Science teachers' perceptions of expertise in practice : An exploratory study.

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Science Teachers' Perceptions of Expertise in Practice: An Exploratory Study

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Abstract

This thesis reports on an exploration of the nature and characteristics of science teaching expertise as exhibited by six identified expert science teachers. An action research methodology was adopted with data gathered through: semi-structured interviews; classroom observations, and reflective discussions. A culture of collaboration between the researcher and teachers was encouraged by the researcher in an attempt to create a 'bottom-up' approach to the study. The teachers acted as research collaborators by continuously reflecting on, and analysing their knowledge and practice within the context of the study.

The reported study emphasises a need for identifying characteristics of science teacher expertise from the insights of teachers themselves. The study considers the reflections and perceptions of the science teachers involved to be an important part of their continuing professional development, which leads to a greater self-awareness and understanding of their teaching expertise.

Findings show that these six science teachers demonstrate: subject master; deep pedagogical understanding; considerable pedagogical content knowledge, and a desire to continue learning for an entire professional life, in an attempt to keep abreast of changes and developments in science and education. Within these characteristics, the teachers exhibit, for example, organisational skills, empathy, flexibility, intuition, enthusiasm and professionalism. Most of all, they demonstrate an ability to operate and communicate at the level of their pupils.

They study contributes to the debate about effective teaching and better ways for teachers to learn from their experienced by offering a detailed account of science teacher expertise from the perceptions of six expert teachers. The study also highlights a wide ranging existing literature base in a attempt to offer a way of thinking about teaching expertise. Findings from the study indicate strong similarities with those of the existing literature.

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1 Introduction

1.1 Context and origins of the study

Central to government policy today, is the aim to modernise the teaching profession. This is backed by an overall commitment to raising standards and achievement. In a recent Green Paper 'Teachers Meeting the Challenge of Change' (DfEE, December 1998) it is stated that the eventual goal is to produce a world-class education system where every school is excellent or improving or both (p.1). So, teachers are now faced with the challenge of improving their knowledge and practice to very high standards.

Changes to Initial Teacher Training (ITT) include national testing in an attempt to secure high skill levels in literacy, numeracy and Information and Communication Technology (ICT) and a review of procedures for Qualified Teacher Status (QTS). These are coupled with an attempt to attract high quality graduates into a profession which currently appears to be an unattractive option for future professionals. The Green paper states that in-service teachers can expect a strong commitment from government to the provision of professional development activities, while outstanding classroom teachers will be rewarded through a new pay scheme that aims to encourage the best teachers to stay in the classroom rather than seeking promotion through management roles.

The publication of the DfEE's proposed framework for professional development- Professional Development: Support for Teaching and Learning (DfEE, February

2000); and the intended introduction of the Performance Threshold, represent a major challenge to teachers. The Threshold Standards, as currently outlined (DfEE, March 2000), place the onus on teachers to provide clear evidence to show that they meet the standards set out. An important element of this is the requirement for teachers to demonstrate their continuing professional development (CPD). To respond to the challenge of meeting the Threshold Standards teachers will be required to take ownership and responsibility for their professional development, and provide explicit evidence of their involvement in CPD activity. The implications for teachers seeking career advancement are clear. They will have to make their own case to their head teacher (and an independent external assessor) and provide evidence in support of it. This will require teachers to identify their strengths and to develop their weaknesses—to know their own practice characteristics and skills.

Those teachers who are recognised as outstanding will be encouraged to stay in the classroom and seek promotion to Advanced Skills Teacher (AST) status. This initiative provides expert teachers with the opportunity to be nominated by their schools and assessed by external consultants, in order to achieve the designated status. The post entitles the teachers to a higher pay range while staying in the classroom. There are however, other commitments that ASTs may have to fulfil, such as:

- participation in supporting Initial Teacher Training
- mentoring Newly Qualified Teachers (NQTs)
- provision of advice on classroom management and teaching methods to other teachers
- production of high quality teaching materials

- provision of advice on in-service training
- provision of guidance and support for teachers who are experiencing difficulties
- participation in teacher appraisal

The standards laid down for candidates seeking to gain AST status (see appendix 1) are systematic but do not provide a detailed account of the key characteristics of expert knowledge and practice. However, it is acknowledged that this is not the aim of the process. Even so, a rich understanding of expert teachers' skills and knowledge may provide a better framework from which to identify prospective AST candidates and also define the statutory duties that individual ASTs may be best suited to become involved in. The criteria laid out for becoming an AST are relatively standard and could be applied to most 'good' teachers. The intention of this present study is to reveal a much richer understanding of the nature and elements of expert science teachers' practice and knowledge.

Through the Office for Standards in Education (OFSTED) and the Teacher Training Agency (TTA), government policy has led to the formulation of a professional development framework for teachers. The National Professional Qualification for Headship (NPQH) and National Professional Qualification for Subject Leaders (NPQSL) are major elements within this framework. The government bodies have used a working party of perceived experts from Local Education Authorities (LEAs), Higher Education Institutions (HEIs), professional associations, head teachers and others both inside and outside the profession. While acknowledging the value of this approach and of the theory driven research presented in the literature review of this

thesis, the approach taken for this present study is fundamentally different. To reveal the implicit notions that teachers have of their practice requires a close relationship between the researcher and those teachers participating in the research. The close relationship induced by the researcher during the study, demonstrates an active partnership between researcher and practitioners. As this study reports, a spirit of trust, responsibility and collaboration was developed with the participants fully collaborating as a group to produce a detailed picture of the nature of science teacher expertise as exhibited by the six teachers involved with the present study.

1.2 Why study expert science teachers?

This study promotes thinking about the nature of science teacher expertise and a range of teaching methods and approaches to choose from (see chapter 6). Also, by making explicit the characteristics and skills exhibited by expert science teachers a pedagogical framework can be constructed which beginning and established teachers may build on to inform their own practice. Furthermore, the constructed framework may be strengthened if experts can provide clear insights into their teaching and learning approaches and underpinning reasoning.

Teachers' knowledge is reflected in their actions and they are rarely called upon to articulate the underpinning features of their expertise and skills (Olson, 1992). Many of their actions are routinised and, although they may reflect constantly in and on their practice, they have little opportunity or need to define specifically what it is they do best (Apple project, 1999). This present study has enabled the science teachers involved to think about their expertise and express their knowledge and practice in a

suitably technical and clear language. Thus, the value of the study is its potential to promote and develop the growth of other (non-expert) teachers, particularly beginning teachers. Through a model of science teacher expertise, formulated from the perceptions of science teachers, non-expert science teachers may be enabled or even trained to think and practice as experts do.

1.3 Aims of the study

The study is built around three main aims which are:

1 To explore the nature of expertise within teaching with specific reference to science teaching.

This is the primary aim of the study. Studies of expertise that concentrate on science teaching are few (Kagan and Tippins, 1992; Barba and Rubba, 1993). Therefore an exploration of its character and how this is manifested is overdue. This point has been achieved by looking at similar and differing perceptions of expert practice from two fields: those of social scientists and educationists, which are contained in the existing literature, and those of the science teachers who participated in the study.

2 To highlight key characteristics of expert science teacher practice and thinking and the nature of the interaction between them.

The second aim focuses on the things which expert science teachers do that other science teachers do not. These methods and approaches have been identified through

descriptive accounts of classroom observations and interviews with identified expert science teachers. Emergent themes are compared to the findings contained within the existing body of knowledge to show tensions and relationships. From these comparisons a detailed model of science teacher expertise has been teased out.

3 To inform the structure and content of teacher education programmes and Continuing Professional Development (CPD).

In the light of recent government proposals to designate Advanced Skills Teachers there is a need to identify how teacher education programmes may benefit from the findings of this current study. By talking to practising teachers (all of whom are regarded by their peers as experts and have been or are involved in teacher education as mentors, and two who are ASTs) about their perceptions of expert practice, the study highlights how we are able to incorporate aspects of expertise into teacher education. Thus, enabling student teachers and NQTs to clarify their experiences and provide a way for them to access expert science teachers' professional knowledge. Established teachers can identify a way of looking at their own practice in an attempt to meet the Threshold Standards and beyond.

The aims have been carefully designed to structure the research and to provide a significant and much needed contribution to the existing body of knowledge in the areas of teacher education and teacher development. Therefore, the study makes a valuable contribution to existing literature in this field. This, together with present governmental policy aimed at highlighting the expert teacher through the AST initiative and with teacher's career advancement reliant on meeting Threshold

Standards, means that the research is very relevant and is potentially of significant value.

1.4 Problems in studying science teacher expertise

Science teaching is a very complex area and presents a number of problems for researchers studying this field. There were three main problems that this present study encountered. Much of what an expert science teacher does is tacit and practised through routines. The main difficulty is in the way that the teachers examine and understand their knowledge and practice, and more importantly, articulate perceptions of their knowledge and practice. As already stated earlier in this chapter (section 1.2) teachers are rarely called upon to articulate their knowledge and therefore, may not have an understanding of the methodological tools available for analysing and articulating their knowledge. So, developing a collaborative approach where teachers and researcher work together is very important.

It was also important that the science teachers involved with the present study remained focused on the aims of the research. With increasing pressures being placed on teachers (i.e. large class sizes, growing administrative duties) a danger of the teachers becoming deflected from the study's focus existed.

Another problem in studying expert science teachers' concerns selection criteria of participating teachers. Although many previous studies provide detailed descriptions of what expert teachers do, there are few which attempt to provide a broad model of teaching expertise and most prefer to concentrate on specific characteristics, such as

problem solving. This presents a problem when identifying 'expert' teachers for research involvement. Without an existing holistic model of teacher expertise to work from it is difficult to describe and select 'expert' science teachers. The large majority of studies seem to rely on experience as a valid indication of expertise. Experience in itself cannot be used as a valid measure of expertise and must be used alongside other criteria, such as peer review (Zeichner and Gore, 1990). The present study combines years of career experience with peer review for selection of the six participant science teachers who took part in the main phase of the research (see chapter three, 3.4).

Finally, in a study of this nature, time is a major issue. Freeing up time to take part in interviews and reflective discussions is difficult for teachers who have a full teaching timetable as well as other duties. Because of this issue dialogue between the researcher and teachers was not confined to face-to-face meetings and utilised email and telephone media to continue dialogue. Email and telephone discussions also helped to overcome the problem of travel, as geographical location of the teachers was also a time problem for the researcher in travelling to and from schools.

1.5 Approach

The approach of the study attempts to explore science teachers' perceptions of their classroom practice and how their knowledge and beliefs of science and pedagogy are manifested within the classroom. Implicit in this context is a notion of teacher as reflective practitioner. Schon's (1983) theory of the reflective practitioner provides a useful perspective for this particular study. His theory asserts that professionals reflect in and on action and was constructed from observations of the practice of a

range of professionals. Very often, the reflective process is so tacit in nature that it is difficult for professionals to articulate their reflections and for researchers to analyse their perceptions of practice and knowledge.

Through the collaborative nature of the study developed by the researcher, the science teachers' tacit understanding of their knowledge and practice is made clear as indicated in the findings (chapter 6). Each teacher was motivated to focus on their reflections and share these with the researcher and the other science teachers involved.

An action research methodology was adapted and used in an attempt to enable the teachers to combine their day-to-day practice with the study. They were able to focus more on their reflections during and after classroom practice by their participation in the study. As they were involved in every stage of data analysis, reflections in and on practice became more detailed and were articulated clearly through expressing perceptions about their own practice and thinking. The six teachers were also able to construct clearer perceptions through collaborating in a group reflective discussion with the other science teachers involved in the study. As the study is firmly based within a qualitative paradigm, semi-structured interviews, classroom observations and reflective discussions were developed and used as appropriate tools for gathering data.

1.6 Outline of the thesis

The thesis is organised through this introductory chapter that attempts to highlight the origins of the study and set the context. Seven subsequent chapters report on the

existing literature, methodology, data analysis, teacher profiles, findings from the study, conclusions, and implications.

Chapter two is the literature review and provides a comprehensive range of existing studies that are relevant to this present study. The review presents an overview of findings from existing studies and demonstrates a gap in the research, which focuses specifically on science teacher expertise. The chapter is organised under four subheadings: the novice-expert comparison; knowledge frameworks and cognitive model representations; the reflective practitioner, and teacher effectiveness. The reported literature presents a framework for thinking about science teacher expertise and sets the scene for a comparison of findings in chapter six.

The discussion of methodology in chapter three concentrates on the approach taken for the study and the justification for choosing a modified action research methodology. It details the collaborative process which was key to the success of the study and considers the tools used to gather data for the study. Strengths and weaknesses of the approach are discussed.

Data analysis techniques are reported in chapter four. Techniques used to analyse data are organised through a discussion that focuses on category identification, interpretation of emergent themes, coding and triangulation of data. The strengths and weaknesses of the techniques are summarised.

Chapter five presents the findings from the study, using the categories identified for organising data (perceptions of learning, teaching, science and reflection) as main

headings. Emergent characteristics are discussed under subheadings, and are supported by relevant quotes and accounts from the data.

Conclusions are drawn in chapter six by discussing the findings and offering supporting and contradictory evidence for a framework of science teacher expertise derived from a comparison of the findings from the present study with those of existing studies. The chapter also summarises the study, highlighting strengths and weaknesses.

Chapter seven discusses implications arising from the study for ITT in science and teacher CPD, while also making suggestions for further study.

2 Literature Review

2.1 Introduction

The existing research literature that concentrates on expert or effective teaching is large and detailed. There is however, by comparison, only a limited range of studies that have specifically investigated science teacher expertise. Despite this there appears to be a high level of consensus about the generic elements of expert teaching. In exploring how the best teachers manipulate techniques, approaches, styles and resources, how they evaluate their practice and that of others and how they think about teaching, researchers hope to disseminate a clear picture of a very complex profession. This chapter concentrates on research which has previously attempted to uncover the complexities of expert thinking and practice in order to provide a framework for this present study.

The literature review is organised into four categories: the novice-expert comparison; knowledge frameworks and cognitive model representations; the reflective practitioner; and teacher effectiveness. These categories were chosen as they represent the great majority of existing literature in this field. They also organise the review and offer a way of analysing the literature concerned with teacher and professional expertise. The categories identify how studies into expertise vary in approach and focus. Each category provides an insight into characteristics and aspects that are deemed to be fundamental to expert practice. While these categories detail research with diverse aims and approaches, there are many overlapping issues which support a rich vein of emerging characteristics of expert practice. A summary

of findings and implications for this current study is presented at the end of the chapter. The chapter will provide a framework for thinking about science teacher expertise and highlight elements of expert thinking and practice. It will also set the scene for contrasting and comparing findings from the present study with those highlighted within this chapter.

2.2 The novice-expert comparison

A good deal of research within the field of teacher expertise has concentrated on comparisons between expert and novice thinking and practice (Borko & Livingston, 1989, 1987; Barba & Rubba, 1993; Berliner, 1985; Leinhardt & Greeno, 1986). Data produced from these studies indicate that there is a vast difference in an expert's practice and thought processes from that of the novice.

Borko and Livingston (1989) interviewed and observed experienced and newly qualified, high school teachers of mathematics. Their findings suggest that novices have cognitive schemata which are less well developed than that of an expert and that their pedagogical reasoning has not matured to its full potential. This supports Norman's (1982) theory of learning. His belief is that novices work harder and at the accretion level, while experts perform with ease at the tuning level. Accretion is defined as the gradual accumulation and assimilation of knowledge while tuning is the process whereby experts put a 'fine edge' on their knowledge. This is consistent with Barba and Rubba's (1993) explanation of 'chunking'. Barba and Rubba (*ibid*) studied six expert and six novice teachers of earth and space science by comparing their problem-solving abilities on a five item problem-solving test. They describe experts as having the ability to select pieces (chunks) of knowledge and integrate these pieces

of procedural knowledge to aid smoothness and automaticity (routines) during practice.

They also state that expert teachers recognise non-productive solution paths early when problem solving, in contrast to novices who enter into a solution immediately only to find at a later stage that the chosen solution path is inadequate. The formulation of cognitive schemata and constant tuning and refining of knowledge of teaching, planning, problem solving and decision making all seem to add to the process of developing expertise. However, Barba and Rubba (*ibid*) do not explain clearly how expert science teachers operationalise their chunking ability.

Leinhardt and Greeno (1986) compared student mathematics teachers' practice to that of more experienced teachers who were acting as the students' mentors. The researchers suggest that by developing complex schemata for pedagogical knowledge, expert teachers (in this case teacher-mentors) are able to plan lessons better and are quicker at making decisions during their classroom practice than novice teachers. Novices may have a well developed content knowledge through their subject learning, but lack the ability to plan and implement a smooth lesson and are far slower in making decisions during interactive teaching.

Berliner (1985) compares the performance of three groups of teachers. One of these groups he designates as experienced/expert teachers of secondary mathematics and science who were nominated as excellent by their school principals. Other groups were established and novice teachers. The teachers were compared on standardised tasks. For example, looking briefly at slides of mathematics and science lessons and

describing what was seen. Berliner suggests that expert teachers have a lower variance than novices when identifying salient issues of a particular topic. What is being said here is that experts can focus on the main issues of a topic through experience of a wide variety of cases. They immediately recognise similar issues from other cases and treat them in a similar manner. This expert similarity he claims is; "*..what people hope for when they visit an expert opthamologist or automobile mechanic*" (p. 602). Chi *et al.* (1982) and de Groot (1966) also found that experts were able to identify underpinning principles and select an appropriate solution from a number of alternatives. In a later paper Berliner (1987) describes a repertoire of expertise being developed over numerous hours of classroom interaction and instruction which the novice has not yet gained. As the expert teacher continues to reflect, plan and interact he/she develops the ability to recognise patterns for action as, for example, an expert chess player would.

Barba and Rubba (*ibid*) cite Gagne *et al* (1988) classification of knowledge as declarative, procedural and structural knowledge. *Declarative knowledge* is knowledge which we are able to state. This includes subject content knowledge together with general cognitive knowledge. By performing an action or a skill *procedural knowledge* is engaged. Procedural knowledge is a plan for carrying out the stages of an activity: tying shoe laces or driving a car are actions within the domain of procedural knowledge. *Structural knowledge* brings together declarative and procedural knowledge and organises the information. Barba and Rubba's study compared expert and novice teachers of earth and space science engaged in problem solving of typical science problems using the three knowledge domains of Gagne. Their study found significant differences between novice and expert teachers while engaged in problem solving activity. Expert earth and space science teachers

generated more alternative solutions and subroutines while shifting between declarative and procedural knowledge less than novices. Their accuracy in solving problems is also greater than the novice teachers. The work of Chi *et al.* (1982) and Chase and Simon (1973) supports this notion.

A number of methods can be and have been used to explore teachers' conceptions of teaching and the nature of their thinking. Kagan (1990) identified various methods of investigation, for example self-report forms that use a similar format to a Likert-style scale. Others are methods of analysis which concentrate on teachers' descriptive language. Analyses of reflective statements were also contained in her review together with concept mapping. In a later study Kagan (1992) argued that the conceptions held by science teachers of teaching science are dominated by the way they themselves learned their subject. This claim was based on a study of novice teachers' self images as teachers. Huibregtse *et al* (1994) supported this argument and suggested further that this may be increased to include experienced teachers.

Kagan and Tippins (1992) studied pre-service teachers' observations of classroom teaching. The researchers analysed notes made by pre-service and in-service teachers who viewed video taped lessons. They found that pre-service teachers tended to comment more on the delivery of the lesson, how boring it was or how many times the teacher had contact with different pupils. In-service teachers however, often ignored the specifics of the classroom behaviour and concentrated on underlying purposes such as whether or not the objectives had been met and the pace and style of the lesson. The researchers concluded that this demonstrated a deeper understanding of teacher performance by the in-service teachers than that of the pre-service teachers. This indicates that expert teachers have a well developed knowledge of the

fundamentals of teaching, which they tend to ignore, and concentrate on the finer points of teaching. Whether or not the researchers are right to view the comments of the pre-service teachers as not demonstrating a deeper understanding of teacher performance is an issue for debate. New teachers may bring differing views and attentional foci to the profession that cannot be dismissed as superficial to a deeper understanding.

Using Berliner's (1988) theory as a framework for comparison, Schempp *et al* (1998) identified teachers' conceptions of knowledge and reflective practice. The study identified five novice and five competent teachers who were interviewed three separate times. They found that experienced teachers were more accepting of their knowledge deficiencies and more willing to learn than novice teachers. In subject areas that they are required to teach but felt that they had insufficient knowledge of, experienced teachers were motivated to research the area in order to identify the main elements of a concept and then to stage their teaching, highlighting important components. This, they felt, would ensure effective coverage of the concept. An interesting point here is that the experienced teachers had no hesitation in using knowledgeable students to help with explanations or discussions. Novice teachers, on the other hand, showed greater concern for the development of teacher-led activity. The researchers conclude that the novice teachers were more apt to shy away from language based interaction and keen to develop a teacher-led lesson. Schempp states that novices differ from experienced teachers in

> *...their interpretive abilities, planning skills and emotional commitment that they give to their work. While experienced teachers appear to be more interested in refining and improving their knowledge and techniques* (p.17).

Eisenhardt et *al* (1991) from a case study of one ITT course in the US recognise an advanced level of teacher expertise. They suggest that this level is reached when teachers begin to make their own decisions, take responsibility for their classes and invest emotionally in their practice. They go on to state that teachers who reach this level of expertise act out of an intuitive sense rather than a conscious sense of 'what to do.' They do not make clear at what stage this may be reached but merely state that it is only after the 'first few years' of teaching. Novices, they say, are unable to assume these roles as they are concentrating on identifying, labelling and following the rules of teaching. A great deal of a teacher's practice and thinking is idiosyncratic, so expertise may be reached after varying years of experience dependent on the individual teacher and not just after the first few years of teaching. It is highly likely that the accumulation of at least a basic amount of quality experience is needed from which to learn.

The studies highlighted above show a number of consistent issues. Rapid decision making abilities, qualitative problem solving skills and an insightful understanding of teaching practice to mention just three, show the development of a knowledge-rich and well organised framework for expert teaching.

The next section of this chapter will show how researchers have collated information about teachers' expertise and attempted to produce models or representations which convey a clear view of the stages and elements consistent with expert thinking and practice.

2.3 Knowledge frameworks and cognitive model representations

Considerable thought and method have been applied to researching expertise over recent years, most of which has overlapped or reinforced central issues relating to the field of expertise. Many detailed views have been offered about model representations of an expert's knowledge. For example, Dreyfus and Dreyfus (1986) use exemplars from the fields of mathematical modelling and computer systems as well as chess, car driving, senior management and plane flying. They explain their model as five stages of skill acquisition, which is rooted in perception and decision making as opposed to routine activity. From this they see skill integrating both routines and the decisions to employ them. Benner (1984) provides a detailed account of the application of the Dreyfus model. She analysed data from interviews based on critical incidents with a sample of nurses. Not only did she justify the model through her research but also presented a detailed explanation of nursing expertise based on it. Berliner's (1988) five stage model of teacher development (table 2.1) not only shares the same five stages of the Dreyfus model but also has very similar underpinning explanations of each stage. Berliner's emphasis is on the cognitive processes fundamental to teacher behaviour.

Table 2.1 Stages of expertise development

Stage 1	Novice
Stage 2	Advanced beginner
Stage 3	Competent
Stage 4	Proficient
Stage 5	Expert

(Berliner, 1988)

In Stage 1 the novice is rigidly bound to rules and plans with little creativity other than that within the scope of the rules. They have limited situational perception that

means they are unable to change tack at will and will carry on an activity even if it is fruitless. Ability to prioritise is also limited, incidents and issues within the classroom, such as monitoring pupils' understanding and distributing equipment, are given equal importance. Once Stage 2 has been reached the teacher has built up a number of guidelines for activities based on prior experience. However, situational perception is still limited as is prioritising. At Stage 3 teachers have developed standard, routine procedures. Teachers are organised and their actions are the result of conscious, deliberate planning. They have also begun to see their actions as part of long term goals and less of a 'one off' situation. By Stage 4 prioritising situations has become part of the routinised actions. The teacher can now separate important events and issues from those that are less so. The teacher has developed an ability to see the 'bigger picture' and plan their lessons accordingly toward annual aims rather than daily aims. Also in Stage 4, teachers begin to perceive deviations from normal patterns and react accordingly. This is to say that they are now developing the ability to change tack when activities are not producing the desired effect. Decision making is less laboured and quicker. At Stage 5, rules and guidelines are no longer relied upon. An intuitive notion of the classroom environment is embedded in a deep tacit knowledge. Analysis of events and actions only occur when problems arise, otherwise routines are kept fluid. Creativity is linked to a wider vision of what may be achieved and non-adherence to novice rules.

It is worth noting here that the above explanations of each stage are stated in terms of teachers as professionals. The Dreyfus model details professional practice and so is general in terminology. Their theory explains expertise as ongoing and non-reflective although they do not discount Schon's (1983) reflection-on-action which they say gives rise to intuition (Olson, 1992). This is a vague view of reflection with the focus

on changing no longer adequate practices, rather than breaking-down the performance into smaller elements for analysis. Dreyfus and Dreyfus do not describe the processes involved in learning from experience, the only indication given of how learning is realised is that of an accumulation of knowledge of cases. How this knowledge is selected, stored and retrieved is not explained. Berliner's model is grounded in cognitive theory and identifies the gradual acquisition of problem solving skills, fluid and flexible performance and standardised automated routines. But here too, an exact account of the process of learning from experience is not given. Human interpretations are susceptible to fallibility and therefore cases may become invalid. Attention must be paid to the quality of the experience and therefore the case, before generalisations can be made.

In a four year longitudinal study Shulman et al (1986, 1987; Shulman & Grossman, 1988; Wilson, Shulman & Richert, 1987) identified three main components of teacher knowledge: pedagogical knowledge, content knowledge, and pedagogical content knowledge. Pedagogical knowledge is knowledge of theories and principles of learning, teaching, classroom behaviour and management. Content knowledge is defined as knowledge specific to the teacher's specialist subject and Pedagogical Content Knowledge allows the teacher to transform content knowledge into a teachable form and it initiates an understanding of how topics are related and most effectively presented to the learner. These components are described as being part of a framework that organises these and other components such as: curriculum knowledge; other content knowledge; and general pedagogical knowledge, into an effective database or 'personal landscape' from which the teacher may draw upon or move freely within, while engaged in action (Salmon, 1995). The knowledge domains

develop cyclically with the teacher transforming, reflecting and gaining new comprehension before transforming again.

In a study of three secondary science teachers who were identified as good teachers by school colleagues, Sanders et al (1993) found that the teachers they observed and interviewed appeared to be expert in many ways, either when teaching their specialist or non-specialist subject. The teachers had a deep insight of how to pace lessons to ensure a smooth flow. The researchers related this to the development of complex schemata for teaching similar to that stated by Leinhardt and Greeno (1986). Two of the more specific conclusions which they drew focused on pedagogical knowledge. They state that the teachers have a strong base of pedagogical knowledge which seems to have the most influence when teaching out of their specialist area. It is also very evident when teaching within their specialism. They also claim that pedagogical knowledge:

> *...provided a framework for teaching that was filled in by content knowledge and pedagogical content knowledge"* (p.733).

Salmon (1995) likened expert knowledge to: "..an intricate personal landscape through which to move at will from one interesting vista to another" (p. 32). It would be fair to say that this notion of constructed knowledge assumes a more personal knowledge base which is uniquely derived from social and situational interaction. This is reinforced by Schmidt et al (1990). In their study of medical expertise they found that exposure to a large and varied number of cases may be an important element in the development of expertise.

> *Based on his/her unique experience with a certain disease, each physician develops rich idiosyncratic scripts for that disease, which may or may not resemble the scripts of other physicians or the text book. This may explain why some doctors have difficulty in diagnosing some diseases where others immediately recognise the essential patterns* (p. 617).

This appears to be a similar notion to that of Berliner (1987) and designates experience as important to achieving expertise. While few would disagree with this it should also be stated that the mere accumulation of hours of practice or exposure to a large number of cases does not in itself constitute nor guarantee expertise. Zeichner and Gore (1990) have argued for the need to consider the quality of the experience rather than the quantity. They emphasise that "one should not assume, as has often been the case in the past, that experience equals educative experience and that the more experience the better" (p. 107).

Jones et al (1997) and Bevins (1998) suggest that student-teacher mentoring is a two-way process where established teacher-mentors can learn from student teachers while offering their expertise and knowledge to students. The researchers interviewed twenty mentors covering a range of subjects and they claim that student teachers bring new ideas and ways of teaching to the classroom that an established teacher-mentor can use and adapt for their own practice. This indicates that pre-service teachers can offer a range of differing perspectives on teacher performance that established and expert teachers may learn from.

Experience then, is not just building a reserve of experiences from which to draw. It is actively seeking specific experiences from which to learn and then assimilating the learning from those experiences (Johnston, 1994). Ey (1978) states:

> *To be conscious is to live the uniqueness of ones' experience while transforming it into the universality of ones' knowledge.* (p.3)

This is an interesting point and has direct relevance to the findings presented in this thesis (see chapter 6). Experience helps to routinise actions through what Anderson (1987) calls 'compilation' of knowledge. Through knowledge compilation, tasks and

activities that are initially executed with much effort can, after repeated experience, become managed more efficiently and quickly.

Glaser and Chi (1988) provide an overview of expertise and highlight seven characteristics presented in table 2.2 which they generalise across professional domains and not just education.

Table 2.2 Characteristics of professional expertise

1	Experts excel mainly in their own domain
2	Experts perceive large meaningful patterns in their domains
3	Experts are fast; they are faster than novices at performing the skills of their domain, and they quickly solve problems with little error
4	Experts have superior short and long term memory
5	Experts see and represent a problem in their domain at a deeper level than novices; novices tend to represent a problem at a superficial level
6	Experts spend a great deal of time analysing a problem qualitatively
7	Experts have strong self-monitoring skills

(adapted from Glaser and Chi, 1988)

Their first characteristic, *experts excel mainly in their own domains*, is based on a lack of evidence of expert skill transfer from one domain to another. They cite Minsky and Papert (1974)

> *A very intelligent person might be that way because of specific local features of his knowledge-organising rather than because of global qualities of his thinking* (p. 17).

What they are saying here is that an expert is so in his/her subject and that there is evidence to show that they may act like novices out of their specific subject area and there is little evidence to prove that expertise is transferable across subject areas. As stated earlier, Sanders et al (ibid) found that expert science teachers teaching out of their specialist area sometimes performed like novices although they were able to draw on their pedagogical knowledge to assist them in such circumstances. This implies that the first characteristic does not take into account an expert teacher's

pedagogical knowledge which they rely on while teaching out of their specialism. This is to say that while teaching is highly context dependent an expert teacher may be able to excel outside of their specialism because of a well developed pedagogical knowledge base.

The second characteristic, *experts perceive large meaningful patterns in their domain*, is supported by the work of Newell and Simon (1972). They show that chess masters excel in their ability to recall patterns and clusters of pieces which they see during play. Glaser and Chi point out that this ability does not, in itself, reflect a superior perceptual capacity. Rather, it shows an effective organisation of the knowledge base.

The speed with which experts solve problems or perform a skill is indicative of the third characteristic, *experts are fast*. Two possible explanations are given for this: the first is put down to accumulated hours of experience of task performance such as a typist. Many hours of practice enable the skill to be executed quickly and more automatically, which in turn frees up memory to process other task related activity and unrelated tasks. The second is based around the assumption that experts arrive at solutions to problems quickly and accurately. Glaser and Chi use the example of a cab driver that will recognise the shortest and most economical route while travelling to a destination.

This also has implications for their fourth characteristic, *experts have superior short-term and long-term memory*. They explain that this is not because experts have a greater memory capacity than others, rather that the automaticity of their performance allows more memory to become available for storage of further relevant information. Barba and Rubba (ibid) found that expert science teachers tended to verbalise more

declarative knowledge and were able to retrieve more facts relevant to a problem situation.

This finding supports the fifth characteristic, *experts see and represent a problem in their domain at a deeper level than novices*. Chi et al. (1981) discovered that experts solving physics problems employed principles of mechanics to organise information, while novices used literal objects within the problem description. Thus, experts have concepts which are semantic or principle based, while novices' concepts are more syntactic or surface based.

Barba and Rubba's (ibid) study also supports the sixth characteristic of Glaser and Chi, *experts spend a great deal of time analysing a problem qualitatively*. In recognising possible alternative solutions and underlying principles expert science teachers analysed problems qualitatively, whereas novices moved immediately into a solution only to find the path they had chosen was incorrect. Glaser and Chi explain this expert behaviour by stating that:

> *Basically they build a mental representation from which they can infer relations that can define the situation and they add constraints to the problem* (p. 14).

Finally, the seventh characteristic highlights the reflection process, *experts have strong self-monitoring skills*. They state that experts seem to recognise their failures and errors in a more proficient and qualitative manner:

> *Experts ask more questions, particularly when the texts from which they have to learn are difficult. Novice learners, on the other hand, ask more questions on the easier materials* (p. 20).

They also argue that the superior self-monitoring skills of an expert reflect the superior domain knowledge and representation of that knowledge by the expert.

In a position paper Sternberg and Horvarth (1995) define a model that is based on psychological research across a variety of professional domains, but is specific to teaching, and raises very similar issues. They present a prototype view of expert teaching and their model seeks to provide a way of thinking about teaching expertise rather than claiming definitive status. Their aim was to distinguish expert teachers from teachers who are merely experienced at teaching. In table 2.3 the researchers suggest three ways in which expert teachers may differ from non-experts.

Table 2.3 Three differences between experts and non-experts

1	Experts bring knowledge to bear more effectively on problems
2	Experts solve problems more efficiently and in less time
3	Experts are more likely to arrive at novel and appropriate solutions to problems

(adapted from Sternberg and Horvarth, 1995)

From these statements they build their model around three core characteristics, *knowledge, efficiency and insight.* They go on to describe knowledge using Shulman's (1986; 1987) notion of pedagogical knowledge, pedagogical content knowledge and content knowledge. They also state that the expert possesses knowledge which is better organised than that of the non expert. This is in the form of mental scripts and schemata. Most of their claims support previous research findings (Shulman, 1986; 1987; Leinhardt & Greeno, 1986; Glaser & Chi, 1988). However, they do make an interesting argument for knowledge of the social context for teaching. They claim that an expert teacher has a tacit knowledge which enables them to cut through, for instance, administrative barriers which may impede the acquisition of resources. Sternberg and Horvarth see this as an important practical skill or 'savvy' which an expert teacher has.

The studies presented so far raise the question of tautology: does research and theory avoid tautology? Some of the studies detailed are simply unpacking linguistic

implications of the term expertise. Glaser and Chi's first characteristic--experts excel mainly in their own domain, is a good example. However, the purpose of presenting these studies is to draw attention to the types of characteristics which experts exhibit; to unpack expertise, and not to attempt to discover new insights into expertise.

As the literature presented so far has concentrated on teachers' thought processes it is pertinent to include in this chapter an overview of the notion of reflection. Whether depicted as a form of metacognition or self-evaluation it appears that reflection is an important process for reaching and maintaining expert practice.

2.4 The reflective practitioner

Schon's (1983; 1987) theory of the reflective practitioner is probably the most referred to in studies of professional performance. His critique of positivist epistemology is based on his belief that the technical rationality model does not articulate how professional's work in practice and that it is inadequate as a descriptor of professional practice. Schon's epistemology highlights creativity and artistry of performance as the way in which some professionals "...make sense of complexity and reduce uncertainty to manageable risk" (p.18) within professional activity. This he calls 'reflection-in-action.' His emphasis on intuition and the ability to reframe or reconceptualise a situation demonstrates his reduced concern with the unproblematic, general issues of professional practice (Eraut, 1994). Therefore, he concentrates less on expert practice when a situation is running smoothly and has centred on critical incidents or problem situations which give rise to reconceptualisation of the situation and reframing in an attempt to find a creative solution to the problem. Schon believes

that when a dilemma occurs the practitioner can, through reflection, draw from a repertoire of understandings and actions to solve the problem.

He indicates that this is a kind of "...thinking on your feet" (p.54). His statements of reflection-in-action and reflection-on-action are observations of engaged activity and of post activity. However, the two statements have been the cause of considerable debate centred on his theory. As Munby and Russell (1989) noted:

> *..his work is not sufficiently analytical and articulated to enable us to follow the connections that must be made between elements of experience and elementsof cognition so that we may see how reflection-in-action might be understood to occur* (p.74).

Eraut (1994) shares this difficulty:

> *Many of his long examples fail to provide any evidence that reflection-in-action is occurring; and in several examples, including all those from science, engineering and management, reflection-on-action appears to have been at least as likely a cause of reframing as reflection-in-action* (p. 148).

Eraut uses the term 'reframing' here to denote the monitoring process involved in metacognition. Indeed he prefers to remove the term 'reflection' from Schon's theory and sees it as a useful theory of metacognition. Olson (1992) believes that reflection is "*..part of the skilful process, not a parallel process which gives the action its intelligence*" (p. 17). Olson also states that reflecting and acting are not a dual process but one reflective action.

What Schon does make clear is that he holds little faith in the model of 'technical rationality' that he believes assumes that professional action is embedded in theory which precedes practice and that expertise lies in the theory and not the practice. He suggests that the challenge for understanding, developing and improving practice is to articulate the tacit knowledge which is at the foundation of practice. This is an

important implication for this present study as it implies that practitioners have a tacit knowledge of their practice, which only they may fully articulate.

