing this questionnaire is very much appreciated. Thank you.

Appendix 3

Questions to be addressed

(Primary Advisers/Field Officers)

In your responses to all these questions it is your considered opinions I am seeking.

1. To what extent do primary teachers understand the key features of the programmes of study for Science (NIC 1996), i.e. is teachers' understanding sufficient for the areas they are expected to teach

2. How do primary teachers perceive their competence in helping children to achieve the attainment outcomes in science and technology?

3. If low competence is apparent - what are the reasons for it and what remedial steps are seen as being required to improve competence?

4. What aspects of pedagogy relating to teaching science and technology do teachers find difficult?

5. What help do teachers receive from in-service training courses in developing appropriate pedagogical skills? (Do the courses concentrate on content or pedagogy and why)?

6. As advisers/field officers do not have the right to sit in on classes (as opposed to inspectors who do have the statutory right), on what evidence do advisers/field officers decide on what to include in their in-service courses?

7. Is there any objective evaluation of the training the E.L.B's provide, apart from teacher questionnaires?

8. What changes in pre-service and in-service training are likely to improve primary teachers' knowledge, confidence and practice in teaching science and technology?

9. Is there the same need for differentiation in primary science as there is in literacy and numeracy?

10. How is the transfer test affecting the teaching of primary science?

11. Is there the need for more science support teachers in classrooms?

12. Has science been effectively downgraded as a result of the School Improvement emphasis on Literacy and Numeracy?

13. Should science be assessed at the end of Key Stages in Northern Ireland as it is in England and Wales?

(Appendix 3a)

Postal Response to

Interview Questions

with

Primary Adviser 1

Questions to be addressed

(Primary Advisers/Field Officers)

In your responses to all these questions it is your considered opinions I am seeking.

1. To what extent do primary teachers understand the key features of the programmes of study for Science (NIC 1996), i.e. is teachers' understanding sufficient for the areas they are expected to teach?

Teachers' knowledge and understanding at attainment target level is on the whole very sound and certainly sufficient.

2. How do primary teachers perceive their competence in helping children to achieve the attainment outcomes in science and technology?

   Most primary teachers would feel fairly confident in helping children to acquire knowledge and understanding, however, many would feel they are not facilitating skills development.

3. If low competence is apparent - what are the reasons for it and what remedial steps are seen as being required to improve competence?

   Not so much a question of low competence with regard to skills development - it is more associated with lack of commitment and support in a system which apparently values recall.

4. What aspects of pedagogy relating to teaching science and technology do teachers find difficult?

   Classroom management and curriculum organisation which facilitates group work and enquiry work, i.e. planning the development of interpersonal and investigative skills.

5. What help do teachers receive from in-service training courses in developing appropriate pedagogical skills? (Do the courses concentrate on content or pedagogy and why)?

Very little in-service training has been offered with relation to primary science. The usual focus has been on developing schemes of work. Where there has been a specific need it has centred on the knowledge area of 'forces' or outcomes which have been content based.

6. As advisers/field officers do not have the right to sit in on classes (as opposed to inspectors who do have the statutory right), on what evidence do advisers/field officers decide on what to include in their in-service courses?

- *School audit*
- *Responses in survey of needs*
- *ETI Reports*
- *Interpersonal discussion.*

7. Is there any objective evaluation of the training the E.L.B's provide, apart from teacher questionnaires?

- *Validation of ETI*
- *ETI inspection of CASS delivery*

8. What changes in pre-service and in-service training are likely to improve primary teachers' knowledge, confidence and practice in teaching science and technology?

- *Hands on enquiry and investigative work*
- *INSET which is all inclusive (Principals, SMT, Co-ordinators, staff)*
- *INSET preceded by audit and succeeded by review*

9. Is there the same need for differentiation in primary science as there is in literacy and numeracy?

Most definitely the need for differentiation in content.
Less need for differentiation in process skills.

10. How is the transfer test affecting the teaching of primary science?

Very much skewing delivery of a content based curriculum at the expense of skills of investigation.

11.Is there the need for more science support teachers in classrooms?

There is a greater need for professional discussion related to the philosophy of primary education and of primary science education to determine educational priorities.

12. Has science been effectively downgraded as a result of the School Improvement emphasis on Literacy and Numeracy?

Yes.

