An Evaluation of the School Based Action Research Project: 'Making science more challenging for gifted primary children'

David Coates

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Abstract

This thesis is a two part evaluation of an Action Research Project carried out in a primary school in southern England. The first part of the thesis investigates whether or not the action research project was successful and the second part looks at teachers' perceptions of action research as a method of professional development for teachers. The aim of the Action Research Project was to make science teaching more challenging for gifted children in all classes. Four teachers acted as teacher researchers who engaged in all aspects of the action research. Their colleagues, though not acting as researchers, supported the teacher researchers by being open to new ideas, trialling interventions designed to make their science teaching more challenging, and providing data to the teacher researchers so that they could assess the impact of the action research project. At the end of the Action Research Project science teaching had become more challenging across the school, but there had been a greater impact in the teacher researchers' classrooms. Data gathered from the teacher researchers indicated that they were very positive in their assessment of action research as a means of professional development as it integrated teaching with curriculum development, research and reflective practice.

The thesis develops a model of professional development which has three inter linking and necessary components; external knowledge, creating knowledge and knowing-in-action. The model was formulated from experience gained when acting as a critical friend to the teacher researchers. Essentially, professional development aims at changing teachers' knowing-in-action. For professional development to be really effective and embedded in classroom practice, it needs to involve teachers in double-loop learning (in which teachers can utilise external knowledge to create their own knowledge). In this way both theory-in-use and espoused theory can be changed which in turn could have a long term impact on teachers' knowing-in-action.

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Glossary

ARP School

The school where the action research was undertaken.

Department for Education and Employment (DfEE) Department for Education and Skills (DfES)

This is a government department which deals with education issues in England. The name has changed slightly over the years when education has been linked to other aspects of government. The Department for Education and Skills was established with the purpose of creating opportunity, releasing potential and achieving excellence for all (http://www.dfes.gov.uk/aboutus/strategy).

Differentiation by outcome

Differentiation is the adjustment of the teaching process according to the learning needs of the pupils. The categories of differentiation usually mentioned in DfES publications are differentiation:

- **by task**: setting different tasks for pupils of different ability;
- **by outcome**: setting open-ended tasks, allowing pupil response at different levels,
- **by support**: giving more help (perhaps via an learning support assistant) to certain pupils within the group.

Excellence in Cities

Excellence in Cities (EiC) is a national programme to improve the education of inner city children. It aims to drive up standards in schools, higher and further, to match the standards of excellence found in the best schools. It is based on four core principles:

1. High expectations of every individual student
2. Diversity of provision
3. Networks of schools working collaboratively
4. Extending opportunity to students

One of the key strands of the EiC Programme involved the development of teaching and learning programmes and increased provision for gifted and talented students (DfEE, 1999c).

Key Stage.

In England, it is statutory that children should attend school from 5 – 16 years. These years of schooling are divided into four Key Stages:

- Key Stage 1 children aged 5 -7 years
- Key Stage 2 children aged 7 – 11 years
- Key Stage 3 children aged 11 – 14 years
- Key Stage 4 children aged 14 – 16 years.

There is a National Curriculum document which sets out the content which must be taught during each Key Stage.

Level Descriptions and Attainment Targets

'An attainment target sets out the 'knowledge, skills and understanding that pupils of different abilities and maturities are expected to have by the end of each Key Stage (as defined by the Education Act 1996, section 353a). Attainment targets consist of eight level descriptions of increasing difficulty, plus a description for exceptional performance

above level eight. Each level description describes the type and range of performance that pupils working at that level should characteristically demonstrate. The level descriptions provide a basis for making judgments about pupils' performance at the end of Key Stage 1, 2 and 3.'
[Department for Education and Employment/ Qualifications and Curriculum Authority (DfEE/QCA) (1999) *The National Curriculum. Handbook for primary teachers in England.* London: DfEE/QCA]

Literacy

Literacy refers to the teaching of reading and writing. In England a Literacy Strategy (DfEE, 1998) was introduced to support primary teachers in their teaching of reading and writing. There was a perception that reading and writing were not being taught in an effective manner.

Learning Support Assistant (LSA)

An LSA is a paid helper in the classroom. S/he may have specific children with learning difficulties to support. S/he may have child care or education qualifications.

Masterclasses

Gifted children are taken away from their normal classrooms to work to work together in a different setting. This may be in a university, as in our work. The children would be given enrichment and extension tasks which they are unlikely to meet in their school classroom setting.

National Curriculum

The National Curriculum sets out the legal requirements of the curriculum for pupils in England aged 5 to 16. It sets out the entitlement to learning for all pupils and the content to be taught. (DfEE/QCA, 1999: 3)

New Star Science

New Star Science (Feasey et al, 2001) is structured scheme of work for science based on the QCA units. It provides all the resources in unit packs from Foundation through to Year 6.

Numeracy

Numeracy refers to the teaching of number and measures. In England a Numeracy Strategy (DfEE, 1999b) was introduced to support primary teachers in their teaching of number and measures. There was a perception that number and measures were not being taught in an effective manner.

Office for Standards in Education (OFSTED)
OFSTED is the inspectorate for children and learners in England. It was set up to contribute to the provision of better education and care through effective inspection and regulation. This is achieved through a comprehensive system of inspection and regulation covering childcare, schools, colleges, children's services, teacher training and youth work. OFSTED is a non-ministerial governmental department accountable to parliament and is therefore independent from the DfES.

http://www.ofsted.gov.uk/

Performance and Assessment Report (PANDA)

A document sent out by the Department for education and employment (DfEE) as *The*

autumn package of pupil performance information (DfES, 2001a). It gives comparative information to schools about their pupils assessments in SATs tests. The school is compared with other schools geographically, schools with similar levels of deprivation (measured by the number of free school meals taken) and year on year comparisons in data from the school.

Programmes of Study

The Education Act 1996, section 353b, defines a programme of study as 'the matters, skills and processes' that should be taught to pupils of different abilities and maturities during the key stage.

Partnership School

Schools that work closely with initial teacher training establishments to help in the training of teachers. This is mainly through the provision of classroom placements where students can engage in all aspects of teaching whilst being mentored, supported and in many cases assessed by staff within the school.

Qualifications and Curriculum Authority (QCA)

QCA is a non-departmental public body, sponsored by the Department for Education and Skills (DfES). It is governed by a board, whose members are appointed by the Secretary of State for Education and Skills, and managed on a day-to-day basis by an executive team.

QCA maintains and develops the National Curriculum and associated assessments, tests and examinations; and accredits and monitors qualifications in colleges and some qualifications gained at work.

http://www.qca.org.uk/

Schemes of Work

The schemes of work (QCA/DfES, 2000) are guidelines to support medium- and long-term planning and were produced by the QCA. They help schools implement the National Curriculum programmes of study. The schemes of work are made up of units that together cover the programmes of study and non-statutory guidelines for key stages 1, 2 and 3 in all subjects except English and mathematics. Each unit sets out learning objectives (which are based on the programme of study), suggests teaching activities to meet these objectives, and defines outcomes of pupils' learning.

http://www.qca.org.uk/8992.html

School Development Plan

A School Development Plan is a document that identifies appropriate improvement strategies, methods for implementation, and regular evaluation procedures to continually monitor and improve pupils' performance, and the teaching strategies and initiatives which could facilitate improvements in children's performance. These documents are updated or revised on a regular basis. School Development Plans are often linked to OFSTED inspection reports and PANDA data.

School Experience

The time when student teachers are working in schools. They will be engaged in all aspects of teaching, planning, teaching and assessment. Students generally spend blocks of time in different schools during their Initial Teacher Training course. As they

become more experienced they are required to take more responsibility for the class.

Science Big Books

These are literally large books that can be read with a whole class or group. The print and pictures are large enough for everyone to see. These can be either story or factual books. They can be used in various ways, for example:

- to act as a stimulus at the start of a topic;
- as a stimulus for science investigations;
- to reinforce scientific concepts.

Scientific enquiry

In the Science National Curriculum (DfEE/QCA, 1999a) scientific enquiry has a central place in science because it helps pupils to understand how scientific ideas are developed and because the skills and processes of scientific enquiry are useful in many everyday applications. Scientific enquiry provides opportunities for pupils to consider the benefits and drawbacks of applications of science in technological developments, and in the environment, health care and quality of life.

Good teaching ensures that scientific enquiry is taught through contexts taken from the whole programme of study and includes a range of domestic, industrial and environmental contexts. Pupils can:

- test out ideas experimentally;
- develop practical skills;
- carry out investigative fieldwork;
- use collaborative approaches to solving problems;
- appreciate the importance of experimental evidence.

Standard Assessment Tasks/Tests (SATs)

A child must take national tests (often known as SATs) at the end of each key stage.

These tests aim to assess children's performance in selected parts of a subject on a particular day. At the end of Key Stage 1 children are tested in English and mathematics. At the end of Key Stage 2 children are tested in English, mathematics and science. These tests give an independent measure of how children and schools are doing compared with national standards in these subjects. The tests are supported by Teacher Assessment.

Teachers

The teachers at ARP Primary school not engaged in the Action Research Project who nevertheless wanted their science teaching to become more challenging for gifted pupils.

Teacher Assessment

Teachers are engaged in assessing children's performance against the Level Descriptions. This assessment is part of the normal classroom practice and could involve written work, children's oral contributions, practical activities and tests.

Teacher Researchers

The group of four teachers from ARP primary school who were engaged in the Action

Research Project which forms the basis of this thesis.

Teacher Training Agency (TTA) / Teacher Development Agency (TDA)

The TTA became the TDA in September 2005. The TDA is an executive non-departmental public body of the Department for Education and Skills.
The purpose of the TDA is to raise children's standards of achievement and promote their well-being by improving the training and development of the whole school workforce.
The strategic aims of the TDA are to:

- ensure schools have an adequate supply of good-quality newly qualified teachers;
- enable schools to develop the effectiveness of their support staff;
- enable schools to develop the effectiveness of their teachers and keep their knowledge and skills up to date;
- support schools to be effective in the management of training, development and remodelling of their workforce. (TDA, 2006)

Chapter 1

Introduction

1.1 My interest and involvement in developing science teaching that is challenging for gifted children

As a primary teacher and science coordinator, I was always interested in developing science teaching that would stretch and challenge all of the children in my class. I saw that part of my role as science coordinator was to try to influence other colleagues to take on this vision. When I moved into higher education as a lecturer in primary science education, I was keen to develop this idea with both initial teacher education students, and with teachers who were attending in-service courses. Unfortunately, much of the science teaching that I observed seemed to involve whole class teaching with activities differentiated by outcome. There seemed to be much scepticism amongst Key Stages 2 and 3 teachers about children being able to achieve highly in science at the end of the previous Key Stage. The expected Levels for the end of Key Stage 1 and 2 are two and four respectively. Could gifted children at the end of Key Stage 1 really achieve Level four? Was Level six in science really achievable at the end of Key Stage 2? If these levels were in fact achievable, how could science teaching be adapted to cater for the needs of this group of scientifically gifted children? The literature uses terms such as *gifted*, *able*, and *more able* to describe these children. For ease of discussion, I will be using the term *gifted*. A discussion of this issue can be found in Chapter 2. To try to answer the first question I worked in collaboration with Deborah Eyre on a research project (Coates and Eyre, 1999) to examine whether or not the Key Stage 1 children who were scientifically gifted could achieve the expected Level for children aged eleven (Level 4). We asked the teachers from three different schools to identify three Year 2 children (aged 6) who they thought were gifted scientists. We chose to research children's performance in scientific enquiry as this was context free and involved the children in the use of higher order thinking (Bloom, 1956). All of the children were found to be working at or near the level expected of eleven year old children. Although the sample was small, the research seemed to indicate that there are scientifically gifted children in primary schools. This led on to trying to answer my third question by developing activities that could challenge gifted children of primary school age in science lessons. Initially activities were trialled in masterclasses for Years 2, 5 and 6 children to examine what children were capable of at the end of each Key Stage. These were organised by Helen Wilson and me and, subsequently, this led to a number of publications:

- an article about the Year 2 masterclasses (Coates and Wilson 2003a);
- a chapter in a book to support teachers to develop challenging science to meet the needs of gifted primary aged children (Coates and Wilson, 2001);

- a book aimed at supporting Key Stage 2 teachers to develop more challenging science activities (Coates and Wilson 2003b).