Silcock (1994) believes that assuming two different types of reflective process (in-action and on-action) may be problematic in the use of reflective techniques today. By identifying core generic principles of reflective practices, contradictions may be reduced and a theory of reflection which does not distinguish between two types may be more useful. Therefore, he states that reflection may be defined as a:

> *Ubiquitous, cognitive process, not only reworking tacit knowledge into skill but providing, through symbolic transformations, a means for linking social and knowledge contexts, and for translating one sort of experience (e.g. academic) into another (e.g. practical)* (p.974).

Silcock suggests this to be a way of justifying competing models of reflective teaching. He does, however go on to warn against claiming too much for professional development programmes from a process which seems to be endemic to every element of teaching practice. This is to say that Silcock believes reflection to be as much a part of teaching as knowing one's subject area. Therefore, he feels that CPD programmes that claim reflection to be an innovative way of developing practice are, perhaps, just another way of understanding the process of reflection.

Reflective processes may enable practitioners to exploit and articulate professional knowledge which in turn enables knowledge and skill development. Reflective practitioners utilise a repertoire of techniques, including metaphors, cooperative discourse and analogies to enhance the process of reflection (Clift, et al, 1990; Yinger, 1987). Schon's account of reflection and subsequent analysis of other accounts (Olson, 1992; Eraut, 1994; Silcock, 1994) has shown that reflection is an important part of professional practice and should not be ignored. Experts are not incapable of

error and are prone to weaknesses common to human thought processes and it is possible for an expert to allow features of their expertise to stagnate or decay (Eraut, 1994). Thus reflection can be seen as an integral part of the process of achieving and more importantly maintaining expertise.

2.5 Teacher effectiveness

A yardstick frequently used to measure teacher effectiveness is pupil achievement. Although this approach was not used in the present study, there are characteristics contained in some of the reported literature which are pertinent to this study. Stallings et al (1978) research (targeted at reading instruction) indicated that the pupils they studied, who worked independently under teacher supervision or took direct instruction from their teacher, had a much higher achievement ratio than those who were expected to learn on their own, and that more frequent instruction was needed for lower ability pupils. This suggests that the effective teacher intervenes regularly to give guidance and instruction, while allowing pupils to work independently. A major review by Brophy and Good (1986) concluded that the quantity and pacing of instruction is essential to pupil achievement. This is consistent with many other research findings centred on this theme. They explain this through a number of key points outlined in table 2.4.

Table 2.4 Quantity and pacing of instruction

produce high engagement rates by effective organisation and management of the classroom
make transitions brief and coordinate smooth running activities which give little time for inattention
ensure a brisk pace through curriculum content which is continuous and progressive; moving through small steps ensuring minimal confusion and frustration
provide appropriate variety and challenge through assignments; demonstrate consistent accountability through feedback and clarity about when and how pupils may get help
structure information by providing advanced organisers, overviews and regular reviews of objectives; outlining content and making transitions clear; organising concepts and providing appropriate analogies
emphasise mastery with lower ability pupils which entails less material coverage; ensure appropriate stimulus and demands for higher ability pupils
continuous praise for pupil success; tolerance of calling out during teacher led activity

(adapted from Brophy and Good, 1986)

Something that is not contained in the above table, which Brophy and Good (1986) found, is that pupils learn more when their teachers cover more subject content. Brophy and Good do not stipulate whether they mean adequate coverage of curriculum content or coverage of a vast amount of subject specific material. If they mean the former then surely this is an obvious conclusion.

However, the abilities stated in the above table would be widely accepted as important factors for effective teaching and thus, successful learning. Implicit in table 2.4 is a strong belief in pupils' ability to learn. Fullan (1985) believes that there is a need for teachers to have high expectations of their pupils. The 'Fifteen Thousand Hours' study (Rutter, et al, 1979) concurred with this. Rutter found that pupils' achievements

were higher where teachers had positive attitudes toward and high expectations of their pupils' capabilities.

A matter for discussion here is whether or not positive attitudes and high expectations of pupils are characteristics of teaching expertise or merely of a teacher 'doing the job'. The literature detailing novice practice concedes that less experienced teachers are rule bound and do not develop flexible working practices and a deeper understanding of classroom dynamics until later in their development. In view of this it may be possible to conclude that because novices are concentrating on the rules of teaching they do not exhibit positive attitudes towards high expectations and understanding of pupils until later in their development.

Opie (1995) interviewed and observed five successful teachers of reading and found that they too exhibit high expectations of their pupils and demanded a lot from them. Opie also found that the teachers valued the construction and maintenance of positive relationships with their pupils and that they felt that this was essential to effective teaching. While exploring pupils' perceptions of a good teacher Younger and Warrington (1999) used focus group interviews with year eleven pupils and found that both boys and girls believed that treating pupils with respect, fairness and equality was a necessary attribute of an effective teacher and that pupils from a wide range of schools *"...preferred teachers to be approachable, helpful and friendly."* The pupils were also critical of teachers who demonstrated moodiness in the classroom.

The recent enquiry carried out by the management consultancy group Hay McBer (2000) into teacher effectiveness, collected data by questionnaire to teachers and pupils, by interviews with teachers and educationists and by classroom observations.

The data was analysed in terms of value-added data throughout one year of performance in classroom tests and school examinations. Over one thousand teachers from primary and secondary schools with pupils from a wide range of social backgrounds were used. Teacher effectiveness was 'measured' against knowledge and skills acquired by pupils as measured by tests and examinations. The research produced sixteen characteristics of effective teaching organised by five categories shown in Table 2.5.

Table 2.5 Hay McBer characteristics of effective teaching

Professionalism	**Leading**	**Thinking**	**Relating to others**	**Planning & setting expectations**
respect for others	managing pupils	analytical thinking	understanding others	drive for improvement
challenge & support	passion for learning	conceptual thinking	impact & influence	initiative
confidence	flexibility		team working	seeking information
creating trust	holding people accountable			

(adapted from Hay McBer, 2000)

Hay McBer claim that there are "clear links between the characteristics for effective teaching and the teaching skills proposed in the DfEE's Threshold Standards" (Hay McBer, 2000, p.1). They also suggest that their research adds an extra dimension to the standards by describing, in detail, the behaviours that underpin effective teaching at the Threshold level. The suggestion that they 'describe in detail' cannot be substantiated as the research is only partly in the public domain—the interim report is not sufficiently detailed and lacks some of the data, while the DfEE website report is a shortened version.

Although the methodologies underpinning Hay McBer's work and the present study are completely different, there are clear parallels between the characteristics which have emerged from both investigations. The Hay McBer approach emphasises their management culture, "management by objectives and performance" (Bassey, 2000, p.29). They concentrate on teacher effectiveness as measured by pupil attainment in tests and examinations and do not have any real focus on teachers' perceptions, views and beliefs (although teachers were surveyed). Interestingly, their interim report does not state what types of knowledge and skills were measured.

Few would argue with the sixteen characteristics identified by Hay McBer, however the value-added approach taken hints towards education as a clinical process where the only objective is to produce pupils with certain knowledge and skills, with scant attention paid to the empowerment of pupils to realise their own values and development above and beyond subject driven knowledge. There is little doubt that the driving force behind the approach taken was a government agenda eager for results, especially when one is led to believe that the research was completed at a cost to the DfEE of around £4 million.

The studies mentioned above are examples of process-product research which dominated studies on teacher effectiveness in the 1970s and into the 1980s. The majority of these studies helped to create a large database of the characteristics of effective teaching. However, the major problem with this type of research is establishing one set of criteria for effective teaching linked to pupil achievement. Due to the range of complex and diverse teaching situations and contexts it is unrealistic to think that all effective teachers have high pupil achievement rates as determined by test scores alone.

2.6 Summary

The literature reported here contains a range of findings relevant to the present study. These studies examine the novice-expert distinction, cognitive theories of expertise development, reflective practice and how this may help expert performance and effective teaching which in turn aids successful learning. The studies presented here are wide-ranging and diverse in methodology and findings, but together they provide a framework for exploring teaching expertise and contrasting and comparing findings from this current study.

In highlighting the distinctions between the novice and expert and less experienced versus more experienced teachers, a picture begins to emerge of the types of characteristics that depict expert teaching. For example, a strong theme which stands out within research on novice practice is that of following rules. Novices appear to be immersed in a notion of 'getting the job done' and generally demonstrate little or no flexibility in their teaching, whereas experts demonstrate their ability to change tack at will and have greater flexibility in their approaches. Thus, an important characteristic of an expert emerges, flexible - not rule governed. By looking at cognitive theories a notion of developmental stages begins to appear. They provide an opportunity to see how skills and techniques mature at each stage and how these are built upon. They also provide a way of looking at how experience effects the development of expertise. It is clear that to progress successfully through each stage is not just a matter of acquiring years of experience of practice. It is a conscious effort of self-development that relies on the practitioner identifying and taking part in quality developmental activity.

Reflection emerges as an important characteristic of developing and maintaining expertise. Whether in-action or on-action, or in the form of metacognition, it appears that critical reflection is an important tool for the expert. Reflection helps to analyse practice and support or contradict notions of success or failure. In this way the teacher may reframe his/her thoughts of the lesson and build on their original framework by adding new information after reflection.

Effective teaching highlights the more explicit characteristics of an expert teacher's behaviour. Fundamental abilities such as effective organisation and management of the classroom, control of lesson pace, providing challenge and continuous praise for the pupils are all aspects which are explicit in an expert teachers' practice.

What is missing from the reported literature is a rich source of detailed accounts of science teachers' perceptions, beliefs and values of their day-to-day practice and how they feel that their expertise manifests itself. There are studies which analyse teachers conceptions about a specific area of their practice (Kagan, 1992), however none of these attempt to encapsulate the essence and nature of the whole picture, which is the expert science teacher. Comparisons between novice and expert teachers are useful in providing an understanding of the differences between the two although they provide no in-depth account of what constitutes science teacher expertise. Cognitive models are also helpful in providing a framework whereby we can see various stages of expertise development. Again they do not clearly define science teacher expertise. But the most important issue which arises from this literature is one of teachers' own perceptions. There is little consideration of expertise from a science teachers' view. So, the path is now clear to tease out an understanding of science teacher expertise as

seen through the eyes of science teachers themselves. The data collected in this current study shows that teachers have very definite and, in many cases, clear views of their own classroom practice which both support and contradict previous research. With current governmental educational policy aiming to achieve excellence there has never been a better time to unpack the notion of science teacher expertise and to try to identify ways of improving and developing expertise as well as describing it.

3 Methodology

3.1 Introduction

This chapter discusses the action research utilised in this study. The chapter is organised under nine subheadings. The first discusses reasons for choosing an action research approach and also highlights case study and personal construct theory as other possible approaches which could have been taken to complete the research. The chapter then moves on to detail typical action research methodology that attempts to act as a framework by which the adopted method may be understood. Observational and interviewing techniques take the chapter through the next two sections and explain how these tools were used to gather data for the study. An emphasis is placed on the collaborative element of the study whereby an attempt was made to allow the teachers and researcher to work in harmony. This will be discussed with relevant examples stressed. The nature of the reflective discussions which took place between the researcher and teachers is discussed together with a group reflective meeting which took place late in the research project, demonstrating the advantages of research groups. Matrix construction is highlighted showing how data was displayed and finally, strengths and weaknesses of the methodology are looked at with a short summary concluding the chapter.

3.2 Choosing an action research approach

The study is firmly based within a qualitative paradigm and therefore could have utilised a number of methodological frameworks. It is important to gain an understanding of the implicit and explicit knowledge of science teachers as well as observing their day-to-day practice, so a method that would expose implicit personal perceptions and beliefs is needed. Case study and personal construct theory are two methods that could have been adapted very well to the context and theme of the study. Case studies may use a variety of techniques such as questionnaires and surveys but are synonymous, traditionally, with participant observation and interviews which were also used in this study. The usual purpose of a case study is to investigate deeply the research subject and analyse assiduously the elements which make up the day to day life of the subject. In this way generalisations may be made to the wider community within which the subject is a participant. A case may range from a single individual or community to a society or international social system. A research question or problem may also give rise to a case study in order to gain a specific insight into the question or problem. For example, secondary school mentors are to introduce a new student teacher profiling system. Will this change the way mentors support and guide their student teachers? And how will the profiling system work? Case study could be used to focus on how the mentors implement the system as a range of cases, or on a mentor as a single case. The profiling system itself may equally become a case. The example above demonstrates case study as instrumental in evaluating a phenomenon with a view to changing or amending the phenomenon as opposed to merely understanding its nature.

Personal construct theory could also have been used effectively as a methodology within the context of this study. Developed by Kelly (1955) personal construct theory is a theory of personality. Its primary concern is with the way individuals perceive and interpret their surroundings and then, as a consequence, behave within those surroundings. According to Kelly's fundamental postulate we see the world in terms of a set of constructs which are derived from our own experiences and which are subject to revision. Thus, the theory suggests that constructs are the mechanisms which individuals use to make sense of and control events, people, places and situations (see Bannister, 1970 for a more detailed discussion). Using the repertory grid method it would have been possible to develop an understanding of the science teachers' constructs that centred on their practice. The triadic technique (see Jones, Reid and Bevins, 1997) could have been a useful approach in eliciting constructs from the teachers during interviews and then analysing them in a quantitative way. However, the technique is complex and can be time consuming in the preparation of elements and explanation to the teachers involved in the interviews.

In many ways the approach taken is a modified version of case study. A small group of selected participants, the use of participant observation and interviews and reporting within individual contexts, are all typical of a case study approach. There is also an element of personal construct theory, in as much as the research has sought to elicit from teachers their perceptions of expertise and expert practice. This is to say that the teachers, through their own constructs, made sense of their knowledge and practice, which is the core of Kelly's fundamental postulate (see p. 41). However, action research is the dominant theoretical approach as the teachers were highly active within the research creating a 'bottom up' approach to the research whereby the

teachers generated and analysed their own perceptions under the guidance and coordination of the researcher.

The methodology on which the study is based is an attempt to evaluate the extent to which expert teachers can articulate their perceptions of teaching expertise by reflecting on their practice. Schon (1983) believes that professionals are often unaware of their tacit knowledge and that having acquired skills through intuition, describing them becomes complex and difficult. The methodology attempts to aid the teachers' reflective processes through reflective discussions and ongoing analysis of the data. Shulman (1987) urged teachers to become involved in studies about teachers' practical knowledge as he suggests that one of the single most important tasks facing the research community is to work with teachers in order to develop a codified but authentic representation of teachers' practical knowledge. Darling-Hammond (1996) also considered the involvement of teachers in research, as research collaborators, to be a powerful way of understanding teachers' knowledge and practice. During their research into standards and methods for assessing teachers' practical knowledge Beijaard and Verloop (1996) indicated the necessity of teachers' acceptance of these standards and methods. They state that as the practitioners have the knowledge which researchers seek to understand, then it is they (teachers) who researchers should look to for acceptance of legitimate standards and methods of assessment. This suggests that researchers and teachers should work closely, in collaboration, if we are to develop an authentic understanding of teaching expertise.

The importance of teacher collaboration is given high priority within the present study. The science teachers involved became full research collaborators and were not just the subjects of the research. The intention of this was to give the teachers a

legitimate voice within the research and to promote an ongoing process of reflection which centred on the research. The reflective process enabled the teachers to reflect on their thinking and practice within the context of being an expert science teacher. They were able to continue this process throughout the research while being in continual contact with the researcher, which in turn enabled on-going refinement of data. This collaboration or close relationship with the researcher is one of the fundamental differences between the approach taken and classical top down models of research. Essentially the science teachers were involved in every possible stage of the research from data generation to analysis and were not used merely as observation and interview subjects. In this way the action research approach taken, within this present study, attempts to democratise the research process by giving responsibilities and interpretations to the research participants. This in turn addresses one of the intrinsic problems of classical educational research: that it becomes too abstract and loses relevance as classroom teachers struggle to understand its theoretical traditions.

Together with the collaborative element, context is also an important consideration. The research is situational, in that there is a topic to be investigated within a specific context (science teaching and schools) and that topic will be reported in that context. The research is directly concerned with science teachers' perceptions of their own expert practice within the classroom, and through this methodology it is possible to safeguard the legitimacy of 'what the teachers say.' In other words this study utilises the teachers as the best informants of their own science teaching expertise. The contextual issue also raises questions of generalising the findings as the study may be heavily constrained contextually. Some models of expertise (Glaser and Chi, 1988) assume a degree of transfer which implies that the expert may perform to the highest

of standards regardless of the context within which the performance is set, although there is no evidence to suggest that this is guaranteed. For example, a teacher who performs as an expert while teaching his/her first subject to high achievers in an A-level class may not be able to demonstrate the same characteristics when teaching his/her second subject to low achievers who have been identified as having challenging behaviour. If the A-level students are highly motivated the teacher may be able to employ complex, intrinsic skills which may normally be associated with expert practice. Whereas teaching pupils who exhibit challenging behaviour may impede transfer of his/her expertise while employing little more than classroom management skills. In this way the effect of context on a teachers' ability to manifest expertise is a very important consideration. Although the findings may not be generalised to other contexts they can be made accessible to other science teachers and indeed teachers of other subjects as hypotheses to be tested.

Taken from Cohen and Manion (1994) three elements featured within action research have been identified, which are directly applicable to this study. First, that action research can address itself to personal functioning, human relations and morale, and is thus concerned with peoples' job efficiency, their motivations, relations and well being. Second, that it can focus on job analysis and aims at improving professional functioning and efficiency, and third, that it provides the opportunity to develop theoretical knowledge. These three elements broadly define the research approach, values and intentions. The fundamental aims of the study are to identify the nature of science teacher expertise while highlighting key components and informing future ITT and CPD programmes. The above key elements of action research begin to form a framework for the study. The research began with a broad question, 'what are the nature and characteristics of science teacher expertise?' The question was then

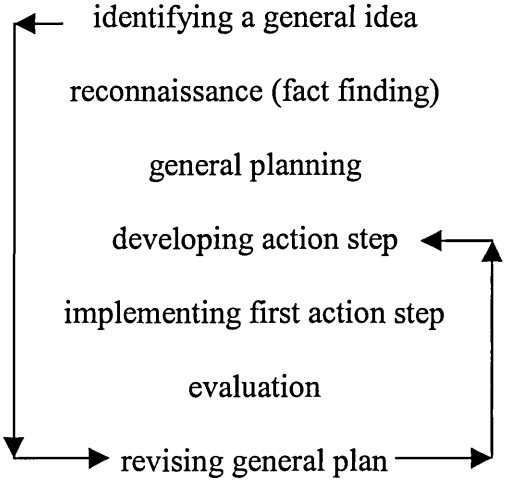
narrowed to the three main aims of the research (see chapter 1) to bring clarity and structure to the research. This is to say that the research was structured to investigate three clear areas of science teacher expertise while asking a further implicit question, 'can science teachers formulate a clear and informative model of science teacher expertise'? The three aims were developed in an attempt to produce an holistic view of expert science teacher practice but with a specificity which would present a coherent notion of each characteristic of science teacher expertise and how it is manifested.

3.3 Action research theory

As already stated action research is ordinarily situational. It is concerned with a problem or question within a specific context and sets out to solve the problem or answer the question within that context. The emphasis is on developing explicit knowledge for a specific situation rather than generalisability. Although this is not to say that the method may not yield findings that are generalisable to the wider community. The term 'action research' may be viewed as containing two separate but complementary processes, 'action' and 'research'. The first process, action, implies an intervention methodology which has the aim of bringing about a certain form of future change. The second process, research, focuses on constructing an understanding of the situation and developing theoretical knowledge. This is done by generating and analysing data within the action process. A cyclical model begins to emerge with the implementation of a certain action, reflection upon that action, amendment of the action and reflection upon the effect of the amended action. Lewin's (see Kemmis, 1980) model involves a spiral of cycles (see fig 1). This step-by-step process allows for consistent evaluation of the process and its findings

through a number of mechanisms (e.g. interviews, case studies, reflective discussions, questionnaires) so as to maximise the effects of the on-going process. Findings may be applied in the short or long term although a frequent justification of action research in an educational setting is improvement of practice, which is often a more long term goal.

Fig 3.1. Action research cycle



(Adapted from Kemmis, 1980)

In almost all formulations action research is explicitly cyclic in operation (Carr and Kemmis, 1986). It is no surprise that early cycles may produce confusing data until further progress is made, but as the cycles progress both questions and answers are refined at each cycle through the on-going process with data becoming clearer. A component of the second process, research, is some form of technique for data analysis. This may consist of categorisations or taxonomies that are used to make sense of the data. Critical analysis of the data has two important elements to consider: checking the reliability of evidence which corroborates findings and identifying evidence which contradicts findings. Both of these processes serve to enhance the reliability of findings and tighten the methodology. They also add to the development of the findings by enlarging them firstly and then constraining them, thus presenting a

clearer understanding of the data. The action and research processes enhance each other and as one might expect action research projects vary in the emphasis placed on each process highlighting it's flexibility (Heller, 1976; French and Bell, 1990). Although this model was used to define the approach and initial set-up of the study, action steps were kept to ongoing reflection and analysis of data.

3.4 Pilot group

Four perceived expert science teachers were interviewed at the beginning of the research in order to build up the researchers' interview skills and create an awareness of how science teachers would react to the research, although these teachers did not take any further part in the study. The four teachers were known to the Centre for Science Education through their involvement with the Centre ITT programme as student-teacher mentors. Discussions with teaching staff at the Centre identified the four teachers as being suitably experienced to take part in this early stage of the study. Each of the teachers had a minimum of four years experience of teaching science at secondary level and were willing to become involved in the study at that stage. The aims of the study were explained to the teachers and they were interviewed individually (appendix 2). Analysis of interview data provided a general overview of what science teacher expertise means to these four teachers. Analysis was conducted by searching the interview transcriptions for emergent issues of expert teaching. A list of issues (appendix 3) was drawn up in an attempt to gain a general understanding of the sort of issues which might be revealed during the main study.

Existing literature indicates a minimum of ten years career experience to be somewhat of a benchmark for identifying expert teachers (Berliner, 1988; Schempp, et al, 1998). Only one of the four teachers had been teaching for more than ten years. This was to

prove significant. Of the three remaining teachers two had been teaching for four years while the third had gained five years experience. None of these three teachers felt they could demonstrate practice at such a high level and felt they could not justify further involvement in the study. Even though one teacher had been teaching for twenty-three years, unfortunately she felt that she could not take any significant role in the main study due to existing commitments and workload.

The true value of the pilot group can be seen in terms of developing:

- a list of potential issues focused on expert teaching
- an opportunity for clarification of techniques
- researcher confidence in the use of techniques

The list of issues generated by the four teachers helped to substantiate emerging issues from existing literature, thus helping to support the developing understanding of the area of teacher expertise of the researcher. For example, these four teachers suggested that expert teachers have defined patterns or routines during practice, an issue that is well documented within existing literature on the subject (Berliner, 1988; Barba and Rubba, 1993). The constructed list enabled the researcher to gain an insight into the types of issues that may be raised during the main phase of the study and informed further examination of the literature.

The group also enabled the researcher to clarify and try out research techniques, such as interviewing. The four teachers agreed that an action research approach would encourage other teachers to be involved in the study although it may be time

consuming. Utilising interviews was also agreed as a good technique for collecting data. Having the opportunity to engage in semi-structured interviews enabled the researcher to trial questions and generate self-confidence in the use of the technique. The value of this opportunity cannot be underestimated.

3.5 Six expert teachers

Six new science teachers were selected, four male and two female to take part in the main phase of this present study. The number selected is consistent with similar, recent studies (Schempp *et al*, 1998; Hewson *et al*, 1995) and was manageable given time and travel constraints. Because the teachers were involved in data analysis at every possible stage the depth of analysis was extremely time consuming. The teachers were identified as experts in three ways: peer recognition by colleagues at the Centre for Science Education (Sheffield Hallam University) who are involved in ITT and the mentoring programme; by educationists (both internal and external to the Centre for Science Education); and by head teachers and colleagues within their respective schools. The selected science teachers have a minimum of ten years teaching experience and are all involved in student teacher mentoring. Peers were asked to comment on the teachers' general teaching abilities within the context of the study (i.e. expert science teaching). Under current governmental proposals it is almost certain that the six science teachers would meet the criteria set for reaching Advanced Skills Teacher status. Indeed, one of the teachers was designated an AST in the first DfEE cohort while another has recently achieved such recognition.

3.6 Observations

Classroom observations of the six teachers took place prior to interviews. Observations were decided upon as a tool for gathering data for three reasons. Firstly, observations can give direct access to social interactions. As many events in a teacher's day-to-day classroom practice occur regularly and are subject to routine behaviour, the group of science teachers may not be consciously aware of them and would therefore not be able to talk about their expertise in an articulate manner. Appropriate notes were taken as behaviour occurred in a natural environment with salient features highlighted and then raised during interviews. Secondly, an intimate and informal relationship needed to be encouraged to develop the collaborative nature of the study. After some initial anxiety the teachers began to work with the researcher by analysing their own reflections of their practice and building on the researcher's original observations. Thirdly, observation can supplement and enrich data by offering a comparison to data gathered by other tools. This helped to provide a more detailed context and understanding of the group's practice.

Observations took place over two - three days with a minimum of two full lessons with different pupils observed. An observation schedule (Hook, 1981) (appendix 4) was prepared in an attempt to provide short narrative descriptions of each science teacher's actions and classroom events. Although pre-defined categories are not normally used for narrative systems or field notes (Simpson and Tuson, 1995), four broad categories were identified and used to organise notes from the observations, rather than as a prescriptive rigid agenda.

The four identified categories are:

- teacher talk
- teacher activity
- pupil talk
- pupil activity

General comments were included together with a diagram of each classroom layout. Narrative field notes detailed teachers' techniques, approaches, interactions with pupils and other colleagues. Notes were also taken for example, on the pace of the lesson, whether this was varied or constant, fast or slow. Details of how and when the teachers changed tack were recorded as was the result of the change. Pupil responses to questions, activities and the general classroom mood were taken down with a view to analysing the teachers' response. Teacher talk identified clarity and suitability of language for pupils' age, ability and topic, as well as highlighting questioning techniques. The examples above show the focus of the observations but are not exhaustive as many other behaviours and events were also recorded. Notes were kept as rigorous as possible and were consistent throughout all of the observations. Where cursory notes could only be made due to a number of events happening at once, more critical accounts were submitted soon after (for methods of analysis see chapter 4).

3.7 Interviews

A common conception of the interview as a research technique is explained by Kitwood (1977).

> *If the interviewer does his job well (establishes rapport, asks questions in an acceptable manner, etc.) and if the respondent is sincere and well motivated, accurate data may be obtained. Of course all kinds of bias are likely to creep in, but with skill these can largely be eliminated* (p.274).

Borg (1963) also believed that the immediate interaction of the interview itself poses problems. For example, that it is prone to subjectivity on the part of the researcher and for that matter, the subject. However, the interview remains a primary tool for gathering research data. Tuckman (1972) explains it as, *"providing access to what is inside a person's head, it makes it possible to measure what a person knows, what a person likes or dislikes and what a person thinks"* (p.272). This explanation best fits with the intention of the technique within this study. A semi-structured format was adopted in an attempt to uncover the deeper attitudes and beliefs of the science teacher being interviewed and to reduce as much as possible researcher bias. Indirect questions were primarily asked though some direct questions were used. Direct questions were concerned with clarifying or expanding on a point in the lesson which was noted through the observation schedule. One example is:

> *...all your interactions seemed to indicate that you were part of the group. Is that right and if so did you intend it?*

Indirect questions were aimed at uncovering the teachers' attitudes, beliefs and knowledge, for example:

> *...so,why are relationships between yourself and the pupils very important?*

Although the indirect questions allow the teachers the freedom to construct their answers in any way they choose, the unstructured response is much more difficult to qualify and code, unlike a structured response which would be in the form of a simple yes or no or on the basis of, for example, a Likert-type scale.

An interview schedule (appendix 5) was designed after consultation with the pilot group of science teachers (see 3.4). Staff colleagues at the Centre for Science Education (Sheffield Hallam University) also contributed their views.

3.7.1 Five key questions

Five standard questions (appendix 5) were included on the schedule, which were put to all six of the teachers. These questions were identified as being effective in eliciting the teachers' perceptions of their expertise. Further questions emerged directly from classroom observation notes and were directed at events and interactions from the observed lessons. It is acknowledged that there is some risk involved using this technique. By asking the individual teachers varied questions it is possible that identifying patterns across cases may be difficult to detect and a sense of general consensus from the group hard to establish. However, as individual cases are being explored primarily, and the varied questions proved to be of a very similar nature across cases, inconsistency did not become a problem. A second round of interviews was conducted using a second schedule (appendix 6) consisting of a further four standard questions, which attempted to explore issues not covered during initial interviews but which had emerged during data analysis and demanded deeper investigation, and to clarify any unclear issues that had arisen during the first round of interviews.

Interviews were audio taped and later transcribed (appendix 7). Interviews were transcribed to ease data analysis and to gather corrections and further analysis from the teachers involved. Transcriptions may also provide a 'true' record of the interviews and help to demonstrate the soundness of the study. However, a major

disadvantage concerns the length of time involved when transcribing audiotapes. Two rounds of interviews took place which is consistent with the cyclical process of the action research approach. On each occasion the science teachers were given a copy of the transcripts for their comments which were fed back into the database. Because the teachers were asked to contribute to data analysis in this way a question of validity is raised. Much of the criticism of qualitative research focuses on its apparent lack of rigour (determining whether or not findings are valid). The collaborative nature of this present study means that the role of participant agreement needs to be addressed as the concept of validity used for this present study is one of respondent validity. Validity in this sense is when others, in particularly the subjects of the research, recognise its authenticity (McCormick and James, 1983).

3.8 Participants responses

There is a question of participants' 'resistance' and 'over eagerness' to be understood during the research process. Cox and Sipprelle (1971) suggest that subjects of social psychological research may 'misbehave' in a purposeful attempt to act in a different way to the aims of the researcher. Orne (1962) indicates that most participants in research studies are eager to act in a way that conforms closely with the intentions of the researcher. Rosenberg (1969) suggests that some research participants are anxious to gain approval from the researcher, which he terms as 'evaluation apprehension.' This indicates that some research participants attempt to preserve their socially presented self. The central tenet here is, *"...that in all social interaction there is the intrinsic determining current of self-presentation"* (Ashworth, 1993, p12). Ashworth goes on to express a view that participant agreement does not: *"constitute evidence*

for validity" (p 14) within qualitative research findings. His reservations are mainly due to his consideration of the research process in the human sciences as interpersonal. Therefore self-presentation is a factor:

> *Human anxiety concerning self-presentation in the face of others is pervasive and can give rise to both resistance and acceptance of findings. Neither resistance to, nor acceptance of descriptions or interpretations are in themselves evidence for or against the findings.* (p 14)

However, he does enter two caveats: firstly, that some research (e.g. forms of ethnographic studies) specifically focus on participant views, perceptions and beliefs. Without participant agreement this type of research would certainly be invalid. Secondly, that participant views should be seriously considered from an ethical and political standpoint.

Ashworth's first caveat is of particular importance to the present study as the study is designed to focus on science teachers' perceptions of expert science teaching. It is acknowledged that participant agreement is not flawless but is necessary given the focus of the study. In an attempt to reduce invalidity of participant agreement comparisons were made between the data gathered from different instruments. For example, observational data was searched to identify characteristics of practice which the teachers explained during interview. Consideration must also be given to the issue of teacher ownership.

Over the three-year period of the study the teachers took ownership of their roles within the research, so it is unlikely that they would risk invalidating findings by presenting a false self. Ashworth's second caveat is important when considering the collaborative nature of the study. The teachers' involvement would have been

seriously undermined had their views been ignored. This study acknowledges that absolute validity is difficult to claim within qualitative studies of this nature and, thus relies on the construct validity of the teachers involved. Throughout the study emphasis has been placed upon the way the teachers perceive their expertise and the way they interpret what they perceive in terms of their practice. Because of this construct validity is of high importance and fits with the research situation.

3.9 A culture of collaboration

The notion of collaboration within this present study goes further than that of 'teacher as researcher' (Hargreaves, 1996). Here that notion is extended to 'teacher as research collaborator'. This is to say that the science teachers involved actually generated and analysed data under guidance from the researcher. This process enabled the researcher to evaluate the teachers' own interpretations of theory and practice. As stated earlier, the teachers were given a copy of the interview transcripts, which they discussed with the researcher. The first phase analysis was completed by the researcher and was then discussed with the teachers who added to the initial findings or dismissed issues which they felt were incorrectly interpreted. This process is key to the methodology and the whole approach to the study. In promoting this type of collaboration a 'bottom-up' approach was generated which empowered the teachers involved and gave them a voice, this point is important. Through the methodology the legitimacy of 'what the teachers said' was safe-guarded. In other words, who better to validate a framework of science teacher expertise than the teachers themselves? Schon (1983) indicated that it is possible to make explicit descriptions of tacit knowledge, by observing reflection-in-action and

on-action. This means that teachers' knowledge should be examined in a language close to that of the practitioners themselves to preserve context and relevance (Carter, 1990). The discussions which ensued were both informative and developmental to the research, and provided from personal perspectives. As one science teacher stated:

> *Receiving a transcript was a fascinating experience because of several reasons. I found out things about myself I did not fully realise, I now know why some people get driven up the wall by my ramblings, in particular the fact that I head off at weird tangents sometimes* (reflective discussion).

Together with the action research cycles, which had now begun to take a spiralling effect, a reflective process began to emerge. As the teachers became more and more involved in the analysis and generation of data they found themselves reflecting on their own practice at a deeper level. They were representing their perceptions, beliefs and views through a more clinical lens. One of the largest problems with a study of this nature is not being able to see the 'wood for the trees.' The difficulties of making the implicit explicit are well documented, but through the reflective process encouraged by the researcher, these teachers were able to make their reflections explicit for much of the time.

What had begun to happen was the unpacking of emerging themes. The teachers and researcher were now clearing away the less important issues and recognising themes within themes. An example would be that of the 'relationship' theme. Initial analysis had cast teacher-pupil relationships as a very important theme. Evidence from observation and interview data shows that these expert science teachers develop and maintain good relationships with their pupils in order to gain the best from them in the classroom. At first glance this may seem a common sense notion. However, as the research progressed and reflective discussions took place the teachers identified that

relationships between themselves and their pupils take place on many levels and for many reasons (see findings, chapter 5). This deeper reading of their practice only began to emerge when the teachers realised the empowerment they had received within the research (initiated and maintained by the researcher) and when they reflected on their actions and thoughts as expert science teachers and research collaborators.

3.10 Reflective discussions

Reflective discussions took part throughout the life of the study with the six individual science teachers. The discussions ranged from general talk around the theme of science teacher expertise, to more focused examination of particular issues or events that had emerged from the teachers' reflections and data analysis. As the teachers were motivated to reflect in and on their classroom practice within the context of being an expert, they often raised issues and concerns that they felt warranted exploration with the researcher, such as curriculum concerns. Reflective discussions took place at the teachers' schools or by telephone and notes were made by the researcher and by the teachers. While the discussions yielded some high quality data and supported other data collecting techniques there were two particular problems. On many occasions the teachers had lost the initial context of the event or issue that had stimulated them to seek a discussion through not having immediate contact with the researcher. Also, as these discussions had no real structure it was often the case that conversations would stray and lose their initial point. To reduce these problems the teachers were, firstly, asked to log any emergent issues as a note with a brief description. For example, an issue focusing on mentoring may have been logged as: mentoring, two-way process - aids sharing of information. Secondly, to

reduce the possibility of a discussion losing its focus the teachers were encouraged to take notes which would inform their reflective summary and reduced side-tracking.

Once agreement had been reached surrounding the emergent themes from the data, a group reflective session was set up at the Centre for Science Education. The researcher and four of the six science teachers involved attended the session. The main focus of this session was to reflect upon the research as a whole and then to discuss the findings in an attempt to gain further clarification and substantiation. The teachers spoke freely about their perceptions of the research. Even though the teachers had never formally met before the session there was a high degree of consistency in their reflections. They agreed on all the elements contained in each category and worked to unpack the data further. Each teacher wrote a short reflective report (appendix 8) after the session which was also used as a source of data. The two teachers who could not attend were sent copies of the reflective reports and asked to comment and to produce a short report focusing on the issues raised. The two reports added to the agreement of the four attending teachers.

There were three main aims in bringing the science teachers together in an informal discussion based meeting:

- to consolidate the collaborative nature of the research
- to provide each teacher with an opportunity to meet the other science teachers and discuss their practice
- to substantiate and analyse data

The researcher felt it was important to bring the teachers together to support the

collaborative nature already promoted within the research. The teachers were able to gain further ownership of the research by meeting the other participants and discussing their perceptions of the research. This created a feeling of unity as one science teacher commented, *"I no longer feel isolated in a wilderness"*. This comment is an indication of how the teacher was feeling as a science teacher in a secondary school. The second aim is closely linked to the first and could utilise the above quote in a similar manner. Emerging early in the research and remaining a consistent theme was one of teacher-to-teacher communication. The teachers all felt that time constraints inhibited informal discussion about their practice with colleagues. The reflective session provided them with an arena to discuss practice and to set up further lines of communication. Finally, substantiating the data together as a group, helped to clarify the researcher's and teachers' perceptions while increasing the strength of participant agreement.

3.11 Matrix creation

In an attempt to provide a conceptual framework to aid understanding of the data and to organise and display findings from the analysis, matrices were used to organise data (see tables 4.3, 4.4, 4.5) and to present the final framework (see table 7.1). The matrices display key themes under four organising categories—— teachers' perceptions of: learning; teaching; science; reflection. The four categories were generated from the primary analysis of data and are seen as the main dimensions that have relationships with each theme contained in each dimension (see chapter 4). The matrices contain data obtained from each of the instruments used.