13. Should science be assessed at the end of Key Stages in Northern Ireland as it is in England and Wales?

No, unless there is a commitment to skills assessment but this is hugely time consuming. Skills assessment in any case is more amenable to formative assessment models.

(Appendix 3b)

Postal Response to

Interview Questions

with

Adviser for Science & Technology 2

Questions to be addressed

(Primary Advisers/Field Officers)

In your responses to all these questions it is your considered opinions I am seeking.

1. To what extent do primary teachers understand the key features of the programmes of study for Science (NIC 1996), i.e. is teachers' understanding sufficient for the areas they are expected to teach?

Science co-ordinators in the main have reasonable knowledge, primary teachers lack sufficient knowledge. In general teachers are apprehensive about investigative science. Technology is an area in which all teachers require a fuller understanding.

2. How do primary teachers perceive their competence in helping children to achieve the attainment outcomes in science and technology?

   Low competence in investigative science and technology skills. This affects their confidence in the classroom.

3. If low competence is apparent - what are the reasons for it and what remedial steps are seen as being required to improve competence?

   - *Lack of teacher training*
   - *Lack of knowledge by non-specialists*
   - *INSET and classroom support might improve competence.*

4. What aspects of pedagogy relating to teaching science and technology do teachers find difficult?

   Classroom organisation; practical work, deciding on the skills required particularly in investigative science and technology.

5. What help do teachers receive from in-service training courses in developing appropriate pedagogical skills? (Do the courses concentrate on content or pedagogy and why)?

A combination of content and pedagogy is promoted in INSET courses.

6. As advisers/field officers do not have the right to sit in on classes (as opposed to inspectors who do have the statutory right), on what evidence do advisers/field officers decide on what to include in their in-service courses?

   Needs are identified by schools and requests are made to the relevant ELB's.

7. Is there any objective evaluation of the training the E.L.B's provide, apart from teacher questionnaires?

   Not that I am aware of.

8. What changes in pre-service and in-service training are likely to improve primary teachers' knowledge, confidence and practice in teaching science and technology?

   Adequate non-contact time for in-school planning, term release to update knowledge and skills and to gain confidence to teach the requirements. Post-graduate qualifications could contribute to teachers' knowledge, confidence and practice.

9. Is there the same need for differentiation in primary science as there is in literacy and numeracy?

   Yes.

10. How is the transfer test affecting the teaching of primary science?

High concentration on knowledge content in Primary 6 & Primary 7 leads to an imbalance of skills.

11.Is there the need for more science support teachers in classrooms?

Yes, in small schools with composite classes, the support teacher is a valued resource to ensure quality teaching and learning in science and technology. However, there are none at present with specific duties for smaller schools.

12. Has science been effectively downgraded as a result of the School Improvement emphasis on Literacy and Numeracy?

No, science and technology remains a core subject in the Northern Ireland Curriculum and rightly so!

13. Should science be assessed at the end of Key Stages in Northern Ireland as it is in England and Wales?

No, formal assessment would place a heavy burden on classroom teachers who are already stretched to the limit.

(Appendix 3c)

Postal Response to

Interview Questions

with

Advisory Teacher for Primary

Science & Technology 3

Questions to be addressed

(Primary Advisers/Field Officers)

In your responses to all these questions it is your considered opinions I am seeking.

1. To what extent do primary teachers understand the key features of the programmes of study for Science (NIC 1996), i.e. is teachers' understanding sufficient for the areas they are expected to teach?

In general, no! Many teachers understand facts but not basic underlying concepts. They think if a child can say for example, ' sounds are caused by vibrations', that equates with a level of understanding.

2. How do primary teachers perceive their competence in helping children to achieve the attainment outcomes in science and technology?

   Primary teachers' competence is very well perceived.

3. If low competence is apparent - what are the reasons for it and what remedial steps are seen as being required to improve competence?

   If competence is low it is due to lack of scientific background or level of study. Poor in-service training, the effects of the 'Transfer' procedure and the government's push on factual acquisition of knowledge are also contributory factors. Remedial action would include in-school support and the removal of level 5 from the Northern Ireland Primary Science Curriculum.

4. What aspects of pedagogy relating to teaching science and technology do teachers find difficult?

   - *skills-based teaching*
   - *Use of tools*
   - *Thinking skills*

5. What help do teachers receive from in-service training courses in developing appropriate pedagogical skills? (Do the courses concentrate on content or pedagogy and why)?