The next stage would be to try out the ideas developed in our masterclasses in a school setting. Part of my role as a science education lecturer involved me in visiting student teachers during their school experience. One student was teaching in the science coordinator's class in the school where this study eventually took place. The school will be called ARP School in this thesis. The teacher had just taken on the role of science coordinator and was keen to develop the science teaching in ARP School. Science had a low profile in ARP School at the time as literacy and numeracy had been at the forefront of curriculum development because of government initiatives (DfEE, 1998; DfEE, 1999b). After this first discussion it was decided that the best way forward was to investigate how to develop science teaching in a more systematic way through action research. The Deputy Headteacher supported this idea as she had already been involved in a research project (Eyre et al, 2002) and was keen to be involved in any further research. From this initial meeting all staff were invited to express their interest in becoming involved in the action research project. Consequently, three other teachers expressed an interest and of these, two finally committed themselves to the full research project, giving a research team of four teachers. In this thesis these teachers will be described as 'teacher researchers'. These colleagues saw the project as beneficial as it was an avenue to develop their own science teaching, to be proactive in influencing science teaching across the whole school and to undertake an action research project for their own professional development. Other staff in ARP School recognised the need within the school to develop science teaching but felt unable at that time to pledge themselves to a research project with a large time commitment. They were positive in their support of the project realising they would be indirectly involved in implementing the necessary interventions designed to make science more challenging. It was therefore felt that this would be a whole school project with the four teacher researchers acting as researchers gathering and analysing data and feeding back information to the rest of the staff. Financial support to give the teachers time to conduct the research was seen to be essential. Initially funding was sought from the National Primary Trust and they were able to give a small grant to purchase resources. The Department for Education and Skills (DfES) operated the Best Practice Research Scholarship (BPRS) scheme, which provided grants to teachers to carry out school based research. Each of the four teacher researchers successfully applied for a Best Practice Research Scholarship grants and received £2500. The money from the BPRS was mainly used to provide supply cover, which allowed the research team to gather, analyse and discuss data, plan interventions and write their final report. This 'research time' was a key issue for the teacher researchers as it gave them time to reflect and consider ideas away from their daily teaching commitment.

1.2 Background information on ARP School and the teachers

The School is situated on the north side of a market town in southern England. It is an above average size primary school for the region with 323 pupils aged between five and 11 years. The school also has a nursery class catering for a total of 52 children aged between three and five years who attend either a morning or afternoon session. The school also has an attached unit for children with special educational needs. The school is organised into 12 classes with an average size of 32. There are 13.7 full-time teachers and the pupil/teacher ratio is 24:1.

The majority of pupils live locally, although the children in the Special Educational Needs Unit come from a much wider area. The school serves a mixed catchment area made up of private and local authority housing. When children enter the school they are attaining broadly average standards in literacy and numeracy.

The teacher researchers were:

- the science coordinator, Year 3-4 Teacher (identified in this thesis as Teacher Researcher 1);
- the Deputy Headteacher, Year 6 Teacher (identified in this thesis as Teacher Researcher 2);
- a Year 5/6 Teacher (identified in this thesis as Teacher Researcher 3);
- a Year 4/5 Teacher (identified in this thesis as Teacher Researcher 4).

For the purposes of this research, all of the other teachers were randomly ascribed a number from 1 to 13. The teacher researchers will be referred to as TR 1 to TR4 and the teachers T1 to T13.

1.3 Links between my research and the action research project in ARP School

The teacher researchers at ARP School were keen to enlist my support for their Action Research Project as I had both the expertise in developing challenging science ideas for gifted children, and supporting teachers who were carrying out action research projects. This close working relationship meant that I could access the teacher researchers' data concerning their Action Research Project and evaluate their findings to see if science teaching really had become more challenging for gifted children. This unique position also gave me access to the teacher researchers to carry out my own research into the effectiveness of action research as a means of professional development for teachers.

There was a belief amongst all of the teachers at ARP School that their own science teaching could become more challenging for the gifted children in their classes. All of the teachers

thought that challenge could be built into normal classroom practice if they were given support and guidance in the development of their expertise. This largely inclusive model of teaching scientifically gifted pupils agreed with my ideas that gifted children could be found in most primary classrooms and teachers could differentiate their teaching to meet the needs of this group of pupils.

1.4 Why the action research project was started

All of the teacher researchers wished to become more effective in challenging children in science lessons. They decided to focus the action research on the development of strategies, which would enhance the teaching for the gifted children as it was felt that this group was at most risk of not being challenged in science lessons. Once the needs of the teachers had been identified, appropriate interventions and strategies were introduced by the teacher researchers and myself. These were trialled by all staff and their impact evaluated. The aim of the project was to try to draw out lessons for other teachers and schools to decide how to engage in the complex process of changing school culture in relation to one curricular area. One of the longer term hopes was that the lessons learnt might be applied to other subjects and school contexts.

The teacher researchers in ARP School identified the following ideas, which would guide the research process:

1. The results of a co-operative project across five schools in Oxfordshire during the 1999-2000 year (Eyre et al, 2002) in which one of the teacher researchers and myself were involved. This co-operative project looked at the skills and attributes of teachers identified as expert teachers of gifted pupils across the whole curriculum and aimed to extend this initial work to focus on the more specific area of science teaching.

2. ARP School's acknowledged focus in the School Development Plan was to raise the level of achievement in science across the whole school. The then most recent OFSTED (Office for Standards in Education) Inspection Report in 1998 stated that there was a slow pace to some science teaching with teachers underestimating what children could do.

3. This suggested that there was a need for a more challenging curriculum in all subjects, science included. Each year, in the autumn, schools are sent information that compares their Standard Assessment Test (SAT) data with schools in the locality and schools nationally with a similar intake profile. Analysis of this Autumn Package and the PANDA (DfES, 2001a) report showed that in science:

- in Key Stage 1, teacher assessments of pupils' science attainment were below the national averages;
- in Key Stage 1, no children achieved Level 3;
- in Key Stage 2, the number of children achieving Level 4 or Level 5 was below comparative schools nationally, countywide and those in the same locality;
- in Key Stage 1, girls achieved higher results than boys; but, by the end of Key Stage 2 there was little obvious difference;
- in Key Stage 2, results were not rising at a similar rate to schools which otherwise were comparable.

There are at least two possible sets of conclusions that can be drawn from this information; one concerns the children and the other the teachers.

1 The children:

- The scientific ability of the children attending ARP School is below that of children in comparable establishments.
- Science is not an interesting subject.
- Science at Key Stage 2 is more interesting and challenging for boys.

2 The teachers:

- As all assessment at Key Stage 1 is carried out by the teachers, they are not effective at carrying out assessment of children's attainment in science.
- Key Stage 1 teachers are reluctant to identify, or are not capable of identifying, children who are scientifically gifted.
- Teaching at Key Stage 2 does not give children the experiences they need to achieve their potential as measured by the standard assessment tasks/tests (SATs).
- Teaching at Key Stage 2 is particularly ineffective for girls and/or effective for boys.

It was clear that interpreting the PANDA data in such a way was simplistic but the teacher researchers thought there were threads of truth in each explanation. What this analysis did was give a number of indicators, which could form the basis of the Action Research Project. It also raised the issue of challenging children in science lessons and highlighted it as a priority in ARP School. The teacher researchers particularly believed that there was a need

to improve teachers' own subject knowledge and pedagogical skills to ensure that the appropriate level of challenge was offered to children of all abilities, not just the gifted, and through this to improve children's attitude to science.

1.5 The school action research project

One of the key features of the Action Research Project for the four teacher researchers was that this should be a co-operative project and that its outcomes should also impact on the rest of the staff and their science teaching. Although the project considered how to improve teaching in science, with a focus on how to provide greater challenge for all pupils, the guiding principle behind this was that if teachers challenge gifted children in their teaching there will be a benefit to all children in the class.

As the teachers adopted an action research methodology:

- evidence was collected in an initial audit to determine how children were being challenged in science;
- as a result of this initial audit, a number of interventions were introduced by the teacher researchers with the aim of supporting teachers in making science teaching more challenging;
- the final stage of the research evaluated the effects of these interventions.

As part of the Best Practice Research Scholarship process, the whole project team of four teacher researchers developed the success criteria and expected outcomes for the Action Research Project. The success criteria for the project at the start of the year were that:

- teachers would be more confident in their ability to challenge children in science activities;
- teachers' planning and teaching would include ideas for providing additional challenge particularly for scientifically gifted children;
- pupils would have a more positive attitude towards science and feel more challenged;
- pupils' science achievements would have improved beyond that which might have been expected, both as indicated by teacher assessments and as measured by test results (recognising that the short-term nature of this project might make such evidence only tentative).

The expected outcomes of the Action Research Project involved three areas:

- exploring which aspects of the teaching of science can be improved, and the most effective mechanisms to enable such improvement to happen;

- examining the impact of this development work on children's learning, and on the resultant attitudes and achievements in science; and
- articulating for a wider audience the key aspects of this development, both for teachers and pupils.

The final £400 of the BPRS grant, per teacher, was kept back until the teachers had written a report for the BPRS website. This report only needed to be short with little detail. The teachers decided that a better vehicle for disseminating their findings would be the National Primary Centre (Midland Region) as this Centre publishes accounts of school based research projects in a user-friendly format. I believe that the process of articulating teaching strategies and how these have been improved has the capacity to help both the teachers at ARP School and teachers in other schools. The strength of action research involving a number of teachers is that these teachers will be able to communicate common themes applicable throughout the whole primary age-range.

1.6 Data collection and timetable for the school action research project

The emphasis was on qualitative research methods. The teacher researchers intended to use a mixture of questionnaires, semi-structured interviews and classroom observations to analyse the success of the development work undertaken and the impact on the children's learning and attitudes to science. Time was built into the proposed programme to analyse the data and to come to conclusions which could be applied more generally beyond the context of one school. The process of articulation and triangulation of findings with each other, and with me acting as a mentor, helped the teachers to check the analysis for validity.