The design used is an adapted clustered matrix (Miles and Huberman, 1984). Each matrix has its columns arranged to bring together themes that naturally cluster together under the organising dimension. The basic principle behind the matrix design is to display data in a simple and brief way while maintaining conceptual coherence.

There are a number of advantages to using a matrix. Firstly, it allows the researcher to have all the key themes on one sheet for quick reference. It also allows for initial comparisons to be made between each science teacher and shows where themes may need further analysis. The main advantage for this present study is that the matrices provide a preliminary and agreed upon standardisation of data. The teachers were able to gain a clear picture of the researchers' analysis and to confirm this or highlight tensions. Also, they were able to gain a quick understanding of the researchers' method of analysis and gain a conception of how themes were generated and what types of themes were emerging.

The main disadvantage is one of construction. The first phase matrices are quite simple and brief. However, as the analysis progressed existing themes were unpacked further while new themes emerged. It became apparent that each cell needed a descriptor in order to delineate cells and columns. Thus, each matrix, although becoming more elaborate, became difficult to contain on a single sheet and they were complex.

3.12 Strengths and weaknesses of the chosen approach

A major strength of the methodology used for this study lies in its ability to facilitate a close collaboration between researcher and teachers. Unlike experimental studies or surveys, the teachers were able to take ownership of the research, which in turn empowered them. This is to say that the teachers were given a voice and an outlet through which their own verbalised perceptions could be analysed and interpreted with fellow colleagues and reported verbatim. This empowerment is particularly important as it reduces arguments against the validity of the research, as stated earlier in this chapter, and offsets any potential problems of a small number of participants. Also, by concentrating on the teachers' perceptions they did not feel as if they were being judged or appraised and so were able to relax and speak openly.

Marris and Rein (1967) saw the action element and research element of the methodology as being fundamentally different and problematic when combined. They state:

> *Research requires a clear and constant purpose, which both defines and precedes the choice of means; that the means be exactly and consistently followed; and that no revision takes place until the sequence of steps is completed. Action is tentative, noncommittal and adaptive. It concentrates upon the next step, breaking the sequence into discrete, manageable decisions. It casts events in a fundamentally different perspective, evolving the future out of present opportunities, where research perceives the present in the context of the final outcomes. Research cannot interpret the present until it knows the answers to its ultimate questions. Action cannot foresee what questions to ask until it has interpreted the present. Action attempts to comprehend all the factors relevant to an immediate problem whose nature continually changes as events proceed, where research abstracts one or two factors for attention, and holds to a constant definition of the problem until the experiment is concluded* (p.15).

This is a somewhat constrained and inflexible way of looking at action research. The level of interaction between action and research is not cast in stone and can be varied according to the study's objectives (Halsey, 1972). For example, in this present study the action element fulfilled by the science teachers was confined to conscious reflection on their classroom practice, including note-taking and analysing their practice in terms of emerging themes from the data.

The question of validity was addressed through the context of the study. That is, that the teachers' perceptions are reported verbatim. The researcher's role here was to form an initial analysis and clarify the method of analysis so that the teachers could then work jointly with the researcher with a clear frame of reference. Researcher bias was also reduced comprehensively in this way. The researcher maintained a role of research coordinator, keeping the study moving, acting as a link between the science teachers, initiating and clarifying analysis, developing the methodology and unpacking matrix analysis further for the teachers to comment on.

The main barrier in using this methodology was an issue of communication and time. With the researcher dependent on the teachers for agreeing data analysis, communication between the two parties needed to be constant. Time constraints reduced the availability of both researcher and teachers, in certain instances, which meant that important issues were sometimes not discussed until a much later date from when they had originally emerged. This meant losing some of the initial understanding and context and thus having to spend more time reflecting back and clarifying.

The observations and interviews also provided their own problems. As there was only one researcher within the classroom there is always a danger that crucial events could

be missed while note taking, although the observation schedule helped to reduce this by facilitating brief notes which could be expanded upon later. Researcher bias is also a problem when observing alone in classrooms. The way in which the researcher sees and records interactions and events may not be the same as the subject being observed. However, it must be noted that this effect was reduced by discussing and analysing field notes with the six teachers, and by comparison with data gathered from other instruments.

Interviews also offer a strong danger of researcher bias. For this reason and the fact that the teachers' perceptions were of primary importance, leading questions were mostly avoided and indirect questions were mainly used. Reflective discussions enabled the researcher to maintain an informal collaboration with the science teachers and produced rich and supportive data. However, the lack of structure during discussions often inhibited a focused investigation of an emergent theme or issue which, on some occasions, led to confusion over exactly what was to be discussed.

As already stated the methodology used enabled an interaction between researcher and teachers, which passed beyond the typical educational research process. Researcher and subjects became collaborators. This was not only fundamental in producing reliable and valid findings but has been instrumental in raising implications on which this study will report and form a foundation for building future research and development projects. There is no doubt that many teachers consider educational research as irrelevant and cast a suspicious eye over researchers who wish to observe them within their classrooms. Their mistrust of findings is due, in the main, to the artificial conditions used for a considerable amount of educational research. They also believe that findings are often insignificant to actual day-to-day teaching (Kelly,

1987). The method used here empowered the science teachers involved and reduced the traditional communication gap between researcher and teachers. This was by far, the greatest advantage of the method. Any perceived loss in research rigour was outweighed by the legitimacy of the teachers' perceptions and involvement. Moreover, the science teachers became more and more enthusiastic about the research as the process gathered momentum. This enabled generation of quality data together with continuous rigorous analysis.

3.13 Summary

The methodology used for the present study was underpinned by two key elements: firstly, to produce an understanding of expert science teaching from the perceptions of the practitioners involved, and secondly to enable a close collaboration between researcher and teachers throughout the research process. These elements were crucial to the success of the study. In obtaining the science teachers' perceptions of their practice it was important to aid their reflective processes in order to produce ongoing reflective perceptions throughout the life of the study. The second element was also intended to encourage the teachers to take ownership and responsibility for their role within the study in an attempt to develop their thinking and reflective processes which focus on their classroom practice further. The methodology also helps to explore whether researchers and teachers working together can improve teachers' knowledge and practice.

The flexibility of action research allowed for elements of personal construct theory and case study to be incorporated without altering the overall action research framework. The cyclical process, typical of action research, fits well with the

constant comparison method used for data analysis (see chapter 4), allowing for on going analysis.

Carr and Kemmis (1986) summarise action research in a way which demonstrates much of the ethos of the adopted methodology for the present study:

> *In practical action research, participants monitor their own educational practices with the immediate aim of developing their practical judgment as individuals. Thus, the facilitators role is Socratic: to provide a sounding-board against which practitioners may try out ideas and learn more about the reasons for their own action, as well as learning more about the process of self-reflection* (p. 189).

4 Data analysis and instruments

4.1 Introduction

As this study aims to provide a detailed analysis of science teachers' perceptions of their practice and knowledge it is important to use analytical tools and techniques, which articulate the teachers' perceptions and not just those of the researcher. Three instruments were applied to collect data based on existing procedures for eliciting and representing teachers' knowledge and practice (Kagan, 1990). The relationship between each instrument was seen to be crucial to the study, as combining the data would be attempted through triangulation. The instruments used are:

- semi-structured interviews
- classroom observations
- reflective discussions

Matrices were formulated to display data in a summarised order. Each matrix is designed to display data interpretations for each of the six teachers and highlight the similarities and differences between each individual also, the trial and rejection of a qualitative data analysis programme is highlighted

The grounded theory approach taken to analyse data collected through each instrument is discussed. An explanation of how the data is combined through triangulation is presented, while a summary of the analysis identifies strengths and weaknesses of the approach.

4.2 NUD*IST

Prior to utilising a grounded theory approach to data analysis an attempt to use the NUD*IST (Non-numerical Unstructured Indexing Searching and Theorising) computer program was made. This program is a qualitative data analysis package that allows the user to code themes from textual data such as interview transcripts. The program also facilitates the construction of an hierarchical 'tree' (network) consisting of 'nodes' (themes). At the root of the tree is the uncoded text. Above the root there are branches, each fork of which represents a new code, created by the researcher, and applied to a chunk of text. For example, in the present study the code 'relationships' was used (see section 4.6), in NUD*IST this would be coded and represented as a node on the tree for that transcript. The network aims to organise themes within 'families' (categories) in order to produce a hierarchical ordering span of concepts (nodes).

The researcher decided to abandon use of NUD*IST due to two significant weakness of the program: once the input of textual data has been completed the user begins to code by fragmenting the data into words, sentences or paragraphs by 'blocking out' or highlighting a particular word, sentence or paragraph and then depressing the return bar once a code has been assigned. However, after the return bar has been depressed that particular fragment of data is then set and cannot be further manipulated if, for example, the user decides that the fragment of data needs further investigation. In order to recode data which has already been blocked out, multiple files of the same data set would need to be kept. As large amounts of data were generated, it is an unreasonable approach to generate multiple files of the same data set.

Also, the preoccupation of NUD*IST with hierarchical trees does not lend itself well to the analysis of relationships between themes that may not be hierarchical (Lewis, 2001). This interface, which focuses the researchers attention on the positions of nodes within an index tree dominates analyses and distances the researcher from the text. While it is recognised that the programme is a good data analysis tool, in the right context, the researcher decided that the context of the present study was to investigate the relationships and nature of emerging themes and not to provide a hierarchical interpretation of them. Interestingly, the current version of NUD*IST—NVIVO, does not utilise tree structures but allows analysis to show relationships of themes through bubble diagrams and has ironed out the problem of developing multiple files of the same data set. Unfortunately the NVIVO program was not available for use during the current study and was only released very recently. Given the researchers reluctance to continue analysis with the NUD*IST program a grounded theory approach was decided upon.

4.3 Grounded theory: an approach to data analysis

A grounded theory approach was adopted to analyse data within the present study. Kinach (1995) suggests that the emergence of grounded theory during the 1960's was:

> *...part of the humanist attempt to tie social science data more closely to the beliefs and concerns of participants so that social science practitioners would find in theory a more congenial guide to the problems of practice.* (p.1)

What most differentiates grounded theory from much other research is that it is explicitly emergent and data driven. Grounded theory attempts to find which theory accounts for the research situation and does not necessarily set out to test a

hypothesis. Glaser and Strauss (1967) suggest grounded theory as: *...the discovery of theory from data systematically obtained from social research* (p. 2). They go on to describe theory in the social sciences as a: *strategy for handling data in research* (p. 3). By this they mean that theory can provide ways for describing and explaining and that theory should provide categories which enable clear understanding. Categories must be applicable to and indicated by the data in order to explain and be relevant to the research study. Glaser and Strauss (*ibid*) emphasise that grounded theory is a process of generating theory and, as such, verification is not entirely crucial:

> *This is especially true because evidence and testing never destroy a theory, they only modify it. A theory's only replacement is a better theory* (Glaser and Strauss, 1967, p. 28).

This view is based on their belief that inductive theories which emerge from the data will be more successful than theories that have been logically deduced from prior assumptions, which is the basis for the data analysis method employed within the present study.

The process of naming or labelling things, categories and properties is known as coding. Coding in grounded theory is usually done quite informally. For example, if after coding much text, some new categories are constructed, grounded theorists do not normally go back to the earlier text to code for that category. However, maintaining an inventory of codes with their descriptions is useful.

Interviews are frequently used as the main data collection instrument with a grounded theory approach. Other instruments include: focus groups, group feedback analysis and informal conversation (for greater discussion see, Kvale, 1996; Bader and Rossi,

1998; Heller and Brown, 1995). As this study only utilised aspects of grounded theory as an approach to data analysis an in-depth discussion is not provided.

4.4 Interview data

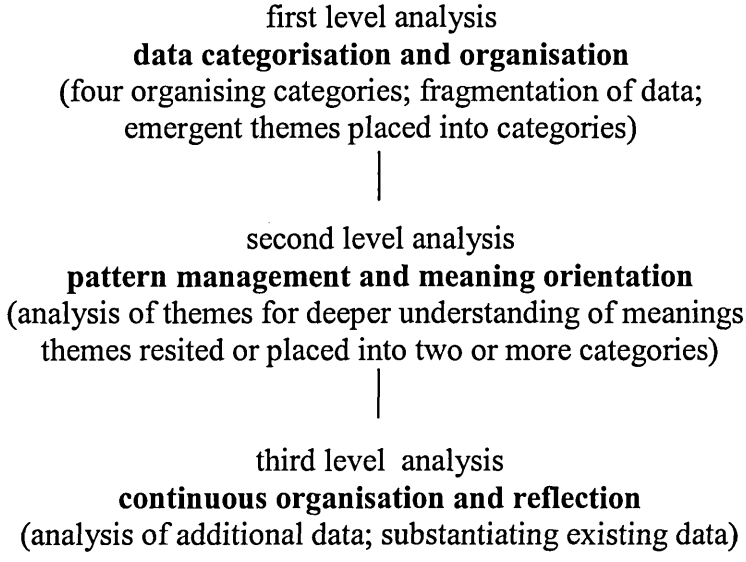
Analysis of interview data took place prior to the analysis of other data sets, and established the analysis method used to analyse all three primary sources of data. Semi-structured interviews were chosen to elicit the initial underlying perceptions of the science teachers (Gudmunsdottir, 1996). An interview schedule (see appendix 5) was designed to indicate the consistency of the teachers' responses and as an aid for the researcher. Questions for the schedule were developed in collaboration with four experienced science teachers early in the research programme (see chapter 3, section 3.4). Collaboration with these four teachers was prior to the fieldwork and they are not involved in the reported study. The four teachers indicated, during discussions with the researcher about their own teaching expertise, areas that they felt would elicit a good response from other science teachers who would be collaborating in the study. A list of questions was constructed which everyone agreed could potentially capture teachers' perceptions of their own expertise. The researcher refined the list further into a manageable number of items and to leave scope for questions, which directly referred to events observed during classroom sessions. Two rounds of interviews took place.

4.5 Categories and themes

Figure 4.1 shows the basic process used to analyse data. The process employs three levels of analysis: the first level involves developing categories in an attempt to make

sense of what the teachers say. Emergent themes are then classified into each 'fitting' category. The second level shows a more intensive analysis and constant comparison of data. The third level describes an on-going process which focuses on organisation and delineation of new data. This process shows the systematic inspection of data and redesigning of developing theory.

Fig 4.1 Process of qualitative data analysis



The interview data consisted of twelve transcripts, two for each of the teachers. The first level of analysis began with an intensive study of all of the teachers' interview data from the first round of interviews. One of the aims of the first level analysis is to generate data organising categories. A category is a theme that is found to emerge with high frequency of mention and is connected to many of the other themes which are emerging. Categories make sense of the themes emerging from what the informant is saying. They are interpreted within the context of the research situation and emerging theory. Predetermined categories were not selected in an attempt to avoid distorting data to fit them. Categories were extracted from the data by summarising themes which appeared to cluster together, and then by compiling a composite list (Table 4.2).

Table 4.2 List of emergent themes

pupil-centred, flexible approach, varies approaches, reflection, informal style, injects fun, no written notes, enthusiasm, organises learning, takes risks, in- depth knowledge of pupils, in-depth knowledge of teaching, cooperative learning, in-depth knowledge of teaching, relevance, innovation, recognises learning development, difficult subject, creative, intuition, extra-curricular involvement, changes tack.

All of the themes were then assigned to one of the four categories that were identified as being common to each list of themes. Four categories were chosen to organise and illuminate emergent themes. This is to say that they emphasised the essence of the clustered themes. The categories identified were, science teachers' perceptions of:

- learning
- teaching
- science
- reflection

These categories were identified after consultation with the researchers' supervisory team and the teachers involved in the study. It was felt that the emergent themes that were arising from the data could be placed into 'families' which were 'parented' by the LTSR organising categories. In other words, the teachers were revealing characteristics of science teacher expertise which the researcher, supervisors and teachers agreed, were best understood in the context of the teachers' perceptions of: teaching, learning, science and reflection.

First level analysis of the data indicated that some individual themes were not readily identifiable in one category and could be situated in two or more. For instance, the theme 'flexibility' was originally categorised as a perception of teaching. However,

discussion with the teachers and supervisory team indicated that this theme represents an understanding of classroom awareness and pupils' moods, as well as having a non-rigid approach to their teaching. So, flexibility is categorised under perceptions of learning and perceptions of teaching. This dilemma highlights the complexity of analysing interview data. Which interpretation is more important: that of the researcher or of the interviewees? A compromise may often be the best answer, however in this present study the perceptions of the science teachers were analysed in cooperation with the teachers, researcher and supervisory team. The teachers were consulted over ambiguous themes in an attempt to determine the precise meaning. An example is 'mentoring' which is a strong theme that emerged from the data. The science teachers perceive mentoring to be a two-way learning process between mentor and student-teacher. Initially mentoring was placed in the learning category, however after discussions with the teachers it became evident that they perceive mentoring to be a form of continuing professional development whereby they gain new ideas. The meaning behind the teachers' perceptions of mentoring therefore was one of teaching. Once the initial categories had been constructed and themes placed the teachers were consulted for their opinions continuously.

The teachers were supplied with copies of the interview transcripts (see appendix 7) and were given an overview of the analysis technique. The collaborative element of the analysis had two aims. Firstly, to gain participant agreement and to ensure that the underlying meanings of the emergent themes had been correctly identified and that the selected categories were representative. Secondly, to urge the teachers to reflect on their knowledge and practice with specific regard to the identified themes. A simple matrix displayed the data, at this stage, for each teacher. The construction of the first stage matrices highlighted the need to delineate themes as well as

investigating categories further. A number of the emergent themes were reported, at this stage, in an ambiguous manner. For example, the theme 'teacher-pupil relationships' does not fully articulate the teachers' perceptions clearly. Indeed, the relationships that these science teachers have with their pupils function on many levels. Further reflective discussions and analysis also revealed that another round of semi-structured interviews needed to take place in order to delineate some of the themes and clusters and to address an imbalance in category perceptions. This is to say that analysis of interview data indicated that even though the interviews had highlighted certain perceptions of science there was a need to investigate this category further.

A second round of interviews concentrated on the teachers' perceptions of science but also dealt with some issues that warranted more attention, i.e. mentoring and teacher-pupil relationships. Transcripts were sent to each teacher and analysis conducted in the same manner.

4.6 Coding

Codes were applied to a phrase, sentence or paragraph in order to classify the meaning of the phrase and identify themes. An example of this is shown below (Table 4.3) in an extract from an interview with one of the science teachers. Emergent themes from the paragraph are shown in brackets to the right of the text. The example shows six themes emerging from this paragraph of the transcript. The themes are coded with the first letter of the category in which they are to be initially placed. Subsequent interviews and data from other sources (see appendices 4 & 8)

were coded in this way, using constant comparison-comparing data set to data set (Glaser and Strauss, 1967).

Table 4.3 Extract from an interview transcript	**themes**
I think relationships, the key to teaching is about relationships but its also about being honest with yourself, being honest as a teacher. Now there are certain techniques that I don't use because I don't feel right with them, they don't sit with me OK, I'm not being honest. I think the kids know when you're not being honest with yourself and with them. So I teach my way, its my character and I'm honest with them and I think kids appreciate that honesty..."	relationships T&L honesty L avoids some techniques T knowledge of pupils T&L idiosyncratic/individual practice LTSR mutual respect T&L

The key theme here is 'teacher-pupil relationships.' 'Honesty', 'mutual respect' and 'knowledge of pupils' cluster together with teacher-pupil relationships however, the two other themes do not immediately indicate relationships. 'Avoids certain techniques' and 'idiosyncratic', appear to be singular themes which warrant further analysis. After discussion and further analysis with the teacher, it became clear that 'avoiding certain techniques' is a perception of teaching which highlights this teachers' understanding of his teaching approach. 'Idiosyncratic', is a general characteristic and is quite easily placed in all four categories. All transcripts were analysed in this way. Making comparisons of data from each transcript enabled a process of continuous reviewing and analysis of the data. An initial matrix was constructed from each of the teachers' interview transcripts, an example is detailed in Table 4.4. The example of an initial matrix shows themes placed into the selected categories in a random order.

Table 4.4 Initial matrix construction from interview transcript

Perceptions of:			
Learning	Teaching	Science	Reflection
pupil-centred	informal style	fun	reflects in & on action
flexible approach	varies approaches	enthusiasm	constant
in-depth knowledge of pupils	in-depth knowledge of teaching	good knowledge of subject	context
teacher-pupil relationships	flexible approach	relevance of subject	creativity
recognises learning development	changes tack	difficult subject	intuition (on the hoof)
cooperative learning	CPD	extra-curricular involvement	explicit
organises learning		empirical model	innovation

Although the initial matrices provided a way of organising early themes the researcher and supervisory team felt that they lacked clarity and needed to be more readily identifiable as characteristics of expert teaching. Tables 4.5 and 4.6 show the development of the matrices as more data was gathered and analysed, using data analysed from Simon as an exemplar.

Table 4.5 Second stage matrix

Perceptions of:			
Learning	Teaching	Science	Reflection
uses pupil-centred approaches	has an informal style with pupils	injects fun into subject	reflects continuously in and on practice
is flexible with pupils	uses wide range of approaches	is enthusiastic	uses reflection to aid creative lessons
has in-depth knowledge of pupils	has in-depth knowledge of teaching	has good subject knowledge	is intuitive
forms teacher-pupil relationships	has a flexible approach to lessons	injects relevance into subject	attempts to make reflections explicit
recognises individual learning styles	can change tack during lessons	recognises science is a difficult subject	uses reflection to aid innovation in classroom
has good classroom management skills	values CPD highly	has an empirical model of science	
	takes risks		

This matrix shows the inclusion of a new theme 'risk-taking', while also showing how the original themes are becoming more identifiable as characteristics of practice.

Table 4.6 Emerging characteristics of an expert science teacher

Perceptions of:			
Learning	Teaching	Science	Reflection
utilises active learning strategies	has an informal style with pupils	has an empirical research model	reflects in & on practice continuously
is flexible within classroom atmosphere	utilises different pedagogues	is enthusiastic about science	reflects on successes & failures
utilises relevant analogies	takes risks during teaching	are teachers of science not scientists	utilises reflection to gain awareness of practice
creates strong teacher-pupil relationships	has a flexible approach	attempts to make science relevant	is intuitive in the classroom
recognises individual learning styles & differentiates learning	changes tack during lessons	is creative & innovative	utilises reflection to aid creativity & innovation
utilises effective classroom management	values CPD	injects fun into lessons	utilises reflection to contextualise practice
supports all pupils	creates strong teacher-pupil relationships		
has a genuine belief in the abilities of pupils	is a strong professional		
has an in-depth knowledge of pupils	has an in-depth knowledge of teaching		

Once again, more characteristics have been added ('genuine belief in the abilities of pupils', 'strong professional' and 'supports all pupils.' Matrix construction continued in this way by adding more emergent characteristics as data collection and analysis continued.

4.7 Observational data

Observation notes (appendix 4) consisted of: diagrams of the classroom layout; indications of teacher movement; short descriptive sentences of events; resources list, and brief summaries. As with the interview analysis, themes were identified but then cross-checked with interview data in an attempt to test or seek confirmation or disconfirmation of tentative themes and to provide a situational context to the teacher interviews. Using the coding system described, notes were scrutinised with emergent themes compared to those from the interview data and then categorised. An example of the analysis of the observations is shown in table 4.6. Selected notes are presented with coding shown on the right.

Table 4.7 Observation coding

teacher talk 1 explaining aims and objectives of lesson; 2 use of direct & non-direct questions; 3 asks for findings, direct Q&A; 4 informal group discussions, joking with students	**Codes** clear instruction, Q&A; fun; clear voice; informal
teacher behaviour 1 sat in centre of room; 2 animated; 3 waits patiently for attention; 4 moves between groups; 5 demonstrates equipment	dynamic; informal; monitors progress instructs/demonstrates
student talk 1 answering questions confidently; 2 attentive; 3 discussing activity; 4 joking with teacher	comfortable with learning; on-task; enjoying humour
student behaviour 1 listening to teacher; 2 working in groups of three; 3 confident; 4 carrying out activity	on-task; enthusiastic; comfortable; confident
general comments using white board-not chalk board; encouraging pupils consistently; H/O from CASE materials; good atmosphere - pupils enjoying activity; teacher moves among pupils, talks to individuals & groups; monitoring progress	works with individuals & groups; moves among pupils; good atmosphere

The above example shows the fragmentation of observation data. Data was searched for themes, and clusters of themes. The data were discussed with the science teachers and supervisory team, and cross-checked with interview data before being categorised. Comparing observational data with interview data helped to produce confirmatory or contradictory evidence for categorised themes thus, enhancing the rigour of the analysis. Where contradictory evidence was found the teachers were consulted and explanations sought as to the reasons for the contradictions through informal discussions. Observational data were discussed with teachers immediately after observations and thereafter, on a continual basis to confirm or contradict new data.

4.8 Reflective discussions

Reflective discussions between the researcher and science teachers took part on a regular basis, either face to face, by telephone and/or email. One group session took place. Discussions usually focused on a particular issue or theme identified from the data analysis. The dialogue was essentially unstructured, with the researcher taking notes or the teachers producing a reflective summary. Often, ambiguities emerged from the data which reflective discussions helped to clear, while enabling the researcher and teacher to uncover deeper meanings through joint analysis.

The method of analysis was kept consistent with the interview and observation data. Table 4.8 provides an example of the researcher's notes during a reflective discussion concerning mentoring. The notes take the form of coding, so words or sentences highlighted in bold represent a theme or underlying meaning to a theme. Table 4.9

shows a selected paragraph from a reflective summary made by one of the six teachers (see appendix 8) after the group session took place (see chapter 3, section 3.9). Analysis is the same as with interview data.

Table 4.8 Researcher notes from a reflective discussion

11 March 1998 Reflective discussion subject: mentoring
mentoring - **form of CPD; two-way process, mentor-student; provide and receive new ideas**; keep **up to date with theory** from student
helps to **reflect on own practice** as well as students' - **time** to sit down and **observe others' teaching**, see what others do and **compare with own practice**
enjoy talking about teaching and science; enjoy **sharing ideas; professionalism** - feel like helping to develop another teacher

Table 4.9 Paragraph from a teachers' reflective summary

para 1 I was fascinated by the common and united feeling throughout Tuesday. I believe that there is a very, 'difficult to put your finger on' aura type thing occurring. A bit like the often snubbed charisma/personality factor of leadership.	agreement of data; similar views; emotional unity

4.9 Triangulation

Triangulation may be defined as the use of two or more methods or techniques of collecting data during a research project. Denzin (1970) developed a typology of six principal types of triangulation, Table 4.10 identifies the six types:

Table 4.10 Six types of triangulation used in research

1	**time triangulation**: is concerned with elements of change and process and uses cross sectional and longitudinal designs.
2	**space triangulation**: attempts to reduce the cultural effects on research methodology by utilising cross-cultural studies.
3	**combined levels of triangulation**: uses two or more levels of analysis i.e. the individual level; the interactive level (groups) and the collective level (cultural and organisational).
4	**theoretical triangulation**: draws upon alternative theories as opposed to utilising one particular view.
5	**investigator triangulation**: utilising more than one researcher.
6	**methodological triangulation**: the use of two or more methods of data collection.

(adapted from Denzin's typology, 1970)

Although the primary method of triangulation for the present study is methodological triangulation, elements from other types of triangulation (consistent with Denzin's typology) are employed, such as: theoretical triangulation and investigator triangulation. The reported study is data-driven and wholly emergent, so consideration of alternative theories and models of expert teaching, from a wide range of approaches, is given by comparing findings with those from the present study (theoretical triangulation). The collaborative nature of this study shows that the six science teachers participated as research collaborators, acting both independently and as a group, also the researcher's supervisory team provided guidance and views on the findings. This has strong similarities to type five of Denzin's typology (investigator triangulation). Through this type of triangulation, data divergence and researcher bias is reduced through participant agreement. The strength of involving the teachers as both collaborators and those being observed is in the ownership which the teachers

took of the research (see methodology, chapter 3). The main weakness is that there is a danger that the teachers could get too close to the research and reduce the validity of the findings (see methodology, chapter 3) by becoming 'over eager' to present themselves as experts. However, of these six types, methodological triangulation is the one most frequently used in research (Cohen and Manion, 1994) and the primary type used in the reported study.

The three collection instruments (interview, classroom observations and reflective discussions) lend themselves well to the analysis technique used. Consistency was maintained between all three of the instruments which enhances the rigour of the analysis. Triangulation was achieved by combining the data from all three of the collection instruments. McCormick and James (1983) suggest:

> *...there is no absolute guarantee that a number of data sources that purport to provide evidence concerning the same construct, in fact do so...In view of the apparently subjective nature of much qualitative interpretation, validation is achieved when others, particularly the subjects of the research, recognise its authenticity. One way of doing this is for the researcher to write out his/her analysis for the subjects of the research in terms that they will understand, and then record their reactions to it.* (p.45)

The collaborative nature of the study means that respondent reliability is high. The triangulation process was also enhanced through continuous analysis and review of data. Each data set helped to corroborate and define other data at a greater level.

4.10 Data integration

Data from observations and reflective discussions were integrated with interview data after the four categories and emergent themes had been organised into initial matrices from the interview data. The initial matrices (see Tables 4.3 & 4.4) were used to

show summary data in an attempt to ease the search for divergent or supporting evidence from observations and reflective discussions. Where interview data appeared to be conflicting with data from one or both of the other data sets, the teachers were consulted and further analysis took place. For example, interview data from one of the teachers suggests that he does not favour didactic methods of teaching, such as dictation. Observation notes show that this teacher used dictation in one of the observed sessions. After analysing the data with this particular teacher it became clear that while he is reluctant to use this method on this occasion, the pupils were exhibiting over excited behaviour that was beginning to disrupt the pace and flow of the lesson. The use of brief dictation, he felt, had the effect of calming the pupils down, and bringing the lesson back to the desired pace and flow. This clarification of divergent data had two effects: firstly, it identified that the teacher has a dominant preference for non-didactic methods and secondly, it substantiated evidence suggesting that the teacher varies his approach and techniques, and will utilise didactic methods occasionally. Supporting evidence was analysed in an attempt to gain a deeper meaning of an emergent theme or themes. An instance of this is highlighted when looking at the supporting evidence of a reflective discussion with one of the science teachers. Interview data suggests that the teacher in question places a great emphasis on continuing professional development. During a later reflective discussion, it emerged that the teacher had developed and led an InSET (In Service Education and Training) programme as well as taking part in, what he terms, a "*quality development programme.*" The reflective discussion not only highlighted data from the interview but provided a deeper understanding of the value which the teacher places on CPD activity. After analysing divergent and supporting evidence,

matrices were added to in an attempt to delineate the information contained in each cell.

4.11 School data

The primary sources of data (interviews, observations and reflective discussions) were supplemented by a secondary source which provided details of each of the teachers schools. Documents were gathered, such as current inspection reports and school prospectus, in an attempt to provide an overview of each school to enrich the story being told in the present study. This data is stored on a floppy diskette at the Centre for Science Education.

4.12 Summary

The aim of the analysis technique employed was to keep the data manageable without distorting it, and to retain the integrity of the science teachers' perceptions. The process of triangulation added to the rigour and validity of the analysis by combining data sets in a search for a clear meaning to each emergent theme, and by acquiring respondent validity through collaboration with the teachers. The main problem of this technique was that an overwhelming amount of data was generated, and it was often difficult to differentiate between unrelated data and data specific to expert science teaching. This was typical of the reflective discussions. Due to the unstructured nature of many of the discussions the teachers would often stray into dialogue which was not specific to expert practice, such as: disagreements with school and

educational policy. However, as this problem was realised early in the research reflective discussions became more focused as the study progressed.

A great emphasis is placed on the importance of the science teachers' perceptions, views and beliefs within the reported study, so the analysis technique employed is influenced by a data-driven approach, and not an adherence to a particular existing theory. Emergent themes are identified from the data and substantiated by the teachers through an on-going process of analysis and reflection.

Comparing findings to existing theories and models demonstrates another element of triangulation. Existing theories may serve as a yardstick for gauging the potential of the findings from the present study.

The use of matrices to illuminate data was useful in providing an illustrative, organised way of presenting data. The teachers found these particularly interesting and informative when reflecting on their teaching. By placing short indicators of each characteristic in categorised cells, interpretation of the data was made easier.

The techniques used to analyse data from the reported study are within the grounded theory paradigm. They are effective in managing and interpreting the types of data collected for the study. As a large amount of data was generated it was important to organise the data into manageable forms, these techniques offer a process whereby categorising and sorting data is done practically and efficiently. The systematic use of comparative analysis (comparing findings from observations, interviews and reflective discussions to each other, as well as comparing findings from the present study with existing studies) is an attempt to produce a rich and dense theory which is applicable to the research situation.

5 Teacher profiles

5.1 Introduction

This chapter sets out brief profiles of each of the science teachers who participated in this present study. Each profile provides an overview of the teachers' schools and schools' aims in an attempt to provide a sense of the environment within which each teacher practices. A brief statement identifies pupils' general attitudes and behaviours during observations. Personal details such as years of experience, qualifications and activities outside of teaching are highlighted to present a broad picture of each science teacher. Data for this chapter were gathered from school inspection reports, school brochures and interviews with the six teachers.

5.2 Profile 1: Simon

Simon teaches at an 11-16 comprehensive school on the East side of Manchester, which has a high level of deprivation and an unemployment rate that is higher than the national average. There are approximately 1,100 pupils presently attending the school. There is ten staff in the science department including one technician and one part-time chemistry teacher. The department has six laboratories, four of which have been recently renovated. The laboratories are well lit and have various science related posters and pupils' work presented on the surrounding walls.

The school's aims identify a commitment to a broad and balanced curriculum that attempts to enable pupils to achieve their full potential. The school is also committed to the promotion of pupils' self-esteem and personal autonomy, while fostering such values as honesty and integrity. The school curriculum attempts to be broad, balanced and conforms to National Curriculum requirements. Pupils in years 7 and 8 are involved in the CASE (Cognitive Acceleration in Science Education) initiative. In year 9 pupils are setted and the science course, while remaining coordinated, is taught as Biology, Chemistry and Physics leading to a dual award at GCSE in years 10 and 11.

Observed sessions show pupils have positive attitudes to learning science, are well motivated and interact well with Simon. Pupils work well in groups and demonstrate sensible and mature behaviour when using equipment in practical work. Most pupils ask questions and seek to discuss concepts and themes with Simon. Often, while working in small groups, pupils acted as a team with a spokesperson asking questions on behalf of the group, though this did not stop other members asking questions also.

For the majority of the time pupils appeared to be on task and enjoying science lessons.

Simon is a Physicist and head of department. He has taught for ten years and at two schools. Simon joined his present school as head of department and has been a member of staff for six years. He is currently finishing his Master's dissertation and has recently achieved Advanced Skills Teacher status. As part of his outreach duties as an AST he has been working with staff at a failing science department in a large comprehensive school in Tameside. Working with staff he has provided them with materials and activities from his own teaching repertoire and has assisted the department's staff in producing their own materials and new ideas for their teaching. Simon is also a student-teacher mentor working with Sheffield Hallam University.

Simon's managerial style with colleagues is similar to his approach with pupils. It is based on mutual respect, fairness and equality. He is organised and has led the development of many of the department's resources. He actively seeks to support staff in their teaching and development. Observations suggest that departmental colleagues value Simon's leadership, while his participation in promoting the school within the wider community is clearly valued by senior colleagues.

Throughout the study Simon has expressed his keen interest in education not just at a professional level but also personally. He considers himself to be an educator with a science background and sees pedagogy as *"..not just my job but my hobby as well."* During interviews and reflective discussions Simon has demonstrated a good knowledge of relevant educational research and explained his interest in wanting to

apply findings from research studies to his own classroom teaching. This he believes will expand his teaching repertoire and continually update his science teaching knowledge and skills:

> *..I do enjoy reading about education and about, I don't know..peoples' images of science, all these things. And I do try to think well what do I do? Do I do that, do I portray that image, do I behave like that? And I try to mate my own teaching styles to what I see in the research. And I'm striving to achieve that.* (interview)

5.3 Profile 2: Debbie

Debbie teaches at a medium sized 11 - 16 comprehensive school in Stalybridge, Cheshire. Pupils come from mixed social and economic areas. There are approximately 800 pupils currently attending the school. There are six teaching staff in the department including one technician. The department has five laboratories all situated within the centre of the building, which means that the laboratories have no windows and only artificial lighting. Pupils' work and scientific posters cover the majority of the walls. The school aims to provide a learning environment where each pupil has the right to be happy in learning and developing. Respect for each other and self-respect is the cornerstone of the school's aim to promote moral values. The school attempts to administer a broad, balanced curriculum which meets statutory requirements. Pupils are not setted and all study for a dual award at GCSE in years 10 and 11.

Classroom observations show most pupils to be attentive, responsive and motivated. However, in some lower band classes a small minority of pupils do not apply themselves positively and can be quite disruptive. Most pupils are enthusiastic about

science and often engage Debbie in discussion and are confident to ask questions. Teacher-pupil interaction shows mutual respect and a willingness, on the part of the pupils, to take responsibility for their own learning. Pupils generally demonstrated sensible and mature behaviour when participating in practical work, and also toward group work.

Debbie is a Chemist and head of department. She has been teaching for fifteen years and at three schools. Debbie joined her present school as head of department five years ago. As well as head of department Debbie coordinates careers and work experience sessions, and is head of year 10. She has an MSc in Educational Management.