Courses deal with both content and pedagogy. Teachers' demand is content focused because this is what they are being judged on by parents, transfer results and the government.

6. As advisers/field officers do not have the right to sit in on classes (as opposed to inspectors who do have the statutory right), on what evidence do advisers/field officers decide on what to include in their in-service courses?

    - *Working with teachers in schools - in this situation their needs are apparent.*
    - *Schools' science schemes which lack evidence of and progression in Attainment Target 1 - planning, making and investigating.*
    - *Needs analysis carried out by the ELB's.*
    - *Evidence from DENI reports.*

7. Is there any objective evaluation of the training the E.L.B's provide, apart from teacher questionnaires?

    - *DENI inspections*
    - *Self Evaluation*
    - *Schools' evaluations*

8. What changes in pre-service and in-service training are likely to improve primary teachers' knowledge, confidence and practice in teaching science and technology?

    Pre-service and in-service training must concentrate on the teaching and learning of Attainment Target 1, also more specific guidance on exactly what needs to be taught.

9. Is there the same need for differentiation in primary science as there is in literacy and numeracy?

   No, literacy and numeracy form the basis of everything, they should be prioritised.

10. How is the transfer test affecting the teaching of primary science?

Desperately! Too much emphasis on factual acquisition.

11. Is there the need for more science support teachers in classrooms?

   Yes, but the level of demand from Government, DENI and CCEA needs to be drastically reduced. Teachers cannot juggle so many balls and keep them all up at the same time.

12. Has science been effectively downgraded as a result of the School Improvement emphasis on Literacy and Numeracy?

   No, science and technology have been greatly enhanced as it offers many opportunities for the development of real life literacy and numeracy.

13. Should science be assessed at the end of Key Stages in Northern Ireland as it is in England and Wales?

   At the moment, no! It would mean considerable pressure for teachers. In the future, yes! When the issues of overload and content have been sorted.

(Appendix 3d)

Postal Response to

Interview Questions

with

Primary Advisor for

Science & Technology 4

Questions to be addressed

(Primary Advisers/Field Officers)

In your responses to all these questions it is your considered opinions I am seeking.

1. To what extent do primary teachers understand the key features of the programmes of study for Science (NIC 1996), i.e. is teachers' understanding sufficient for the areas they are expected to teach?

Many teachers are not well versed in the knowledge and skills requirements..

2. How do primary teachers perceive their competence in helping children to achieve the attainment outcomes in science and technology?

   Teachers underestimate their competence.

3. If low competence is apparent - what are the reasons for it and what remedial steps are seen as being required to improve competence?

   Low competence is apparent because of teachers' lack of knowledge. Very few have a science background at 'GCSE 'or 'A' level.

4. What aspects of pedagogy relating to teaching science and technology do teachers find difficult?

   Practical science, the investigative approach and the practical technology skills in manipulating materials and constructing models.

5. What help do teachers receive from in-service training courses in developing appropriate pedagogical skills? (Do the courses concentrate on content or pedagogy and why)?

Courses in the past concentrated on both but the focus is now on pedagogy as the knowledge element is largely embedded.

6. As advisers/field officers do not have the right to sit in on classes (as opposed to inspectors who do have the statutory right), on what evidence do advisers/field officers decide on what to include in their in-service courses?

- *Responses from teachers at INSET courses*
- *Specific requests from schools*
- *Comments in inspection reports.*

7. Is there any objective evaluation of the training the E.L.B's provide, apart from teacher questionnaires?

Mainly three months later in the form of a questionnaire to ascertain if strategies are being implemented. Follow-up visits to schools and inspection findings also allow for evaluation.

8. What changes in pre-service and in-service training are likely to improve primary teachers' knowledge, confidence and practice in teaching science and technology?

There is the need for school focused and class based support also team teaching and the promotion of literacy and numeracy through science and technology.

9. Is there the same need for differentiation in primary science as there is in literacy and numeracy?

Yes but differentiation in primary science is problematic because of equipment and resource requirements. Differentiation in primary science is mainly through outcome.

10. How is the transfer test affecting the teaching of primary science?

The transfer test omits practical science and process development in Primary 6 and Primary 7

11.Is there the need for more science support teachers in classrooms?

In smaller schools maybe!

12. Has science been effectively downgraded as a result of the School Improvement emphasis on Literacy and Numeracy?

Yes, by schools but both literacy and numeracy can be developed through science and technology. The Transfer procedure ensures the high profile of science and technology.