Built into the timetable were regular opportunities for collective discussion of the lessons learnt, which were supplemented by the more informal discussions in the staff room and around the school. It was intended that teacher researchers would use both notes from staff development sessions, their own teaching plans and journals/diaries as data for the project itself and as a way of monitoring their own learning. Self-monitoring of the teacher researchers' own learning was an integral part of the School Action Research Project. The lessons learnt through these reflections could develop their own practice and be articulated to the wider team of colleagues in the school to support their professional development. The data collection methods and time line for the School Action Research Project can be found in Appendix 1. I examined these data for my own research to determine if the teacher researchers' success criteria had been met. After discussion, the teacher researchers decided that monitoring pf pupils' achievement would not be possible. This left the following success criteria for the Action Research Project:

- teachers would perceive themselves to be more confident in their ability to challenge children in science activities;
- teachers' planning and teaching would include ideas for providing additional challenge, particularly for scientifically gifted children;
- pupils would have a more positive attitude towards science and feel more challenged.

1.7 An outline of my research

In this research, I sought to evaluate and highlight some of the main factors, which helped to improve the teaching of science in ARP School, and to see what lessons could be learnt for other schools and teachers. I would be examining both the products of the action research and the process of action research. The first part of my research could be described as a secondary evaluation concentrating on the effect, effectiveness and value of the action research project (Evaluation Research Society, 1980 cited in Robson, 1999; Robson, 2000) because the focus is on the results and efficacy of the Action Research Project. The second section of my research, which is an evaluation of an action research project as a model of professional development, takes a more interpretive approach (Greene, 2000) or impact evaluation (Evaluation Research Society, 1980: 3-4 cited in Robson, 1999: 177). The aims of my research were therefore:

- to examine the success criteria (see previous section) of the action research project and see if they have been met; and,
- to evaluate the effectiveness of action research as a means of professional development and hence school improvement in the context of this project.

I believe that the process of articulating teaching strategies and how these have been improved will help both the teachers at ARP School and teachers in other schools. The strength of this approach involving several teachers will be to articulate common themes applicable through the whole primary age-range.

For this thesis I have translated the two research aims into research questions:

1 to what extent were the expected outcomes and success criteria of the Action Research Project achievable within the time scale?
2 How effective is action research as a means of professional development?

For further clarity I have sub-divided each of these research questions into sub-questions. Question 1 has been sub-divided to reflect the success criteria of the School Based Action Research Project:

1.1 Did the teachers become more confident in their ability to challenge children in their science lessons?

1.2 Did teachers' planning and teaching include ideas for providing additional challenge particularly for scientifically gifted children?

1.3 Did pupils develop a more positive attitude to science and feel more challenged?

Question 2 has been divided into the following sub-questions to reflect different aspects of action research and the issues associated with teachers carrying out their own action research projects:

2.1 To what extent is action research an effective means of professional development?

2.2 How did the teacher-researchers view the roles of different stakeholders in the Action Research Project?

2.3 Are there tensions, conflicts and ethical issues associated with the Action Research Project for the different stakeholders? If there are tensions, how did these arise? How might they be resolved?

1.8 An outline of this thesis

The thesis has the following chapters:

- Chapter 2 – a literature review related to both research questions;
- Chapter 3 – a discussion of my research design and its implementation;
- Chapter 4 – an analysis and discussion of research question 1;
- Chapter 5 – an analysis and discussion of research question 2;
- Chapter 6 – conclusions and lessons for the future related to both research questions.

Chapter 2

Review of the Literature

2.1 Introduction

In my research, I investigated the perceptions of teachers in one school (it will be referred to as ARP School) who were undertaking a year long action research project to make science more challenging for gifted pupils in their school. The DfES (2005) has suggested that even where it is a priority teachers can struggle to *tailor teaching and learning* to meet the needs of gifted pupils (DfES, 2005: para. 4.22). Non-challenging science teaching had been recognised as an issue for ARP School and therefore became the focus for the professional development of the teachers in the school. Various forms of professional development were examined by the staff before deciding on action research. Action research was chosen by the teachers as it was thought to be solution oriented and could be specifically designed to influence the science teaching in all classes in ARP School. Therefore this literature review has nine sections dealing with:

- the meaning of the terms gifted, talented and able;
- how we can recognise children who need to be challenged in science;
- the challenging science curriculum;
- effective professional development;
- teachers as researchers;
- a brief discussion of action research;
- the nature of action research;
- models of action research;
- action research as professional development; and,
- limitations of action research as professional development.

2.2 The meaning of the terms gifted, talented and able

In the literature of different countries, many terms are used to describe children who come within the remit of this thesis, for example 'able', 'highly able', 'very able', 'gifted', 'talented' and 'highly talented'. In England, there has been a preference to use the terms 'able' or 'highly able' or 'talented'. As George (1997) stated the number and variety of definitions only adds confusion to an extremely complicated matter. In her research, Freeman (1998) found there to be around one hundred definitions of 'giftedness'. In 1997, a newly elected Government indicated the need for a national strategy to deal with the needs of highly able children. This resulted in a review of current practice undertaken by the House of Commons Education and Employment Committee (1999). The committee report *Highly Able Children* (Education and Employment Committee, 1999) identified the definition of the target group as

being the most complex aspect of their inquiry. When the National Strategy was finally introduced, the term 'gifted' was used to allow England to come into line with the United States, Australia, Canada and other countries around the world. Many teachers with whom I have discussed this term still have concerns about the concept of 'gifted'. It still seems to them to have undertones of elitism and links to the idea of 'genius' (Freeman, 1991). Some areas of the country, for example Hampshire County Council, use the terms 'able and talented'. The term gifted may also be further modified by the addition of adjectives: highly gifted, average gifted:

> *...suggesting the possibility of precise identification along a single spectrum of ability, usually* IQ'
>
> (Freeman, 1998: 1)

The conceptions of giftedness have broadened over the last hundred years but they share two common elements (Australian Government, Department of Education, Science and Training, 2001):

- Gifted pupils have the potential for unusually high performance in at least one area (DeHaan and Havighurst, 1957; Marland, 1971; Gardner, 1983; Taylor, 1988; Gagné, 1991; 1995; DfEE, 1999c);
- Gifted children are not always successful (Gagné, 1991; 1995; Mönks, 1992; Renzulli, 1995; Eyre, 1997; 2004; Morelock and Feldman, 1997; Porter, 1999).

Eyre (2004) has come up with a definition of giftedness, which she describes as the English Model. She suggested that giftedness was a term used to describe children who have the capacity to achieve high levels of expertise or performance. Implicit in this definition is the concept that gifted children do not always succeed. Freeman (1991), in her account of gifted children growing up, indicated that support and encouragement were vital to success. This has also been highlighted in a recent White Paper (DfES, 2002). In the White Paper it was suggested that some teachers were reluctant to recognise gifted children's needs because it was thought by a significant number of teachers that gifted children would do well without any support. Gagné (1991, 1995) noted that catalysts, such as environmental, intrapersonal and motivational, are needed to transform a person's intellectual abilities into academic performance. Renzulli (1995) stated that pupils need a combination of innate ability, creativity and task commitment before they can truly demonstrate their giftedness. Eyre (1997) has summed these ideas up in the model:

Ability + Opportunity/Support + Motivation = Achievement

In England there is now a clear distinction made between the terms gifted and talented. The QCA Guidance on Teaching Gifted and Talented Pupils (QCA, 2001a: 1) defined gifted and talented as follows:

- *Gifted pupils are those who have abilities in one or more subjects in the statutory school curriculum other than art and design, music and PE.*
- *Talented pupils as those who have abilities in art and design, music, PE, or in sports or performing arts such as dance or drama.*

These definitions came out of the National Strategy in England called Excellence in Cities (EiC) (DfEE, 1999c) which began in 1999 as a major initiative involving twenty four Local Education Authorities (LEAs) in six major conurbations. EiC has a number of strands one of which is 'gifted and talented'. This strand was based on the conviction that high achievement is possible for some pupils in all schools. The aim was therefore to support underachieving gifted and talented pupils from disadvantaged backgrounds by improving their attainment, aspirations, motivation and self-esteem.

The definitions from the QCA Guidance (QCA, 2001a) are at odds with research and ideas from other parts of the World. Winner (1996) makes the evidence based assertion that there is no justification for two different labels for gifted and talented pupils as it is not possible to make such a distinction. The terms could be used interchangeably (Davis and Rimm, 1998). Morelock (1996) however, did make this distinction between the terms 'gifted' and 'talented'. He viewed talent as a remarkable ability which however, was inferior to the superlative levels associated with giftedness. They were on a continuum with gifted at the upper end (Davis and Rimm, 1998). Other writers have stopped using the term gifted and replaced it with talented because giftedness was perceived as getting something for nothing and that the gifted person did not have to work hard to achieve (Colangelo and Davis, 1997; Feldhusen, 1996). Gagné (1991, 1995) indicated that there was a difference between the two terms as he saw giftedness as innate potential which was genetic and talent as the actualisation of that potential. Giftedness was a necessary condition for talent, but not vice versa and demonstrable talent is a certain indicator of giftedness.

I believe that the use of the term 'gifted' in relation to academic subjects (QCA, 2001a) was part of the political agenda in 1998. The Annual Report for 1997/98 (OFSTED, 1999b: no page numbers given) identified key issues from their inspection evidence which were seen to be in need of addressing in order to maintain the improvement in standards in primary schools. Two of these were:

- *the need to improve standards of literacy and numeracy;*

- *urgent action in the one in ten schools at Key Stage 1 and one in eight at Key Stage 2 where there was substantial underachievement.*

In 1998 the Government set national targets for English and mathematics for English primary schools, to be achieved by the year 2002 (OFSTED, 1999a). These targets identified the proportions of pupils who it was thought should achieve Level 4 at the end of Key Stage 2: 80 per cent in English, and 75 per cent in mathematics. As the political agenda was concerned with improving standards in English and mathematics there was a perceived need to distinguish between academic and non-academic ideas concerning giftedness. Giftedness could not simply refer to English or mathematics hence the move to include other statutory academic subjects. However, only guidance materials concerned with supporting teachers to meet the needs of gifted pupils in English and mathematics (QCA, 2001b) were sent out to primary schools. Unsurprisingly, OFSTED (2003) found that primary schools were far less adept at identifying talented pupils than they were gifted ones.

In 2002, the Government set up the National Academy for Gifted and Talented Youth (NAGTY) for secondary-level students between the ages of 11 and 19, who were both resident and being educated in England, and who could demonstrate that they were working in, or had the potential to work in, the top 5% of the national ability range (NAGTY, 2006). Again there was a standards agenda that unpinned the mission statement which emphasised maximising potential. The aims focused on the boosting of attainment (NAGTY, 2006). Only comparatively recently (in 2005 – 2006) were the eligibility criteria amended to now include guidance on the identification of students on the basis of talent in the arts.