When Debbie arrived at the school the science department had just received an unsatisfactory OFSTED inspection. She has now built up a resource base of teaching materials and leads the department well. During observations Debbie appeared very well organised and efficient. In 1997 the school achieved a satisfactory inspection, which singled out the science department's leadership for particular praise. She has an efficient management style and is well organised. Observations suggest that colleagues within the department have a healthy respect for Debbie's leadership. The department staff often holds team meetings, led by Debbie, in an attempt to develop the department and highlight individual concerns. Debbie is part of a staff team within the school who organise an annual, international trip for selected pupils who have exhibited high levels of commitment over the school year.

Creativity in lessons is important to Debbie. Her time constraints are compounded by responsibilities other than teaching, such as administrative duties. Because of this she

makes use of industrial and science initiatives, as well as developing a bank of resources for the department that include worksheets, activities and visual aids. Debbie also feels that her continuing professional development is important. She says that *"I don't need any more science knowledge..its just how I could make it a lot more interesting."* She feels it important to update her educational and pedagogical knowledge rather than her subject knowledge.

During interview Debbie spoke of her professional and personal interest in education and teaching. The following quote appears to indicate a sincere belief in teaching:

> *Because you've had an influence on somebody's life. I mean, I remember the good teachers at school, it isn't the ones that you think are dead easy, a pushover, its the ones you respect and they change your life in some way* (interview)

5.4 Profile 3: Steve

Steve is a Biochemist and is second in the science department at the same school as Debbie (two teachers were chosen from the same school because of their different approaches and styles, and because of their strong interest in the study). He has taught chemistry for eighteen years at two schools. He has been at his present school for seven years. Steve's qualifications include a first degree in Biochemistry and a PGCE (Post Graduate Certificate in Education). He is a student teacher-mentor linked to Manchester Metropolitan University.

Observations and discussions identified Steve as a very approachable and warm person. He accommodates this in his teaching by utilising an informal and empathic approach to pupils. Many of his teaching strategies involve discussion and

negotiation with the pupils around topics and how they like to learn a topic. He perceives his approach to teaching to be based on a counselling model and likes to interact closely with pupils to gain an in-depth understanding of why they behave in certain ways. He then takes this knowledge and uses it to inform his classroom techniques and teacher-pupil interactions. He too, uses mutual respect between teacher and pupils as a mechanism for classroom management. During observations it was clear that relations were strong with the pupils and that they felt comfortable and suitably motivated in the classroom, with hardly any off-task behaviour observed.

Steve says that he may choose to apply for a head of department position at some time in the near future, though he does not wish to go further into management. He states that he enjoys teaching and does not want to move out of the classroom into a management role. He also warns of the dangers of teacher burnout from too many administrative duties and management pressures. Steve sees classroom teaching as his main responsibility and feels privileged to be teaching pupils science:

> *Its easy to take on too much and lose sight of the primary goal, teaching kids. Burnout comes from pressures outside of the classroom, admin and management. I love being with the kids, it's a pleasure to help them understand and enjoy science.* (reflective discussion)

5.5 Profile 4: Andy

Andy teaches at a medium sized 11 - 16 comprehensive school situated on the outskirts of Sheffield. There are 1136 pupils currently attending the school. Pupils are from social and economic areas that are reported to be of higher than average levels of deprivation. The science department has four laboratories with pupils' work

and posters decorating the walls. Hanging from the ceiling are cards with key words on them such as, variable, atom and concept.

The school's aims include providing a caring and ordered learning environment for pupils that cater for all abilities. The school also promotes such qualities as understanding, respect, generosity and pride. These aims are all key to the school's vision of delivering effective and quality learning. Pupils are setted at year 9 and all are entered for dual award at GCSE.

During observations it was clear that pupils enjoyed science lessons and responded to Andy in a positive and enthusiastic way. Talking to pupils before and after lessons revealed that they gained a lot of motivation from his own enthusiasm for science and that they enjoyed his sense of humour during lessons, which added to their feeling of comfort and safety (confidence) in the class. Pupils frequently asked questions and demonstrated strong enthusiasm for practical and group work, acting sensibly and maturely around equipment.

Andy is a Physicist and has been teaching ten years and at two schools. He has been at his present school for five years and joined as head of department. Andy has completed a Master's course but has yet to finish his final dissertation. He is a student-teacher mentor linked to Sheffield Hallam University and has also been given Associate Teacher status for his work with the Pupil Researcher Initiative and other projects at the University. Since joining the school as head of department, Andy has built up a strong resource base and is seeking to gain accreditation for the department as a centre of excellence.

Andy's vision of the department becoming a centre of excellence demonstrates his motivation and belief in the science department and in the school as a whole. His managerial style reflects his commitment to the school and colleagues, through his enthusiasm and willingness to listen to and value the opinions of others. Observations show that staff within the science department work as a team and value Andy's guidance and energy. Andy's involvement in extra-curricular activities, such as science fairs and school events, also demonstrates his commitment to the school.

As with the other teachers, Andy believes in building teacher-pupil relationships based on mutual trust, respect and a genuine belief in the pupils' abilities. This demonstrates his overall attitude towards teaching and education which he feels is about encouraging pupils and helping them to get the most out of their education.

> *Its being very positive and believing they can do it. So I genuinely believe that they can do what I ask them to. With positive encouragement they get more out of it [lesson] and at the same time it builds a better relationship with me and the way I work.* (interview)

5.6 Profile 5: Janet

Janet is a member of the teaching staff at a large 14 - 19 community college in Leicester. The catchment areas are mainly from the southern and eastern parts of the city and rural areas surrounding the college, because of this pupils are from a mix of socioeconomic backgrounds. The number of pupils currently attending the college is approximately 1649. There is eighteen full time staff in the science department. The college has six well equipped and modern laboratories all displaying pupils' work and also has scientific posters on the walls.

The college's aims include: producing self-reliant, lifelong learners; the promotion of multicultural diversity and preparation for global citizenship. The college encourages its aims by providing a culture of encouragement and an investigative, challenging approach to teaching and learning. Pupils undertake coordinated science at year 9 and all are entered for dual award at GCSE.

Observations demonstrated that most pupils are responsible, enthusiastic and enjoy lessons. The majority of pupils are confident and frequently ask questions, while showing a good understanding of chemistry. Pupils work well both individually and in groups.

Janet is an experienced chemistry teacher who has been teaching for thirty years in six different secondary schools. She has been in her present post as head of the science department for twelve years. Janet was one of the first cohort of Advanced Skills Teachers and has links with the University of Leicester where, as part of her AST outreach duties, she delivers a chemistry component for KS3, KS4 and post 16 on the PGCE course. She also has experience in mentoring student-teachers. She states that her promotion to AST status will enable her to stay in the classroom as she greatly enjoys teaching, but will allow progression of her career. Janet has recently gained a research fellowship to identify and integrate study skills into the science curriculum and to use this as an opportunity to promote the use of ICT in science. She hopes to count this towards her Master's degree.

Janet exhibits strong organisational skills and a commitment to developing the department's resources and staff. She has initiated several CPD programmes for

colleagues within the department and believes that teachers need to take part in continuous professional development activities. Observations indicate that a positive and friendly atmosphere exists between staff in the science department. Janet's style of management is based on respect for others and understanding their concerns and views. Janet expresses her total commitment and belief in teaching and education as a:

> *...love of the job. I love teaching, I wouldn't do anything else. I get a great deal from teaching and learning with the kids.* (reflective discussion)

5.7 Profile 6: Ian

Ian is a science teacher at an 11 - 18 comprehensive school in Derbyshire. It is grant maintained with 1031 pupils currently attending. The majority of pupils transfer from eight local primary schools in an area reported to be relatively prosperous. There are six well equipped laboratories in the science department, all with science posters and pupils' work displayed on the walls. The ethos of the school is very relaxed and is demonstrated through an informal dress code. The teachers and pupils communicate using first names rather than the traditional 'Sir' or 'Mr.'

The aims of the school underpin the informal but professional atmosphere which is promoted. The school encourages development and achievement for all and aims to nurture empathy and understanding for all pupils and staff. Pupils are setted in year 9 and all study for dual award at GCSE.

Observations identified the vast majority of pupils as hard working and responsible. They appear to take pride in their achievements and talked openly with the researcher. Teacher-pupil relationships are well established and work effectively. The pupils

seem keen to take responsibility for their own learning and enjoy practical and group work. Some pupils were observed generating discussion with Ian and asking work related questions.

Ian has been teaching for twelve years and has taught at two schools. Currently he is head of year 10 and has been in his present school for five years. Ian holds a Master's degree in Educational Studies and is a student-teacher mentor linked to Sheffield Hallam University. He also has strong links with the Pupil Researcher Initiative (Centre for Science Education) as a Teacher Associate.

Ian regularly contributes to extra-curricular activities and has a strong commitment to developing the school's image within the community. This is also reflected within the department and his involvement in departmental meetings.

He has a very informal approach with his pupils, in line with the school ethos. He perceives a pupil-centred approach to be beneficial in breaking down barriers between the teacher and pupils. His vision of teaching and education is based within this perception. He believes that teacher-pupil relationships are the cornerstone of teaching. During interview, when asked if he was conscientiously looking to set up this kind of relationship with the pupils he stated:

> *Yes, very much so. I mean that is the ethos of the school, not to set up these barriers its the same with the first name terms, its not them and us you know.* (interview)

5.8 Summary

These profiles aim to provide an overview of the schools in which the science teachers practice, together with an indication of each teachers' background and overall educational philosophy. The profiles show that two of the schools are sited within mixed socioeconomic areas, two are in areas of higher than average deprivation, while one is situated within an area which is relatively prosperous. The schools have similar philosophies which indicate a strong responsibility to the pupils and the wider community. Three of the science departments appear to be of an adequate standard with good resources, although two of the schools have departments with new, modern laboratories which are of a high standard. During school visits, pupils from the schools appeared to be responsive and polite to visitors, while classroom observations suggest that the majority are hard working and willing to learn. The science teachers share a keen, professional attitude towards teaching, and enjoy interacting with pupils, in and outside of the classroom. They indicate a deep sense of satisfaction about their profession and are motivated to keep abreast of educational and scientific developments. These profiles attempt to provide a setting for the study by presenting a brief glimpse into professional environment of each of the science teachers, and by providing general details about the teachers themselves.

All of the teachers were observed teaching in their specialist subject areas, although Janet was observed teaching a topic new to her (Plate Tectonics). The present study did not aim to measure expert science teaching by pupil achievement, however as the schools were all in the secondary sector taking their pupils from relatively mixed social and economic backgrounds, observations included pupils from comparable groups.

6 Findings

6.1 Introduction

The findings presented in this chapter are derived from data gathered from interviews, observations and reflective discussions. The data shows a high degree of agreement between the six science teachers as to what characteristics constitute expert science teaching. The findings detailed are supported by relevant quotes from interviews and reflective discussions and accounts from observations. Emergent characteristics are detailed under the four core categories used in the data analysis: perceptions of learning, perceptions of teaching, perceptions of science and perceptions of reflection. The important issue of how the teachers changed as a result of their involvement in the study is indicated throughout the chapter, but is emphasised before the summary conclusion.

6.2 Perceptions of learning

This category organises emergent themes under the teachers' perceptions of learning. The researcher, after consultation with supervisors and participating teachers, decided that themes such as analogies and pupil achievement are more clearly defined in the context of the teachers' perceptions of how pupils learn and how expert science teachers are aware of the mechanisms of learning.

Interviews and observations, in particular, show that the teachers in this present study have perceptions of learning, which appear to be linked to an in-depth knowledge of pupils. The data indicates that they perceive a pupil-centred approach to be essential in maximising effective learning, as opposed to a didactic approach, although they acknowledge that they do use didactic techniques (i.e. dictation and instruction) if they feel the situation warrants this, for example, when the teachers feel that greater control of the class is needed or a change of pace. During classroom observations the teachers used a number of active teaching and learning approaches to engage and challenge pupils. In one observed session investigating types of fuel, Simon produced a box of varied examples of fuel, which ranged from wood to petrol. Through whole class demonstration and discussion, the pupils were able to touch and see the examples as Simon explained the origins and substance of the fuels. They were then asked to work in small groups and produce a group transparency detailing one fuel, its origins, substance and uses. The transparencies were then presented to the other groups. Simon states that:

> *There are lots of different techniques, I like the kids to be actively involved. Some people are auditory they are going to listen to what I'm saying. Some of them are going to be very visual so my lumps of coal help them*

with it. Some of them like kinaesthetic, touching, so they can look at my dirty hands. (interview)

Actively involving pupils in science is something these teachers feel is of fundamental importance. By using active teaching and learning approaches the teachers attempt to develop pupils' creativity, enjoyment and motivation as well as cognitive aspects of science. Andy explains this view:

> *Using activities that are fun and interesting to do the kids get a feel for science, an interest, more than just facts and concepts. They like to do science, and that helps them to learn science.* (reflective discussion)

The motivational issue in utilising active teaching and learning approaches is also felt to be of great importance by these science teachers. They feel that by designing and utilising activities based on variety and interest, pupils' motivation will be stimulated by features such as, curiosity and enjoyment. Andy suggests that:

> *Motivation comes with enjoyment, kids need to be interested and curious especially in science. If they are enjoying the lesson they are not going to get bored and switch off, they'll want to do more. (reflective discussion)*

Observations of all of the teachers in this present study suggest that active teaching and learning approaches such as the example detailed above is common practice for the six teachers. Role playing, small group and whole class discussion were also observed. Other approaches such as CREST projects, PRI and science clubs are or have been utilised by this group of science teachers.

6.2.1 Analogies

Using interesting analogies to explain concepts and theories in science is a technique that this group of science teachers demonstrated often. An observed lesson which involved Andy teaching energy and movement, highlights this theme. Andy referred to the television programme, 'Star Trek'. The starship, which is central to the show,

has a warp drive process that creates its own space via a bubble for the ship to travel in at high speeds, thus reducing friction and pressure. The pupils responded well to this with subsequent questioning revealing that pupils had understood the concepts or objectives of the lesson:

> *Yes, the Star Trek thing usually works well. I don't know any kids who are not familiar with the programme. Its interesting for them and fun and I can get my point across. It might not be real life but some of the stuff they [programme] talk about is real, and useful.* [reflective discussion]

Another example from classroom observations shows Simon explaining the concept of satellites by explaining how we receive television pictures with Sky TV. By using chalkboard diagrams he demonstrated the signal transfer from a satellite to a television. He asked how many of the pupils had a satellite system and then asked the respondents if they had experienced problems with reception. He then explained why such problems occur. Through this analogy Simon had captured the pupils' interest by injecting relevance and realism into the content of the lesson:

> *Well, most people have satellite television these days so I felt it was something the kids would respond to and they did. When you talk about things they know about, can visualise, they find it interesting and want to know more.* (reflective discussion)

Reflective discussions reveal that the six teachers all perceive analogies to be a powerful tool in explaining difficult concepts to pupils and creating interest. They also see it as a way of bringing relevance to lesson content by highlighting processes, uses and products that the pupils recognise from their day-to-day routines.

6.2.2 Teacher-pupil relationships

Evidence from the data shows that this group of science teachers establish and maintain good relationships with pupils. One clear reason for doing this is that the

teachers have a commitment to building pupils' self esteem. This is something they see as essential to successful learning. The teachers attempt to build the self esteem of pupils by providing a safe classroom environment. Although they do manage safe working practices within the classroom, 'safe' in this context means creating a classroom atmosphere that is comfortable for the pupils to learn in, as Ian states:

> *I think its perhaps providing a safe environment so that they [pupils] feel they can say 'no, I don't understand it.' And then I can go through the process of looking through the book or whatever, so they know they can do it next time.* (interview)

Ian's statement is supported by observations of his practice. While teaching a Y10 group the features of sedimentary and igneous rock, he challenged one pupil to identify a sample of rock on display in the laboratory. The pupil could not readily identify the rock. Ian asked the pupil to search through the text book, which the group were using, and to identify the rock and its features. As the pupil searched the relevant text Ian instructed the other members of the group to do the same. After a short period the pupil correctly identified the rock and its salient features. Ian asked the other group members to confirm the individual's response and then praised the individual pupil for his efforts. At no time did the pupil appear threatened during the exercise. His response was positive and supported by other pupils in the class.

During interviews and reflective discussions it emerged that providing a safe environment was also about breaking down barriers between the teacher and pupils. Each of the science teachers expressed this view, which they see as a way of encouraging mutual respect between teacher and pupils. However, this does not mean that they do not lead the class, as Janet and Ian explained during interviews, when asked if they attempt to break down barriers with pupils:

> *It is but on the other hand I want some respect, I mean they have to see me as being the leader of this activity and that basically most of the time it doesn't matter but occasionally you need to be in charge. And they need to respect you for someone who has more knowledge than them and more responsibility in a way.* (interview)

> *...its not them and us you know, we're here together and its the same with the student-centred approach, erm you muck in and get in with the students have a bit of banter with them er, but they know where the boundaries are.* (interview)

The data indicates here, that the group of teachers perceive a co-operative learning approach to be conducive to effective learning. They do not see themselves as a separate entity within the classroom but as another participant with a different role and responsibilities to that of the pupils. By breaking down barriers and creating relationships based on mutual respect these teachers encourage their pupils to take responsibility for and enjoy learning. This co-operative learning approach appears to be grounded in their view of pupil-centred learning. Analysis also reveals that the science teachers from this current study inform their knowledge of pupils by utilising such an approach. Andy highlights this by suggesting that as a teacher he is part of the classroom group:

> *Yes I think we are all together on the journey sort of thing, we're all going in the same direction. Erm, I can play that to an extent as well, because sometimes when I'm asking questions I can actually play right down to the role of being the idiot with me not really knowing it [answer]...I can generally get them to start telling me, you know I can say, I don't know this how would I go about it? And they will take responsibility. They know what I'm doing but they will do it.* (interview)

The teachers' concern for pupil achievement is also linked to knowledge of pupils through an understanding of individuals' abilities.

6.2.3 Pupil achievement

An emergent theme, which seems to underpin the teachers' knowledge of pupils, is a strong desire to see pupils achieve their full potential. They have a genuine belief in pupils' abilities, and attempt to pass on this belief and confidence to their pupils. Janet emphasises this point clearly during interview:

> *They know that I am there for them [pupils], which is what I value very much, you know the fact that I have the privilege of teaching them and I want them to do well. What ever they achieve I believe in them.* (interview)

Reflective discussions show that the teachers believe that a co-operative learning approach helps them to understand how groups of pupils learn together and also how individual pupils learn.

The teachers consolidate this by adopting techniques and approaches, such as group work, to build pupil self esteem and aid their learning. A technique consistently used by the teachers is 'encouragement and praise.' All the teachers delivered continuous encouragement and praise to pupils for their efforts, both individually and to the whole class. Simon indicated this point during interview:

> *Now to learn, you've got to be able to feel comfortable, you've got to feel sort of, well this person wants me to learn, wants me to understand this, cares how well I do...You're not going to judge them, you're not going to say hey you're rubbish...If you keep saying well done they think they can do it. Its like Sarah and Joanne, they're struggling like hell with this [concept] but they're trying, they're not switched off, they haven't given up.* (interview)

During a group reflective session the teachers acknowledged that this technique does not work for all pupils (expressed by Janet below) but there is a consensus among them that encouragement and praise is a vital technique for motivating pupils and producing effective learning:

> *...if they are enjoying what they are doing and wanting to do they are less likely to feel this is all a waste of time. It doesn't always work, I mean every teacher, if we're honest, will tell you that there are students who don't come around.* (interview)

Recognition of pupils' moods is also an element which is part of these science teachers' knowledge of pupils. Interviews revealed that they instantly recognise how pupils react to activities and approaches, as Simon explained after taking a decision to change his planned approach during one lesson:

> *I did consider doing a bench talk but having seen them coming in and the sort of mood they're in...I thought OK its going to take too long and they won't get through the second part of the lesson, so what I'll do is this. And so on.* (interview)

He states further that this perceptive ability is on-going during the lesson, something that all of the teachers concurred with during discussions. Because they can identify pupils' moods and changes in classroom atmosphere they have developed a flexible approach. In this context, the teachers see flexibility as classroom awareness. The essence of flexibility here then is, as Simon states, *"...recognising what they [pupils] are doing...the problems the kids are having and reacting to them in a positive manner."* During an observed session with Debbie, pupils were conducting an investigation into chromatography. She stopped the bench work after a short period and instructed the pupils to consult a worksheet she then handed out. Her reason for doing this was that she felt the pace of the lesson had slowed and that the pupils were not going to finish their investigations. She wanted them to summarise their findings on the worksheet. Debbie had planned to introduce the worksheet much later in the lesson but thought that the pupils would benefit from the listed guidelines. She referred to her awareness of classroom activity as the *"eyes in the back of the head syndrome."*

"I think I could tell you what every single person in that room was doing if I had to look back and think about it. I could tell you which ones weren't on task or whatever and I'd hope I'd pick it up quick enough." (interview)

This example from Debbie's practice demonstrates a tacit awareness of pupil activity and behaviour.

The teachers' perceptions of pupil achievement appear to indicate that they prefer formative assessment by working closely with their pupils, having an understanding of individual pupils' learning, and utilising questioning techniques. This may explain why they made no comments about summative assessment and suggests that they see summative assessment in terms of exams, end of term tests and school reports, which are not necessarily indicate characteristics of expert science teaching. However, in the absence of data to confirm this the issue warrants further investigation.
The data suggests that the teachers in this present study have a perception of learning that is built on an awareness of:

- active learning strategies
- stimulating and relevant analogies
- strong teacher-pupil relationships
- a co-operative learning approach
- pupils abilities
- classroom atmosphere
- flexibility

The chapter will now proceed to consider findings from the data categorised as perceptions of teaching.

6.3 Perceptions of teaching

Perceptions of teaching was chosen by the researcher, again in agreement with supervisors and participating teachers, to organise themes which demonstrate the teachers' perceptions of the mechanisms which expert science teachers utilise to teach science effectively. For example, risk taking and autopilot are described in this context as the teachers perceive these characteristics to be practical mechanisms that experts make use of during practice. They do not see them in a way which enhances their understanding of learning processes or as perceptions of science or reflection, but as pragmatic tools that help to take their practice into the arena of expert.

The six teachers differed slightly in their perceptions of teaching. Andy and Simon see their teaching as a performance based approach. While Janet, Steve and Ian express their approach as essentially guidance and coaching. Finally, Debbie perceives her approach to be based on a training model. Reflective discussions revealed that Andy and Simon define their performance based approach as dynamic interaction with the pupils. They feel that teaching is about the pupils being motivated to discover knowledge for themselves. Andy suggests that:

> *I don't see teaching being all that different, in some ways, to entertaining. ...Yeah, its performing but with a goal, that it will set some interest in the content. So it is a performance...there is an aim to try and get the students interested to want to learn about the information.* (interview)

Janet, Steve and Ian explain their approach in terms of guidance and coaching, which they see as providing scaffolding for the pupils to discover knowledge. This is to say that they act as a support mechanism for pupils by providing direction, motivation and support. They do this by guiding pupils to information sources and by using informal discussion, which they believe helps pupils to think about knowledge for themselves

rather than providing knowledge in a didactic instructional sense. Their approach has an underpinning empathic quality that they believe enables them to communicate with pupils more effectively. Ian states:

> *I always think that they [pupils] can pick it up themselves and having gone through the process of thinking about it themselves, then it stays in a little bit more than it would do if you just tell them what it is. Its feeling something rather than being told it, that's the underpinning thing I think.* (interview)

The five teachers all agree on a knowledge discovery model that allows pupils to find out subject knowledge for themselves by having limited information given to them by the teachers and through stimulating and challenging activity. This is done through their preferred approach. Debbie's perception differs from the other teachers in that her approach is based on a training model underpinned by knowledge transfer. Her approach is typified by providing full accounts of information for the pupils followed by practice.

Debbie provided evidence for this, particularly, when instructing pupils in a recipe type investigation on chemical reactions. Classroom observations highlighted Debbie's approach as she instructed pupils and then assessed their understanding in practice. She gave pupils all the information they needed to complete the investigation while reinforcing knowledge through informal questioning at each bench. The pupils practised the knowledge Debbie had given them as opposed to having limited information and discovering results from investigations. Debbie explains her approach from the context of the school:

> *I think this particular school...I've been here five years and I think now I'm a better teacher than I was before and I haven't learned any more content knowledge, I've learned more classroom skills I think, because I didn't need to use them [in other schools]. I didn't have difficult children like this, I mean I'm not saying its a difficult school to work in, I enjoy this school more than any of the others because I think you get more satisfaction out of them than at*

> *the other school, the kids they do like you and if you do something they appreciate the fact. Whereas at the other school they just take it for granted.* (interview)

This is also linked to the teachers having the ability to develop strategies to cope with deviant behaviour (see 6.3.6). Debbie also states that the *"National curriculum has taken a lot of the interesting stuff out of science. All the stuff that kids did enjoy and that we enjoyed doing."* In later reflective discussions, Debbie suggests that a training based approach can help pupils prepare for the demands of a labour market that does not always require intensive knowledge of subject content but seeks practical skills such as, manipulating equipment correctly and communication with others together with basic skills:

> *Many employees now are looking for common sense skills like, initiative and communication skills as well as basic skills. As long as subject knowledge is at a good standard people can develop that during employment.* (reflective discussion)

She believes that concentrating too much on knowledge discovery may inhibit some of the skills which her training approach, based on knowledge transfer, aims to enhance, and that the curriculum, to an extent, constrains creative knowledge discovery approaches through being inflexible and having a heavy emphasis on subject content as opposed to developing skills through learning.

The data suggests that five of the teachers act more like a coach than a teacher, for most of the time. As coaches they send messages to the pupils through demonstrations and interactions. The pupils, in turn, send messages to the teachers through their performances. The coach interprets pupils' messages and responds to problems and difficulties that the pupils may be experiencing. This dialogue appears to be a form of reciprocal reflection-in-action. Both teacher and pupil reflect on messages sent, act and move on. Debbie is the exception within the group however,

although her approach is based on knowledge transfer and not discovery, she did demonstrate an acute awareness of pupils' problems and difficulties.

Although these teachers express differences between their individual approaches, during interviews and reflective discussions, observations proved that they did employ a variety of approaches. When asked to clarify this point the teachers agreed that there is a need for flexibility within their classroom approaches and that they do use other ways of teaching, although their preferred approach dominates.

6.3.1 Flexibility

Being flexible not only affords these teachers an awareness of the classroom environment, as discussed earlier but also enables them to change tack during lessons. During one observed session, Andy asked pupils to stop their investigations and gather at a workbench occupied by two pupils. He then asked the two pupils to recreate their investigation following the same steps as before. After they had concluded their recreations, a short discussion followed with Andy then instructing the class members to rotate from bench to bench after they had completed each investigation. When asked during interview why he had done this, Andy explained that some pupils had completed their individual investigations far quicker than he had anticipated while others had not understood the activity. Two of the pupils had taken their investigations further and expanded on their results. Andy's change of tack had two objectives: firstly to show the other class members how to continue their investigations and to rotate between different apparatus on other benches and

secondly, to highlight the findings of the two pupils and to bestow some praise for their initiative:

> *But there are times when I've got to try and work out in my head how many children understand what they are supposed to be doing and how many don't so that activity this morning is very close, probably half the children, which is actually a good number for that activity, were getting to grips with it and understanding and I was also very aware that the other half were not...what I've got to do now is go in and talk to the whole class.* (interview)

This example, explained by Andy, is typical of the science teachers in this present study. As Simon explains further after taking a decision to change his plan during a lesson:

> *...I'm not going to do it. I'll put that to one side, I'll do this...I don't think I ever, in any lesson, have a linear plan. I don't think I ever see it as a linear function that I start here and I'm going there. I do see the end points, these are my objectives this is what we are going to learn...Between that I've got to be very, very flexible.* (interview)

These science teachers agree that changing tack is an important element of a flexible teaching approach. Flexibility also helps them to pace lessons effectively so pupils with varying abilities are never lost or held back. Steve suggests that the ability to be flexible comes from experience and not having the constraints, due to the pace of the lesson, which he had early in his career:

> *I think, when I first started teaching I was blinkered. I stuck closely to my lesson plan and wasn't able to move from it. I was too busy managing the kids and concentrating on my prep. Now I have the confidence to have a start and an end point, the middle bit I do to fit with the kids. I am not frightened to prolong a discussion or activity if I think they will benefit from it.*
> (reflective discussion)

Reflective discussions confirmed a strong consensus between the teachers that experience has enabled them to be less rigid in their approach and while they are organised, by having lesson objectives and planned activities, they can and do alter their lesson plans when needed. Being flexible may also be related to the teachers' perceptions of taking risks during their teaching.

6.3.2 Risk takers

Evidence from the data suggests that all of the teachers in the group believe in taking risks during their teaching. The teachers agreed on a perception of risk taking as pushing the boundaries of teaching, which means that they are not content to stick with tried and tested activities and techniques. They take risks in a relaxed rather than anxious manner which appears to indicate a self-confidence in their practice. Inexperienced teachers and even experienced teachers who work to regular, set routines generally resist taking risks in their teaching. There may be severe reasons for this. For example, fear of the unexpected, lack of confidence in dealing with new and untested ideas (Berliner, 1988). The notion of expert teachers as risk takers reported in the present study appears not to have been reported hitherto in existing literature and is therefore an important finding from this study.

The expert is able to judge when it is appropriate to change tack or utilise a new idea/technique and move away from the prepared, and has the confidence to do so skilfully. Yet he/she does not know, with any great certainty, if the untried approach will work out and so must be willing and confident to take a risk. As Steve and Simon suggest (below) that creative steps in to the unknown can result in an inspirational and memorable lesson for both teacher and pupils. Risk taking may indeed be one of the key determinants in separating the expert from simply the experienced.

The teachers involved in the present study express a strong emphasis on creativity, which is linked to a desire to make subject content interesting for pupils and to

increase their own repertoire of activities and techniques, Simon summarises this consensus:

> *There are teachers at this school who have been teaching for thirty years OK, and they have never got past the basics of teaching. They never ever have taken a risk in their teaching. They've never turned around [experimented] and they've never made a complete mess of it. And I've tried certain things and thought, this is great, the best lesson. You come out of it and think what the hell went wrong? One little spanner in the works, but you remove that spanner and you've got a great activity and you lock it in. There's another one, another activity I've got lined up, another string to my bow.* (interview)

During his second interview Steve consolidated Simon's explanation by stating:

> *...we could all teach the curriculum as its laid out and not really care about being inspirational, but that's the difference. Being creative, finding new activities, making it interesting for pupils, that's what drives you, drives the best. Its about never standing still, learning new things and teaching new things.* (interview)

These two statements are indicative of all six teachers' views of taking risks. They share the confidence and ability to be creative and inspirational through their teaching. Even though they perceive the National Curriculum to be constraining, as stated by Debbie earlier and Steve here, *"the National Curriculum limits my teaching I think"*, they strive to be innovative in their teaching. They see experience as a factor in the development of their teaching expertise, which may enhance confidence and enable them to be innovative and inspirational.

Because the teachers believe in continually improving their practice they build on their risks by utilising a process of development which embodies: taking risks, reflection and adopt or discard. Figure 6.1 shows how the teachers utilise this model.

Fig 6.1 Process of risk taking and development

risk taking ⟶ reflection ⟶ adopt or discard

They deliberately take risks in an attempt to achieve a specific objective, after taking the risk they will reflect on the outcome and decide whether to adopt the risk as part of their repertoire of strategies and approaches or to discard it.

The level of risk can be varied dependent upon the activity or the event and how the teacher rates the importance of the risk. For example, during an interview with Janet, she explains how she has recently begun to teach Plate Tectonics. She suggests that her knowledge of the topic is weak and probably only slightly more advanced than that of the pupils. However, she accepted responsibility for teaching the topic—accepting the risk of failure to deliver to an acceptable level:

> *You have to be concerned that the kids will get the very best you can offer so it's always a risk to do something new like this..You don't want to let them down you know. I've been watching television and reading a lot of books* (interview).

Classroom observations of Janet teaching this topic show how she takes a further risk by admitting to pupils her weak topic knowledge. She stated later that she had had concerns over do*ing* this:

> *I wasn't sure how they [pupils] would react. They could have lost total confidence in me and the topic and switched off. As you saw though they valued my honesty and we worked well together through the lesson. I had hoped that they would share some control over what we learnt and how we discovered it, I think they did* (interview).

Janet took a risk in exposing her weak topic knowledge to the pupils. She explains her doubt in doing this but could also see the potential benefit. She suggests that the risk paid off in terms of the pupils taking ownership of the lesson and of their own learning. During a later reflective discussion she commented:

> *Yes my knowledge of the topic [plate tectonics] has improved, mainly because the kids have inspired me by their enthusiasm for taking this topic forward. They are learning a great deal and so am I* (reflective discussion).

This example demonstrates risk taking as a purposeful and conscious act. The teachers have objectives which drive their risk taking showing that they do not blindly experiment with strategies and approaches.

The teachers also feel that they take risks by letting their pupils learn independently. For example, during an interview with Debbie, she explained how letting the pupils research a certain topic in the library can involve her taking a risk:

> *It's sometimes worth it to give a small group or pairs of pupils the chance to go and research a topic in the library. They get a sense of achievement from gathering knowledge for themselves. But it can be a threat to my discipline strategies, I've learnt from past experience that some of them just doss about, so I have to monitor that type of activity closely* (interview)

Debbie states that during an activity of this type the benefits offset potential problems as she has gained experience from this type of risk and now uses mechanisms such as, careful selection of pupils and negotiation with the librarian (for supervision) which reduce her concerns.

The types of risks that the six teachers involved in this study take may be summarised:

* changing tack during a lesson and abandoning the lesson plan in order to improve the learning experience for pupils
* being creative and trying out new ideas, strategies, approaches and techniques
* teaching new topics previously not taught and learning alongside pupils
* encouraging pupils to do their own research out of the classroom
* taking on pupil-centred active teaching and learning strategies

6.3.3 Utilising experience

The teachers in this present study express their perceptions of experience through a belief in continuing professional development as well as risk taking. In order to learn from their experiences they believe that they have to actively seek out learning opportunities and build on their successes and failures. As Simon indicates:

> *You develop experience through learning and you've got to take every opportunity you can to learn and to improve and to not accept that you are a finished article.* (interview)

Further to this, Janet states that as an expert science teacher she is continually developing and that *"...there are always new challenges if you look for them."* Debbie noted, during a reflective discussion, that *"...through experience I have to hand a repertoire I can use within the lesson."* By this she means various techniques, ideas and analogies which she can use to develop the lesson.

Janet explains the desire of these six teachers to continually develop their knowledge and practice through a perception of challenge and interest:

> *I mean this is how exciting it is, things that weren't discovered when you were at school you're now trying to teach. So I'm on a steep learning curve, teaching new things that I've got to find out about.* (interview)

As specified in the teacher profiles (chapter four) all of these science teachers have either gained or are working toward a Master's degree or are trying to develop their careers in some way. Andy describes his criteria for success as *"Luck, tenacity and a belief in lifelong learning."* It is clear that these teachers are fully committed to continuing professional development and are constantly seeking to gain new knowledge and update their existing knowledge. It is interesting to note here that since their involvement with this study all of the six teachers have progressed their

careers with Simon and Debbie gaining Deputy Head posts, Steve progressing to Head of Department, Janet obtaining a senior education post with GATSBY, Ian moving in to a senior management role and Andy taking on an academic role at the Centre for Science Education. This provides further evidence of their commitment to continually developing their experience and professional roles by seeking new challenges and maintaining the ambition to succeed.

6.3.4 Mentoring and expertise

A theme that emerged very strongly from the group of science teachers' interview transcripts and reflective discussions is mentoring. The process of student teacher mentoring usually involves an experienced teacher acting as a support mechanism for a student teacher, on teaching practice, at the school of the mentor. The main principle underpinning the process is for the mentor to observe the student teaching and provide feedback to the student and the university at which the student is studying. Together with providing ideas and offering their teaching experience, mentors act as a liaison person for the student in the school and help to induct student teachers into the whole school environment as well as a particular department. The process is voluntary and mentors receive training from the host university. The six teachers from the present study are all mentors for ITT students undertaking teaching practice.

These science teachers have no doubts that mentoring student teachers is a process that greatly enhances the development of their own expertise. The six teachers

perceive mentoring as a way of developing their reflective technique and of gaining new ideas, as Steve explains:

> *I think it helps me to think about my teaching in science...It gives me time to evaluate what I'm doing. Because most of the time its lesson after lesson, teach, teach, teach. So there is no time to sit down and think well that went well and that didn't, so next time I'll try it this way. Erm you know, how can I improve?...The training days for mentors are good, you learn new things and come back with ideas that you can try out.* (interview)

As well as providing them with an opportunity to learn new ideas and reflect on their practice the group of teachers believe that mentoring casts them in the role of experts, which forces them to articulate their knowledge and practice clearly and precisely to student teachers and thus, develops their understanding of their own knowledge and practice to a greater level. During a reflective discussion Simon stipulated that mentoring:

> *Gives you the role of expert to help another become a teacher. Observation feedback gets you to think, for the first time, that you are an expert. Passing on knowledge, but this can be like an apprenticeship, craft based if it isn't supported by academic input.* (reflective discussion)

The data indicates that all six science teachers perceive mentoring as a process that helps to develop a way of thinking about their own knowledge and practice as well as the student teachers' knowledge and practice whom they mentor. This perception of mentoring further emphasises the commitment of these six teachers to continuing professional development. In identifying mentoring as a two-way process whereby they develop their own knowledge and practice as well as developing that of the student teachers, they are actively seeking learning opportunities from experience. These teachers have no immediate vested interest in the development of student science teachers, they are school teachers and not university lecturers. However, their professionalism and enthusiasm drives them to seek learning opportunities and pass on their experience. As Debbie states:

> *And they [students] stimulate you, they give you ideas, different ways of looking at things. I do like to pass on knowledge to them as well, you know, knowing at the end of it you've helped to make a good teacher.* (interview)

The evidence here suggests that these science teachers have a perception of mentoring, which highlights their enthusiasm for science teaching, commitment to continuing professional development and over-all professional attitude.