13. Should science be assessed at the end of Key Stages in Northern Ireland as it is in England and Wales?

    Probably!

(Appendix 3e)

Telephone Interview

with

Assistant Advisory Officer

for

Science & Technology 5

Questions to be addressed

(Primary Advisers/Field Officers)

In your responses to all these questions it is your considered opinions I am seeking.

1. To what extent do primary teachers understand the key features of the programmes of study for Science (NIC 1996), i.e. is teachers' understanding sufficient for the areas they are expected to teach?

With regard to the revised science curriculum, teachers' understanding is sufficient in Living Things and Materials. Grater understanding is needed in some aspects of physical processes, in some areas of forces, sound and light.

2. How do primary teachers perceive their competence in helping children to achieve the attainment outcomes in science and technology?

   Primary teachers are not competent or confident in their ability to help children achieve the attainment outcomes. They are not familiar with the attainment outcomes. Competence is judged on transfer results.

3. If low competence is apparent - what are the reasons for it and what remedial steps are seen as being required to improve competence?

   Low competence is apparent. There is a particular problem with Attainment Target 1 and the development of process skills. Teachers need to see good practice, discover how others are succeeding, reflect on their own methodology and plan accordingly.

4. What aspects of pedagogy relating to teaching science and technology do teachers find difficult?

   Organisational issues with regard to practical work and differentiation, also deciding what is actually required in scientific investigations. Teachers tend to experience difficulty when there is a process involved..

5. What help do teachers receive from in-service training courses in developing appropriate pedagogical skills? (Do the courses concentrate on content or pedagogy and why)?

There has always been a concentration on content. I personally have prioritised practical sessions with a focus on science process skills. The professional skills associated with science teaching have not been given precedence because schools and teachers have not voiced pedagogy as a concern.

6. As advisers/field officers do not have the right to sit in on classes (as opposed to inspectors who do have the statutory right), on what evidence do advisers/field officers decide on what to include in their in-service courses?

   Consultation with schools, principals and co-ordinators. Judgement is also based on teachers' responses and work in courses. I have gained information from the 'Technology Challenge'. I am aware of pupils lack of independence in planning, manipulating materials and tools, explaining and constructing. This must inform the content of future courses.

7. Is there any objective evaluation of the training the E.L.B's provide, apart from teacher questionnaires?

   No, only informal remarks from teachers and other support personnel.

8. What changes in pre-service and in-service training are likely to improve primary teachers' knowledge, confidence and practice in teaching science and technology?

   Pre-service and in-service training must focus on Attainment Target 1, planning, making and investigating. Teachers' knowledge can develop alongside scientific process skills.

9. Is there the same need for differentiation in primary science as there is in literacy and numeracy?

   Yes, there is the same need but a different set-up is required. There must be differentiation in task as well as outcome. Skills development and academic achievement do not always coincide.

10. How is the transfer test affecting the teaching of primary science?

The primary science curriculum, particularly in Key Stage 2 is dominated by the acquisition of knowledge.

11.Is there the need for more science support teachers in classrooms?

Yes.

12. Has science been effectively downgraded as a result of the School Improvement emphasis on Literacy and Numeracy?

Definitely

13. Should science be assessed at the end of Key Stages in Northern Ireland as it is in England and Wales?

Yes, it must become part of the assessment procedure. It has lost its profile because it has not been assessed. Assessment must focus on both content and process.

(Appendix 3f)

Interview

with

A Former Primary Science

Field Officer 6

Questions to be addressed

(Primary Advisers/Field Officers)

In your responses to all these questions it is your considered opinions I am seeking.

1. To what extent do primary teachers understand the key features of the programmes of study for Science (NIC 1996), i.e. is teachers' understanding sufficient for the areas they are expected to teach?

Depends on how well organised and structured the primary science programme is within the school. If it is well planned within year bands and key stages and teachers understand the programme they have to cover and the range of activities they must undertake then they are comfortable.

Teachers' science knowledge is not as thorough as some might want but if support within the school is available, teachers find it is sufficient for them to get through.

2. How do primary teachers perceive their competence in helping children to achieve the attainment outcomes in science and technology?

There is a considerable number of teachers who are 'unsure' in primary science particularly in terms of investigative science, i.e. in trying to ensure that Attainment Target 1 is covered.