In England therefore, there are rather hybrid definitions of the terms gifted and talented. Internet based guidance for teachers still refers to 'more able' children (QCA, 2004). There is a perceived need to raise standards in academic subjects, in particular English and mathematics, whilst realising that there are external factors which can influence whether innate ability is converted into attainment (DfEE, 1999c; Eyre, 2004). In this thesis, I will be using the term gifted to describe children who have innate ability in science which could be actualised by the mediation of external catalysts. There is evidence however, to suggest that searching for a precise definition might be a distraction for schools when they are trying to meet the needs of gifted children (Education and Employment Committee, 1999: x1ix); the focus of the School Action Research Project. I feel that the focus of teaching should be on meeting the needs of all pupils, including the gifted, and not on giving them labels. The next section will examine how we might recognise gifted scientists in order to meet their needs. I have included this section because of the difficulty associated with evaluating relevant material from outside England and in some cases from within England.

2.3 How do we recognise children who need challenging in our science teaching?

Giftedness in young children refers primarily to precocity, a rapid rate of development in one or more areas (Smutny, 2000). Porter (1999: 33) defined gifted young children as *those who have the capacity to learn at a pace and level of complexity that is significantly advanced of their age peers.* Maker (1982) suggested that gifted pupils differ from their classmates in three ways, the pace at which they learn, the depth of their understanding, and the interest they hold. This is reinforced by a study conducted by Cross and Coleman (1992) involving gifted high school students which found that the students' major complaint about instruction was the frustration of being held back by the pace of and content of the courses. Lynch (1992) found that scientifically gifted middle school pupils taking a three week summer school outperformed high school students who had taken the courses for a full year. Allebone (1998) identified one of the key characteristics of gifted children as their ability to use higher order thinking skills at an earlier age. Coates and Wilson (2003b) found that scientifically gifted six year old children were capable of giving correct answers to Standard Assessment Test (SAT) questions set for eleven year old children. The questions required the children to interpret graphical data and use higher order thinking skills, and were not simple recall. The QCA Report 'Standards at Key Stage 2, English, Mathematics and Science' (QCA, 2000) indicated that only half of the Year 6 children entered in 1999 gave correct responses to these questions.

If being gifted is simply seen as rapid progress through normal developmental stages, it could be perceived to fade as other people caught up or even went beyond. However, a gifted child's development is thought to be asynchronous and qualitatively different from the norm (Columbus Group, 1991). A gifted child deals with abstract concepts early and brings those concepts to bear on later experiences. This different, more complex way of processing experiences creates essentially different experiences (Tolan, 1992). Freeman (1998: 54) suggested that gifted children were different in their educational needs because of *their capacity to learn more quickly, deeply and autonomously, and to take their learning further in creative ways.* What all of the literature suggests is that gifted children have the potential for unusually high performance in at least one area. They have the capacity to think clearly, analytically and evaluatively.

The QCA definition of gifted (QCA, 2001a: 1) suggested that there will be children who have above average ability in science and are therefore seen to be gifted in that subject. This ability in science may or may not be combined with abilities in other subjects (Poncini and Poncini, 2002). Rakow (1988) found that gifted scientists, with demonstrated ability in the subject, were intensely curious about science and mathematics, engaged in investigations of science topics and were tinkerers. He does not however indicate whether giftedness in science resulted in the characteristics or if innate characteristics produced a gifted child.

Sometimes gifted pupils use a vocabulary that is beyond other pupils of their age. They also may be intensely curious about science and become engrossed in ideas and investigations. A scientifically gifted child will create a prodigious data base in his/her field(s) of interest (Geake et al, 1996: 46). The Dudley Local Education Authority (LEA) (1998) noted that pupils of all ages who are gifted scientists are generally the ones who ask perceptive, provocative questions. They bring background knowledge to bear on their school work and show a greater proclivity for independent work (Geake et al, 1996: 46).

The QCA (2001a: 1-2) has identified a list of twenty-three characteristics from which a range should be evident in the gifted scientist. This is a very comprehensive and extensive list, ranging from being *imaginative* to being *able to analyse data or observations and spot patterns easily*. The checklist is designed to be used with all children from Key Stage 1 to Key Stage 4. It is self evident that the children aged five will not exhibit the same characteristics as a gifted sixteen year old. Research by Coates and Hazell (2002) with a Year 1 class demonstrated that the three most gifted children in the class showed on average ten of these characteristics but 38 per cent of the children showed none at all. This may be why out of the twenty-three traits, the year one children scored on average three characteristics per person and these only occurred within a limited range of fifteen characteristics. As the QCA document indicates, these are characteristics *from which a range should be evident* (QCA, 2001a: 1).

When working with groups of primary children in masterclasses, Coates and Wilson (2000; 2003a) identified a number of characteristics associated with the scientifically gifted children involved. All of the scientifically gifted children exhibited some or all of the following:

- a natural curiosity about the world and the way things work;
- an enjoyment of hypothesising;
- an ability to express scientific knowledge and understanding logically and coherently;
- an ability to use scientific vocabulary accurately and appropriately;
- an ability to transfer knowledge and understanding from one situation to another;
- an ability to spot and describe patterns in results;
- an ability to show innovation in experimental design and/or in the collecting and recording of data.

What there seems to being lacking at the moment is hard, wide ranging evidence about the characteristics of gifted pupils and even less concerning the scientifically gifted. This lack of research evidence about the characteristics of gifted children was illustrated by Stopper in his evidence to the Education and Employment Committee (1999):

> *Hundreds of value judgements have been published on the subject. What they are not, despite the eminence of their authorship in numerous instances, is evidence based on valid conclusions drawn from an adequate range of research studies.*
>
> (Education and Employment Committee, 1999: x1viii)

For teachers therefore, the most effective and classroom friendly means of identifying those pupils who are gifted is by monitoring their performance when faced with challenging science activities. This is identification through provision, which Freeman (1998) calls the 'Sports Model'. The sports analogy is apposite because, in order to discover who is the best high jumper, the bar is raised for all and we watch to see who can make the leap. Therefore, providing the whole class with challenging tasks and questions will result in opportunities for pupils to demonstrate the depth of their thinking and understanding. The learning context is therefore seen to be an essential feature of this more flexible means of identification (Coates and Wilson 2003b). For as Freeman (1998: 15) stated, the gifted *cannot make progress without the means to learn*. Hence aptitude and provision are considered together to find and provide for potential strengths and abilities. Gifted children will not make progress in their learning if the identification stops at a checklist (for example, Coates and Wilson, 2001; 2003b). The learning context is therefore seen to be an essential feature of this more flexible means of identifying gifted scientists. Indeed I could argue that some gifted scientists may not reveal themselves until given challenging activities (Geake et al, 1996). Aptitude and provision are considered together to find and provide for potential strengths and abilities (Freeman, 1998). Identification therefore occurs when teachers recognise the advanced way in which a child responds to the curriculum. This method of teaching is a continuous and exciting process, which motivates the gifted pupils and encourages them to identify themselves through their achievements (Coates and Wilson, 2003b).

Identification of gifted children, therefore, only makes sense when it is linked to effective provision and this, in turn, is linked to the individual child's rights. As George stated:

> *Educationalists are agreed that it is every child's right to go as far and as fast as possible along every dimension of the school curriculum in order to reach their considerable potential, and that this is one of the main aims of education.*
>
> (George, 1997: 4)

By differentiating the curriculum to build on gifted pupils' natural scientific curiosity teachers can therefore reveal the *excitement and beauty of science to gifted pupils* (Geake at al, 1996: 45). Although identification through provision could be viewed as the most straightforward way for practising teachers to identify scientifically gifted pupils it is potentially fraught with

difficulty. This was the main reason why the development of challenging science for gifted children was the focus of ARP School's Action Research Project.

2.4 The Challenging Science Curriculum

Challenge for gifted children can be achieved through *appropriate teaching and expectations of pupils...and through the curriculum* (Education and Employment Committee 1999: 1iv.). This does assume that teachers have the capability to develop appropriate teaching or the means of developing their teaching. It is therefore imperative to recognise the importance of individual teachers in considering curriculum development (Eyre et al, 2002). This is particularly important at a school level where teachers are looking to modify the National Curriculum (DfEE/QCA, 1999) to meet the needs of all the pupils in their class. All children, including the gifted, need to be challenged by their science work in order to achieve their full potential (George, 1997). When meeting the needs of gifted children it is not always necessary to look towards the *amount* of work that is done but rather to the cognitive demands (Coates and Wilson, 2003b) and intellectual demand (OFSTED, 2000) that activities make upon the children and in particular the use of higher order thinking skills.

The National Curriculum (DfEE/QCA, 1999) requires teachers to provide effective learning opportunities for all pupils. It states that:

> *Science stimulates and excites pupils' curiosity about phenomena and events in the world around them. Because science links direct practical experience with ideas, it can engage learners at many levels. Scientific method is about developing and evaluating explanations through experimental evidence and modelling. This is a spur to critical and creative thought. Through science, pupils understand how major scientific ideas contribute to technological change – impacting on industry, business and medicine and improving the quality of life.*
>
> (DfEE/QCA, 1999: 76)

Recent studies in America have identified materials that are most appropriate for challenging able children in primary schools (Johnson et al, 1995). These materials have a similar feel to the English Science National Curriculum. The similarities include a balance between process and content, an emphasis on original student investigations, concept development and interdisciplinary applications. In England, the process of science and investigative skills are set out in Sc1 Scientific enquiry and the concepts to be studied in Sc2 Life processes and living things, Sc3 Materials and their properties and Sc4 Physical processes. In the section Breadth of study (DfEE/QCA, 1999: 27) the interdisciplinary nature of the curriculum is set out where it is stated that:

During the key stages (1 and 2), pupils should be taught the knowledge, skills and understanding through:

a. *a range of domestic and environmental contexts that are familiar and of interest to them;*
b. *looking at the part science has to play in the development of many useful things.*

In the United States curriculum ideas were further refined by Van Tassel-Baska (1998) who indicated that the essential features of a science curriculum that has the potential to meet the needs of gifted children (i.e. to challenge them) should contain the following features:

- an emphasis on learning concepts;
- an emphasis on higher level thinking;
- an emphasis on enquiry, especially problem solving;
- an emphasis on the use of technology as a learning tool; and,
- an emphasis on learning the scientific process, using experimental design procedures.

If the National Curriculum vision of science is realised then science should be an exciting and challenging subject for all primary children. The concern for a primary teacher is to plan for a working environment in which all pupils, including the gifted, can fully develop their science capability and interests within the confines of a normal mixed ability class. Maker and Nielson, (1995) make the point that the provision for gifted pupils should be qualitatively different and not simply more of the same. If, once they have finished a task, they are always given more work of the same type or yet another worksheet, gifted children soon realise that the intelligent thing to do is never to finish before anyone else (Coates and Wilson, 2003b). The skill of the teacher is to ensure that the differentiation is appropriate, effective and exciting so that the children are engaged in their learning. It is essential to provide an extensive range of experiences and examples so that pupils' mastery of the important concepts embedded in the Science National Curriculum is strengthened (Gallagher, 1985).