Whilst experts may not always recognise themselves as experts these six teachers seem able to articulate their expertise through their mentoring role and want to pass it on to student teachers. Certainly mentoring offers the opportunity to share their expertise but the most important thing to ask is 'do experts want to share their expertise?' It is clear from the findings of this study that these six teachers do want to share their expertise moreover, that they see it as an important element of their profession.

6.3.5 Autopilot

> *...it [teaching] becomes an automatic skill...For instance if you look at one of the great saves of all time 1970, Gordon Banks yeah, dived to one side. If you thought about it, no way can you do this. Its got to be completely instinctive, he, er jumps because he's out of position, flips it over the bar hey! So I think with a teacher one of the things you've got to do is get a lot of what you're doing down, to almost like a skilled level, a craft activity. So you can run that on autopilot. So you are working on various levels as a teacher. Positioning yourself in the room comes almost automatic, that's a skill that you don't even consider...A more experienced teacher can have more and more things running on automatic, sensing, feeding into yourself and providing everything is hunky dory you don't bother registering it. But as soon as that information comes in and its not going well you do register it.* (interview)

This description from Simon, explains his perception of much of his day-to-day practice. He believes that his expertise in science teaching enables him to utilise a

routinised structure to his practice—routines that are grounded in experience and intuition. Because he has a repertoire of classroom experiences much of his practice flows through a routine based format while the lesson is running smoothly. However, if he suspects that the lesson has broken down in some way, such as the pupils' understanding of the content is not clear or the pace of the lesson is not running as expected, he will concentrate on the cause of the break down until smooth running of the lesson has resumed. During reflective discussions the six teachers agreed that for most of their classroom practice they operate within a routine and that routines enable them to focus on questioning, key points within subject matter and pupil learning. Debbie perceives routines to be intuitive and that *"...when you first start teaching its exhausting but it becomes second nature I think, you don't notice you're doing it as much."* The data shows that the six science teachers practice through routine behaviour which enables them to concentrate on more specific issues within the classroom, such as pupil learning and creative approaches, and that their routines are intuitive, based on a repertoire of extensive classroom experiences.

6.3.6 Classroom management

Classroom management emerged firmly located within the teachers' perceptions of teacher-pupil relationships. All the teachers feel that positive relationships between the teacher and pupils produce a classroom atmosphere in which the pupils often control themselves. Janet highlights the teachers' views by acknowledging the importance of teacher-pupil relationships:

> *Oh very definitely yeah. And that's good because if anybody [pupils] steps out of line, peer groups administer the admonishment rather than the teacher. That helps because that helps create the atmosphere.* (interview)

The group of science teachers agreed, during reflective discussions, that working within a co-operative learning approach gives pupils responsibility for their own learning and for others. While acknowledging that this does not work with every pupil these science teachers believe that being fair with pupils produces a classroom, which almost manages itself. Andy expresses his concept of fairness, *"...it's a shared thing, which is important. I treat them [pupils] fairly but to do that they must treat me fairly too and be responsible."* The other five teachers share Andy's view.

While they allow a considerable amount of autonomy to pupils, the teachers do lead the class. During the group reflective discussion the teachers concurred that teacher-pupil relationships exist on many levels, especially when concerned with classroom management. Their concept of 'fairness' highlights this. These teachers take full responsibility for administering punishment for disruptive behaviour. However, they do attempt to explain their actions to pupils. Simon highlights this point during interview:

> *...I'm honest with them and I think kids appreciate that honesty and they appreciate that you treat them as an individual, you sit and talk to them. You don't bawl them out for no apparent reason, when you do bawl them out they understand why you're doing it and they feel 'OK I deserve it.'... there has got to be mutual trust.* (interview)

The teachers also agreed that integrating an element of fun into the lesson helps with classroom management. During a reflective discussion Debbie emphasised this point:

> *Having a bit of a joke lightens the atmosphere, they [pupils] see that you are human. Kids always respond to a bit of fun but it has to be controlled or some of them [pupils] will take it too far and get distracted.* (reflective discussion)

Debbie's view is demonstrated further through classroom observations. During a lesson with a Y9 group Debbie responded to a number of light hearted comments made by pupils concerning Bolton Wanderers Football Club, a team that Debbie

supports. She joked with pupils about the team's recent loss. The interactions took place while pupils were completing a worksheet. Debbie responded as she moved between groups of pupils while monitoring their progress. At no time did any of the pupils stray far off-task and all completed the worksheets within the designated time. This example is typical of all of the six teachers observed. Integrating fun into lessons is commonplace and appears to add to the pupils' enjoyment of lessons and helps the classroom management process.

The teachers' strategies for handling deviant behaviour are based on respect, honesty and good relationships with pupils. They have patience with their pupils and are willing to discuss reasons for deviant behaviour with pupils. Pupils are given clear boundaries for expected behaviour in the classroom and are expected to respond to the teachers with the same respect and honesty.

Summarising the perceptions of teaching of the six science teachers the findings indicate that they see their own teaching expertise to be based on:

- utilising different pedagogies
- having a flexible approach
- being able to change tack and monitor pace during lessons
- taking risks in their teaching
- being creative and innovative
- having a commitment to continuing professional development
- being enthusiastic and professional about science teaching
- having well-developed routines for classroom practice

- developing relationships based on fairness and mutual respect
- developing strategies for handling deviant behaviour

6.4 Perceptions of science

Perceptions of science was a clear choice to organise exactly what the category suggests—the teachers' thoughts and beliefs about science. Their personal models of science emerged quite clearly from interviews and reflective discussions and provide an interesting insight into how the teachers think about science.

There were differences in the group's perceptions of science. Four of the teachers share a perception of science as a research based model and two have a classical model. Ian, Andy, Simon and Janet all have a perception of science based on an empirical research model. They see science as a process of investigation whereby new knowledge is constantly being discovered. Andy summarises this consensus:

> *...my scientific thinking is quite good, I'd actually say that was good. And my main interest is that its a way of investigating, you know, to find out.* (interview)

Debbie and Steve have perceptions based on a classical interpretation. They see science as a body of knowledge that provides answers to certain life questions, Steve explains:

> *...answers to questions, which I had in my head that I didn't expect from religious teaching. At some point reading the bible didn't match up with life as I saw it. I believed more in the answers of science than in religion.* (interview)

The main difference between the two sets of perceptions, agreed by the teachers, is one of deductive and inductive reasoning. Steve and Debbie see their classical

interpretation as essentially a deductive approach, which uses a sequence of formal logical steps to reach a valid conclusion, as Steve states:

> *I believe that science determines universal laws and that methods of finding these laws are through logical deduction.* (interview)

The remaining four teachers agree on an inductive approach, which they see based on discovering empirical evidence from investigation. As Andy suggests, *"...we construct knowledge from investigation, evidence and interpretation."* This group of teachers believe that these are the underpinning perceptions of science with which they started their science teaching careers. They believe that their perceptions of science have little influence on the way they teach science now as the National Curriculum dictates the science they teach and in particular, how they teach it. Steve and Debbie highlight this point:

> *...you can teach science and what scientists do but what the pupils do might not actually be science. They might be learning about scientists and what they do, but they won't actually be doing any real science.* (interview)

> *...the problem is now there is so much of the National Curriculum to get through, it's at the expense of the practical work because you're trying to get through all the science knowledge...I'm very conscious of the time constraints.* (reflective discussion)

While they believe in making science relevant, fun and interesting they are battling against a curriculum that is, as Simon states: *"too rigid."*

The data shows clearly that these six teachers perceive themselves to be teachers of science and not scientists teaching science. They emphasised that they did not want to talk about themselves as scientists, which could explain why the teachers made few comments on their science knowledge, aside from stating that they believe their subject knowledge is of a good enough standard to teach effectively. Andy summarises the groups' perception:

> *I'm trained as a scientist...now I would actually say I'm a teacher first because more and more, what's become interesting to me is how to convey the information from one person to another.* (interview)

During a reflective discussion the teachers pointed out that as they are not involved in scientific research they do not consider themselves to be scientists, as is the case in universities where often a significant aspect of a science lecturer's role will be research. As science teachers their communication and promotion of science will need to be more heavily stated than that of a lecturer, because school children do not possess the underpinning science knowledge or even motivation to learn science as undergraduates may have.

The data indicates that all six teachers have a personal as well as a professional interest in science. They enjoy their subject and take every opportunity to promote science within the school and community. All of the teachers are or have been involved in extra curricular activities such as science fairs and attempt to inspire pupils through their own interest in science and science based activities. Andy helps to express this point by stating, *"I do like the subject of science very much."*

The evidence suggests two underpinning themes to the group's perceptions of science. Whether they have an empirical research based model or a classical model, they are all enthusiastic communicators and promoters of science. They attempt to communicate science through unambiguous language and clear strategies and to bring relevance through their teaching to pupils. They are promoters of science and seek to pass on personal as well as professional knowledge and interest to pupils. These themes indicate that successful science teaching does not rely on teachers' theoretical/philosophical models of science. The six science teachers have perceptions' of science which may be summarised as:

- personal models of science which do not significantly affect their teaching styles
- a belief in making science relevant for pupils
- a desire to be communicators and promoters of science

The final category used to organise emergent themes from the data is reflection and will now be discussed.

6.5 Perceptions of reflection

As with perceptions of science, perceptions of reflection emerged clearly as a choice of organising category and were agreed by the supervisory team and teachers. The mention of reflective processes was frequent throughout interviews and reflective discussions, and demonstrates clearly that these science teachers are reflective practitioners.

All six of the science teachers who participated in this study stated that they do reflect on their classroom practice and on their knowledge. The data shows that they reflect during and after practice. Reflection during practice involves many of the skills and attributes already mentioned so far in this chapter. For example, skills such as, changing tack, monitoring and controlling lesson pace and classroom management are usually done while reflecting during practice. During interview, Ian was asked if he was aware of his changing vocal tones and questioning techniques. His answer highlights the intuitive behaviour demonstrated by the six teachers during this study:

Er yes, but its nothing conscious though. I suppose its a natural emphasis

> *when you want to explain to people and you're building up to it. You know you're getting their attention by talking quietly. You know they don't have to strain to listen but they have to be listening to hear what you're saying. Erm, but yes, I do use that a lot, in fact various students come to me and very rarely complain but I'll ask them about such and such a teacher, you're interested how they're [pupils] getting on, you know. And they will say oh just the same tone all the time. And I'll go in and observe and it is the same tone. And its a complete switch off you know, its a drain and er, yeah there's that in the back of my mind and subconsciously maybe causing me to emphasise.* (interview)

Ian's explanation suggests that reflection during practice is tacit and triggers intuitive action, which is spontaneous. However, Debbie suggests that reflection during practice can also be explicit, leading to conscious action:

> *Yes I do it [reflect] on the hoof. And when I stopped that lesson before I knew it was going too mad [off task], I thought I might change direction completely and* sometimes, *when the kids are really misbehaving like that year eleven, I'll just stop the class and pack the practical away and do something else. I don't mind doing it in the lesson. And then afterwards I'll sit down...I was thinking what could I have done better and think next time I come to another class, that same class in another year, it'll be slightly different. So its just tweaking it all the time.* (interview)

The data indicates that whether tacit or explicit, reflection during practice provides these teachers with a capacity to respond to pupils' understandings, problems and behaviours through improvisation and spontaneity, as Simon explains:

> *...I did think is this going to work? And then I made the decision bang! I'm not doing it...But you do it instinctively almost. With a student teacher, you'll see it time and time again, they'll not look up. They get around a bench with one student and do a quick scan. I know I'm not perfect but its there. Erm, asking the kids questions you've got to keep thinking, do I just tell them the answer? Do I teach them? How much are they struggling here?* (interview)

From the evidence presented earlier in this chapter concerning teacher-pupil relationships, there are indications that these six science teachers have perceptions of reflection and relationships that are strongly inter-related. The reflective process, which helps spontaneous improvisation, involves gauging pupils' understanding of the subject content and helping to coordinate that understanding with the teachers'

understanding. They interpret pupils' messages and act to prohibit any misunderstandings or difficulties the pupils may have. This is also further evidence of the teachers' knowledge of individual pupils. As Simon explained previously, some pupils have greater auditory skills, others have better visual capacity, while there are those who have kinaesthetic skills. The evidence suggests that this group of teachers have the ability, through reflection, for inventing new techniques and methods on the spot in order to respond to the difficulties incurred by pupils. They do this without an adherence to one tried and trusted method.

Reflecting on-action appears to be equally as important as reflecting in-action to this group of science teachers. Reflecting after practice is done explicitly and often. Although all six teachers state that they do not write down their reflections, they do reflect continuously. When asked how often he reflects on his practice, Ian states:

> *Oh, all the time. After a lesson, on the way home, on the way in. I never write anything down but I'm thinking about what went well and what didn't go so well. Constantly, constantly.* (interview)

Andy also states that he reflects often but does not keep written notes:

> *I do reflect, I reflect on how would I do that again? I'm not very good at writing things down...but I do think about how am I going to do this next time?* (interview)

The consensus among the teachers is that they feel that reflecting on-action enables them to fine tune their practice by adding and removing certain techniques and activities. Steve highlights this point:

> *Its [reflection] about tweaking the lesson. Putting the finer points to an activity or techniques. Building on what you learn from reflection, making the lesson better all the time.* (reflective discussion)

Reflection on-action however, does not produce the spontaneity that reflection in-action prompts. Reflecting after lessons tends to focus on the lessons and the day as a whole. Even though they may isolate issues and events from the day, for further

reflection, generally they think about their practice in the context of the whole day.

Steve suggests:

> *Reflecting after school helps me to bring the whole day into perspective, a sense of the bigger picture.* (reflective discussion)

The teachers from this present study also reflect upon pupils' reactions after lessons.

As Janet points out:

> *Oh yes, every time you come out you think, do I feel pleased with that [lesson], what did the kids say to me as they left? Were they saying see you next week or that was good? I mean my students tell me if something's not working. They'll say, god this is boring or oh I didn't like that bit or why do we have to do this? This is the feedback that you want from them, the bits that are not working. I don't write it all down, I store it all up.* (interview)

We can see then, that these science teachers critically evaluate their practice and actively seek critique from others. This highlights an important outcome of the methodological approach used for this present study. The teachers found that reflecting with the researcher, looking at the analysis of the other participants' data and meeting and discussing the research with the other participants, was of immense value to their professional development. However, when asked if they get time to reflect on their practice with other colleagues only Ian had a positive response:

> *...you will talk to someone who happens to be free at the time, you know, and you will perhaps have a discussion about a student, which will lead on to something else. But it won't be as a faculty because faculty meetings are taken up with other things. If we get a session when we can sit down and really scrutinise our teaching styles in the way we would wish to operate, er we would probably get one session in a year.* (interview)

The five other participants do not get opportunities to reflect on their practice with other colleagues. Steve summarises the issue, *"No, never. There are too many other things like administration. They are on top of your teaching timetable."* These science teachers strongly value positive critical reflection with others and feel that, as

a tool for continuing professional development, positive reflective criticism is very useful.

The teachers believe that the methodology employed within the present study enabled them to develop their reflective processes further. They suggest that the collaboration between the researcher and teachers helped them to analyse their practice in a deeper way, as Simon notes:

> *Having a focus helped me to reflect on my practice more deeply than I normally do. I found myself deconstructing my practice and looking at small elements of it as well as looking at the wider picture* (reflective discussion).

The teachers were able to focus on emergent themes and characteristics from the data and discuss these with the researcher. They particularly valued talking with the other science teachers involved in the study. The group found that being able to discuss their practice with others enabled them to unpack their reflections and gain a clearer understanding of what it is they do well and not so well. Steve and Andy suggest:

> *I've been able to gain a better understanding of the things that are good and bad about my teaching, I can see more clearly where I need to develop* (reflective discussion).

> *I've found out things about myself I did not fully realise* (reflective discussion).

The teachers also explained how they felt more able to articulate their practice to others as a consequence of their involvement in the research. By gaining a greater understanding of their practice they feel that they can express their perceptions and beliefs in a suitably clear language, whereas prior to their involvement in the research they believed that talking about their practice was difficult and often ambiguous. Simon states:

> *By reflecting on my practice and then discussing relevant issues with you (researcher), I think I have learned to talk about my*

teaching in a clear way. I can pick up on a single point in my practice and analyse it without talking about other issues which are probably not related and cloud the focal point of the conversation (reflective discussion).

By this Simon means that he can break his practice down into component parts and analyse each part in detail, rather than reflecting in a broad manner which is something he believes he did before becoming involved with the study:

...before I would reflect on the lesson as a whole and not necessarily pick up on the finer details (reflective discussion).

This is something that the other teachers agreed with too, Andy states:

I see my teaching in greater detail. I can see the little things that make a big difference, like asking the right questions at the right time (reflective discussion).

This group of science teachers clearly value opportunities to reflection and discuss their practice with others. Something which is currently not easy to access during their normal teaching processes. As Debbie suggests:

We hardly ever get time to talk about our teaching to each other, not quality time. It would be good to share our practice that way and hear the views of departmental colleagues (interview).

The science teachers in this present study make sense of and develop their classroom practice by utilising the reflective process. They constantly reflect in and on-action in an attempt to create a better learning experience each time they teach. The reflective process enables them to:

- improvise - by reflecting and acting on pupils' messages on the spot
- build on experience - by reflecting on their successes and failures
- gain a greater awareness of their practice
- fine tune their lessons
- learn from the critique of others

- contextualise their practice

6.6 Reflection: a process of change

> *I'm more aware of the subtleties of my practice, like questioning, than at any other point in my career* (reflective discussion).

This statement, made by Simon, emphasises the outcome of the reflective process enhanced through the methodology of the study—that the teachers have unlocked knowledge of their practice they were unaware of prior to their participation in this study. Although the teachers admitted to being of a high standard professionally, from the on-set of the study all six teachers refused to accept that they were experts, as Debbie explains: *It's a label given to you by someone else.* When asked why they were not experts they could not suggest a specific reason why, only indicating that modesty may have an influence. During further reflective discussions Debbie indicated that she might be an expert teacher not an expert scientist. This highlights an issue which the teachers agreed with—that their knowledge of pedagogy is stronger than their subject knowledge.

However, as the study progressed the teachers began to identify strengths and weaknesses in their practice—they were 'unlocking the unconscious.' As this process progressed the teachers became more and more comfortable with the term 'expert' as Simon indicated during the group reflective meeting:

> *perhaps I am an expert, perhaps we all are. I can see things in my practice now that I do very well like, being very flexible during lessons. I'm not saying that that's it, I can't improve anymore but perhaps you do reach expertise and keep improving* (reflective discussions).

This appears to suggest that the teachers did not initially accept the label of expertise because they were primarily focusing on their weaknesses. Identifying weaknesses in

the search for improvement is clearly an important strategy, however these teachers had neglected to balance their focus by having a clear awareness of their strengths. The methodology used empowered them to focus on the things they do well in the classroom by casting them in the role of expert and exploring their perceptions and gradual understanding of their expert practice.

6.7 Summary

The findings presented in this chapter provide an insight into the ways that six identified expert science teachers use their knowledge, transform it and expand it, and how they inform their practice and utilise their expertise while in the classroom. The findings clearly show that the expertise of this group of science teachers is very complex and is made up of a wide range of knowledge and skills. Even though the data indicates differences between the teachers' perceptions there is a strong agreement amongst the teachers of what constitutes expert science teaching. While sharing an understanding of expertise this group of teachers also show that they act and think individually within their practice. Their knowledge is organised in such a way as to inform their practice, which is demonstrated by the four categories used to organise emergent themes from this study. The four categories are not exclusive but illuminate the characteristics which these six teachers utilise in their practice. These six science teachers valued the research process and found that it enabled them to articulate their knowledge to themselves and others through reflecting on their practice and sharing ideas and perceptions with other teachers and the researcher. The findings demonstrate that the teachers have a clear understanding of the nature of their practice, and that of others.

7 Conclusions

7.1 Introduction

The present study shows that science teachers' expertise is highly complex and sophisticated. The nature of secondary science teaching, exhibited by the six teachers collaborating in this study, means that their knowledge and practice is broad based and influenced by many factors. It is clear that the science teachers' understanding of their knowledge and practice is very often tacit and difficult to articulate. However, the present study demonstrates that access to this group of science teachers' understandings is gained through a collaborative process which empowers the teachers, and enables them to think more clearly about their knowledge and practice through helping them to reflect on their classroom skills. Furthermore, the potential power of unlocking the knowledge hidden within those understandings is evident. This penultimate chapter will contrast and compare the findings from this current study to those from the existing literature reported in chapter two. The chapter will then continue by discussing a model of science teacher expertise formulated from the six teachers' perceptions and conclude by summarising the study.

7.2 Towards a unified understanding

The establishment of a clear set of characteristics of expert knowledge and practice, as exhibited by this group of science teachers, presents an opportunity for the comparison of these characteristics with various existing theories of expert teaching. In doing so, an attempt can be made to confirm or contest the findings from the present study. As stated in chapter two (literature review) there are few existing studies that have concentrated on the expertise of science teachers and none that have used teachers as active collaborators. However, given the findings of the current study, it is interesting to note that the six identified expert science teachers do not demonstrate behaviour or express views that appear rigidly constrained by their subject (see chapter 6, section 6.4). Indeed they express views about teaching which are generic and in many instances would apply to most subjects.

Shulman's (1986; 1987; Shulman and Grossman, 1988) work identifies pedagogical content knowledge as the way that teachers make their subject knowledge teachable. Shulman claims that good teachers have a well developed pedagogical content knowledge that enables them to make use of various strategies and techniques to teach their subject effectively. The data from this current study also shows that the six science teachers have well developed strategies and techniques for teaching science. Salmon (1995) states that expert teachers can choose from a wide, internal repertoire or database of techniques, methods and strategies for achieving quality teaching and learning. Through observations and interviews, the group of teachers in this study demonstrate that each of them purposely use various techniques and methods to reach desired learning outcomes which are well organised through an internal database of

knowledge and skills for classroom teaching. For example, they are able to utilise appropriate analogies to explain difficult concepts or vary the pace of a lesson to allow for differentiation during lessons. The complex schemata which Sanders *et al* (1993) and Leinhardt and Greeno (1986) put forward also seems to indicate a well-organised, internal database of knowledge and skills for teaching. Anderson's (1987) notion of knowledge compilation suggests a structured database of knowledge containing experience of tasks and activities that an experienced teacher can use. Sanders *et al* (*ibid*) claim that teachers rely more on their pedagogical knowledge than any other. Evidence from this current study suggests that this is also the case. The six science teachers suggest that their pedagogical knowledge is broader and more in-depth than their subject knowledge (see chapter 6, section 6.4), and that although they value quality learning experiences and CPD programmes concerned with up-dating subject knowledge, they value more highly, CPD that focuses on pedagogy.

Findings concerned with teacher-pupil relationships share similarities with the existing work of Fullan (1985), Rutter *et al* (1979), Opie (1995) and Younger and Warrington (1999). Fullan (1985) and Rutter *et al* (1979) believe that effective teachers have high expectations of their pupils. Rutter *et al* (*ibid*) also state that teachers who have positive attitudes toward their pupils produce higher achievement rates from pupils. Data from the present study suggests that these claims made by Fullan (*ibid*) and Rutter *et al* have a firm base, although this study did not set out to correlate teacher performance with pupil success rate.

This group of science teachers demonstrate a very positive attitude towards their pupils and expect pupils to achieve their maximum, individual potential (see chapter

6, section 6.2.3). However, Fullan and Rutter *et al* do not suggest that having a positive attitude and high expectations of pupils is part of a teacher's desire to create a safe learning environment, (in which pupils are confident and comfortable) as indicated by the science teachers from this current study. The belief of Fullan and Rutter *et al* is that by developing high expectations of their pupils, teachers will motivate their pupils who will then respond to the challenge and aim to reach their maximum potential. While acknowledging that this is highly likely, the findings from the present study indicate that creating a safe classroom environment for pupils to learn in can maximise the likelihood of this happening (see chapter 6, section 6.2.2).

The establishment and maintenance of good relationships between teacher and pupil is highly important to the science teachers from this present study. Opie (1995) also found this while studying five successful teachers of reading. Younger and Warrington (1999) studied pupils' perceptions of a good teacher and claim that the pupils from their sample believe that teacher-pupil relationships that are built on respect, fairness and equality are essential characteristics of a good teacher. The six science teachers suggest that they attempt to develop relationships based on mutual respect and fairness. Classroom observations support the teachers' claim that this aids pupil motivation and classroom management (see chapter 6, section 6.2.2).

Berliner's (1988) model of expertise development (or any other existing educational studies in this field which the researcher could find) does not identify risk taking as perceived by the group of science teachers from this present study. The six teachers see risk taking as an important factor in developing their repertoire of knowledge and skills by experimenting with new techniques and activities, and building on their

failures (see chapter 6, section 6.3.2). However, Berliner (*ibid*) does claim that during Stage five in his model, experts have developed a creative approach to their practice although there are no clear indications of how creativity is manifested. These science teachers suggest that taking risks in their teaching not only helps them to develop their knowledge and practice but also enables them to increase their creativity levels by developing new, innovative ideas. Shulman (1986; 1987) and Salmon (1995) stipulate that a strong characteristic of teaching expertise is having a broad and well-organised framework of knowledge and skills for teaching. But they too, do not cite risk taking as a way of developing this framework.

As stated in chapter six 'experience' is a notion closely related to risk taking within the science teachers' perceptions. They see risk taking as actively seeking new experiences and from this new ways to teach. These teachers also believe that expertise is not about the mere accumulation of years of experience (see chapter 6, section 6.3.3). This perception concurs with Zeichner's (1990) argument for the consideration of quality experience rather than quantity. Berliner (1985) and Schmidt *et al* (1990) both claim that exposure to a wide variety of cases or experiences is important in developing expertise as it enables the expert to focus on specific experiences which fit the situation in hand. Novices are unable to draw on such experiences to help them. Experts can quickly identify salient points or problem areas of a topic, as they have to hand knowledge of similar, previous experiences. Berliner (1987) later suggests that a repertoire of expertise is developed over many hours of classroom practice. While the findings from this current study support this latter claim, the former claim made by Berliner (1985) and Schmidt *et al* (1990) cannot be substantiated by this study as a comparison with novices was not made, although

observations did indicate that the expert teachers from the current study did recognise the salient points in a topic and ensured that these were made explicit to pupils.

Glaser and Chi (1988) suggest that experts have strong self-monitoring skills, by which they recognise their failures in a more qualitative way than novices. The findings from this study confirm this claim in as much as the teachers search for quality learning experiences and attempt new, innovative ways to teach and learn from unsuccessful attempts (see chapter 6, sections, 6.3.2., 6.5). They analyse their failures so as to gain from experience.

The science teachers from the present study also see mentoring as a process which aids development of expertise. They believe that mentoring is a two-way process between mentor and student-teacher and that the mentor can learn new ideas from the student-teacher while acting as an experienced guide to the student (see chapter 6, 6.3.4). This supports evidence gathered from a study of the perceptions of mentors (Jones, Reid and Bevins, 1997; Bevins, 1998) which suggests that some student teachers bring to the classroom fresh ideas and energy which established teachers can build on.

Findings from the present study (see chapter 6, section 6.3.5.) show that much of the science teachers' classroom practice is carried out through routines or intuition. A number of studies concur with this finding (Schon, 1983; 1987; Berliner,1988; Barba and Rubba,1993; Norman, 1982). However, Dreyfus and Dreyfus (1986) define their model of expert practice by allowing routinisation, against which flexible decision-making stands out. While the science teachers from this present study do make

explicit decisions during practice, they also have standardised routines that enable them to concentrate on such things as pupil progress and creative practice. Schon (1983; 1987) suggests that professionals pay little attention to the day-to-day activity of their profession until a problem arises to interrupt the smooth running of the activity. Observations and interviews indicate that while this is true of the science teachers working within this current study, they also show evidence of conscious interaction and teaching through reflection (see chapter 6, section 6.5).

Barba and Rubba (1993) and Norman (1982) indicate that experts pay more attention to refining or tuning their knowledge than novices. When problems do arise they are quick to generate productive solutions. Glaser and Chi (1988, table 2.2) suggest that experts produce more productive solutions to problems than novices. The group of teachers from the current study demonstrate that they continuously tune their knowledge and practice in four primary ways: concentrating on the finer points of teaching when engaged in routines; analysing their practice qualitatively through a reflective process; by taking CPD opportunities and by solving problems quickly and effectively (see chapter 6, sections 6.3.3., 6.3.4., 6.5.) .

The six science teachers claim that they constantly reflect both in-practice and on-practice. They believe that skills such as, classroom management and controlling lesson pace are carried out, mostly, through an intuitive, reflective process during practice. They also suggest that this process enables them to fine tune their practice and concentrate on developing creative activities. Schon suggests that there is an artistic, intuitive process that some professionals use in their practice in situations of uncertainty and uniqueness. The data here indicates that these science teachers

believe that reflective processes helps them develop spontaneity within their practice that they can use during unique situations. These six teachers use reflection to help them organise the day's events and so they may analyse more closely their successes and failures (see chapter 6, section 6.5). Schon refers to a process of reflection-on-action which is about making sense of an action once it has transpired, and learning from that action in an attempt to extend one's knowledge base. The teachers from the present study emphasise their willingness to learn and understand from new actions brought about through reflection by risk taking and seeking new experiences (see chapter 6, sections 6.3.2., 6.3.3.)

From a study of teachers' observations of classroom teaching, Kagan and Tippins (1992) found that established teachers focused on underlying purposes of lessons as opposed to general classroom behaviour. They suggest that this is because established teachers have a deeper understanding of teaching processes. The present study shows that the science teachers' perceptions of expertise are based on a deep understanding of their knowledge and practice, and that they too, tend to focus less on the more general day-to-day issues of teaching (see chapter 6, section 6.5). They focus on issues that they prioritise as being of high importance, for example: lesson development; meeting objectives, and monitoring pupil progress. Three of the characteristics suggested by Glaser and Chi (1988, table 2.2) are confirmed by the findings from the current study. They state that experts: perceive large and meaningful patterns in their domain; see and represent a problem in their domain at a deeper level than novices and that they spend a great deal of time analysing a problem qualitatively. Glaser and Chi focus mainly on the problem solving skills of experts, but data from the present study suggests that these three characteristics not only

represent problem solving but also a deeper understanding of practice by the six science teachers (see chapter 6, section 6.5).

Huibregtse (1994) states that experienced teachers are strongly influenced by the ways in which they were taught science. Although some of the teachers from the current study made brief references, during interviews and reflective discussions, to the way they themselves were taught between Y7 and Y11, they provided no evidence of a strong influence of this kind, while this shows a difference from the existing literature it should be noted that questions exploring this issue were not asked, although the assumption may be made that the teachers were not influenced by teachers when they were pupils. However, the data suggests that the teachers value discussion with colleagues which focuses on pedagogy and science, and that they believe sharing resources and ideas with colleagues and other teachers is highly beneficial to their professional development (see chapter 6, section 6.3.3).

Sternberg and Horvarth's (1995) model of teacher expertise is constructed around three central characteristics: knowledge; efficiency, and insight. These core characteristics typify the knowledge and practice of the science teachers from this present study but do not sufficiently delineate the complexity of their broad and well-organised knowledge base and classroom skills. Sternberg and Horvarth also state that expert teachers have a pragmatic knowledge or, as they term it, 'savvy'. The researchers believe that this practical 'savvy' enables experts to get around administrative barriers, for instance. While evidence from the current study indicates that the science teachers have an understanding of wider educational issues, concerning the school and educational politics, there is no clear evidence that suggests

'savvy', as explained by Sternberg and Horvarth, enables them to cut through school bureaucracy. Observations of the science teachers show that they are aware of school policies and communicate effectively with senior and administrative staff. However, interviews show clearly that the teachers find that administrative issues and duties place a constraint upon their time (see chapter 6, section 6.5).

The interim report published by Hay McBer (2000) of the findings from their recent study into the characteristics of effective teaching, shows a number of similarities to this present study. The researchers used a similar peer group strategy for selecting a sample. Head teachers were asked to nominate one typical teacher and one outstanding teacher from their staff, and although the researchers use five organising categories to display data, the findings are highly consistent with those from the reported study. The researchers measured teacher effectiveness in terms of pupil achievement, which is fundamentally different from the methodology used for the present study, although the emergent characteristics are highly consistent with those found during the present study. However it is unlikely that teachers who contributed to the Hay McBer research gained any sense of ownership or empowerment from the research in the way that the science teachers involved in the present study experienced (see chapter 3, section 3.8).

The characteristics identified by Hay McBer (Table 2.5) easily resonate with existing literature which focuses on 'leadership' (for example, Hooper and Potter, 2000). In fact, Hay McBer appear to purposely set out the characteristics in a fashion that strongly eludes to effective teachers being classroom leaders. Indeed one of their organising categories is 'Leading.' By comparison, the present study does not readily

identify leadership as a category or a key theme. However, there does appear to be an implicit notion of leadership within the emergent themes. For example, effective mentoring, developing strong relationships (with pupils) and risk taking are all skills identified in recent literature on effective leadership (Hooper and Potter, 2000). Furthermore, these teachers have a strong commitment to their pupils, are not afraid to effect change in the classroom through risk taking and take pride in developing a team approach through cooperative learning. These issues are identified by Hooper and Potter (2000) as important leadership characteristics. The six teachers also demonstrate leadership through their roles as department Heads/second in the department and ASTs (see chapter 5). This coupled with strong similarities with the Hay McBer characteristics suggests that it is quite likely the six teachers from the present study are effective leaders in the classroom and therefore, it is reasonable to assume that expert teaching is strongly influenced by qualities/characteristics of effective leadership. Further study based on this assumption should aim to establish firm links with expert classroom practice and leadership.

There are several significant outcomes from this present study which add to those from existing studies. However, there does appear to be a high level of concurring evidence. What is encouraging is that the database of existing studies which focus on teaching expertise, emerge from a wide and varied combination of methodologies and approaches. This concurrence of evidence reinforces further the effectiveness of the unique collaborative approach adopted for this present study. The collaborative approach will add a new dimension to research methodology which will hopefully be used effectively by others in the future, helping to produce valid and reliable findings which was fundamental in the present study. Although it is not the intention of this

study to make generalisations, summary conclusions indicate that there are generic characteristics of teacher expertise which are nondependent on subject area. For example, creating strong teacher-pupil relationships, utilising a wide repertoire of approaches and controlling lesson pace.

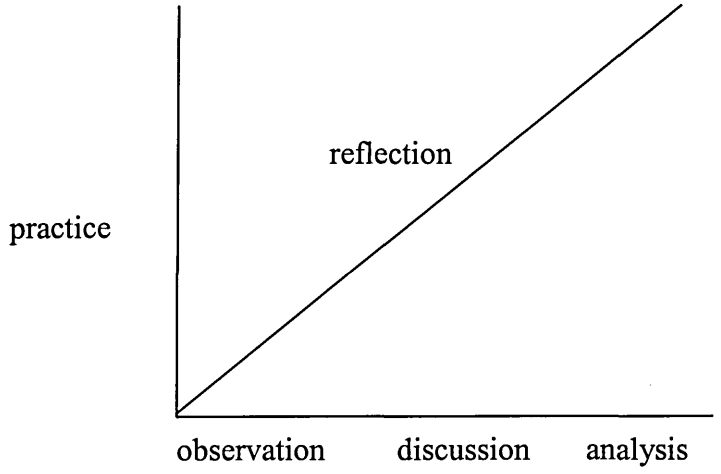
7.3 Teachers reflecting on teaching

These six science teachers believe that reflecting during and after practice is of high importance. They suggest that reflection enables them to identify strengths and weaknesses within their teaching, and enables them to develop their expertise through a greater understanding of their practice. They particularly value opportunities to discuss their practice with others and feel that the collaborative approach employed within the study helped them to refine their reflective processes. By sharing their reflections with the group, researcher and researcher supervisors involved in the study, the teachers suggest that they are now able to utilise a more focused approach for their individual reflective processes. The six teachers state that they rarely get time to discuss teaching with other teachers which is something they would like to do on a regular basis. The research process enabled them to talk about their practice through interviews, reflective discussions and a focus group meeting. They feel that these processes helped them to develop a language by which they can articulate their practice to others more clearly.

Over the duration of the study the teachers believe that they developed professionally through widening their understanding and awareness of their knowledge and practice.

The process which enabled this has at its hub 'reflection'. Figure 7.1 shows the model of teacher development experienced by the six teachers.

Figure 7.1 Model of teacher development



The researcher observed each of the six teachers in practice (between two and three times) and provided feedback on the observed sessions. The researcher and individual teacher then reflected on the feedback which gave rise to a greater discussion of central themes arising from the feedback. Themes were discussed in depth between researcher and teacher and again reflected upon further, between researcher-teacher discussions and in-practice. Researcher and teacher then analysed arising themes from the observations and discussions (using a grounded theory approach, see chapter 4) in an attempt to unpack and clarify a joint understanding. For example, during feedback after Debbie's first observed session the researcher noted that she appeared to have a keen awareness of events going on the classroom while remaining focused on the task in hand. She responded to this by stating ...*its the eyes in the back of the head syndrome.* Reflection led Debbie to raise the theme at a later discussion where she suggested that *constant reflection while I'm teaching gives me a way of knowing what every kid is doing at any one time.* Further reflection led to this being defined in similar terms to Schon's notion of reflection-in-action.