In my experience teachers generally cover science content through:

- *Teacher led practical work*
- *Teacher demonstration*
- *Small group activity*

All rely on considerable question and answer technique which results in a lot of recorded work. Practical work is done - but it is not investigative work.

Teachers do not have the confidence or competence to set up an hypothesis. They don't encourage pupils to ask:

- *What are we looking at?*
- *Why are we looking at this?*
- *What are the stages we must go through?*

Teachers are uneasy with this structure. They are not encouraged that it is O.K. to do so - let go of the written work - be prepared to give pupils freedom to carry out tests, control variables, step back, analyse and report back.

With average class sizes of twenty five and mixed ability groupings, how practical is this?

Teachers are more comfortable with keeping control.

3. If low competence is apparent - what are the reasons for it and what remedial steps are seen as being required to improve competence?

Teachers are not confident with full delivery of Attainment Target 1.

Schools can try to solve this problem in their planning.

Primary science is unique - it is delivered through a process - it cannot be delivered effectively through question and answer process.

Teachers do not have the experience, ability or knowledge to take on board the investigative approach.

Remedial steps must happen within the school in the form of workshops - this is how you would work with this in the classroom.

4. What aspects of pedagogy relating to teaching science and technology do teachers find difficult?

Teachers do not have scientific knowledge - they basically don't know the answer. If they read up on it they need reassurance and confirmation.

Some good teachers have the process but science content can cause problems.

Initially in my role as field officer, I pushed the process because I believed that content would take care of itself.

5. What help do teachers receive from in-service training courses in developing appropriate pedagogical skills? (Do the courses concentrate on content or pedagogy and why)?

Teachers receive increasingly little help from in-service. In recent years the focus has been on cluster groups and the teachers themselves to act in a co-ordinating role.

Field officers are now spread thinly around.

Courses concentrated on content because it is what principals' and co-ordinators' requested.

6. As advisers/field officers do not have the right to sit in on classes (as opposed to inspectors who do have the statutory right), on what evidence do advisers/field officers decide on what to include in their in-service courses?

   CASS survey of needs and feedback from cluster groups.

7. Is there any objective evaluation of the training the E.L.B's provide, apart from teacher questionnaires?

   I am not aware of any specific evaluation of INSET. The Inspectorate do investigate the E.L.B.'s INSET provision.

8. What changes in pre-service and in-service training are likely to improve primary teachers' knowledge, confidence and practice in teaching science and technology?

   Within Initial Teacher Education there must be an element which looks at primary science and the range of programme that teachers' are expected to deliver within schools.

   Within the Induction Programme attention should be directed not only to content but the teacher's ability to develop investigative skills.

   If SDPR is implemented correctly teachers should have the opportunity to identify weaknesses and make school management aware that they are in need of support.

   In-service training has fallen away - primary science is now up an alley, there is no dramatic need to push it. ICT has taken over. Unless science re-emerges, it will be an also ran in terms of in-service training.

9. Is there the same need for differentiation in primary science as there is in literacy and numeracy?

   Most definitely. Pupils are coming at science with different concept levels and they have different levels of skills.

   However, if teachers have difficulty with differentiating in literacy and numeracy they are really going to struggle with differentiation in science.

10. How is the transfer test affecting the teaching of primary science?

The transfer has choked the life out of what I understand to be true primary science - it has not choked the life out of science in primary schools.

It has become very formulate. The extent of investigative science in the transfer test is down to the control of very simple variables.

Investigative questions cannot be written. The transfer test pays lip service to investigative work.

Whilst the transfer system has done irreparable damage in terms of pure primary science, teachers are relatively happy with it. - it can be done in a comprehension question and answer format.

11.Is there the need for more science support teachers in classrooms?

No - we need more teachers competent in primary science in classrooms.

My experience as a science support teacher has been:

you go ahead and teach it, why should I duplicate what you are here doing?

12. Has science been effectively downgraded as a result of the School Improvement emphasis on Literacy and Numeracy?

Yes. Science has secured its place in the curriculum only because of the transfer system. The focus is now ICT.

13. Should science be assessed at the end of Key Stages in Northern Ireland as it is in England and Wales?

Yes - it would help to promote investigative science and ensure an equal balance between content and process.

Teachers don't see the development in Attainment Target 1, it is qualitative. An assessment unit which sets the pupil a practical test and hypothesis and allows the teacher to observe the stages the child moves through would be appropriate.