Allebone (1998) identified one of the characteristics of gifted children as their ability to use higher order thinking skills at an earlier age. Lewis and Smith (1993: 136) consider the difficulty of defining higher order thinking and offer the following definition:

Higher order thinking occurs when a person takes new information and information stored in memory and interrelates and/or rearranges and extends this information to achieve a purpose or find possible answers in perplexing situations.

Thinking skills can be divided in two levels: higher order and lower order (Bloom, 1956). The teaching of these lower and higher order skills (see later on in this section for more details regarding these skills) should be closely interwoven in the classroom (Lewis and Smith 1993). While lower and higher order thinking may be taught together in a class, for a given individual, the need to use higher order thinking will depend upon the nature of the task and the person's intellectual history. Gifted children should, however, spend more time on higher-order activities (Davis and Rimm, 1998).

Bloom's taxonomy describes six levels of thinking arranged hierarchically in order of complexity (Bloom, 1956). It stresses six levels of thinking with the last three listed (see below) being considered as higher order.

Bloom's taxonomy comprises:

- **Knowledge** : remembering previously learned material;
- **Comprehension**: ability to grasp the meaning of material and convey it to others;
- **Application**: ability to use learned material in new contexts or situations;
- **Analysis**: ability to break down data into significant component parts;
- **Synthesis:** ability to create new structures using combinations of learned parts;
- **Evaluation**: ability to judge material in terms of its value for a given purpose.

The Science National Curriculum (DfEE/QCA, 1999) sets out levels of achievement in the Level Descriptions. At the end of key stage 1 children should achieve between Levels 1 to 3 and at the end of key stage 2 between Levels 2 to 5. Scientifically gifted children can achieve beyond these levels in Sc1 (Scientific enquiry), for example, they could reach Level 4 at age seven (end of key stage 1) and Level 6 at age eleven (end of key stage 2). Research by Coates and Eyre, (1999) suggests that gifted scientists can be found in most classes of seven year olds with the potential to reach Level 4. Tables 2.1 and 2.2 (Coates and Wilson, 2003b) show the links that there are between Bloom's taxonomy and scientific skills as set out in the Science National Curriculum programmes of study.

Table 2.1: Links between higher level thinking and Level 4 in scientific enquiry

Higher Level Thinking in Bloom's Taxonomy	Scientific enquiry. Sc1/AT1 Level 4
Application	□ Where appropriate, children can make predictions
Analysis	□ In their own investigative work, they decide on an appropriate approach to answer a question.
Synthesis	□ They begin to relate conclusions to patterns in data and to scientific knowledge and understanding. □ They describe or show in the way they perform their task, how to vary one factor while keeping others the same.
Evaluation	□ Children can suggest improvements in their work, giving reasons.

Table 2.2: Links between higher level thinking and Level 6 in scientific enquiry

Higher Level Thinking in Bloom's Taxonomy	Scientific enquiry. Sc1/AT1 Level 6
Analysis	In their own investigative work, they (the children) use scientific knowledge and understanding to identify an appropriate approach.
Synthesis	Children draw conclusions that are consistent with the evidence and use scientific knowledge and understanding to explain them.
Evaluation	Children make reasoned suggestions about how their working methods could be improved.

Science lessons provide an ideal framework for cognitive work and the use of higher order thinking. O'Brien (1998: 4) notes that:

> *Children reveal something of their close understanding of science and the way they are viewing the world in the way they tackle thinking problems. It is therefore important for teachers to observe closely the way pupils think in science as well as what knowledge they display.*

However, research in England indicates that this is not always a routine outcome of classroom science. Luxford (1997) suggests that content based teaching, which she describes as the focus of most primary science lessons, only deals with lower order thinking.

The hierarchy of scientific skills suggests a difference between lower order and higher order thinking skills. The utilization of higher order thinking skills has been developed in other ways, for example, the Thinking Science Project (Israel) which integrates higher order thinking skills into the science curriculum (Zohar, 1999). The basic (lower order) process

skills include observing and classifying, whereas integrated (higher order) process skills include interpreting data, controlling variables and formulating hypotheses.

Recent advice to teachers has suggested that the curriculum for all children should be more cognitively based. The teachers' guide update to the Science Scheme of Work (QCA/DfEE, 2000d) gives guidance on different types of thinking skills and which topics would benefit by their inclusion;

> *By using thinking skills children can focus on knowing how as well as knowing what – on learning how to learn. Many aspects of science contribute to the development of thinking skills.*
>
> (QCA/DfEE, 2000d: 8)

Although this document deals with making science education more challenging for all children, similar activities in the classroom can be adapted to include aspects of enrichment and/or extension so that gifted children are challenged by the work (Coates and Wilson, 2003b). In the guidance for working with gifted children within the Numeracy and Literacy Strategies, five key dimensions are highlighted for the planning of appropriate differentiation:

- breadth
- depth
- acceleration
- independence
- reflection

(QCA, 2001b)

In science, breadth involves 'going sideways' for example applying scientific knowledge in a new situation, beyond the confines of the Science National Curriculum, but not necessarily at a greater level of complexity. Depth involves an increase in the complexity of the task but without going beyond the actual content of the normal curriculum, for example hypothesising and predicting. This will often involve the encouragement of the pupils to access higher order thinking skills (Bloom, 1956). Acceleration involves covering the material more quickly and embarking on work from the following key stage. The children are accelerated through the curriculum so those primary age children may be taught some of the secondary school syllabus. Acceleration as a means of creating sufficient challenge for gifted children can be a particular problem for primary teachers, especially in areas of the curriculum where they lack confidence or specific expertise. Effective teachers of gifted children need to have a good knowledge and understanding of their subject (Maker and Nielson, 1995) and also need to be confident when applying this knowledge in the classroom (Education and Employment Committee, 1999). This is not simply to convey factual information to children but to have the confidence:

> *...to ask questions which will lead children to reveal and reflect on their ideas, so they can avoid "blind alleys", so that they can provide relevant sources of information and other resources, so that they can identify progress and the next steps that will take it further.*
>
> (Harlen, 1997: 335)

Alexander et al. (1992) argue that effective teaching depends on the successful combination of knowledge, understanding and skills. When these are combined together they should *provide pupils with maximum opportunity to learn* (Silcock, 1993: p. 13). Acceleration will inevitably result in overlap with work that pupils will be doing in later years and it can be demotivating for (gifted) pupils to repeat work. However, it may be appropriate in certain areas of the curriculum, for example, electricity. The gifted pupils can be encouraged to plan and carry out investigations with less adult support than the rest of the class, to work independently. Pupil research can also be a useful tool for challenge, as long as it is not a case of pupils being completely left to their own devices, with no structure or planning behind the exercise. Reflection involves making explicit what they understand and evaluating what they have done. Evaluation is the final stage of an investigation and is an integral part of scientific enquiry but it is something that is too easily omitted because of time constraints (Coates and Wilson 2003b). For many teachers the emphasis was on children completing a fair test and with a limited time slot for science evaluation was neglected. Evaluation gives pupils the opportunity to learn to criticise their work and suggest improvements.

2.5 What is effective professional development?

Making primary science lessons more challenging might be achieved through various forms of professional development, the core of which is the production and sharing of new knowledge about practice (Sachs, 1999). Methods utilised in professional development include in-service training, reflective practice and teacher research (Denscombe, 1999; Shafer 2000). Unfortunately, some of the more traditional approaches to professional development have failed to promote the expected changes in teachers' thinking and classroom practice (Schön, 1983; Clark, 1997; Sagor, 1997; Doerr and Tinto, 2000). This is because this form of professional development does not facilitate perspective transformation (Lieberman and Grolnick, 1997) as teachers are not expected to question and adapt their thinking and practice, but accept the new ideas without much difficulty (Clark, 1997). These traditional approaches do not facilitate perspective transformation as they ignore the needs of individual participants (Lieberman and Grolnick, 1997). Workshops where teachers were told what to do in their classrooms have little effect on practice (Hawley and Valli, 1999; Ponte, 2005). Grundy (1995: 7) describes this as *pit stop* professional development – isolated, externally

provided, training sessions designed to *fix teachers up*. Such approaches to professional development have been criticised for being piecemeal, haphazard, brief and atheoretical (Collinson and Ono, 2001) and failing to take account of the context in which participants work (Hargreaves, 2000).

Hargreaves (2000) argued that there need to be new models of professional development for teachers to meet the challenges of their rapidly changing roles, contexts and pedagogy. Joyce and Showers (1984), writing at a time when the norm for professional development was through taught courses, proposed that effective professional development has four hierarchically-linked components: theory, demonstration, practice and feedback. Sustained practice in the classroom is then necessary for the transfer and incorporation of skills, strategies and curriculum patterns into participants' active teaching repertoires (Buzzard and Jarvis, 1999). Showers et al (1987) suggested that nearly all teachers need social support and 'follow-up' provided by expert or peer coaches during the transfer process to enable them to sustain their practice. However, Kinder and Harland (1991) acknowledging the model advanced by Joyce and Showers (1984) suggested that it omitted factors that can be highly influential on teachers' subsequent classroom practice. They identified the importance of differentiation, identification of and negotiation of individual needs, sustained and substantial involvement, coherence, continuity and progression, motivation, high expectations, eclectic approaches, classroom support, external agency input, reflective practices, and on-going evaluation. A study of 1000 teachers in the USA (Garet et al., 2001) found that the following professional development activities had the greatest impact on classroom practice:

- a focus on content knowledge;
- provision of opportunities for active learning; and,
- coherence with other learning activities.

They concluded:

> *...that it was more important to focus on the duration, collective participation and core features (i.e. content, active learning and coherence) than type of learning*
>
> (Garet et al., 2001: 936)

The Evidence for Policy and Practice Information and Co-ordinating (EPPI) Centre review (Cordingley et al, 2003) examined the literature on collaborative continuing professional development (CPD) and its effects on teaching and learning. Through the synthesis of research ideas the EPPI review came to the conclusion that positive outcomes from professional development which encompassed all aspect of teaching and learning were linked to the following features:

- *the use of external expertise linked to school-based activity;*
- *observation;*
- *feedback (usually based on observation);*
- *an emphasis on peer support rather than leadership by supervisors;*
- *scope for teacher participants to identify their own CPD focus;*
- *processes to encourage, extend and structure professional dialogue;*
- *processes for sustaining the CPD over time to enable teachers to embed the practices in their own classroom settings.*

(Cordingley et al, 2003: 5)

In 2004, the DfES identified other factors which should be added to the EPPI list that were associated with effective CPD:

- *is likely to have a direct relationship with what teachers are doing in their own schools and classrooms;*
- *provides scope for participants to identify the focus of their development;*
- *enables all staff to be reflective and focus on their contribution to children's learning and attainment;*
- *provides opportunities to work with other colleagues and share practice;*
- *includes opportunities to receive regular and structured feedback;*
- *includes opportunities for independent self-study.*

(DfES, 2004b: 6)

There now seems to be a consensus based on the analysis of research carried out into what is thought to be effective CPD. In the next sections I will discuss how teachers acting as researchers can be an effective form of CPD, and the nature of action research and how it relates to effective CPD.