Analysis by the researcher and Debbie gave rise to an understanding of this theme as a tacit awareness of classroom behaviour, a kind of 'flexibility'. This model of teacher development shows three techniques or activities (observation of practice by a colleague or other; discussion of observations with a colleague or other; and analysis of emerging issues) in combination with a continuous reflective process of reflection in and on practice. The model enabled the six teachers to view their practice in a much more critical way which led to them gaining a much greater understanding of their practice. Although the model has been developed and used by expert teachers, it is important to note that the principles of the model may be applied to NQTs and established teachers.

7.4 A framework of science teacher expertise

Even though the science teachers demonstrate differences in their perceptions of expert science teaching there are strong characteristics which emerge from their perceptions that are common to all of the six teachers. These teachers share a common understanding of science teacher expertise but also demonstrate idiosyncratic beliefs and behaviour about their practice. Table 7.2 shows a matrix of the characteristics of expert science teaching which are shared by the science teachers and, in the main, supported by the existing literature. The matrix is constructed to be read by columns with each cell representing an emergent theme or characteristic contained within the four organising categories.

This matrix differs from the individual matrices in two ways: it does not indicate each science teachers' personal model of science, and it does not show their dominant

teaching approaches. The matrix shows thirty-three core characteristics of expert science teaching as exhibited by the six science teachers. 'Creates strong teacher-pupil relationships' is contained in both learning and teaching categories, as the teachers perceive this to be inseparable from either category. 'Flexibility' has two separate meanings for the teachers and so is placed in both, learning and teaching. The matrix is constructed to present a summarised set of the characteristics of expert science teaching. It does not claim to be a definitive list, but shows the core characteristics common to all six of the science teachers from this present study.

Table 7.2 Shared characteristics of six expert science teachers

Perceptions of:			
learning	**teaching**	**science**	**reflection**
utilise active learning strategies	utilise different pedagogues	have models of science that do not affect their teaching	can improvise through reflection
utilise a co-operative learning approach	have a flexible approach	have a strong belief in making science relevant	reflect on successes & failures
utilise stimulating & relevant analogies	are able to change tack & monitor pace	are good communicators of science	gain greater awareness of their practice
create strong teacher-pupil relationships	take risks during their teaching	are enthusiastic about science	utilise reflection to fine tune their practice
have a genuine belief in pupils abilities	are creative & innovative	inject humour & fun into science	learn from the critique of others
are flexible within classroom atmosphere	have a commitment to CPD	are creative & innovative	utilise reflection to contextualise practice
utilise effective classroom management strategies	are enthusiastic about science teaching	are teachers of science not scientists	Reflect in & on practice
monitor pupils progress consistently	are keen professionals		
encourage creativity & innovation in pupils	utilise routines during practice		
support all pupils	create strong teacher-pupil relationships		
	are intuitive in the classroom		

Table 7.2 identifies a number of characteristics which have resonance with current thinking about 'leadership skills'. Hooper and Potter (2000) state that the best leaders possess the three Ps: Passion for change, Praise for people's efforts and Pride in the results of the team. The authors interviewed twenty-five top business leaders including Sir Stuart Hampson, Chairman of the John Lewis partnership and Sir Peter Davis, Chief Executive of J. Sainsbury PLC. Hooper and Potter (*ibid*) identify five qualities which they believe mark out the best leaders:

- creating an understanding of change
- effective communication
- realising potential
- setting an example

These four qualities (as relating to teachers providing classroom leadership) can be clearly identified within the model of expert science teachers (Table 7.2). Although Hooper and Potter base their qualities on a different professional arena the qualities can be clearly linked to characteristics from the expert science teacher model. The participant science teachers create an understanding of change by embracing change through their risk-taking in the classroom, commitment to CPD and by getting their pupils to understand the need for change. They create experience of change by varying their teaching and learning approaches, being creative and innovative, varying the pace and changing tack during lessons and by being flexible in the classroom (see findings chapter 6). Because the teachers accept change through these types of techniques it is reasonable to assume their pupils gain greater experience of change.

They are all effective communicators of science through their science teaching and take pride in this as a key professional attribute. The teachers realise the potential within their pupils, have a genuine belief in pupils' abilities, monitor pupils' progress consistently and create strong teacher-pupil relationships—these are all characteristics which can be said to assist the realisation of potential. Finally, the teachers are all keen professionals and aim to set an example in the classroom by having a commitment to continuous improvement and learning through CPD, being creative and innovative in the classroom and by being enthusiastic about science teaching. These teachers get involved as facilitators, working amongst their pupils, rather than as instructors who often become isolated from the intimacy of the classroom (see findings chapter 6). Pupils see these teachers leading from the front and encouraging and supporting from behind as facilitators. They are constantly setting an example for pupils in this way.

While there may be contextual differences, the essence of what Hooper and Potter recognise as qualities of the best leaders, do have some clear resonance with the characteristics identified within this present study. Perhaps the most interesting characteristic to emerge from this present study is 'risk-taking'. Cooper (2000) states:

> *Fifteen years ago we had around 1200 MBA students per year. today, there are around 100,000. We have qualified managers, what we need today are risk-taking ones* (p. 1).

Katzenbach (1996) recognises personal initiative as going beyond defined boundaries as an important characteristic of good leaders. Therefore, a notion of expert teachers as good leaders in the classroom is worth further discussion as it is potentially an important issue that may be implicit in the findings from this present study and have significant implications for teacher CPD.

Hooper and Potter (*ibid*) believe:

> *...the key skill of the leader is in creating a climate where change is welcomed, not feared. Human beings need the stimulation of change in order to grow and develop. Invariably it is in the presentation of the case for change that the problems occur. As Shakespeare once said, 'there is nothing either good nor bad, but thinking makes it so'. The real test of effective change leadership is in the selling of the change, creating emotional alignment, and winning hearts and minds* (p. 123).

The expert teachers from this present study appear to present a case for change by explicitly encouraging a classroom atmosphere which is flexible. They then experiment with change through their willingness to take risks in their teaching approaches, varying approaches and changing pace and tack during lessons.

There are, of course, contextual differences between Hooper and Potter's claims and this present study. However, there does appear to be enough resonance to warrant further investigation into a notion which suggests that highly effective classroom teachers exhibit leadership characteristics.

The current study indicates that leadership and expert teaching have close similarities in the ways described in this present study. *Leadership implies direction and progress towards a vision* (Hooper and Potter, 2000, p. 198). Few educationalists would argue that the primary objective of teaching is to help pupils achieve direction and progress towards their maximum learning potential. Therefore, the challenge for teachers is to capture the 'hearts and minds' of pupils to enable direction and progress to happen. The teachers from the current study have all realised that they possess the types of skills and characteristics accepted as leadership skills in the existing relevant literature (for example: Hooper and Potter, 2000) as suggested by Simon:

> *Yes these skills, although they seem to be talking about business, do link very well to the types of skills that expert teachers have. It's the language that's different that's all* (Reflective discussion).

While showing contrasting and supporting views, from existing literature in the field of expert teaching, it has also presented an argument for expert teachers as 'leaders' in the classroom. The study has been set within the participating teachers' perceptions and shows how they developed their understanding of their practice over the duration of the study. In relating expert teaching to current thinking around leadership it is plausible to suggest that intelligent leadership in a teaching context relates to the teacher acquiring self-knowledge (Hooper and Potter, *ibid*; Adair, 1989). Existing literature on leadership states that effective leaders are very aware of their strengths and weaknesses and capitalise on their own abilities and those of colleagues, while also learning from their mistakes and risks.

These six teachers clearly indicate that they have benefited from the opportunity to reflect upon the nature of their teaching suggesting that they have informed their knowledge of their practice through the study. However, the study also shows that the task of teaching is complex and multiple, yet often schools do not provide the conditions or encouragement to reflect, regularly in a structured way, upon professional practice with the aim of improvement.

As demonstrated by this study, a key issue in the effective improvement of teaching practice is collaborative endeavour by teachers and/or researchers. Pragmatic and feasible approaches, such as the methodology utilised for the present study, could be offered to incorporate regular reflection within normal school practices. In many schools this may confront existing priorities for teachers, however they have a crucial

role to play in promoting the importance of reflection and the need to create opportunities to exploit the process.

7.5 Aims and original contribution to knowledge

The present study set out to achieve three main aims:

1 to explore the nature of expertise within teaching with specific reference to science teaching.

2 to highlight key characteristics of expert science teacher practice and thinking and the nature of the interaction between them.

3 to inform the structure and content of teacher education programmes and Continuing Professional Development (CPD).

Aim one has been achieved through the action research methodology of the study by exploring, collaboratively with the six science teachers, their perceptions of science teacher expertise. Supporting the methodological approach is a substantial literature review which reports on many aspects and issues of expertise in the general field of teaching, science teaching and other arena's such as Mathematics (Dreyfuss and Dreyfuss, 1986) and Nursing (Benner, 1984).

Similarly aim two has also been achieved by an in-depth study of existing literature and by identifying a set of the key characteristics of expert science teaching emerging

from the data. The key characteristics are a result of rigorous in-depth analysis of the data which not only provides a number of key characteristics but provides an understanding of the relationship between each characteristic contained in the model and how the teachers think about them. An important addition has been the identification of a number of characteristics not hitherto reported in the existing literature along with some differences with the existing literature.

Finally, aim three has been addressed by offering strategies and models (see chapter 8), which have emerged from the methodology and findings of this study, which could be of significant value to ITT and CPD programmes.

The original contribution to knowledge arises from four areas:

1 the contribution to existing research

2 a framework of science teacher expertise

3 the chosen methodology

4 a model of teacher development

Little existing research focuses specifically on the characteristics of expert science teachers. The present study contributes to the debate on teaching excellence by offering a detailed account of science teacher expertise from the perceptions of six science teachers.

This study also reports on characteristics of expert science teachers and presents a set of characteristics which may be used as useful guidelines for student and established

teachers wishing to develop their professional practice. By examining the key characteristics contained in the framework they may identify more clearly their current strengths and weaknesses. The matrix therefore offers a framework for development teachers to improve to excellence by comparing their current practice characteristics to those contained in the framework. The extensive literature review indicates that it is unlikely that a model or framework containing key characteristics of expert science teaching exists prior to this study.

The methodology used in the study provided an opportunity for teachers to reflect on their practice both individually and as a group. While it is acknowledged that these teachers were reflective practitioners before their involvement in the study, they have few if any, opportunities to reflect on, and discuss their practice with others. The methodology of the study allowed them to do this by bringing together a group of science teachers in order to share their perceptions of expert teaching with their peers, the researcher and supervisory team. Under the guidance and co-ordination of the researcher the group of teachers discussed their teaching, shared and analysed perceptions while working with the researcher and supervisory team to formulate an agreed model of science teacher expertise.

The methodology used also provides an approach to educational research that promotes collaboration between researchers and teachers, and thus empowers teachers to take ownership and to commit to research in the classroom. It is worth stating here that since this study the DfEE has commenced a drive to encourage more teachers to undertake classroom-based research through research scholarships for teachers (DfEE, February 2000).

Finally, a model of teacher development has been developed directly from the methodological approach. The framework (which is now being used by student teachers at the Centre for Science Education and by teachers in Sheffield and Manchester schools) enables them to reflect on practice with others while utilising a framework of activities such as classroom observation, discussions and analysis of emerging themes/issues. The model may be used as a framework to guide their classroom-based development and for departmental development activity.
It represents an effective and economical method of CPD for teachers who are now required to present evidence of CPD activity if they are to progress their careers.

7.6 Summary

The reported study set out to explore six expert science teachers' perceptions of their own teaching expertise. In doing so a number of characteristics have emerged which are generic to the group, the existing literature and which provide several additional characteristics not found in the literature. The insights of these six teachers have provided a picture of what science teacher expertise means to them, while producing interesting and valuable data to add to the current debate about teacher effectiveness. It is clear that the teachers found their involvement in the study interesting and valuable. They claim they have gained a greater awareness of their practice, developed their reflective processes and learned to articulate their practice much more clearly. The study also presents a methodology that is sufficiently clear in its use of analytical tools to produce data which is rich and of good quality. The collaborative process used relies heavily upon clear, precise communication between researcher and

teachers made easier with emerging technology, such as email. The process emphasises the importance of teachers' insights when researching this area, and shows the benefits of research partnerships between researchers and practitioners.

Reviewing the outcomes of the study and the procedures that were followed, it is concluded that the study achieved its aims of capturing science teachers' perceptions of their expertise. The study provides insights into the way that these teachers think about their knowledge and practice, and identifies a model of science teacher expertise for consideration and debate, while offering tools and stimulating thinking about Initial Teacher Training and Continuing Professional Development programmes.

What is very encouraging is the high level of agreement between the findings from this present study with those of previous work (e.g. Shulman, 1986; 1987; Sanders *et al*, 1993; Fullan, 1985; Opie, 1995; Younger and Warrington, 1999; Zeichner, 1990; Berliner, 1988; Schon, 1987; see section 7.2). The methodologies, in most cases have been quite different, but have produced comparable results. As more studies like these bring ever more insights into effective teaching, the pool of knowledge and understanding continues to grow, giving teachers and teacher educators a continuously improving framework with which to enrich and enhance classroom teaching and learning.

8 Implications and final remarks

8.1 Introduction

In presenting the perceptions of six science teachers about their knowledge and practice a problem occurs in identifying implications for science teaching in general. With a small number of selected teachers collaborating within the study, implications may only be tentatively suggested. However, the six teachers do demonstrate a closely shared understanding of their expertise with only limited differences between them. The study also shows much agreement with the literature on teaching expertise. However, whether the collaborating teachers are representative of the majority of science teachers remains undetermined, although equally, there is no evidence to suggest that they are not typical of science teachers. Moreover, their profiles show that they are from a wide range of schools and experience (see teacher profiles, chapter 5). Never the less the data raises important issues for consideration, which highlight the perceptions of these teachers that concern Initial Teacher Training and Continuing Professional Development programmes. The chapter will discuss the ownership and empowerment that the teachers from the present study experienced, and show how ITT and Continuing Professional Development programmes may benefit by taking an approach similar to the methodology utilised within this study. The chapter will continue by showing how these teachers possess implicit, underpinning characteristics that are generic to emotional intelligence and process skills (Honey, 1995), and how profiling in these skills may enhance the development of beginning teachers. Finally, limitations of the study will be discussed, highlighting

opportunities for further study that may build on the findings and methodology of this reported study.

8.2 Ownership, empowerment and structure: CPD for the future

One of the major strengths of this present study is undoubtedly its methodology. In creating a research culture which embraced the science teachers involved, it enabled the teachers to:

- take ownership of their roles within the research process
- become empowered by the research process
- gain an understanding of the research process

Few existing studies, which concentrate on the characteristics of classroom teaching, utilise a collaborative approach that enables teachers to become research collaborators. Educational research in the field of teacher expertise has traditionally drawn on teachers' understanding of their knowledge and practice, by placing them as subjects of the research and not as collaborators. The approach used within the reported study provided the six teachers with an opportunity to take ownership of their role within the study. In doing so, these science teachers took full responsibility for on-going reflection on their knowledge and practice. As the teachers' commitment to the study was strong, the researcher did not have any real difficulties in motivating them to take part in interviews, observations, reflective discussions, meetings, telephone discussions or to write reflective reports.

By bringing the teachers closer to the research process they were empowered within it. This is to say that the teachers had full knowledge of analysis techniques and findings.

The six teachers were able to share their views of the research with each teacher from the group and the researcher. On-going feedback provided by the researcher, nurtured the collaborative culture and developed a sense of real contribution and ownership from the teachers, which they may not have realised had they been involved to a lesser degree. This helped to produce a more refined and rich collection of data. They were also empowered by each other through a type of community spirit. They did not feel isolated within the research and were able to share their perceptions and beliefs of teaching with each other. This is not to say that they lost any of their individuality. Each participant was confident and at ease in small group discussion, and well able to argue and express their views in a firm but friendly way. Indeed, at no time did the researcher feel that certain individuals had too much influence at the group meeting. In any case each teacher was able to express his or her views individually to the researcher.

This group of science teachers also valued the opportunity to gain a practical understanding of the research process. They perceived their exposure and contribution to the research as a quality learning experience. It was noticeable that over the course of the research the teachers developed skills that enabled them to reflect on and discuss their expertise in a structured, analytical manner. This enabled them to articulate the underpinning themes of their expertise with clarity and precision.

These issues suggest strong implications for the continuing professional development of teachers, especially in the light of a recent paper published by the DfEE (2000). The paper suggests that teachers should take ownership of their own professional development and share responsibility and commitment with their schools for development. The paper also encourages teachers to share knowledge and expertise with colleagues from their own schools and other schools. As this study shows, these six teachers value opportunities to discuss pedagogy and science with other teachers, and that they have a strong belief in continuing professional development. The group of teachers place an emphasis on these issues which suggests that future development activities and programmes may be enhanced by utilising the abilities and experiences of committed teachers, and cultivating a sharing environment where teachers may discuss their knowledge and practice with other teachers:

> *...teachers should learn on the job and from the best working alongside other professionals in the classroom* (DfEE, 2000, p. 3).

By encouraging an environment which is built on a philosophy of sharing information, knowledge and resources, it is possible that best practice may be disseminated throughout the profession with teachers taking ownership and responsibility for their own development and for that of others. Reflective partnerships where teachers act as, critical friends, guides, coaches and mentors, to colleagues from within their own schools and from others, would enable teachers to create an organic teacher-led developmental programme, whereby teachers act as a support mechanism for each other, help to develop each other's practice by reflecting on a partner's practice, and by sharing experiences, knowledge and resources. The teachers in this study benefited from the experience of discussing their practice and sharing views which is something they do not normally have the opportunity to do.

The introduction of the Threshold means that it is imperative for teachers to undertake professional development activity and provide clear evidence of this. It is this factor that has the widest possible implications for teachers, schools and CPD. For the very first time explicit evidence of CPD has become a key aspect of the conditions of service of any teacher seeking promotion above the basic scale. Prior to this teachers have been able to regard CPD as an add-on or luxury they could put to one side. Potentially, of even greater importance is a further implication, namely that successful teachers in the future will be those who take further ownership of their CPD. This marks a key shift in CPD terms away from providers (of courses) to clients (teachers). To respond to this challenge providers will need to reconceptualise CPD provision in order to meet a client led and individualised economy given that the future acid test of effectiveness will be set against a client assessment of need:

> *effective teachers should take ownership and give high priority to professional development, and schools and teachers should share responsibility and commitment for development, supported by government.* (p.3 DfEE, Professional Development)

Three key elements in developing an effective CPD system of this kind are: that it is sustainable, economical and value for money. The system must be capable of being sustained and developed by its clients with limited input from a provider. It must also be economical, capable of achieving desired outcomes at minimal financial cost and value for money. There is also the issue of school-based and school-focused CPD. The Achilles' heel of much school-based and school-focused CPD is the assumption that advice and support mainly exists within the school, whereas the current INSET model assumes it is only available outside the school. Neither position is fully tenable and what is required is a network that connects teachers with teachers sharing common experiences and working towards solutions that specifically meet their own needs and contexts. In many cases this may be a simple function of knowing and

borrowing what others have developed, but in many other cases interaction will lead to joint problem solving.

The teachers from this study have become the nucleus for a pilot programme which builds directly on the findings from this study. 'Reflective Partners' attempts to enable teachers to reflect and act on their professional practice in collaboration with other, more or less, experienced teachers. The aims of the programme are to enable teachers to:

- share best practice and develop new ideas and approaches
- learn from others and improve their own practice
- gain mutual support and encouragement
- raise standards of teaching and learning

The six teachers (in partnerships of two) met for an initial 'development meeting' which enabled each partner to identify personal aims and agendas. Once the teachers were satisfied they had identified the scope of the partnership, dates were set to visit their respective classrooms and conduct observations in order to gain a greater understanding of how their partners perform within the classroom and to identify issues and concerns for development as well as highlighting good practice. After observations partners held in-depth discussions with the aim of generating action plans for future development of their partnership. For example, one partnership decided they would like to develop a joint research project focusing on pupils' understanding of 'energy' in the hope that it would lead to a better understanding of how to teach the topic.

Teachers were observed by the researcher of this present study during initial meetings, observations and discussions and were asked to produce a reflective summary of their meetings and observations outlining future aims and developments. Data is currently being analysed but early indications suggest that the programme has great potential for teacher CPD. The six teachers have all agreed that discussing their teaching and professional development with other teachers is something they value very highly. The partnership context appears to set a forum where each reflective partner can develop strategies for their own development while contributing to the development of their partner. Self-esteem and motivation also seems to be enhanced through a perceived supportive environment.

The participant teachers, working with researchers from the Centre for Science Education, have utilised the GRASP[1] (Getting Results and Solving Problems) framework to provide a structured approach to the partnerships. GRASP utilises a questioning structure (Figure 8.1) which promotes a continuous process of reflection by enabling a way of thinking about one's professional development.

At this early stage there is evidence to suggest that the programme can be developed successfully. Departments other than science, within the participant schools, have shown interest and indicated that reflective action partners may be utilised across departments (e.g. science teachers partnering English teachers). It is hoped that one of the outcomes of the programme will be the establishment of an on-line community of teachers who will share their knowledge and practice and contribute to a 'skills

[1] GRASP is a registered trademark of the Comino Foundation.

bank' where partners would submit their expertise to a database so that others could access their expertise and formulate new partnerships on-line.

Figure 8.1 GRASP

what am I/we trying to achieve?
(clarifying purpose)

what am I/are we actually trying to achieve?
(review)

how will I/we know when I've/we've succeeded?
(choosing success criteria)

is that right? am I/we sure?
(review)

what alternative ways are there to achieve this?
(there is always another way)

which is best?
(choosing which best fits the criteria)

how should I/we keep track of the process of getting there?
(monitoring, evaluating, controlling)
(The Comino Foundation)

The success of the Reflective Partners pilot programme, as perceived by the teachers involved, is in no doubt. Observing and discussing classroom practice through a systematic reflective process has proved extremely valuable to these teachers in terms of their own understanding of their practice, and in their own professional development. It's success lies within the process of empowering the teachers involved to take charge of their own professional knowledge, understanding and development. As with the present study the teachers involved in the Reflective Partners programme took complete ownership of the process. The Reflective Partners programme has been developed as a direct result of this research study and utilises the

reflective approach developed by the researcher (see conclusions chapter 7, figure 7.1).

However, often schools do not provide the necessary conditions that encourage and support regular reflection on practice (Baird, 1999). In the drive to produce teaching excellence the challenge for schools is to execute a clear programme and conditions which will invite teachers to embrace change and effect improvement in their practice. Schools need to provide an environment that encourages innovative practice by teachers, an environment that allows for risk taking in the classroom. Schools must be prepared to accept failures as learning experiences and develop a culture which does not seek to blame individuals for mistakes but sees them as potential for development. Provision for regular reflection and discussion about teaching by teachers has been identified by the present study as an effective method for developing such an environment.

UK teachers are faced with developing their practice to a high standard in order to advance their careers up to, through and beyond Threshold. To achieve this they are required to provide an evidence base of their continuous development. The key to this must surely be through a reflective process that enables them to make explicit, to themselves and others, the rich tacit knowledge of teaching that they possess. Once this has been achieved clear pathways for professional development can be identified, taken and documented by teachers maintaining a professional portfolio of development activity. This present study has led to the creation of the Reflective Partners model of development that may be used to support NQTs and established teachers to identify and undertake required developmental needs.

A recent article focusing on research conducted by the APPLE team (TES, September 1999) concerning teachers' knowledge, criticised teachers for being unable to articulate knowledge of their practice in a suitably technical language. The article suggests that teachers do not need to express their knowledge regularly enough to develop a theoretical understanding of what they do. This current study shows that these teachers can articulate their knowledge in a clear, technical language, and that they value the opportunities to do so. If researchers are to investigate the underpinning principles of teaching practice, they must do so in partnership with the teachers themselves. Stimulating a professional dialogue between teachers and researchers is of great importance. Teachers' stories can become a very useful tool for professional development (Jalongo and Isenberg, 1995; Moje and Wade, 1997) and, in bringing theory and practice closer.

8.3 Process skills

Over recent years a number of studies have reported on the importance of knowledge worker process skills within the professions (Honey, 1995; British Chambers of Commerce,1999; the Royal Society of Arts 1999). The concept of 'knowledge workers' has recently emerged with reference to the 'information society.' Honey (1995) suggests that the development of personal and organisational success depends upon the way that professionals utilise skills and knowledge to work collectively or independently.

The British Chambers of Commerce (1999); and the Royal Society of Arts (1999) have called for these skills to be integrated into the National Curriculum in an attempt

to reduce, what they see as, a 'skills gap' in young people looking for employment. Table 8.2 describes a number of skills which are thought to be generic to effective professionals.

The emergent characteristics from the present study compare well with those contained in Table 8.2. The science teachers' possession and use of interpersonal awareness and concern for impact is probably more evident than others. The data suggests that this group of teachers have a strong understanding of pupils' abilities, learning requirements and moods, and a willingness to listen to their views and thoughts. These characteristics, exhibited by the teachers, are part of a desire to create and maintain good teacher-pupil relationships. These characteristics appear to be typical of interpersonal awareness and concern for impact as described within the existing literature which focuses on this area.

Table 8.2 Process skills

Skills	**Behaviour**
independence	holding to personal convictions in situations of resistance
innovation	devising imaginative ideas and solutions to problems
positive self-image	believing in oneself
conceptual thinking	identifying important issues and drawing them together coherently
initiative	being proactive and taking opportunities
flexibility	altering personal behaviours and views in the light of new information
strategic thinking	developing long term goals and objectives
analytical thinking	breaking down problems logical
results orientation	wanting effective outcomes
tenacity	repeating efforts to overcome barriers and complete tasks
self-control	performing effectively in difficult situations
self-development	actively seeking and taking opportunities to continuously develop
rational persuasion	making persuasive arguments built on logic
concern for impact	responding to the views and needs of others

(adapted from Honey, 1995)

The six teachers also appear to exhibit behaviour which indicate certain other process skills, such as: innovation; initiative; tenacity; independence; self-development orientation; interpersonal awareness; concern for impact, and concern for standards. These are all implicit within the findings of this study. The key here is making teachers aware of these skills so that they may develop their practice by utilising these implicit strengths.

8.4 Initial Teacher Training

One clear implication for ITT, which has emerged from this present study, is the emphasis that teacher trainers need to place on reflection as a process of development. These six experts have consistently demonstrated how the reflective process can enhance teachers' awareness of their strengths and weaknesses, and how this awareness can aid the development of practice. Teacher training programmes should seek to integrate methods of reflection that allow student-teachers to share new ideas, and discuss practice on a regular basis with peers, colleagues and trainers. Students placed as 'pairs' or 'partners' in the same school would enhance reflective opportunities.

These reflective methods should go beyond normal lesson evaluation and discussions with mentors. Reflection should use a regular process to enable student-teachers to identify key characteristics of their practice with the aim of analysing and continually improving.

By engaging in continuous reflection in and on practice, as well as continuous discussion of practice, student-teachers may be able to build a 'developmental

pathway' by which they can monitor their successes and failures, while highlighting strengths and weaknesses as they undergo training. The framework of expert teaching characteristics that has emerged from this study may be used as guidance for student-teachers to gauge the development of individual characteristics of their practice and to identify quality practice to which they should aim.

Initial Teacher Training programmes could employ a structured profiling tool by which student-teachers may identify specific strengths and weaknesses, characteristics of their practice and process skills. The results of their personal profile may form the basis for a developmental pathway where student-teachers and NQT's may choose professional development programmes that are specific to their needs, using expert characteristics as a bench mark for development. Profiles could be modified as teachers continue their professional journey and identify new opportunities for expanding and developing their knowledge and practice. The model from this study may be used as a framework in developing a personal profile by focusing on the emergent characteristics, again, as a benchmark to gauge best practice.

ITT tutors at the Centre are now using the Reflective Partners model for Science Education with their students. It is expected that the students will keep detailed diaries of their teaching practices as well as a constant dialogue with their reflective partner. A course assignment focused on their partnership is intended for inclusion towards the completion of students' courses.

The knowledge of practice which the six teachers from this study have demonstrated could be used by student and beginning teachers to critically analyse their own knowledge, through a collaborative, reflective dialogue of stories and experiences, as

opposed to theory dominated research reports. It is not enough to have knowledge of teachers' knowledge and practice, models of learning and of knowledge application need to be integrated into ITT in such a way that expert teachers have a direct influence on content, and can disseminate their expertise to student-teachers. Considering teachers' reflection processes to be an important tool for professional development may be a useful way of developing student-teachers' knowledge through regular reflection with practising teachers who have been identified as effective teachers. The AST initiative offers the opportunity for existing ASTs to have a strong involvement with ITT departments in universities, although these links are currently only tentative and still need to be substantiated.

The model of teacher development presented in figure 7.1 (see conclusions chapter 7) captures all that has been stated thus far in this chapter. It has at its core a reflective process which epitomises the Reflective Partners scheme, it can be used to develop specific teaching skills and process/generic skills, and it may be used by student teachers, NQTs, established teachers and ASTs. The model is deceptively simple with its complexity hidden within the teacher's own use of the activities (observation, discussion, analysis). Teachers may choose to concentrate on particular elements of their practice and thoroughly scrutinise these with in-depth use of each activity and reflection. They may also choose to use the model as a method of support by 'just' talking about their practice with others and utilising careful reflection of the discussion content.

In combination with the GRASP framework (figure 8.1) the model represents a powerful and flexible approach to CPD whatever level a teacher may exist at. The model's power lies in its simplicity, flexibility and reflective philosophy. Those

teachers who have been exposed to the model so far (through the Reflective Partners scheme) have responded enthusiastically and positively towards its use.

Interestingly, these six teachers did not identify subject knowledge and summative assessment as major concerns. However, it is reasonable to assume that the teachers do not see subject knowledge and summative assessment as key issues.

Given the assumption that these teachers feel that their subject knowledge is just a vehicle for being teachers, ITT and CPD programmes would need to focus on teaching skills and reflective practices in general with less emphasis on subject related content. The six teachers involved in this study appear to be comfortable with their level of subject knowledge and are more concerned with developing teaching strategies, techniques and approaches. This is not to say that teacher educators should ignore student-teachers level of subject knowledge, indeed, with a drive to improve the quality of teaching in our schools teachers should possess appropriate subject knowledge. However, a greater focus on the mechanics, operation and theory of teaching through ITT and CPD programmes may well give rise to more thoughtful, innovative and creative practice.

The issue of summative assessment is possibly a little less thought provoking. It is perhaps not surprising that these teachers do not mention summative assessment in any great detail as they show a distinct interest in monitoring pupils' progress formatively. It is possible that they see summative assessment in terms of SATs and in-school examinations and perceive formative assessment as a more important tool for helping to develop pupils' abilities. However, questions focused on these issues

would have enabled a clearer and more discursive insight in to the teachers' perceptions around subject knowledge and summative assessment. It is worth emphasising again that over the course of the study it is interesting that the teachers did not raise these issues of their own volition.

8.5 Further study

This study could be replicated with a larger number of teachers in an attempt to produce findings which can be generalised across the wider science teacher community. However, this is a very researcher intense study and demanding of teachers, so it would be difficult to envisage the group increasing significantly in size. It is essential that teachers play a principal role in any further research if an expert knowledge base for teaching is to be established. Because of the deep insights that the group of teachers provided within this present study, close co-operation between teachers and researchers has much to recommend it. Groups of identified expert teachers with a wide range of experience and from schools that represent differing philosophies and cultures, may act as reflective experts while collaborating with researchers in an attempt to disseminate science teaching expertise through the profession.

Further study into the expert teacher's possession and use of knowledge worker process skills in teaching is also recommended. Additionally if we were to integrate process skills with subject teaching then clearly, teachers need to have and be aware of these skills. The six science teachers involved with the reported study appear to utilise these skills in an implicit manner, and do not overtly attempt to pass them on to their pupils. Therefore, research into teachers' understanding and possession of these

skills, and how they might incorporate them, more explicitly, in their subject teaching is suggested.

An interesting area for further study is the notion of 'classroom teacher as leader.' As a result of this study the researcher has attempted to identify existing literature focusing on this notion with little success. It is possible that this is an important area of classroom teaching, closely aligned with expertise, and one that needs further consideration through research.

8.6 Final remarks

This study has consistently emphasised the importance of teachers' involvement in the research process. Their insights, stories and perceptions of their knowledge and practice can and should, contribute to the widening database of research into teaching practice. However, there are insights available from research into teaching practice which do not use a collaborative format, that can be legitimately used to authenticate and support studies such as the present one. Moreover, this study does not diminish the importance of research that utilises teachers as subjects rather than collaborators. The present study offers an approach to research on teachers which is not, presently, widely used. It is conceivable that a science teacher community could be built whereby a pool of experience, expertise and differing teacher philosophies could be combined to produce a rich database of best practice from the insights of committed science teachers. Together with the educational research community, teachers may contribute as partners to the continuing professional development of those in the

profession, as well as providing a rich source of insights into science teacher expertise for student-teachers.

This current study has succeeded in capturing and interpreting the perceptions of six science teachers about their knowledge and practice. It is fervently hoped that the findings contribute to the debate about teaching expertise. It has already been acknowledged that it was beyond the scope of this study to make generalisable claims, and that its purpose was to present a way of thinking about science teacher expertise. However, as the teacher profiles (chapter 5) suggest these six teachers appear representative of the wider science teacher community. Further more, the comparisons made between the findings of this present study and those from existing studies, indicate that these science teachers possess characteristics of expertise which other teachers of science, and other subject teachers also exhibit.

It is clear that teachers need to be aware of their own knowledge and practice, and the characteristics of expert teaching if they are to continue their professional development throughout their professional careers. This reported study shows that these six science teachers utilise high quality skills and knowledge which are likely to be generic to other expert science teachers and other subject teachers.

The study also shows that the teachers have individual characteristics within a broad congruence of characteristics. With this in mind, personal profiling appears to be a sensible tool for teachers to use in identifying continuing professional development activity that will enable them to reach expert status and/or to expand their teaching expertise. Also, with the introduction of the Performance Threshold the onus to provide clear evidence that he/she satisfies the standards laid out is firmly placed on

individual teachers. For the first time explicit evidence of CPD involvement has become a key aspect of the conditions of service for teachers seeking promotion above the basic scale. To respond to this challenge teachers will need to have a clear vision of their CPD needs. It follows then, that teachers will be required to analyse their practice thoroughly and be able to identify their strengths and weaknesses clearly. Teachers who keep a personal profile of their CPD activity and their career progression will have a tool which enables them to pinpoint development and show clearly their professional route to expert practice. Key outcomes of this research study can assist that process.

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Appendix 1

Standards for Advanced Skills Teacher candidates. (Note by the DfEE, September 1998).

The standards set out the high levels of expertise required of those teachers wishing to become Advanced Skills Teachers (ASTs). They will need to be:

a) highly effective teachers in their phase and/or specialism(s); and
b) effective in disseminating their expertise.

These standards build on the Secretary of State's standards for Qualified Teacher Status (QTS) and the proposed induction standards, and set out high expectations appropriate to the very best teachers.

Standards

While all those wishing to become ASTs will need to meet the standards specified below, they will need to be interpreted and applied appropriately in relation to teachers in different phases and with different specialism(s) and roles. The standards do not debar any teacher from being able to demonstrate the required expertise, including part-time or peripatetic staff.

1. Excellent results/outcomes

As a result of aspiring ASTs' teaching, pupils show consistent improvement in relation to prior and expected attainment; are highly motivated, enthusiastic and respond positively to challenge and high expectations; exhibit consistently high standards of discipline and behaviour; show a consistent track record of parental involvement and satisfaction.

2. Excellent subject and/or specialist knowledge

Aspiring ASTs must keep up to date in their subjects and/or specialism(s); have a full understanding of connections and progression in the subject and use this in their teaching to ensure pupils make good progress; quickly understand pupils' perceptions and misconceptions from their questions and responses; understand ICT in the teaching of their subject or specialism(s).

3. Excellent ability to plan

Aspiring ASTs must prepare lessons and sequences of lessons with clear objectives to ensure successful learning by all pupils; set consistently high expectations for pupils in their class and home work; plan their teaching to ensure it builds on the current and previous achievement of pupils.

4. Excellent ability to teach, manage pupils and maintain discipline

Aspiring ASTs must understand and use the most effective teaching methods to achieve the teaching objectives in hand; display flair and creativity in engaging, enthusing and challenging groups of pupils; use questioning and explanation skilfully to secure maximum progress; develop pupils' literacy, numeracy and ICT skills as appropriate within their phase and context; are able to provide positive and targeted support for pupils who have special educational needs, are very able, are from ethnic minorities, lack confidence, have behavioural difficulties or are disaffected; maintain respect and discipline and are consistent and fair.

5. Excellent ability to assess and evaluate

Aspiring ASTs must use assessment as part of their teaching to diagnose pupils' needs, set realistic and challenging targets for improvement and plan future teaching; improve their teaching through evaluating their own practice in relation to pupils' progress, school targets and inspection evidence.

6. Excellent ability to advise and support other teachers

Aspiring ASTs must provide clear feedback, good support and sound advice to others; are able to provide examples, coaching and training to help others become more effective in their teaching; can help others to evaluate the impact of their teaching on raising pupils' achievements; are able to analyse teaching and understand how improvements can be made; have highly developed inter-personal skills which allow them to be effective in schools and situations other than their own; provide a role model for pupils and other staff through their personal and professional conduct; know how to plan and prioritise their own time and activity effectively; are highly respected and able to inspire others.