(Appendix 3g)

Interview

with

A Former Assistant Primary Adviser for Science and Technology 7

Questions to be addressed

(Primary Advisers/Field Officers)

In your responses to all these questions it is your considered opinions I am seeking.

1. To what extent do primary teachers understand the key features of the programmes of study for Science (NIC 1996), i.e. is teachers' understanding sufficient for the areas they are expected to teach?

For me the key features of the programmes of study are the emphasis on the development of skills - through the skills children access the knowledge.

The education system, however, demands the knowledge more than the skills.

Teachers' understanding is not sufficient for the areas they are expected to teach, especially in upper Key Stage 2. Teachers limit their knowledge to factual recall (i.e. the 'Transfer').

It is of course not the teachers' fault but what the system demands of them.
For example: Sound / Light
Teachers will develop those areas to the specification of the Transfer Test but will not have the deeper understanding to respond adequately to pupils' questions.

'Every time I look at sound/light in the programmes of study, I have to go back and remind myself of the scientific concepts involved in order to ensure correct feedback to pupils'.

2. How do primary teachers perceive their competence in helping children to achieve the attainment outcomes in science and technology?

   Most teachers I have worked with do not have the confidence to help children achieve the attainment outcomes in science and technology.

   Teacher confidence is probably a barrier to teachers approaching science in a fun way.

   When teachers are confident they encourage children to think in a more logical way. Knowledge is, therefore, secondary to process - sadly this is not in vogue with the 'transfer procedure'.

3. If low competence is apparent - what are the reasons for it and what remedial steps are seen as being required to improve competence?

Lack of confidence is partially responsible for low competence. Teachers need greater understanding of the statements of attainment.

4. What aspects of pedagogy relating to teaching science and technology do teachers find difficult?

Teachers' find the following difficult:

- *Accessing of skills.*
- *An understanding of how to build them into teaching.*
- *How to develop skills through content.*
- *The importance of skills before content.*

Many teachers may not admit to the above as being difficult but the focus of training has been on developing areas of curriculum content: e.g. courses on forces and energy - the emphasis has not been on investigative skills!

5. What help do teachers receive from in-service training courses in developing appropriate pedagogical skills? (Do the courses concentrate on content or pedagogy and why)?

Training courses concentrate on content because teachers demand this. There has been some attempt recently to redress the balance - field officers are now encouraged to promote the development of skills.

6. As advisers/field officers do not have the right to sit in on classes (as opposed to inspectors who do have the statutory right), on what evidence do advisers/field officers decide on what to include in their in-service courses?

Field officers have a grasp of key issues from:

- *Evaluation reports from previous courses*
- *School Survey of needs*

Co-ordinators are subsequently interviewed to determine the school's requirements.

Often, however, what the co-ordinator claims isn't what the school in effect needs!

Many co-ordinators call for schemes of work, lesson plans, etc. From anecdotal evidence and visits to actual classrooms you become aware of the fact that this isn't really the issue., e.g. the real focus is the link between structured play and science!

7. Is there any objective evaluation of the training the E.L.B's provide, apart from teacher questionnaires?

Field officers write reports of work in the particular school. The principal and staff comment on the field officer's intervention. In my experience schools were complimentary - everything was great and super and indeed it probably was to have someone coming in with ideas and resources.

- *Nothing was measured as such.*
- *There is an attempt at the moment (by the ELB's) with the introduction of action plans/success criteria to evaluate more fruitfully the training provided.*
- *DENI have an overall monitoring role in E.L.B. provision*

8. What changes in pre-service and in-service training are likely to improve primary teachers' knowledge, confidence and practice in teaching science and technology?

Teachers are attracted to accreditation. In-service training should offer more accredited courses, where teachers have to take a 'learning part' into their practice in school during the week and comment in following sessions. Teachers therefore 'design to best fit their situation'.

'Teachers will stick their big toe into the water and find out it is not so difficult - they will realise the spin offs'.

9. Is there the same need for differentiation in primary science as there is in literacy and numeracy?

The differentiation in literacy has a knock on effect into science.

Differentiation in science is down to:

- *How children access information?*
- *Can they read the worksheet?*
- *Can they respond on the report?*
- *Do they have the numeracy skills?*

The differentiation in literacy and numeracy is already affecting science. It is easier to differentiate in literacy and numeracy because teachers are confident in their ability to do so. When teaching science we teach a topic, it is safe, pupils record in a differentiated manner. Differentiation is by outcome not by intent.