2.6 Teachers as researchers

Teacher research is not new but there are now a growing number of advocates who are suggesting that practitioner research can form the foundation for teachers' learning and educational change (Peters, 2004). With the support of higher education institutions however, teachers have been encouraged to carry out research for many years. They have engaged in action research, practitioner research and collaborative inquiry in order to refine and develop their practices and innovate, evaluate and improve their teaching (Stenhouse, 1975; Elliott, 1974; Hustler et al, 1986; McKernan, 1996). Stenhouse (1975) suggested that all teachers

needed to study their work themselves, to become researchers of their own practice. This required teachers to be willing and able to question their own teaching and theories, which underpin it as a basis from which to develop as practitioners. Handscomb and MacBeath (2005: 15) found that teachers researching in their own schools and classrooms have found the process of carrying out the research:

- *encourages practitioners to question, explore and develop their practice;*
- *to be a highly satisfying and energising professional activity;*
- *has become an integral part of continuing professional development.*

The linking of teacher research and professional development helps to define the process of professional development in a growth model rather than a deficit one (Huberman and Guskey, 1995).

Cochran-Smith and Lytle (1993: 27) define teacher research as:

> *Systematic and intentional inquiry about teaching, learning and schooling carried out by teachers in their own school and classroom setting.*

Teacher research is concerned with understanding and improving practice and can be seen as a way for teachers to know their own knowledge (Lytle and Cochran-Smith, 1994). It can generate both local and public knowledge, local knowledge informing their own practice and potentially benefiting the immediate community of teachers, public knowledge for the wider community of educators (Cochran-Smith and Lytle, 1993: 42). The Action Research Project reported in this thesis was designed to generate both kinds of knowledge as the main aim was professional development of all teachers in ARP School but the findings were also disseminated through the Best Practice Research Scholarship (BPRS) website and a National Primary Trust publication (Coates et al, 2003c) for other teachers to utilise in their teaching. Cochran-Smith and Lytle (1992) suggested that research can help teachers to pose questions and identify where their theory and practice show discrepancies. It provides opportunities for teachers to become more reflective and critical of their professional practice. Rudduck (1991) argued that research provides a practical way of seeing beyond what is commonly taken for granted in school life, and seeing 'with new eyes' that look more deeply at phenomena that are normally ignored, and more deeply at the processes underlying the surface observations of classroom life.

There has been a Government drive to promote teaching as an evidence based profession. Such an approach is seen by the Government as a means of improving teaching and raising standards (Marsh et al, 2001). The Green Paper (DfEE, 2000a) emphasised the need for CPD to meet individual teacher needs and suggested that this might happen through teacher

research in partnership with higher education institutions thus working independently or in cooperation with external researchers (Bolan, 2000). The emphasis on evidence-based practice, the greater use of research findings by teachers, and links with teacher research and the professional development of teachers became a significant part of the Government's CPD Strategy (DfES, 2001b). The Green Paper gave birth to the Best Practice Research Scholarship (BPRS) programme which was part of the DfEE Continuing Professional Development Strategy (DfEE, 2000b). Best Practice Research Scholarships were introduced to:

> *enable teachers to undertake classroom-based and sharply focused small scale studies in priority areas, and to apply and disseminate their findings.*
>
> (DfEE, 2000b: 1)

The BPRS scheme was recognised as a useful way of building knowledge and understanding about raising the standards of teaching and learning among those chosen teacher researchers (Bartlett and Burton, 2003: 111). Unfortunately it has now been abandoned as dissemination did not always occur and there was a perception that the DfEE did not see the BPRS programme as cost effective.

The BPRS scheme superseded the Teacher Training Agency's (TTA) Teacher Research Grant Scheme (TTA, 1999). The TTA funded teacher research for a number of years. The research had differing levels of effectiveness which allowed the TTA to identify (TTA, 2000) what they saw as the characteristics of the most effective teacher research. These characteristics are:

- *the research looks at how things are done as well as whether they should be done and does so in relation to pupil outcomes;*
- *the projects contain a wealth of detail of teaching and learning processes in classrooms;*
- *many of them are cumulative; they build effectively on previous projects, moving forward progressively;*
- *the projects start from and try to contribute to what's known already. This shapes methods and analysis rather than being an "add-on"; and,*
- *the projects are steered and supported by colleagues able to combine sympathy and support with challenge and relevant knowledge.*

(TTA, 2000: 10)

If teachers are involved in research, their professional work will be *more effective and satisfying* (Hargreaves, 1998: 1). The earlier ideas of Hitchcock and Hughes (1995: 3) went even further when they state that research is an *essential and important aspect of the teacher's responsibility*. Brause and Mayher (1991) saw practitioner research as a significant

part of a cycle of a teacher's professional development and renewal. McNiff (2002) suggested that research should encourage in teachers a desire to interact with new ideas and develop their independence of mind. The emphasis for school based CPD has been on learning together, learning from the best and learning from what works (Hanscomb, 2003) with teacher research and professional development at much more centre stage than before (Campbell and Jacques, 2004). There was therefore an implicit policy which aimed to promote teaching as a research based profession. This was linked to the Government's concern to raise standards in schools. The underlying aim has been to have a more effective school system, where the product of 'effective' teaching and learning was demonstrated through higher achievements as measured by SAT and GCSE results. The system was thought to be effective when the target number of children attained the expected National Curriculum Levels for their Key Stage or number of GCSE grade Cs or above. This is a rather limited and narrow view of the term 'effective' which seemed to have influenced the Government's perspective on teacher research. This was exemplified by a comment that the research process has been seen by many teachers as a good way of increasing understanding of how to raise standards of teaching and learning (DfES, 2001b). Elliott (1999: 1) has criticised this Government strategy as he suggested that it was not designed to support the empowerment of teachers but was an attempt to *establish an epistemic sovereignty to legitimate its* (the Government's) *interventive policies to drive up standards.* The focus of much classroom and school based research has therefore been on 'what works' rather than 'why' or 'how' it works. There are also suspicions of pressure on teacher researchers to endorse current Government policies such as the Numeracy and Literacy Strategies (Campbell and Jacques, 2004: 76).

A recent report on Continuing Professional Development in Wales commissioned by the General Teaching Council of Wales (Egan and James, 2002) found teachers indicated that research was the least popular form of professional development. As Hanscomb and MacBeath (2005: 16) noted, many teachers remain to be persuaded of the value of research and the notion of being a teacher researcher was considered unhelpful and might be off-putting. This seemed to contrast research carried out with headteachers by the National Foundation for Educational Research (Archer et al, 2003) which indicated that ninety two per cent of them thought participating in educational research was worthwhile. Wilson et al (2003) also found that headteachers and class teachers were enthusiastic about the benefits of engaging in research, particularly for improving learning of pupils. In their evaluation of BPRS, Furlong et al (2003: 40) found that those teachers involved were overwhelmingly positive and enthusiastic about the scheme. It was seen to value their professionalism. Teachers in the Furlong study (Furlong et al, 2003: 40) also thought that that their own research had the capacity to contribute to the development of teaching and learning in their schools and beyond.

2.7 The nature of action research

Action research is often the methodology used for school based teacher inquiry because it aims to give teachers practical methods to develop knowledge from their experiences and to make a contribution to the shared knowledge of the profession (Altrichter et al, 1993). Action research in education can be said to be a process in which the teacher is the main researcher, problem identifier and investigator (Brown and Macatangay, 2002). The nature of action research will therefore, be examined in the next section of this review.

Desirable change and improvement are primary concerns of action research (Carr and Kemmis, 1986). This can be achieved by teacher researchers' own practical actions by reflection on the effects of those actions (Ebbutt, 1985: 156). The teacher researchers in ARP School ultimately wanted to achieve two benefits through their Action Research Project: the improvement of their science teaching, and an improvement in children's performance.

Discussion of the concept of action research in the past has tended to fall into two camps, the British and the American traditions. In the British tradition of action research, there was a view that it was research-oriented to the enhancement of direct practice especially when linked to education (Smith, 1996; 2001). Teachers would be engaged in action research as an emancipatory process. This can be summarised by the definition given by Carr and Kemmis:

> *Action research is simply a form of self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own practice, their understanding of these practices, and the situation in which these practices are carried out.*
>
> (Carr and Kemmis, 1986: 162)

In this model of action research, the researchers are also (some of) the participants. They are insiders using their own site as the focus (Anderson et al, 1994; Bassey, 1995). As action research is concerned both to understand and to change particular situations, external researchers, who are not in or of the situation, are not in a position to do this. They cannot share the informal theory of practitioners and cannot possess the situated knowledge essential for change (Bryant, 1996: 114). In the case of ARP School this was the four teachers who were the insiders who wanted to make science teaching more challenging. The aim was to improve practice through the transformation of the teaching situation. In action research there is a particular kind of relationship between transformation and understanding (Bryant, 1996). Schön explains it as:

> *The practitioner has an interest in transforming the situation from what it is to something he* (sic) *likes better. He* (sic) *also has an interest in understanding the situation, but it is in the service of his* (sic) *interest in change.*
>
> (Schön, 1983: 14)

There is therefore interplay between understanding and change as understanding is oriented by interest in change and the change itself increases understanding (Bryant, 1996). Schön (1983) characterised this process as reflection-in-action and those teachers who were engaged in this were viewed as reflective practitioners. A key feature of the Carr and Kemmis (1986) definition is that action research is closely linked with the notions of reflective practice. If teachers do not have this capacity for reflection, there can be no change in pedagogy brought about by self-reflection (Schön 1983, 1987, 1995). Schön's ideas would seem to indicate that reflective practice and action research are akin to each other and that reflective practitioners are researching their own practice (Bryant, 1996) because they are according to Bryant, freed from established theory and techniques and are able to construct new theory to fit their unique situation (Schön, 1983). Elliott (1991) regarded action research as a part of reflective educational practice. He indicated that action research:

> *... integrates teaching and teacher development, curriculum development and evaluation, research and philosophical reflection, into a unified conception of a reflective educational practice.*
>
> (Elliott, 1991: 54)

When engaged in reflective practice, time is taken to consider one's own teaching. This begins with identification of underlying assumptions and views that motivate how teaching is undertaken. Reflective practice and action research are not, however, viewed by some writers as the same thing (Denscombe, 1999; Shafer, 2000; Pereira, 1999). Action research involves strategic action with a deliberate planned intent to solve a problem (McMahon, 1999). Action research is the examination of the reasons why something is done in teaching by looking for underlying motivations. If we combine this with systematic gathering of triangulated information, rigorous analysis of data, we move from reflective practice to action research (Denscombe, 1999; Shafer, 2000; Pereira, 1999). Research, therefore, can be defined as *systematic critical enquiry made public* (Stenhouse,1984: 77).