Appendix 2
Sample interviews from the initial cohort of 4 teachers

int = interviewer
res = respondent
--- = undecipherable
... = pause

int Can I ask you Mal, how long you've been teaching?

res 10 years.

int How many schools?

res Three

int Did you come into teaching because you wanted to, was it second choice, or....?

res To be absolutely honest, it was, probably second choice, actually. I did a PGCE because I wanted to do some ---- I didn't want to work in the pharmaceutical industry, so I took a term off, to see if I could start anything off myself, but you need quite a lot of capital. I thought I'd go into teaching for a couple of years, make some money and then start something myself. Ten years later and I'm still here, but enjoying it very much at the moment.

int Right, Right. Do you consider yourself an expert teacher?

res No. Not at all. I mean, things are always changing. I mean, no. Besides the basics, what you do in terms of curriculum knowledge and safety --- within the science department. Other than that, I am always willing to accept advice in terms of yes, I'm a chemist, but then we teach Biology and we teach physics, but I'm not a specialist in those areas --- therefore I am always seeking advice in those areas and I don't claim and you know, to be able to teach it to the highest levels in Key Stage 4 in my third subject for instance, I'm quite happy to teach chemistry and biology, not physics necessarily. That contradicts in terms of how the PGCE courses are run these days, because they aren't expected to do the student teaching and secondary schools are also expected there students that they receive, to be teaching all three, my own view is that yes you could possibly teach it the human syllabus but your background on genetics needs to stretch pupils to, at the levels of enjoyment that you want them to have won't be there superior teaching at low fashion --- text books. But ultimately your knowledge is text book knowledge, not necessarily what you've put into it.

int O.K that's fine. So if you don't believe that you personally are an expert do you think there are experts out there?

res I would say that there are good teachers in terms of expertise, yes I would say I've got expertise in chemistry, yes. I can influence other staff by offering my experience to make it

interesting for the pupils and enjoyable. In terms ... it depends on the definition of expertise. I think anybody and everybody should be willing to adapt and to change and to accept advice, not necessarily say that I know it all and therefore I'm going to teach it the same, ----

int O.K so it's an ongoing process?

res Oh I'd say it's ongoing, totally I mean it's been ongoing now for nearly ten years in teaching and there must have been one occasion where --- two years running. We've gone a whole circle really, going from secondary sciences form when I started going to modular courses now going to coordinated sciences we are changing borders you've got the Deering Report. So it's been constantly changing, I taught A' levels for five years taught three different A' level syllabuses in five years, I was teaching it. You know, therefore you're always adapting and changing it. As you go into it.

int Are there any constraints to this, either political, administrative, or anything like that, ... to the development of good practice?

res Constraints are whittling down on ---on top therefore you haven't got the time to develop or take further what you've already established, we are always trying to ....just writing the syllabus in itself takes time it may be just a wording problem. I mean this ----- position I was going in chemistry we've got two or three people working on it, it's easier, but I'm sure there are schools out there, secondary schools, where there is only one member of staff in each department therefore they are simply rewriting the same thing over and over again the time and the freedom to establish further than they've already got.

int Do you think that it's possible to see a teacher as an expert if you are only competent in a certain area? You say you are an expert chemist, are you an expert teacher?

res I would say there are good teachers and then there are not so good teachers, yes. Unfortunately it's down to the controlling influence you have over the pupils in front of you. If you've got control you can teach the kids actually anything and they will enjoy it, even though it maybe not very --- I'm not saying you should do that, but I would say that expectations ..... establish that.... they have to have a ..... in the class, I mean that's lacking..... and the hope that you are --- your own knowledge and if you can't help the kids, if you can't enthuse the kids in anyway then it doesn't matter how good you are technically --- teach the kids. Lunchtime---the lab actually---- it might be better actually. Sorry about this, I thought it may be better if we come out of there.

int Yes People are going to be.....

res That's right.

int Do you reflect on your lessons?

res At first yes, you would have to because if you feel that if things didn't go as well as you do .... you may not write it down, but ultimately, yes, you always will reconsider if a practical hasn't worked properly, you may want to go back and actually reconsider how you were doing it. Especially when you are influenced in what other people are doing in their lessons as well. Therefore you may want to change the work, you may want to change the cards or the equipment, or any --- of any particular experiment. Therefore yes, that does take place. It may not be written down.

int Yes

res It may be equally relating to work schemes the following year in terms of adjustments that you make and so one, but ultimately if you are not reflecting anything you're doing wrong you are simply not doing anything about it. You have to do it. It may not be so obvious actually written down on a piece of paper, it may not even be that conscious, it could be something you do in the car.

int That's right. Yes, Yes. There's a definite influence.

res I think it has to be done. You've got the constraints in terms of expectations, what people expect in terms of OFSTED...We will be OFSTED'ed next year again and therefore the expectations there are that it should be all written down. But when you've been teaching for a period of time yes you can make these decisions, but not unless you write it down all the time and you may not need a lesson plan it may be just one sentence and then you can adapt any time as the lesson progresses. Ultimately yes I would say at the start of the first couple of years I did write everything down and changed my lesson plan - - - all the rest of it two possibly three years I mean for 'A' level you have to continue all the time anyway, doing proper lessons.

int Getting to that actually, the years experience. Is it, in your view, that an NQT could be an expert or very good teacher at the beginning or in the first few years?

res I'll say it would be...I think they would bring their own thoughts and views to teaching where I think the way they come into the classroom would be totally different to what their own experience...there's a balance between what their academic expertise is and what their expertise is and I would say that yes, they may be very good. But ultimately yes, they may have had --- been into a classroom about a week or so they're an expert regardless of how good they may be. There are always things that you will learn on a range of activities that you undertake in school because it wont necessarily be in a science lab because I'm a teacher, there's less pastoral duties, there's duties you have to do, there are break time duties, there are after school duties. There's all these other things, there are meetings and all the rest of it that I'm involved

in in normal teaching mode. There's parents evenings, there's report writing. All these things are expected. Therefore, yes, academically you may know your knowledge or subject was how you deliver that and whether you can get the interest from the kids. Ultimately the best thing I would say, the actual judges of how good a teacher you are, the kids in front of you. And it may be at some point...I mean I used to do that, I used to have a report that they used to fill in in terms of the topic that we did. It got so expensive in terms of photocopying that it went out the window.

int That's a shame.

res But the kids did used to fill in how they thought the topic actually went.

int So that worked.

res It worked, but then again its finding the balance between how often you do these things kids will get bored, they're writing the same things over and over again. That's how complacency sets in, some kids will take it seriously. It may be useful to do that possibly once a year. Possibly people reports, its like you've got their views on how they've seen how the subject has gone and how the teaching has gone and there may be an avenue there where the head of department takes these in as well and has a read through them as well. Yes, that's a way forward. As I said, we did that after every topic here at one point, but in terms of expense as one matter and secondly our kids were filling them in every six or seven weeks.

int If you teach out of your area do you feel anxious or are you confident to do that, do you struggle in any way?

res I think you feel confident for the work that you learnt and the expertise you built up, you know, within a fairly narrow area, if a person then asks a question that you may not be familiar with, that then has its own problems in that you are stood there in front of the whole class and a kid asks a question which is related to that particular topic, but maybe beyond what you actually already prepared, what do you say? Do you say that sorry I don't know the answer, I will get onto it its a possibility you could say, but it doesn't stand you in much esteem in front of the pupils if you are having to do that. What they want is answers there and then. And if you are unable to give those answers there and then you're basically taking away their enthusiasm and they stop asking you questions. Whereas if you can answer them they will continue asking more and more questions and therefore they will get more enthused into it and you can go and look there and join up with the subject as well. Yes, so it comes back to the same old argument yes you can teach and you can be an effective teacher and yes I could teach physics upto GCSE but if someone asks me anything beyond what I have learnt myself then the kids wouldn't get as much out of it as I could put into 'A' level chemistry, I could put chemistry and beyond into it in terms of my own speciality in chemistry. Even biology, if I

make a mistake because you've got biochemistry coming into it and all the rest of it and these things are related, then you can. And you can diversify - - - information which is what you need.

int I think the fact that you are aware of that demonstrates a certain expertise doesn't it?

res What gets me is...I mean I was in Sheffield on Monday, is the expectations of students such as...schools as well, of students to come into their schools to teach all three and my argument has always been that schools should not expect that which is one of the questions I raised with the view of getting the information on students really early on so that we can put the students into the appropriate class. So that we know if they are a biologist, a chemist or a physicist. Yes there would be expectations for them to teach two, but not all three. There's an expectation here to teach four.

int So why are you a mentor?

res Its developing your own role in terms of you go for appraisal within school work and you are in effect mentoring staff within the school as well. This was a natural development along the same road. You want to be involved or you want to actually develop teachers who are good in classrooms and not necessarily get stereotyped, people you want to...you know if you can influence somebody in some way then you try to get involved.

int Yes

res And hopefully we are trying to...hopefully we've done that. In terms of what our students feel and in terms of what they will take away and may not get a job here but hopefully they can see what we've done here and what I've done here, possibly, and they can take that away. I'm not saying this place is brilliant, but there are some good set ups here and therefore you are...its a way of passing on your own experience to them and they can take it elsewhere. It gives you a different dimension to your own role, it makes you stop and think as well in terms of what you are teaching and how you are teaching it, you are watching somebody else and you naturally think about how you would do it, which you may not other wise do. That's been the response off other people who have been involved in delivering, not necessarily the - - - in terms of pastoral and whole school policies, that we are involved with, you are asking certain people to talk to students and they feel the same way. That gives them a different dimension and that makes them stop and think and they do it year in and year out, they don't necessarily ever stop and think well as here, when you are talking to students you have to stop and think and therefore you can develop yourself. If you are thinking about it, yes, you are talking about going back and reflecting, its a mirror progression from that - - - again you start reflecting on what you want.

int That's interesting. You say its definitely a two way learning situation.

res Otherwise there's no time really when you can stop and think, whereas if you're observing students and you're seeing it being done this way you can see what they're doing wrong and what they're doing right. I mean, they may be very good students and they may give you...I mean they may bring things back from university in terms of what they picked up in terms of latest developments. Yes, it's a two way process. I think both of us could learn. I think students can learn from the experience we've got and we can help hopefully, if they are good students and they are bringing things in and they are developing things then we can share those ideas.

int I think that's good. What's coming across is that there is no power struggle. But it seems a very closed door profession...this is my classroom, I'm teaching and don't come in. It seems to be beginning to change.

res I mean, I don't know, I mean I've been in schools where...I don't know, I've been very lucky in that I've always been able to help with the policy that you see people. I mean in this building in particular the middle doors are always opening and closing. People you are used to...you don't just stop...I mean I've been across there when I've been showing students around, yes the door is closed and everything is absolutely silent and suddenly you open the door and everybody looks round as though to say what are you doing in here. Here, expectation in science isn't like that though, because the doors are always opening, technicians are always walking around, staff are always walking in and out and therefore you are aware. You know, you don't necessarily need, you know, you could say that was a role for heads of department to go and observe lessons but here that open door policy which doesn't necessarily need to be the case because your always aware of what other staff are doing. If there is any disruption in the classes. So, in some respects yes, I think we are slightly different to other areas even within the school. I've been working there all the time and everything and a classroom in here and the doors been open and there's been no pressure to close this door so I don't reckon the person whose office this is and they're usually in there and there's a class in here. And there is always comments being passed on that, you know, you can always learn from what other people are doing even just by sitting here and you know what sort of atmosphere exists in the classroom.

int Mmm, that's good. Is there anything else you would like to add, anything you can think of.

res The problems and conflicts I can see arising is if you get a poor student, then that's when you get some problems. You know, you've got this, this is the way I want you to do it. The student doesn't necessarily see it like that, but you can see that the pupils are being turned off and the pupils are losing interest in a subject that, which up until then they have enjoyed.

The student can't see that that's when you get conflicts that's when you get the situation that this persons telling me exactly what to do and I'm sure I'm doing it the right way. And the evidence that I come back to is the pupils. And if they're not interested they start saying I'm glad so and so is away, then that really gives you a bad note in terms of what they're actually learning and how much interest they've got in the subject. Because if you're normally strict and they're used to that and you think ahh, should I be that rigid and should I be that...but the pupils at the end of the day like that, they like structure I would say and we each receive comments as they'd like to have you about because someone is absent that day. That causes problems and that causes concern, especially if the student who cannot necessarily be noticed or the ability to do anything about it. Yes you can encourage and you can support as much as you can but ultimately the hardest part is trying to tell them that teaching may not be for you and I'm a great believer that if you're not enthusing the kids then you should not be in teaching basically.

tape ends

Jane - Biology

int	interviewer
res	respondent
-----	undecipherable
...	pause

int I've got five questions which are really more like guidelines if you like.

res Yes.

int First of all I'd like to ask you, if you don't mind, how long have you been teaching?

res Since '74, so 23 years.

int Right and how many schools?

res 1,2,3 schools, and 2 weeks as a supervisory teacher, in Derbyshire.

int Did you enter teaching because you really wanted to?

res Yes.

int So it was your first choice?

res Yes.

int Do you consider yourself an expert teacher?

res (laughter) ooh, that's a hard one .... Experienced teacher yes, good in terms of motivation, yes, I'm a good teacher of children, whether I would define myself a good teacher of science, is different. My history is quite interesting in that I went as a primary teacher, went training as a primary teacher, stayed on and did the BEd year and when I came out when I got my degree, there were no primary jobs. 76 of us who had done the course couldn't get jobs. Which was really really sort of knocked me back, and I came back home to Stockport, ended up working in Marks & Spencers for the summer, and thought well, I've done four years and it's got me nowhere, and then I got two jobs in two days. One in a prep school, and one in a comprehensive. And I thought that the comprehensive would be more fun basically, at 23. I went for that and ended up there, really sort of as a halvling rather than by design. My first experience of a science lab was the first I'd had since leaving school having done A'level Biology, English and Geography, so I'm a bit sort of hybrid of its the way things have gone.

int Which Comprehensive?

res Cheadle Hulme.

int I live in Audenshaw

res Oh right, small world.

int Is there anything about your practice that you feel is a major strength? Or is it quite balanced?

res I think that the fact that I'm there for the children first, and the subject is second. Helps me to put across difficult concepts. I think the fact that I mean I've taught maths, I've taught a little bit of geography at one time. I've taught mainly science, then I came to PSE, so I'm quite an unusual science teacher because there aren't many scientists who have got time for PSE, because they find it difficult, you know, they want theirs content base so I think perhaps I put things across differently and I think certainly they're - because I'm not an academic, by any means. I mean I'm not saying I'm stupid, but I'm not an academic, and I think for that reason, I think I am a better teacher in some ways than others. The only time I've done A'level, I struggled with that. That was the only area of my teaching that I felt that I was sort of two pages ahead of them, and that wasn't enough.

int Aah, that's interesting. So when you're teaching, or if you teach out of your subject area would you say your struggle there?

res Yes, I mean my BEd was in Biology, so certainly the chemistry and physics. I struggle with when I first started teaching, in some ways, certainly up to I mean I do obviously all three sciences up to year 9, years 10 and 11 I do modular courses here, because my chemistry and physics isn't isn't that good. I mean, I think, I can deliver it, but it's the background and the extra stuff you put in, and dealing with the questions that even after 23 years, which is not really my area, I find it harder. Key stage 3 is fine, I can cope with that no problem at all. I mean, I did teach biology at O'level and C.S.E and some biology A'level, I wasn't really .....really comfortable.

int Are there any constraints, which you can think of political or any constraints whatsoever? To developing a degree of expertise, or to becoming a good teacher?

res I think personal constraints, certainly early days, as a single teacher, I had much more time to put into studying and following things up. Certainly as I've gone up, I mean I'm now an E post. They call me assistant deputy, so that's an E post. I do lots of things. As well as a science teacher I do records of achievements, I co-ordinate PSE in school, I do the personnel

stuff --- I line manage. I teach new students, Mal's obviously involved. I line manage him staff development. And there is so much now, that's in a way, by the time you've done all that there's no time for sort of further study. I did at one time consider going back and doing possibly an A' level in physics or chemistry, to broaden that side and in fact it may always have me doubting in science - - - and warming to the pupil management side, I think.

int Is that something you like?

res Oh yes, yes my strength is people. I think maybe if things.... I went to one school as a head of science, an 11-14 school, where I was head of science erm... post, and I enjoyed that. But even there I got involved in the PSE and I became the head of year as well. It was a small school and ended up doing multi-roles. I think that teachers in general, to go back and so further qualifications is becoming increasingly difficult. I've noticed a big change certainly with newly qualified teachers in the kind of commitment they can give to extra curricular activities, for example, just because they've got so much on, in terms of preparation, marking, record keeping, as a young teacher back in the '70's when schools were expanding there were loads of us doing it. And we'd get up on Wednesday nights, Saturday mornings no trouble at all. But then, you know, you'd use your --- marking you did your preparation. You prepared your lessons the first year you were there, and I used the same lesson notes for 4 or 5 years, I don't teach two lessons the same two years running in any area now, and that's the big change.

int This strength in people is that what helps your relationship with pupils?

res I think so, yes.

int Do you reflect at all on a lesson? On your role?

res Yes. I mean certainly. I think having more ITT students in has made me reflect more on the lessons and I think that's been a real benefit for us having students in school.

int Right.

res That the fact that you're observing them and looking at how they do the crits on the lessons, makes you stand back, and even in PSE lessons, when we have assistance, we have the careers service and the police and we are taking officers and people in I think we are able to just stand back and watch how they deliver a lesson, it gives you a chance to look at it a different way. I think it's very easy when you get into... you know, you hit it running and you go to a full timetable you don't have time, if you think well that didn't go very well. What will I do next time? But you don't often think that went well, why did it go well? And I think we tend ...I think it's government influence we were having a discussion about the new government as

well, is making us very critical of ourselves, and we don't do an awful lot of praising and I think that's one of the roles that we've got as management and looking at all staff and actually say that's really good, that went well, we are all very.....I think that as a country we have got to the stage now that we are so ready to criticise, but we are not ready to say "that's great, you've done well there". And it lifts people, you look at morale as a whole and that is where the problem that you've got in terms of me getting there, I mean, I talk to people an awful lot. Sometimes that means that paperwork doesn't get sorted but I don't get the opportunity to go around and see as many teachers and classrooms as I like to and that's something we need to be doing more of. The head is very good with people and certainly when he first came he was out and about in classrooms which was brilliant and even he has got tied down more to his office with pupils and parents and other visitors but it's how much that you can get around in the day that's important. What we do as management is have a lunch time duty rota which means you do get out, for example today is my lunchtime, Monday and Wednesday, so you're out with the kids then and you're seeing and you're chatting to them in quite a different light, and that's important, it's important to get around. But it's how much you're available to staff and how much you say "no, no, I've got to get on to something".

int With your experience with ITT students is it possible, you think, that an NQT could be an expert almost immediately.

res No I mean, I think an awful lot of it. I think there are some very good students coming through and I'm very impressed with the quality we've had I mean certainly, one of the most exciting things for me this year were the two we had on first practice and the progress they made, I mean they came in and they .... yeah, they were a great pair, but they were kids! And they grew up so quickly and that was amazing to see the change that took place in them. Now, now what worries me we've got three NQT's coming in September which is quite a lot, we've got OFSTED in November, which is extra pressure, what worries me is there is still a certain naivety with them and I'm not sure quite how they are going to cope I mean, they've got to commit... I mean, I hope they've got idealism, because if they don't come in at 20, 23-24 idealistic, then we are a self-profession, but I am concerned about how they are going to make the transfer from doing part timetable they've done on two practices, during full timetable plus tutor group and I know the Derbyshire's induction booklet suggests that they don't have a tutor group but we are struggling, as you know, all schools are, by the time you've got your management, your heads of years and your assistant head of years you need to use them as tutors, and I think work load is tremendous. I think in terms of delivery of interview purposes this time has involved more than teaching first hand. We've done it with more senior posts, but it's the first time we've done that with NQT's so the appointments were made on the quality of teaching as far as the references and the quality of the interview that was very interesting. I was involved in the interview process and some people came across as being very strong on the interview didn't deliver in the classroom. I know it's a one off and we could be proved wrong, it will be interesting to hear what I say in a year's time, but I do feel that yes, many of them have

learnt an awful lot, but I mean, there are still situations that could phase me in a classroom after 23 years. And I don't know whether you ever become expert. You become more expert and more experienced, and your range of measures of dealing with things has improved and I think that the fact that many institutions have got two teaching practices now, they're learning the crafts a lot faster and they are coming through with the experience of two schools and many of them have done extra. No, I don't expect them to be expert. I'm very happy if they are (laughter) but I don't expect that in September.

int OK. Do you think that you are quick to recognise problems in the classroom, maybe behavioural problems or something wrong with your delivery ?

res Yes yes, I mean a lot of lessons now I would say that can tell from the way the class come in, once I know them apart I know from the way they come in how the lessons going to go and it's the one thing that still amazes me, is how the weather changes children and the way they behave. I remember someone who had been a farmer at my first school and he said they are like pigs the wind winds them up [laughter] and they are noisy and wound up. They had been dreadful. I mean our kids are good, this is an easy school compared with... we have our moments, but by and large it's an easy school and discipline wise. The last few weeks they've been so fed up and depressed with the rain and a bit of sunshine, there's a difference again, even though it's near the end of term. And you can tell from the way they come in. Times like after break, depending what they've had and looking at lesson patterns as well I can learn that pretty quickly, when you know somethings gone off when one child comes in and you know how it's going to be.

int Is this kind of knowledge you've got somewhere in there [mind] or do you have particular techniques.

res I think it's experience that you recognise, you get that gut reaction, you know how they come in. You know sometimes...I mean I know particular times during the week and particular times during the term that I will use a sort of quietening settling down activity. I've got a very difficult year too and I know with them I need five or ten minutes at the beginning as a sort of a quiet settling down time and then they are fine. I mean, yesterday they came in and for five to ten minutes there was a quiet settling down and we talked about what we are going to do, just quietly and then we went outside to the quadrants, if I tried to take them out at the beginning of the lesson to the quadrants I'd have been - - - -myself, and they were fine. It's that I think that one of the other things that comes with the experience of teaching is not being afraid to say in your own head I was going to do that but there's no way that it's going to work today and changing straight away.

int That's interesting.

res Yes...yes I think so.

int It's quite funny really because if you think of students, it is there time to try new things and throw their mistakes away.

res No, because that is partly... isn't it that it's so planned and it's right that it is planned and structured but then you can't move away from that plan you sort of knock out the spontaneity thats there.

int mmm thats good. I've got one more somewhere. Oh yes, if this expertise does exist, does it continue to develop or does it reach a peak where you become the expert and that is it?

res I think it goes on infinitely. As I say there are new situations that come up each day and you learn how to cope with them and do things. I have a girl at the moment in year ten who's got epilepsy and it's a relatively new new thing and I am staggered by the way the kids are responding to it, she's had four do's in twenty four hours, two in year ten science lessons and one in my PSE lesson and that was amazing how well the kids were coping with it. How supportive they are towards Sam and that is...I've had kids faint on me before, I've never had anybody in this situation and I think I've sort of learnt then that you can use the kids as a resource because it happens then in any lesson, they are more expert than I am on this. And they've said shall we put her in the recovery position ? One of them said that maybe she ought to go on her back, a friend said, this is right, she does go into the recovery position and I was panicking inside...I mean it's not fun is it. And I thought I'm going to be guided by the kids here, I mean if that was with a newly qualified teacher there's going to be quite a situation. She is actually out of the school for two days because we've got an industry day tomorrow and we didn't think it was fair to ask her to deal with employers, although stuff will be there for her support. Those sort of things, I think, I mean, I'm not good with sick people anyway, but those sort of things it does come, we expect it to be experience. And you learn as you go through with that - - - situations are - - - I would think. One of the things I'm feeling at the moment with some of our lower ability children, we are dragging them through so much content and in fact what they are wanting is time. And when we went out on this quadrant thing yesterday I sat down under the tree and explained, we'd done a bit of it in the lab, but I went through what we were going to do and I said to them, it's like infant school isn't it, when the teacher took you outside and read to you, and they said, are you going to read to us ? [laughter] I said no. But we just chatted and we chatted about Rebbeca and her problems because they'd been witnessed although it was in the class next door someone saw what was going on. And I thought, yes, this is really what I came into teaching for. And this, I mean...the white paper has really angered me and I hope New Labour is going to bring lots of new things...I'm getting political now and I shouldn't be. I do still worry, that we are dragging these kids through and they are going to be measured on their exam results and not measured as people. I mean a lot of what I do is helping them to be more rounded people. That doesn't satisfy statistics does it.

int That's right.

res I mean, how do you measure it ? I mean we could look at crime rates and divorce rates in five to ten years, but no ones going to say that is because of the teacher and what they did.

int That's right, I think it's a shame that there are teachers like you...that the enthusiasm is there and there's a lot - - - and there are a lot of teachers like you who are considering leaving the profession and it's worrying.

res It is worrying because, I mean staff morale is very low across the whole board and really that many teachers have got friends across the country who are teaching and they are all saying the same thing. There are things that...maybe those of us who came out in the sixties and seventies really held dear to us as being reasons to come into teaching - - - resignations and early retirement to the people who have been forced to and thats because they're not coming upto the mark.

int What is your role in terms of newly qualified teachers, are you part of a support mechanism ?

res Yes. I will be the main mentor now because we've moved from Derbyshire County Council to Derby City Council, there's a new booklet coming out...do I have it with me?...No it's in the car. They do have a booklet with guidance for mentors and entitlement for newly qualified teachers so I've met each of them for half an hour already, just for an informal chat, a sort of get to know chat. I'll meet them in September on the first day, we'll have a session where we'll go through basic things, then the idea is that I shall meet them individually each for half an hour for the first few weeks, which is quite a time commitment, but then hopefully we can adopt that back to a fortnightly meeting and then some of them will be group meetings but there's the induction process there and then the more formal one where they have time to go out visiting other schools, to visit college departments and look at that but really it's because they have got someone there other than the head of department. There will be things that crop up that will not necessarily be departmental based and I think with OFSTED on top of it, it's going to be quite hard for them.

int Yes, I see...Given all the things you are involved in I don't know how you find the time.

res I sort of feel like I'm running to stand still at the moment.

int Was it a difficult decision then, to do the mentoring ?

res Erm, no because it's...I've had to make the decision whether I go for a deputy headship

and go for a move or whether I stayed here and changed roles slightly. So I came here on a 'D' post on a PSE course in 1989 and then I got a temporary post doing day to day covering plus other things and we lost one deputy but it was a way of managing how to go ahead without redundancies. He took early retirement and this personnel post came up and I thought, yes, that's the kind of thing I'd like to do. And I think, well I'm pretty sure that I'm going to stay here now because there's loads of things to do. And I think, well I'm pretty sure, there's loads of new challenges. I've got my teaching, I like the kids here, I like the staff and there's lots of areas that can be developed.

int That's good. You're lucky considering what we've just been talking about.

res Yes, that's right.

int Is there anything more you would like to add ?

res I didn't know quite...when you said it was about expertise I noted down a few...I don't know if it is any use to you ? [produces a sheet of notes]

int Oh definitely.

res It's not in any sort of order of priority, but it was just some things I thought through, so whether you can use that ?

int Actually, this is something that will be done in the second phase. We are hoping that teachers like yourself will get the time to sit down and just fill out a reflective sheet on how a lesson which you particularly enjoyed or did not enjoy.

res So you're talking to people who have been teaching sometime are you ?

int Well actually it has varied, we are mainly looking at mentors at the moment because we feel we can justify some kind of expertise because they are mentors, so they have some experience. We have just spoken to two who don't have that much experience, four to five years, but then experience is relative I suppose.

res Yes, I think so.

int And we would like to get them to come to Sheffield Hallam and sit down for a round table discussion.

res Oh right, sounds interesting. Excuse me just a sec. [telephone rings] It's finding the definition of a good teacher isn't it ? And increasingly the government see the good teacher as

someone who can get the highest exam results.

int Yes.

res I remember talking about whether how many deaths a hospital has means whether it is a successful hospital. Where are we going ?...It's terrible, I mean, I do think one of the things I've done, the advisory teacher job I did was in health education and I worked with primary and secondaries throughout Derbyshire. Put a lot of mileage on the clock, but that taught me a hell of a lot and it gave me a much broader perspective and I'd add that to your list of expertise, you should have a broader perspective of what goes on in schools, I think then you have a better understanding of what the kids are going through as well as what other colleges are going through and it sort of worries me when people sort of walk back into the corner where they are fighting for their own department and not fighting for the good of the school.

int So are you saying it's not just about teaching ?

res No, thats right. It's the understanding of the sort of education and philosophy and I think increasingly there is competition with the vetoes and everything else, where people are going back into there own little corners and holes and whatever and they're not mixing. I mean thats one of my roles. We have a staff committee which is a welfare or a social - - - and the other side. We are trying to bring staff together and getting them integrated and there aren't as many of the sort of development groups that were cross curricular in the 80's and we'd have lots of discussions. Those have gone. Because you are so busy doing your own thing. I mean we've got equal ops here, we've got resource management and we've got one or two other groups, staff developments for example, that bring together reps from various departments but more and more on training days and other meeting times the regular Monday cycle is back to your department or back to your - - - and the last couple of training days we had, most people sat working on their own because they needed that time.

int Well thanks very much Jane, er, for your time and honesty. Lets hope that we can repay the participants by giving teachers a voice through this research. I think we should be able to formulate a good enough schedule from this, I'll contact you next week. Thanks.

tape ends

Appendix 3

List of emergent issues from interviews conducted with the first four teachers.

Teacher-pupil relationships important

Uncomfortable teaching out of specialist subject

Rely on pedagogical skills

Time constraints - many

Commitment to pupils education

Commitment to school development

Value CPD

Teaching profession de-valued by government

Not enough time to reflect on practice

Range of strategies and approaches improve with experience

Recognise problems in the classroom quickly

Recognise pupils' varying moods

Have good classroom management strategies

More difficult for student-teachers in present (more work load, less time)

Values discussion with pupils

Has patterns/routines of work

Would like more opportunity to discuss practice with colleagues

Subject knowledge adequate - not expert

Teaching knowledge primary - over subject knowledge

Appendix 4

Sample of an observation schedule, notes and classroom layout from one observed lesson.

Two Trees High Y8 - Energy Resources

8 July - 10:30 am

teacher talk
Chatting informally with pupils on entrance. Settles pupils - then explains exam results, praising pupils.
Recaps energy topic from previous lesson and highlights objectives for this lesson.
Instructions clear and defined. Indicates timing of each activity to pupils.
Uses whole class and individual questioning. Is not monotone. Good use of analogies - splitting the atom.
Consistently asking "are you sure of what you are doing?" follows-up with informal questioning.
Is consistently reinforcing information. Clearly defined transition points.
Summarises lesson - with brief talk, questioning and quiz.
Reminding pupils of homework assignments and science club as they leave. Thanks pupils for their efforts.

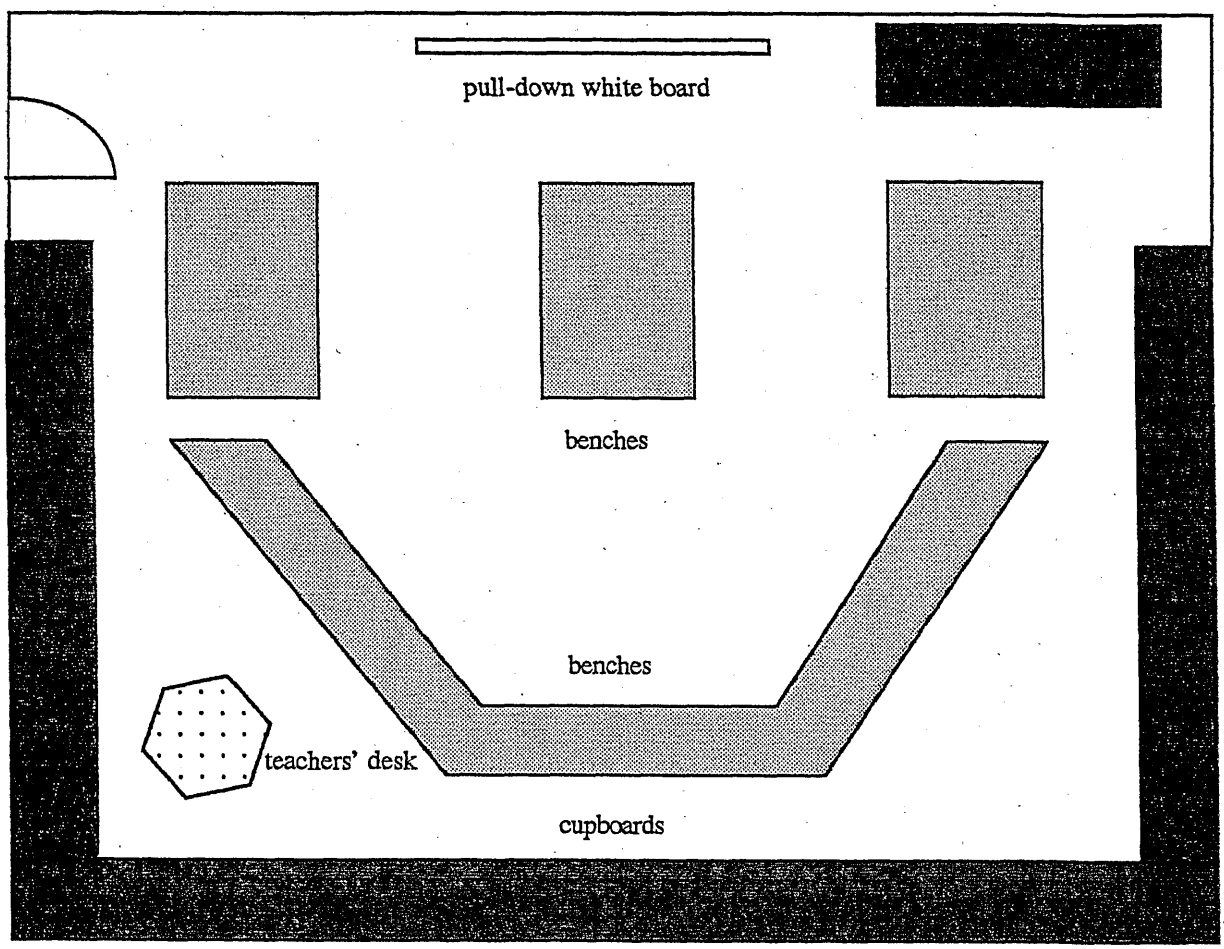
teacher activity
Uses transparency to show objectives - clearly written. Uses food, gas canister, coal and wood to demonstrate types of fuel - sited in the centre of room. Encourages pupils to touch resources.
Distributes worksheets while providing further instruction. Provides clear timings for pupil activities. Informal approach. Moves around room and works with every individual.
Provides extra support for some pupils. Monitors pupil activity while moving between groups.
Is not afraid to sit with pupils and talk through long explanations.
Is fast to control off-task behaviour - moves to pupils' bench lets pupil know he is aware.
Works with pupils - encouraging them, providing support.

pupil talk
Chatting as they enter - hello to teacher. Asking about exam results.
asking what they are covering today. Answering questions on previous material - volunteering answers.
Asking questions on previous material. Asking questions during demonstration of coal, wood, etc.
Laughing carbon deposits on teachers' nose. Discussing worksheets in groups - some off-task chat.
Asking questions focused on worksheets. Some pupils from other groups volunteer answers before teacher.
Discussing work as groups with teacher - also informal joking with teacher. One pupil shouts to teacher - "I'm stuck" followed by another. Not afraid to ask questions and admit they are lost.
Answering questions on quiz. Asking for homework submit date.

pupil activity
Noisy on entrance. Remove coats and bags - place under benches. Settle down quite quickly - wanting to know their exam results. No apparent dominant group or individual - boy/girl spread quite even.
Are attentive and motivated - touching resources and asking questions. Not afraid to ask or answer questions.
Pupils appear relaxed and enjoying worksheets - joking with teacher.
Have direction and know what is expected of them in the time provided.
Appear comfortable working in groups - discussing worksheets - some off-task behaviour.
Replace text books in cupboard. Are excited during quiz - shouting out answers.

general comments
Interesting lesson. Well motivated group - my presence not a major factor. Teacher and pupils appear to have good relations. Lesson structured - objectives clear, pupils knew what was expected of them, clear transition points. Informal approach - incorporates fun. Pupil-centred with maximum support and consolidation. teacher moves around room well - every pupil received attention. Pace good. Good good analogies - 'Greek philosophy.' Teacher working with pupils as a team - classroom management and pupil enjoyment enhanced.

Example of a classroom layout at Two Trees



Appendix 5

Five constant items contained on the initial interview schedule.

1 Are you an expert science teacher if so why, if not why not?

2 How do you reflect on your teaching?

3 Do you think that teacher-pupil relationships are important, if so why, if not why not?

4 Do good relationships aid your classroom management skills, if so how, if not why not?

5 Are you teaching to your full potential, if so how do you know, if not why not?

Appendix 6

Three constant items contained on the second interview schedule.

1 What is your criteria for success?

2 What is your model of science?

3 Why are you involved as a student-teacher mentor?

Appendix 7 Sample interview transcripts.

Simon: Physics

Int = interviewer
Res = respondent
... = long pause

? teaching
learning
Science
reflection

Int Er, the first question, I've got to ask you. Are you an expert science teacher?