10. How is the transfer test affecting the teaching of primary science?

The Transfer Test affects the teaching in primary 6 and Primary 7. The focus is on content, the grounding in concepts. There is the suspicion that level 5 is included in the transfer and therefore, the teaching of facts is paramount, rather than investigating and discovering.

The Transfer has:

- *had a clamping down effect on science*
- *reduces the fun of science*
- *has put science on the map - but in the wrong way*

11.Is there the need for more science support teachers in classrooms?

No - not with the focus on literacy, numeracy and I.C.T.

12. Has science been effectively downgraded as a result of the School Improvement emphasis on Literacy and Numeracy?

The Transfer keeps science on the agenda but it is no longer a number one priority - it has been downgraded.

The emphasis on literacy and numeracy should be extended into science.

Schools have already looked at the basic areas of literacy and numeracy. They are now choosing contexts for their development in other curriculum areas. Now is the time for literacy to be developed through science.

13. Should science be assessed at the end of Key Stages in Northern Ireland as it is in England and Wales?

Yes: Instead of assessing in the Transfer procedure, science should be assessed in a process similar to the 'assessment units' in English and Mathematics. Teachers would therefore have to look critically at the teaching of science throughout the school and become involved in internal standardisation to see how their children are performing.

(Appendix 3h)

Postal Response to

Interview Questions

with

A Former Primary Science

Field Officer 8

Questions to be addressed

(Primary Advisers/Field Officers)

In your responses to all these questions it is your considered opinions I am seeking.

1. To what extent do primary teachers understand the key features of the programmes of study for Science (NIC 1996), i.e. is teachers' understanding sufficient for the areas they are expected to teach?

With the introduction of the Northern Ireland Science Curriculum understanding was poor, it has improved but still is not sufficient.

2. How do primary teachers perceive their competence in helping children to achieve the attainment outcomes in science and technology?

   Many teachers feel apprehensive. They need reassurance, support and resources.

3. If low competence is apparent - what are the reasons for it and what remedial steps are seen as being required to improve competence?

   The reasons for low competence are inadequate initial training, lack of staff development and a very negative attitude towards science. There is a need to address teacher training and put in place strategies to release teachers for further training. Lack of funding impedes this.

4. What aspects of pedagogy relating to teaching science and technology do teachers find difficult?

   - Scientific concepts and lack of expertise
   - Classroom management of groups
   - Recording skills

5. What help do teachers receive from in-service training courses in developing appropriate pedagogical skills? (Do the courses concentrate on content or pedagogy and why)?

Courses in which I was involved concentrated on both content and pedagogy - the topic, the concepts and the strategies involved.

6. As advisers/field officers do not have the right to sit in on classes (as opposed to inspectors who do have the statutory right), on what evidence do advisers/field officers decide on what to include in their in-service courses?

- *As a field officer I was involved in team teaching with classroom teachers. This gave me a 'fair claim' to teachers' knowledge and concerns. This allowed me to plan accordingly.*

- *CASS survey of needs.*

7. Is there any objective evaluation of the training the E.L.B's provide, apart from teacher questionnaires?

   DENI Inspections.

8. What changes in pre-service and in-service training are likely to improve primary teachers' knowledge, confidence and practice in teaching science and technology?

- *Expertise needed in basic concepts.*
- *Classroom management skills.*
- *A positive attitude towards science education.*

9. Is there the same need for differentiation in primary science as there is in literacy and numeracy?

   Yes, there is the same need but a different set-up is required. There must be differentiation in task as well as outcome. Skills development and academic achievement do not always coincide.

10. How is the transfer test affecting the teaching of primary science?

Too much emphasis on rote learning of facts to the detriment of skills development.

11. Is there the need for more science support teachers in classrooms?

Yes, in terms of pedagogical skills required in teaching science.

12. Has science been effectively downgraded as a result of the School Improvement emphasis on Literacy and Numeracy?

Probably and there is certainly no need for it. Literacy and numeracy can embrace many of the scientific concepts and skills - language, reading, writing, measuring and interpreting.

13. Should science be assessed at the end of Key Stages in Northern Ireland as it is in England and Wales?

The transfer test in year 7 coupled with existing Key Stage 2 assessment places an enormous burden on teachers. The entire assessment system would need to be redesigned to include science.