The idea of action research that was broadly understood in America in the late 20th century was associated with the social welfare field (Smith, 2001). It was tied to the desire to do good in the world, through direct social action. Action research was seen to be *the systematic collection of information that is designed to bring about social change* (Bogdan and Biklen, 1992: 223). The practitioners gather together evidence to expose injustices or environmental dangers and recommend action for change (Bogdan and Biklen, 1992). The practitioner is

actively involved in the cause for which research is being conducted. The emphasis was on the process rather than the action as in the English tradition.

More recently Reason and Bradbury (2001) have synthesised ideas, from both camps, concerning action research and developed the following definition:

> *Action research is a participatory, democratic process concerned with developing practical knowing in pursuit of worthwhile human purposes ...It seeks to bring together action and reflection, theory and practice, in participation with others, in pursuit of practical solutions to issues of pressing concern...*
>
> (Reason and Bradbury, 2001: 1)

I feel that this definition clearly describes the Action Research Project at ARP School. When action research involves education in schools there are generally two main purposes for the research. Firstly, the improvement of teaching in order to enhance children's learning. Secondly, to improve understanding of the educational situations in which they (the teachers) teach so that they then can become part of the knowledge base of teaching and learning (Carr and Kemmis, 1986). I think that action research could therefore be viewed as a research methodology or approach and not a specific set of research methods (Feldman and Minstrell, 2000; 431).

The purpose of the teachers' research at ARP School was to extend all of the teachers' understanding about how science was being taught, what challenge in science teaching means, confronting teachers with evidence of their practice and then to try to resolve the issue by making the teaching more challenging, particularly for gifted pupils. Stringer outlined the following characteristics of community-based action research:

- *It is democratic, enabling the participation of all people;*
- *It is equitable, acknowledging people's equality of worth;*
- *It is liberating, providing freedom from oppressive, debilitating conditions;*
- *It is life enhancing, enabling the expression of people's full human potential.*

(Stringer, 1999: 9)

2.8 Models of action research

There are many models of an action research cycle (or spiral) (for example: Kemmis, 1981) and researchers (for example, Elliott, 1991) attribute the origins of action research to Lewin (1946). All of the models have similar widely accepted features and related theories around them (Atkinson, 1994).

Action research has a number of key processes; observation, planning, action and reflection (for example: Carr and Kemmis, 1986; Elliott, 1991; McNiff, 1995; Robson, 1999; Zuber-Skerritt, 1995). The action phase is the planned intervention and the heart of the research is to watch the impact of this intervention and to be open to revising it in the light of data being gathered. The cyclical nature and the division into phases are therefore, generally agreed principles of action research (Carr and Kemmis, 1986; Hopkins, 1993; McNiff, 1988). At each stage, there is considerable self-reflection, collaborator reflection and discussion (Borgia and Schuler, 1996). In reality, the process of action research is not quite as neat as this since data collection, analysis, action and implementation might all take place concurrently (Gummesson, 1991).

Ebbutt (1985) indicated that the action research spiral was not appropriate and suggested that it should be changed to a looping back model. The point that he was making is that researchers often have to go back and start again. A spiral will not allow that to happen. Ebbutt viewed action research as a series of successive cycles with the possibility of feedback between them. For McNiff (1988), the problem with the spiral model was that it only deals with one problem at a time. What she proposes is called 'generative action research'. Here the researcher can deal with the many small problems that may arise without taking her/his eye off the main question under investigation. Atkinson (1994: 399) saw the spiral model as *messy and fraught*, particularly for teacher researchers. In the busy life of a teacher, she suggested that *decisions... carefully planned and based on neat hypotheses, are often of necessity made instantly and based on pragmatism.* Waters-Adams (2004) argued that the range of diagrams of the action research process can give a false sense of regularity to teachers. Hopkins (1993) suggested that teachers may become dependent on frameworks in models which could inhibit independent action. What is important and significant to teachers is not the model to be followed, but that the action research is a process which increases their knowledge, which will eventually, it is hoped, lead to a solution to their research question.

2.9 Action research as professional development

Action research has the potential to be turned into a vehicle for effective in-service education and training for practitioners (McKernan, 1996). Hargreaves (1998) goes so far as to state that educational research is the most effective form of continual professional development and Brause and Mayher (1991: 23) describe it as part of the *never ending cycle of professional growth.* Through engagement in practitioner research Sagor (1997: 172) suggested that teachers can develop habits of mind and the discipline of enquiry, become more effective practitioners and more fulfilled educators. Action research can therefore

incorporate both in-service training and reflective practice into professional development (Shafer, 2000). Action research carries with it an intention that teachers should, through research, bring about change (Cervero 1988; Wadsworth, 1998) which is beneficial to others (Dadds and Hart, 2001) or the school (Bassey, 1995) by improving the quality of action within it (Elliott, 1991). Lomax (1990: 10) indicated how teachers' action research can impact on professional development within a school community:

> *...action research is a way of defining and implementing relevant professional development. It is able to harness forms of collaboration and participation that are part of our professional rhetoric but are rarely effective in practice...*[it]*...starts small with a single committed person focusing on his/her practice. It gains momentum through the involvement of others as collaborators. It spreads as individuals reflect on the nature of their participation, and the principle of shared ownership of practice is established. It can result in the formation of a self-critical community: extended professionals in the best sense of the term.*
>
> (Lomax, 1990: 10)

McNiff et al (1996: 8) went further, claiming that:

> *well conducted action research can lead:*
>
> - *to your own personal development;*
> - *to better professional practice;*
> - *to improvements in the institutions in which you work; and,*
> - *to your making a contribution to the good order of society.*

Action research is therefore concerned primarily with improving practice rather than increasing knowledge (Hopkin, 1989; Elliott, 1991) although this would undoubtedly happen. It is concerned with the evaluation of interventions to determine their impact (Gabel, 1995).

One of the characteristics of action research is that practitioners participate in researching their own practice (Ponte, 2005). Action research is, therefore, a form of practitioner research carried out by individuals on and in their own practice, with the objective of professional development (McNiff, 1995). It is research which pursues action (change) linked to research (understanding) at the same time (Dick, 1999; Kemmis and McTaggart, 2000). Action research requires the participants to examine what they do implicitly and perhaps take for granted, and to make this information explicit.

For some writers in the field, action research must be collaborative (Reason and Bradbury, 2001) and involve dialogue with colleagues (Ponte, 2005). It entails group work where the action research of the group is *achieved through the critically examined action of individual group members* (Kemmis and McTaggert, 2000: 6). Others see this collaboration in two forms; with others who have a stake in the problem, or outsiders who have relevant skills and resources (Anderson et al, 1994: 2).

I feel however, that the relevance of distinctions and debates about action research have little real relevance to teachers and agree with Zeichner (1993: 200-201) when he suggested:

> *There has been a lot of debate in the literature about what is and is not action research, about the specifics of the action research spiral, about whether action research must be collaborative or not, about whether it can or should involve outsiders as well as insiders, and so on…a lot of this discourse, although highly informative in an academic sense, is essentially irrelevant to many of those who actually engage in it…*

Action research gives a voice to those teachers involved as it emphasises the importance of the teachers' knowledge. Key features of action research are the production of specific practical changes and the empowerment of those involved. Action research values local advances in practice, no matter how limited. It does not however, condone teachers not being up to date with their professional knowledge.

This thesis however, is concerned with the process of action research and how the teacher researchers perceived action research as a means of professional development for themselves and their teacher colleagues. The thesis will therefore evaluate the process of action research *in an academic sense* (Zeichner, 1993: 200-201).

3.0 Limitations of action research as professional development

Ebbutt in his definition of action research suggested that it should involve *systematic study of attempts to change and improve educational practice* (Ebbutt, 1985: 156). As action research is value-laden and based on practical reflections it might be difficult to carry out a systematic enquiry. The notion that action research is actually 'research' could therefore be challenged (Bryant, 1996). Researching changes in education practice means turning the changes into a field of public inquiry (McNiff, 1988). Action research becomes 'research' when evidence is presented in relation to research questions upon which the public inquiry can feed (Cousins,

2000). The research questions should be linked to changes under investigation and be open to testing by the gathering of rich data. The data should be then subject to scrutiny and the interpretations checked for validity. If enough co-researchers and critical friends agree on the interpretations, the more sound and reliable the data analysis becomes (Cousins, 2000: 4).

Action research is inherently non-reproducible (Feldman and Minstrell, 2000). Teaching situations change, no two classes are the same and it is therefore impossible to control variables in an experimental design. Teachers may be exploring an aspect of teaching, which has inherent strength that it would be unethical to withhold it from a 'control group'. This might suggest that action research does not meet the demands of traditional research. In traditional research methodologies, for example the scientific methodology, there is objectivity in the relationship between the researcher and those being researched. A process that promotes change through action research remains outside the scope of traditional (scientific) methodologies.

Foster (1999) would go even further when arguing that much of the small-scale classroom investigations in which teachers were engaged are not 'research'. He examined TTA funded projects and found that most were relevant to practical applications but were flawed in terms of validity because of their data collection methods and analysis. Gorard found that much of the TTA funded research was descriptive of current practice with conclusions which were *mainly repetitions of previously held opinions* (Gorard, 2000: 382). In their desire to arrive at practical solutions some teachers may overlook the complexity of what they are researching and arrive at solutions which are simplistic and naïve (Pirrie, 2001). This criticism of the validity of action research can be countered by suggesting that it is impossible to access practice without involving the practitioner. Practice is action informed by values and aims which are not fully accessible from the outside (Water-Adams, 2004: 24). Handscomb and MacBeath (2005: 16) characterised teacher research as evidence-informed practice which involved teachers reflecting on their classroom practice, and sharing ideas with colleagues in a climate that promotes challenging discourse. They view 'research' and evidence-informed practice as ends of a continuum in which the two merge. The issue of validity for small-scale teacher research can be improved if a mentor or critical friend challenges and supports teachers in their research activities. This would be part of my role in the Action Research Project. Most teachers involved in action research are trying to develop their understanding or meaning, they are not trying to demonstrate what they have done is applicable in all cases. They are trying to show that what they have learnt is true in the case of their classroom or school (Feldman and Minstrell, 2000). Collecting data which give several views of the same situation will enhance the trustworthiness of action research and move it away from simply being a reinforcement of personal beliefs and justification of practice (Bartlett et al., 2005) to an effective means of professional development. This process is called triangulation and will be discussed in Chapter 3.

Argyris and Schön (1974) argued that people have a mental map with regard to how to act in a situation. This involves the way they plan, implement and review their actions. They go on to suggest that there are two contrasting theories of action; those that are implicit in what we do as practitioners and those on which we speak about to others. The former can be described as theory-in-use and the latter as espoused theory. Whitehead (1989, 1993) has developed a concept of living educational theory in which each of us is a living contradiction of ourselves. This is not unlike Argyris and Schön's 'theory of action' (1974) differing principally in its emphasis upon values. Whilst we may hold dear certain values, these are often negated or denied in practice.

As teachers become more aware of their theory-in-use, they will, hopefully, become more conscious of the contradictions between what they do and what they say they do (Osterman 1990; Schön 1988). The analysis and interpretation of data would allow teacher researchers to become aware of the values that drive their teaching so that they would become clear about what they were doing and why, and thus develop their espoused theory. Through this process, teachers acting as researchers can construct their own living education theory (Leitch and Day, 2000).