Res [laughter] Er, no I don't think I am. Its been quite amusing really you coming in to talk about this concept of the expert science teacher and er, I have had a certain amount of piss taking, a bit of ribbing about it. I think you'd have to be very arrogant to describe yourself as an expert in someways I think other people give you that tab. Er, I wouldn't consider myself to be an expert I know a fair bit about the theoretical background to science teaching and I've made that my business to find that out. I think that I've got a more detailed knowledge of some of the theoretical aspects of science education than my colleagues in the department. I think I'm more aware about the research, I think my extensive reading, I've read a lot therefore I feel in someways that when I'm making a decision I'm basing it on more of an intellectual research plane than on a sort of just experience plane. [Int this is educational research not scientific?] yeah. Now in terms of actually being an expert scientist I don't think I am. I am no longer a scientist I don't even consider myself to be a scientist erm, because I don't do science. I don't do research, what I'm doing is passing on the notions of the science community, the standing of the science community their

reluctance to admit expertise

Modesty
Recognised by peers

T&R
CPD – motivated to continually develop
detailed knowledge
Professional
Reflecting on teaching/practice

S
not a Scientist – not engaged in research/lab –

T+L
Communicating Science
facilitating Science

sort of norm etc. But I don't consider myself to really be a sort scientist anymore, I consider myself to be an educator. If I'm a scie specialist I'm an educator not a scientist. Now my special sort of spe knowledge base is science but I'm not a scientist I'm an educator. kno Erm, to come back to the expert thing, its a very strange label, I Erm think as a classroom practitioner I'm OK I think there are certain thin things that I do that I need to improve on. And I need to be very thin very aware of those improvements now, I think that when you ver look at an expert in a field there should be less room for lool improvement than I need to make. Now I'm quite happy to let im you come in and other teachers to watch me teach but I'm very you aware that I have short comings. And one of the reasons I enjoy awa people coming to watch me teach is because they are going to people coming to watch me teach is because they are going to pick up my mistakes my faults, do make sure everyone's pens are down you know all those little nitty gritty things if, are there better ways to do them and that way I can learn. I think one of the things about becoming an expert teacher is that you've got to kind of learn and you got to keep on improving and eventually I think you will reach a stage where you get a level of expert. But I have never met an expert science teacher, I've met some damn good teachers but I wouldn't say I'd met an expert.

Int I think the way your talking shows a belief in the reflective process, how do you reflect on a lesson?

Res I think, I mean I laugh about this, student teachers come through here and you can see the agenda set by the colleges these days, reflective practitioner right. When I did my PGCE you had to evaluate your lessons nobody told you why [laughter] it was just "your doing an evaluation afterwards" OK. Now I don't think when I, during my PGCE I was a reflective practitioner, I don't

S
not Scientist-reinforced
is a teacher T

Knowledge-Science for teaching
does not like 'expert' label

R
knowledge of own practice
reflects on practice
Reflection important reinforced

aware of weaknesses
is confident in practice
values comments from others
CPD - need to improve
CPD - need to improve

T to R
Continuous improvement
through reflection?

think I was. I think my greatest strength on my PGCE course was my organisation and what I did was I thought my way through the lessons before I did the lessons. So I visualised the whole lesson, how would I do this, how would I do that OK. But what I think I did was made mental notes to myself you know, as things went on make sure I'm looking for that, make sure I'm looking for that and yeah and then I got the feedback from the staff who watched me and they did a lot of reflection for me. Does that make sense [Int yes] didn't actually have to be that active in it because I new somebody was going to tell me what I'd been doing wrong. So thats why [undecipherable] and then I'm came into teaching and I thought right I think it is important and I made a decision myself, perhaps I can dig out my first year teaching notes for you, and I actually evaluated every single lesson I taught in my first year teaching and I made a little grid which I pass on to the students now. Classroom management, on a scale of 1 - 10 just put a little tick. If it was 10, it was perfectly managed if it was 1 it was a disaster if you if it was below a 5 I sat and made a note to myself right what did I do wrong in that lesson, where did it go wrong. Content, wasit to much, to little, over the top and only if I thought there was a big problem here that then I really sat down but that was in a formal way, in a less formal way I am continuously assessing in the lesson what I'm doing. I'm continually assessing what the kids are doing, am I getting over what I intended to do, am I doing that. I walk out of the lesson and I will make mental notes to make it better and next time it will be better. So yeah I do think I'm reflective. Also I try and be reflective erm, in an experiential manner, in terms of if I just use my personal experience, I do enjoy reading about education and about I don't know..peoples images of science all these things. And I do try to think well what do I do? Do I

T & R
Organised
planning
Reflecting ? Imagining lesson
deep
understanding of lesson — understa
Reflecting in-action
Joint reflection — learning from others

R
values reflection

reflection on-action

Values passing Skills on - professional T

on-action R

deeper analysis of practice

T & L
formative assessment
Concern for learning - pupil

R
Confirmation

T & L & S
reflection — inspiring
love of the job
interested in Science/ image of Science
enthusiastic — Science/ teaching

do that, do I portray that image, do I behave like that? And I [illegible] my own teaching styles to what I see in the research went. And I think I'm striving to achieve so in that I am reflective, I'm never happy with what falls. Like today, I should've shuffled them around a little but I let them form their own groups so some pupils were not performing to their best. Therefore I have to be more disciplined with them saying "keep focused, keep focused" and yeah, I new that was going to happen so thats one of the things I will take from todays project, make sure they stick to their groups. I did a talk at the front, I did consider doing a bench talk or leave them where they are. But having seen them coming in and the sort of mood they're in and one thing and another I thought OK its going to take to long and they wont get through the second part of the lesson so what I'll do is [indicates and so on].

Int Is that something that you recognise immediately, look at the pupils and.

Res Yeah, yeah I did think, I did think is this going to work and then I make the decision bang I'm not doing it. I'll put that to one side, I'll do this. And slight adjustments, I don't think I, ever, in any lesson, have a linear plan. I don't think I ever see it as a linear function that I start here and I'm going there. I do see the end points, these are my objectives this is what we're going to learn and at the end say "this is what we should've learned folks". Between that I've got to be very, very flexible and part of flexibility is recognising what goes on in the room, recognising what they're are doing, recognising my mistakes, the problems the kids are having and reacting to them in a positive manner don't say "oh god I hate you, go on sit down

Strives to improve T
trying new things/new ideas

T + L
flexible in classroom
cooperative learning – assessing
pupils progress – Concern
encouragement – classroom
Management
on-action R

T + L
Recognises pupil moods
changes tack during lesson

T
Changing tack
fine tuning
flexible approach

T + L
Confirmation – awareness
of classroom environment

developing relationships with
pupils – positive

copy that" because if you get to that stage its normally your fault [laughter].

Int Right, so your, your constantly thinking on your feet aren't you?

Res Yeah, yeah you're processing all the time, all the time every interaction is er, a real processing thing like, and this is one of the things we , I talk to some teachers about is that erm, I read years ago a book called the 'Inner Game' and the inner game was this concept that you can make something into a skill er, it becomes an automatic skill now Mick's [Mick Nott] written a paper I think [undecipherable] this concept of skills. For instance, if you look at one of the great saves of all time 1970, Gordon Banks yeah, dived to one side. If you thought about it, no way can you do this. Its got to be completely instinctive, he er, jumps because he's out of position, flips it over the bar hey [laughter]. So I think with a teacher one of the things you've got to do is get a lot of what you're doing down, to almost like a skilled level, a craft activity yeah. So you can run that on autopilot. So you are working on various levels as a teacher. Positioning yourself in the room comes almost automatic thats a skill that you don't even consider. But you do it instinctively almost while a student teacher you'll notice again and again they'll not look up they get around a bench with one student and do a quick scan. I know I'm not perfect but it, its there. Erm, asking the kids the questions you've got to keep thinking do I just tell them the answer? Do I teach them? How much are they struggling here? So I think you work on many levels. A more experienced teacher can have more and more things running on automatic, sensing, feeding into yourself and providing

L
providing 'safe' environment

T + L + R
problem solving?
routines/auto
reflection

T
routines/automation

T
intuition/instinctive

T
performing a different/more levels
novice expert distinction

T + L
an acceptance of 'expert' label
concern for pupils' progress (assessment - formative)
routines

everything is hunky dory you don't bother registering it, but as soon as that information comes in and its not going well you do register it.

Int Now you mentioned experience there, is that how you get to be an expert teacher, purely through experience?

Res There are teachers at this school who have been teaching for thirty years OK. And they have never got passed the basics of teaching. They never, ever have taken a risk in their teaching. They've never turned round and they've never made a complete balls of it. And I've tries certain things, this is great the best lesson, you come out of it and you think what the hell went wrong. One little spanner in the works but you remove that spanner you've got a great activity you lock it in, there's another one, there's another activity I've got lined up, another string to my bow. And I think that is where it took experience. Experience is about trying ideas out, about pushing new boundaries pushing your limits as a teacher, getting through zones that you're not particularly comfortable with stuff that your not happy with. I don't want to do dictation, I hate dictation but occasionally I do it with the upper school because "look you're going to go on to college, this is how they are going to teach you. So you have got to have a bit of a practice here". I hate dictation I get bored, you know and I attempt to moderate my voice up and down to keep the interest. But occasionally I try it. So coming back to this idea of experience I think experience is not about chronology not about number of years, I think its about experiences how you deal with those experiences how you push those experiences further. Erm, you've got to try, like in my activities for instance I can go around this department and say "Have you

T
Problem Solving

T
Risk taking / Creativity
trying new ideas
accepting failures

T
building teaching repertoire

"pushing boundaries"
Confidence to change / try new things
will use range of techniques

T
not about years – actively Seeking opportunities
CPD

ever used a darts activity" and in my department of ten people three people would know what I'm on about, two people would have used it. Now its not because they don't use it because.. Its because they've never used it because they don't bother to use it and they've never bothered finding out about it. "The way you do this is to write on the blackboard, why do use the blackboard? Because I've always done it that way. It always works. But if you did it another way would it work better?" And I think, one of the reasons I find this..also about pushing the boundaries of the way I teach and one thing and another. The more and more I read the more and more I've seen pupils. You dealing with thirty individuals in the classroom and education i don't think is specific enough yet to be able to say "this is the answer, this is how you teach". So I come out to my students and I tell myself use a scatter gun approach. There's lots of different techniques, I like the kids to be actively involved. Lots of different pedagogues, lots of different ways of seeing the lesson. Some people are auditory, they are going to listen to what I'm saying, some of them are going to be very visual so my lumps of coal [refers to visual aid] help them with it. Some of them like kinesthetic, touching, so they can look at my dirty hands and its those kind of things you are trying to communicate on many different levels. And that comes again through, going back to the reflective practitioner looking at the experiences looking at what's happening and thinking right, I've learnt this is been good or it went bad. What you're doing is making judgments rather than ignoring it and I think one of the ways of making sure you stay on your toes is by watching what you are teaching. You are perpetually learning, so I think the concept of experience is this, you develop experience through learning and you've got to take every opportunity you can to learn and to improve and to

T
active approaches / varied techniques
⇕
others don't

Continually striving for improvement

T
active approaches / variety
C-Central

T ↔
aware of individuals needs / strengths
utilise many techniques

R
Watching your own teaching

CPD — experience aid development

not accept that you are a finished article.

Int In every session I've observed there seems to me to be a mutual respect between yourself and the kids, do you think that the pupil/teacher relationship is really important?

Res Oh yeah, absolutely. I think respect, respect in the environment is of prime importance, it really is. Now you can intellectualise this and talk about Mazlow's hierarchy of needs thats the classic one isn't it? And, if they keep coming in here and I'm a grumpy old sod who moans at you all the time, you wont enjoy being in here. You're not going to like it. Now to learn you've got to be able to feel comfortable to be able to learn, you've got to feel sort of, well this person wants me to learn, wants me to understand this cares how well I do and I think its so important to have that relationship with kids that they see you supporting the individual. You're not going to judge them, you're not going to say "hey you're rubbish". You've got to make them feel good about themselves. If you keep saying to them "well done" they think they can do it. Its like Sarah and Joanne, they're struggling like hell with this but they're trying, they're not switched off, they haven't given up. Now all I've got to do is keep that up for another three years and hopefully they will achieve their potential and the only way that you achieve your potential is if you feel you can do it, you value yourself you feel other people value you and you value everybody's contribution. And you've got to give them that sense of worth, high self esteem I really do feel thats the basis of good learning. You've got to have high self esteem. Now in addition to that the relationship has also got to built on having a bit of fun. You've got to have fun, learning is about fun if you watch little kids learn they do

improving

respect for pupils

pupils need to enjoy learning

Comfort - Safe environment
Support for pupils
↕
relationships
non-judgemental - positive
building pupils self-esteem

understanding learning

Concern for pupil achievement

Self-esteem - part of basis for good learning
Praise

inject fun into lessons.

stuff because its fun, they do it because that tastes good, that feels good thats interesting to interact with. Now learning should be fun. I'm not saying it should be all zippy do da and all the rest of it, well you saw me stand up for twenty minutes and discuss the atom with them. Now I try and put enthusiasm into that I show my interest and say "I think its great because its bizarre, its wonderful really it stretches your mind". Now hopefully my enthusiasm catches the kids hopefully they see this is fun, you've got to have that enthusiasm because they think yeah it is fun its not so much of a grind, not boring work. I mean one of the things I hate I'll go into other peoples classrooms not in this school but in a grammar school you see all these kids sat in silence with a [inaudible] in front of them and answering questions yeah and I'm betting you that those kids are managing to get the answers out of that text without reading the text. I'll bet at no point any of those answers have crossed through their brain at any point. And I remember the lecturers at university that I really liked were the ones that somehow managed to make a relationship with you. You went to them, they were enthusiastic about their subject and they talked to you one to one as a person, I mean they approachable you didn't feel stupid if you said "hey I don't understand this". But one or two you would be sat there and its delivery, delivery, delivery and you'd go to them and say "look I can't understand this" "your stupid". And you'd go away destroyed and think I don't like this subject. Now what your actually saying is not that I don't like this subject, I don't like the individual whose teaching it to me. So what I've got to do with my kids is get them so that they feel confident, have high self esteem high regard, they're going to generate enthusiasm they feel valued can achieve then I'm doing my job.

L + T
learning should be fun

enthusiastic about teaching
enthusiastic about Science

T
influences/ demonstrating enthusiasm — professional

T + L
interaction — personable
'one-to-one'

positive/support/encouragin

Sees pupils positively
Wants to enthuse and generate enthusiasm
good teaching

Int Would you agree that that also helps with the classroom management?

Res Yeah it does, I think relationships, the key to teaching is about relationships but its about being honest with yourself, being honest as a teacher. Now there are certain techniques that I don't use because I don't feel right with them they don't sit with me OK I'm not being honest. I think the kids know when your not being honest with yourself and with them. So I teach my way its my character and I'm honest with them and I think kids appreciate that honesty and they appreciate that you treat them as an individual you sit and talk to them, you don't bawl them out for no apparent reason, when you do bawl them out they understand why your doing it and they feel Ok I did deserve it. But if you bawl a kid out, occasionally I'm tired or what ever and I'll say "look shut up" but maybe next lesson or at the end of the lesson I'll go and apologise and say "look I'm really sorry about that but ... " there has got to be mutual trust, "I was tired but you were shouting" Its based on trust. But if you get high motivation or high self esteem they will do the work because they can do it, why don't kids do work? Because they don't want to appear stupid, they're going to get more kudos from playing Jack the lad than doing the work. Hopefully in the lessons I can give them as much kudos from doing the work as there is from being Jack the lad. I can also accommodate Jack the lad by having a bit of a joke with him and saying "now hey pack it in, get on" and its all the individual relationships. You spot what kids need and you feed them that need.

T & L
relationships – key element good teaching
does not use certain techniques

honest / mutual respect

Communication –

T & L
Mutual trust – teacher-pupil

T & L
motivating pupils

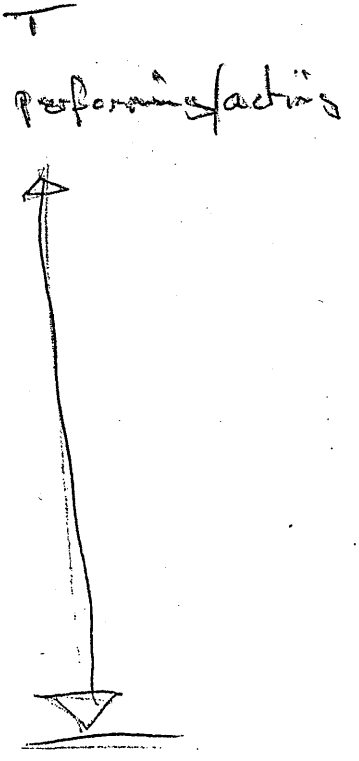
relating to pupils at their level
fun in lesson

understands individuals as well as groups

Int I couldn't agree more actually Simon. I think that is really important. We spoke the other day about teaching being a

performance, if we go with that notion, are you different at home or in other activities?

Res Yeah. Its bizarre. My wife laughs at me, I have very very few friends I'm quite antisocial I love my own company. I really enjoy my own company I enjoy sitting and reading quietly I love that. I love going out climbing, I love climbing by myself I'll just sit there the suns out, I like being quiet and especially by myself. My wife sometimes jokes that we go out to a pub and sometimes basically I can ignore people because I can't be bothered with them I just can't be bothered with these people at all. However, if its important then I can switch it on and I can put my show on and give an act. I remember my first teaching practice walking down the corridor to this class, this class I bloody dreaded I hated this lot. Bloody hated this lot and these bunch of lads and two girls who wanted to do home economics or something yeah, they were all about eight foot tall [grunts] and your a student teacher and your thinking I hate this, they're going to rip me limb from limb and as I walked down the corridor I thought listen, if you go in with that attitude they're going to smell this they're going to see this. Walk in the room with a smile on your face like you're going to damn well enjoy this. And it was amazing, I said to my tutor at the time this is all about acting this is all about putting a performance on. And it doesn't matter how down you are you've got to give you're performance because those kids are only going to get this one opportunity and therefore you must perform and you are basically an actor. We have got the same tools as an actor near enough, maybe a few more bits of paper and overheads and stuff. But basically we've got to use the same skills, we've got to use our bodies our voices and we've got to use eye contact to



get over ideas. They are our basic tools and somehow I've got to get what's in here in my head into the students so that the students may be able to reform ideas that are already there so I've got to be able to make that communication and communication is an act. For instance, salesmen they use certain techniques now I use techniques therefore I figure I'm acting, I'm putting on a performance and that performance is my access to good teaching. Now when I've seen student teachers stand up there they are usually two dimensional. And I'm thinking for Christ sake put some life into it, be yourself. Talk to the whole class as if it was one person. So thats how I feel it works out.

Communication - act - practice

Performance/technique

is 3-dimensional

whole-class approach

+ not linear

Int Thats really interesting, I certainly wouldn't argue with you. Er, are you teaching to your full potential?

Res No, definitely not. There are a lot of things which stop me from reaching my full potential. Do you want me to list them? [Int yes, as many as you can] Right erm, one of the real problems is resourcing in our department. We're very low on books so we've got a lot of paper resources as they stand here, we've made up a lot of our own books and stuff yeah. I've set up a resource centre within the department which has made life a lot easier so we share all our resources. Erm, talking about resources, my time is very precious because of my managerial role therefore I find it very difficult to produce lots and lots of new resources so I'm using stuff which is a bit dead really because I haven't got the time physically to keep replacing them. Erm, ideas I've talked about ideas of pushing my own limits thinking of new ways of teaching. I am nowhere near as innovative and so full of ideas as say four years ago. Because I simply don't have the time to put in for

resources

share - develop

want to be creative

preparation to make something work really well because I've got to be a manager and that management role involves administration. Mounds and mounds of bloody administration. Checking grades, filling in forms, sorting out the timetables absorbing time and time and time. So what I've got to do is that I try and innovate in little ways with the lesson. Other things which stop my performance my limits, are I teach to many lessons. I work from the next to the next to the next, straight through the day. Plus I'm having to deal with problems at lunch time, by the time I get to period four I'm thinking gee whiz, where am I what am I doing and you feel like its almost a production line. I have nowhere near as much time as I would like to talk to people about what I do, what they do, to generate ideas I think thats something that really does constrain me. Computers, the problem with the school is that we only have three IT suites and they are often booked out so some classes never ever land on them. So I think things that affect my performance are; one is materials. Two is time to reflect and talk to others. Three is simply the amount of time I've got to stand in front of class and keep going. Four its all the managerial head of science rubbish and that really does impeach out of the whole lot, I could sort the other three if I didn't have to be a manager and I find that I'm dealing with admin which could be done by admin staff which don't require my input. Analysing SAT results, I need to talk to my staff about that I need to do that. But putting the grades into the bloody computer those types of things just draw my time away and we end up shifting pieces of paper about because those pieces of paper are needed by administrators in the education system. And what we should be doing is saying "how have you taught today, what's been good?" I am not completely focused and thats what you need to be to be a

time Constraints
admin (management role

teaching to many lessons

T

takes on pastoral role

IS Manager + teacher

really good teacher. And I think what we end up doing in education is doing loads of other jobs. Its a balance and I struggle to balance.

Tape ends

T

need to be focused to be good

re: perception of science

Int: What do you see as being distinctive from being scientific as a teacher and being scientific?

Res: You have to be very impartial when you are passing on scientific knowledge. You also have to be answerable to the national curriculum. You are trying to make sure that kids have a foundation for building on and you give them a foundation of science and your trying to improve certain science skills, your trying to improve their investigation skills. Your making them question things. Your also making them think in a logical mind. So it's training them in a routine. So you're there as a science teacher to impart that knowledge and then point them in the right direction and try to raise their interest and make them more aware of the things around them.

T
responsible – objective
Communicator

L & S
foundation for Science – not
Subject intensity
improving skills

T & L
Constructivist
routines – influencing direction
creating interest/enthusiasm

Int: Do you see science as a practical subject?

Res: I think there's a balance, the problem is now there is so much of the national curriculum to get through, it's at the expense of the practical work because you're trying to get through all the science knowledge and you haven't got time to say to the kids we're doing this experiment to show you this or to find out this because you're so tight on time. I'm very conscious of the time constraints. One of the things which the research student (researcher in residence) said after talking to the kids is that the kids would like to discuss

NC – Constraint
time Constraints

things and somethings which are topical and are interested in they would like to spend a couple of lessons on, expand on it and we can't because of the time constraints.

Int: So there's a theme of making science relevant isn't there but it's difficult to make it that?

Res: It is, I mean there are courses which are more relevant, that try to be more relevant like Salters. But it is hard for them (pupils) sometimes, like when you're explaining atomic theory say, the kids think well how am I going to use this in everyday life. whereas if you look at technology where they learn how to make things, they can see the object you know. There are things in science which are easy to show the relevance to real life but there are a lot of things in the curriculum which you can't see the relevance of.

Int: OK. Er...you're a mentor as well aren't you?

Res: Yeah but not this time.

Int: But you have been. What made you take that role on?

Res: I enjoyed doing it. I think it's good for the kids to see someone else, so I quite like the fact that there is a student in the classroom. And they stimulate you they give you ideas, different ways of looking at things. I do like to pass on knowledge to them as well, you know, knowing at the end of it you've helped to make a good teacher. I always ask myself, I haven't any children but I always ask myself whether I would like that student to teach my children and if the answer is no then

T wants to be creative 'real' - 'relevance'.

ToL
relevant topics
↓
promotes interest / enthusiasm

ToL
enjoy mentoring - sharing knowledge
Motivation for pupils - 'R in R'
professional learning - 2-way process

I question there teaching. I know it is time consuming but it is enjoyable.

Int: Ok Debbie that's great. Is there anything more?

Res: No I don't think so.

end

Appendix 8

Sample reflective summaries.

Summary of Expert Teachers Meeting

Similarity of those present

Amazed how much alike we were and how easily we got along.

- We all have progressed up the career ladder relatively quickly
- Most have undertaken further study i.e. M.Sc.
- Positive towards science education we are not moaners
- Hold considered positions i.e. we have thought about our perceptions and can articulate these.
- Very similar attitudes towards pupils we are positive like the pupils
- Accept responsibility i.e. we don't blame others, look for ways of overcoming problems
- Willing to share ideas, exchange views in a positive manner therefore appear very open to the whole notion of change
- Innovators risk takers with a good deal of self-belief and confidence in our own abilities

Personal

I felt it was a positive experience allowing personal issues to be explored and ideas to be exchanged.

Realisation: science knowledge is background, it's a base that can be added to but it is communication that is the underlying key. If we moved out of our own area the base would be narrower therefore we could not be as automated and reactive because we would lack breadth. In such a scenario the base would be pedagogical.

Future development

Peer support i.e. observations and feedback, recording through diaries and interviews, progress and improvements. Job swaps??? spread good practice in schools.

Self-perceptions of an expert teacher

Must be a process rather than an event therefore must have a past. Look at where I have come from in the last ten years. Start from student-teacher. Highlight critical incidents.

Mentoring gives you the role of expert to help another to become a teacher, observation feedback gets you to think first time that you are an expert. Passing on knowledge but can be apprenticeship craft base if not supported by academic.

Theme of reflection - going through what can I change, where are my weaknesses? Automation of routines, noticeable with NQTs. Experiential learning.
Internalised a lot that had previously required conscious thought.

46 Newlyn Road,
Woodseats,
Sheffield,
S8 8SU.

17/02/1999

Dear Stuart,

Here goes my attempted deciphering of what taking part in your project has so far meant to me.

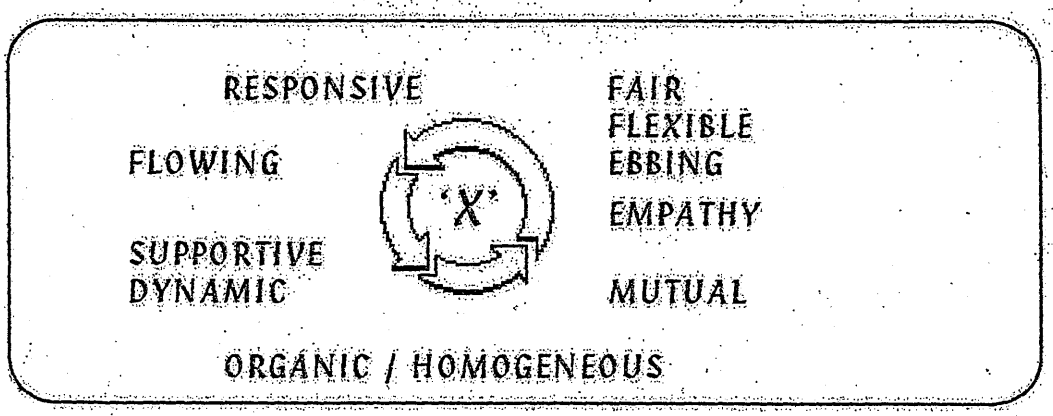
Discussion based on Science Expertise

I was fascinated by the common and united feeling throughout Tuesday. I believe that there is a very difficult to put your finger on 'aura' type thing occurring, a bit like the often snubbed 'charisma/personality' factor of leadership.

I suspect that there is also a factor that because we all seemed laid back types it equips us well to deal with teaching in the nineties! I suspect that if we had been about in the Edwardian era we would have been poorly adapted to what was wanted at that time. The minister for education would have probably prescribed us a diet of amphetamines/barbiturates to get us up to speed.

I think the amount of overlap is both staggering and at the same time very heartening columns a,b and d do encapsulate good practice to me. I no longer feel that I am isolated in a wilderness. Column 'c' is important for the science specificness of it.

Here are some words to try and describe my feeling towards the life that a lesson has. A bit like a Formula 1 race analogy a good lesson is slick and full of a certain passion.



Reading your paper made me feel really good about myself, pleased to be a teacher proud of the job that I do, it made me feel like a *valued professional science teacher*. I liked your style of positive approach and most of all the readability, top marks for communication here.

It seems funny to me and I wonder if you set out to do this in the first place but you have created a fascinating model for continuing professional development through your research methodology. As with teacher student relationships you have created a feeling of

mutual respect. The process of you visiting school was beneficial to my teaching. You identified the positive I liked that, you flagged up observations about pace and repetition that have helped me further tweak the suspension for the Adelaide Grand Prix.....
Receiving a transcript was a fascinating experience because of errr, ummmm several reasons. I found out things about myself I did not fully realise, I now know why some people get driven up the wall by my ramblings in particular the fact that I head off at weird tangents from time to time.

Pedagogic knowledge is also organic and grows, the chance to share this with fascinating people was a privilege the meeting up in a different place and a different time scenario was a very powerful experience for me. I found Denise's thoughts on common good teaching really interesting.

I feel sure that you are heading along the right lines and I fully endorse your approach. Hope to see you soon and hope that this project will grow and grow, hope that I can be of further use too. Thanks for involving me in this process it has been a most pleasurable and beneficial experience to me.

Stuart Take Care and Good Luck.

Andy.

ACB's progress through Berliner's (1985) 5 stage model of expertise.

Novice September 1990 onwards

On being appointed to the same school as completing my second teaching practice, for the next year and a half I felt to be slipping in a variety of directions. Sometimes slipping at high speed but not high velocity because the direction never seemed to be the same. In Formula 1 analogies I was undergoing all variety of possible incidents : technical engine failure, being shunted off the track, crashing due to driver error, poor race strategy and of course off track incidents galore.

technical engine failure :-

Lack of information and not enough time to develop ideas, compared to being on teaching practice. Working within a department which was based on two sites that lacked NQT's made life tricky. To this day I have taught nearly all my lessons in one science lab, 'K16' is my home from home. Working within the tight often unknown school procedures was difficult as I had an inherent desire to get things right. I asked a lot of questions in the first twelve months, too much to take on board all at once.

being shunted off the track :-

Other teachers exert a great pressure upon you, especially when you are a novice. In my school I was the only new member of staff in what seemed to have been a static group of people for too long. Incidentally this offered advantages as well as disadvantages in that people seemed to find my sometimes blind enthusiasm an endearing quality. The Science Department and most of the school had a macho image. Pressure was indirectly and unwittingly put upon me to comply with behaviour management style of others who were far more established than me. There was a great deal of formality expected of teacher pupil relationships, I clung onto a desire to be less formal than most whilst experimenting within peer expectations. Newly qualified teacher meeting however were a great relief and let me meet people in similar situations, this culminated in me meeting a suitable lodger for my first house.

crashing due to driver error :-

This was due to often trying to be too adventurous in lessons, interestingly though these experiences were very formative. Developing the use of tone and intonation was taking place as was the realisation that I needed a more solid base to work within. Lots of questioning, What sort of teacher do I want to become ? Will I ever get there and where exactly is there ? I used to find writing lesson plans rather tedious and difficult I would write up plans in a hurried rush over weekends sat at a desk with a variety of pens and some alcohol. The plans would usually be backdated just as children today write their scientific predictions after the event. Plans were written in no particular order collated after writing. These plans were to show my mentor and the LEA advisor who incidentally quite liked them. I did however spend a vast amount of time preparing actual materials for use within the classroom and lots of time thinking of how to put my ideas into practice. Much soul searching and self evaluation took place.

poor race strategy :-
a) a great weakness of my own at this stage was that I seemed to have a total lack of temporal awareness of lessons and their structure. What I had planned for would seem to have taken an age to prepare yet would be exhausted within the first fifteen minutes of a lesson, often due to an often over enthusiastic pace of delivery on my behalf.
Combine this with often poor preparation for lessons sometimes inappropriate yet hugely enjoyable ways ways of doing things chaos seemed to rule.
Couple the above with a desire to succeed and a drive to expand ones own horizons and you have an erratic route to success through finding out by experiential learning.

off track incidents
The main difficulty here was that I had really enjoyed my two year PGCE and it took about eight months and several weeks of illness due to various viral infections to realise that my lifestyle had to change. The realisation of this hit me at 3am one Thursday morning having been at the Limit club the night before wondering what I was going to do with my Y10 the following morning !

Advanced beginner about October/November 1991

Out of chaos order started to take place. there were a variety of key elements in becoming an advanced beginner. Firstly I had met some very nice and supportive members of staff in the school workroom an annex to the staffroom. I realised that these people were the experts and that being the only new teacher was a great opportunity to watch and work with them. They are people whose skills I admired and then hoped one day to aspire too what then seemed to be dizzy heights. incidentally I still admire them greatly and still aspire but now to more specific skills. Then there was the realisation that one of my Y11 classes behaved better for me than for other people [this was my first podium finish]. This was a revelation because the class was full of characters who others revered too as difficult. I started to give a colleague a lift to work he had taught at Westfield 18 months longer than me. Over the next five years the journeys to and from school provided invaluable opportunity for discussion and comradeship. I began to become a more organised individual. Idealised that I needed to state my aims and be more explicit in what my expectations of students were. I began to lower some defences and establish real working relationships with students based on trust and mutual respect. My head of Department appraised me and the school supported me in enrolling on the MSc in Science Education at SHU....things were moving forwards. Somewhere around here I managed to separate the idea that pedagogic knowledge was different from the subject knowledge, this was a key moment for future progress.

Competent 1993

I felt competent and was made to feel valued by what happened around me. My HOD went off long term sick and as he was also in charge of physics I was given temporary responsibility for physics. Suddenly I had space to do what I wanted to within a small area of school. Concurrently I was getting so many good ideas from participating in the MSc at SHU and also meeting very interesting like minded people that things just got better. With my HODs departure I felt strangely reassured in my own very different style to his. I rapidly expanded my pedagogic knowledge and its application within the classroom. I began to work on what I perceived as my strengths :-
Repetition, keeping cool, explaining things in a variety of ways, good under pressure, repetition, a desire to communicate through an almost narrative style, working with

students as individuals. At this stage I was not challenging weaknesses but building upon strengths. Importantly though I would not forget the weaknesses but had a desire to return to them at a later date.
The department began to work as a team. This was borne out of necessity in the absence of our HOD, who was an insular person none too good at delegation. In fairness I think that he felt he bore overall responsibility for science and found delegation tricky. I then began to realise just how talented some of my closest colleagues are. This is funny because I had thought the same thing during my teaching practice but failed to capitalise on it during my first four years at Westfield !

Proficient 1994

Pedagogic technique was becoming more expansive. We were Inspected and I suspected that I had a better understanding of what teaching was about than our Inspector did. I was made IC physics permanently. The MSc was great but I found that I had to make a choice between either completing the assessed components of the course or directly applying them in a pragmatic way within school. I chose the later. Confidence kept on growing and the teaching got better. Involvement in the PRI and associated recognition boosted my confidence. Then in Summer 1995 our new HOD was suspended. The Department again pulled together as a team I took temporary control of KS4 and an expert colleague [who had been my teaching practice mentor] took control of KS3. At this stage I also met a new partner now my wife. She too is a teacher and her influence and encouragement could never be underestimated. I was made Head of Science in January 1997 I felt that I was in ascendancy. The biggest indicator of reaching proficiency was when my form left school in the Summer of 1996 and myself and the colleague who I gave a lift to school were both in the same year team. We decided to test our 5 years spent building relationships with our forms by taking them out for a meal, 4 adults and 44 students in an Italian restaurant turned out to be the best evening of my career [to date].

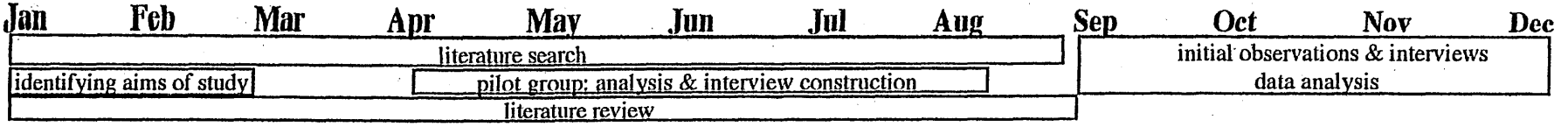
Expert

Expert what does it mean, it sounds really frightening. Expert in terms of teaching is a dangerous concept in some ways because I believe that we are on a journey which never quite ends, This is not a race but the experts are somehow ahead of the field. They are more intuitive, perceptive, communicative self critical, good at assimilating ideas, creative, versatile, have empathy. The list in some ways seems endless so perhaps an expert teacher is a jack of all trades and master of no specific skill but luckily all the said skills support teaching. I did feel expert during our 1998 Inspection I am very proud of the lesson that was identified as excellent. 1 out of 4 not bad as some others were good too. I felt a mutual admiration for this inspector and we gained nice comments I felt proud.
The route from Novice to expert has so many variables that impinge on the way there. It is a Wacky Race, with Dick Dastardly the Ant Hill Mob, Creepy Coupe and all the other characters present. Luck, tenacity and belief in lifelong learning seem to me to be the key to success.
All teachers are individuals but no one teacher should be alone. All schools are individual too but no one school should be an Island. I believe that communication, collaboration and time to plan/reflect are the keys to more positive progressions.

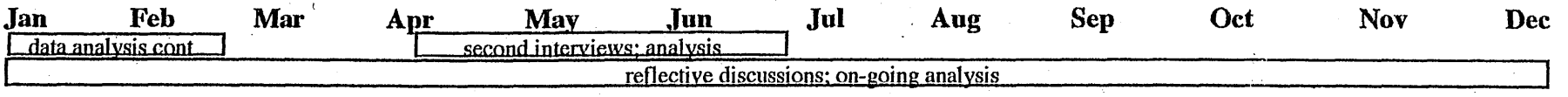
Hope that this is not too much like a biography Stuart, and that you are well
Regards Andy
PS Eddie Irvine is my prediction for 1999 World F1 Champion.

Timetable of events (appendix 9)

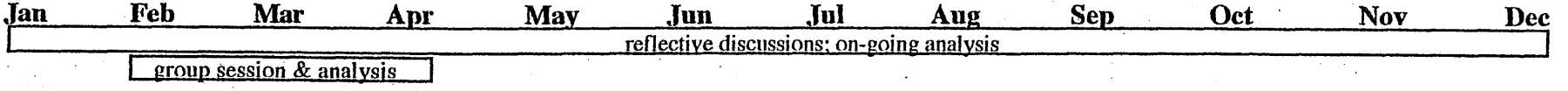
1997



1998



1999



2000