The development of theory-in-use has three interlinking components; our underlying beliefs or governing variables; the action strategies which we use, plan and carry out; and the consequences of these actions. In ARP School there was a mismatch between intentions and outcomes and the theory-in-use was disturbed; gifted children were not being sufficiently challenged in science lessons and the teachers wanted to develop their teaching to resolve this problem. Argyris and Schön (1974) suggested that initially many people look for another strategy that will address and work within the governing variables. In other words, given or chosen goals, values, plans and rules are operationalized rather than questioned. According to Argyris and Schön (1974), this is *single-loop learning*. An alternative response is to question the governing variables themselves, to subject them to critical scrutiny. This they describe as *double-loop learning*. Such learning may then lead to an alteration in the governing variables and, thus, a shift in the way in which strategies and consequences are framed (see Figure 2.1). It could be argued that much of the literature cited in this review concerning action research and the education of gifted pupils assumes that the reader agrees with the underlying values and governing variables and as such engages the reader in single-loop learning.

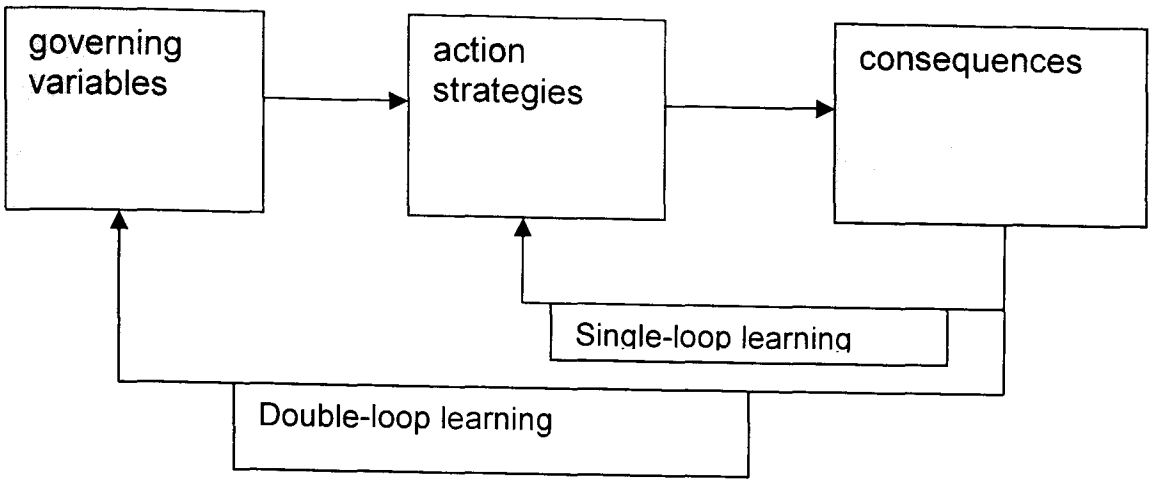

Figure 2.3: Single- and double-loop learning (Smith, 2001)

Single-loop learning seems to be present when goals, values, frameworks and, to a significant extent, strategies are taken for granted. The emphasis is on *'techniques and making techniques more efficient'* (Usher and Bryant: 1989: 87). Any reflection is directed toward making the strategy more effective. It is less risky for the teachers and affords greater control (Argyris, 1982). Double-loop learning, in contrast, *involves questioning the role of the framing and learning systems which underlie actual goals and strategies* (Usher and Bryant: 1989: 87). It is more creative and reflexive and involves the notion of good (Argyris, 1982). Single loop learning has been referred to as lower level learning (Fiol and Lyles, 1985) or learning to cope (Senge, 1990), whereas double loop learning is seen as higher level learning (Fiol and Lyles, 1985) or learning to expand an organization's capability (Senge, 1990). With double loop learning there is likely to be more congruence between teachers' theory-in-use and their espoused theory for gifted children. As there is an emphasis in action research on the process of 'action' there is the real possibility that the professional development will be single-loop learning with no changes to underlying beliefs. Without the transformation of norms and values (governing variable) associated with double loop learning, changes may not be sustainable nor embedded in teaching and teachers' theory-in-use might revert back to the status quo.

Hoyle (1980) differentiated between two types of teachers; restricted professionals and extended professionals. He regarded restricted professionals as conscientious teachers who worked hard in the classroom but had a limited outlook as they were concerned with the practical rather than the theoretical aspects of their work. Extended professionals seek to improve by learning from other teachers and professional development. They constantly question and try to link theory and practice. If the extended model of professionalism is the aim for all teachers, action research could be seen as a natural and important part of professional development (Bartlett, 2002). In the context of ARP School only four teachers wished to engage as teacher researchers in the Action Research Project. This might suggest that their colleagues were restricted professionals when considering changes to their science

teaching to make it more challenging. For them single-loop learning would meet their needs as it would help them to make changes to their classroom practice. Bassey (1998) suggested that action research has a subjective quality in which personal involvement is essential. Judgements concerning the worthwhile nature of innovations are made based on evidence and the values of the teacher (Bartlett and Burton, 2003: 109). The teacher researchers may engage in this way but their colleagues may not. The problem of meeting the needs of scientifically gifted pupils may therefore be solved in a superficial and temporary manner in their colleagues' classrooms (Anderson et al, 1994). The issue for the ARP School Action Research Project is that this may not be detectable as the professional development is due to be finished in a year with no follow up planned in subsequent years.

There are several factors, which apparently make it difficult for teachers to carry out research that fits into the Stenhouse (1984: 77) definition: *systematic critical inquiry made public.* As action research is inquiry into one's own practice the subject and the object of study are the same person. Fielding (2003) indicated that the causal link between professional development and classroom impact was problematic because it is difficult to isolate and control the social variables of a classroom. Flecknoe (2002) suggested that teachers who are willing to engage in professional development are likely to be concerned about improving the teaching and learning in their classrooms. The impact reported could merely be a report of what would have happened anyway (Flecknoe, 2002: 133). Action research however, could be the vehicle which gives a more reliable view of impact because it is concerned with bringing about change in a social situation through participation in cycles of planning, acting, observing and reflecting, thereby creating possibility for change and transformation (Pedretti, 1996; Kemmis and McTaggert, 2000).

One of the problems associated with being a teacher researcher is that the process involves a synthesis of two very different domains, teaching and researching (Atkinson, 1994) each with its own, and often competing set of priorities, expected outcomes and ways of working. This is illustrated in her diagram (Figure 2.2):

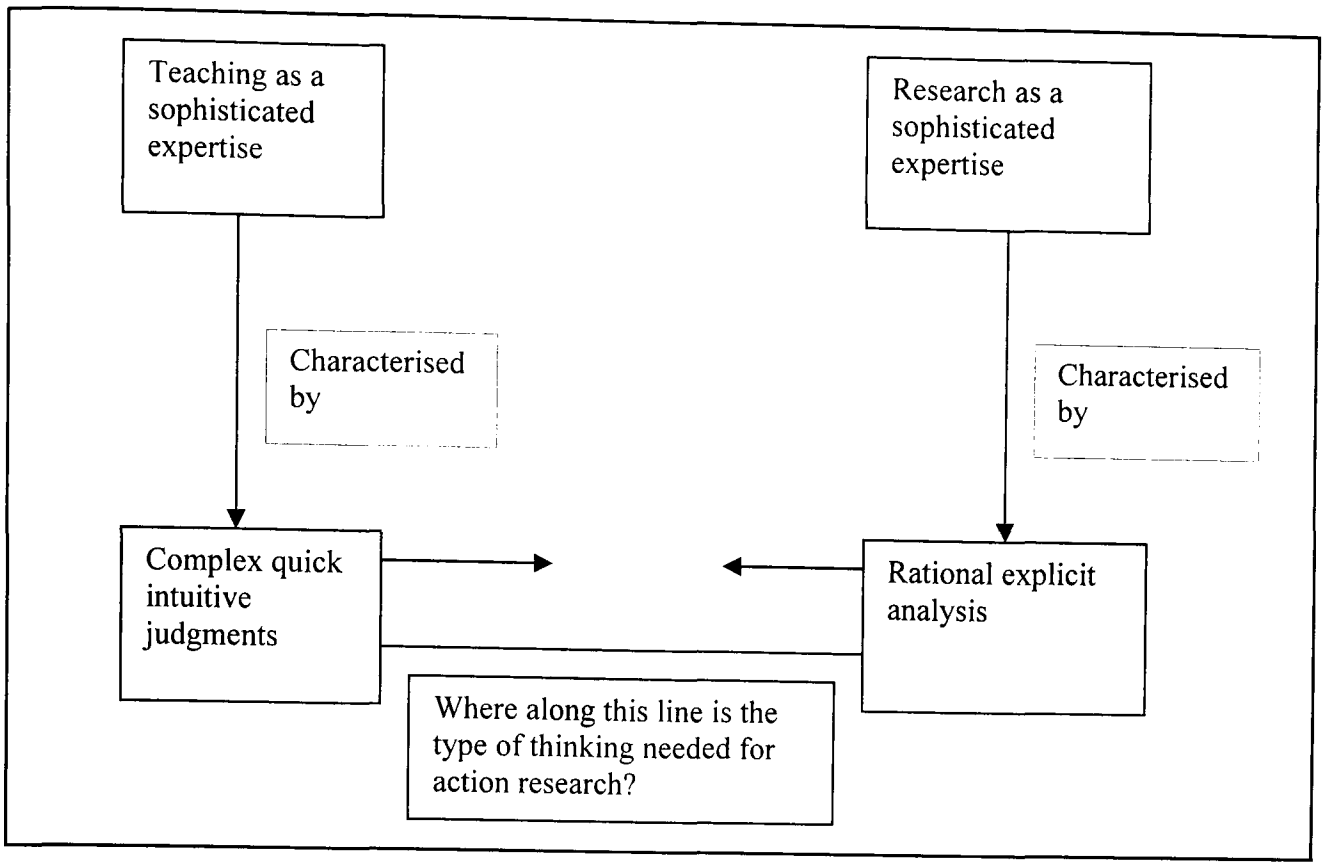

Figure 2.4: The synthesis of teaching and research (Atkinson, 1994: 390)

The roles of teacher and researcher lie within one person in practitioner research and this can obviously cause difficulty to determine where along the line between the two types of thought and actions the teacher researcher is. The type of thinking needed for action research *sits somewhere uncomfortably between the quick intuitive judgments of the teacher and the more rational and explicit analysis of the researcher* (Atkinson,1994: 398). McTaggert et al (1997) also noted that action research was a difficult process for teachers to learn and sustain because of its complexity and lack of congruence with the hectic nature of life in classrooms. Teachers sometimes feel guilty if they have to leave their classes in the hands of a supply teacher. Hargreaves attributes teachers' feelings of guilt partly to *a commitment to care and nurturance* (Hargreaves, 1994: 145). I have similar issues as I am involved in the School Action Research Project as critical friend to the teacher researchers and teacher to all staff as I will be leading staff meetings on science challenges. My role will be that of an outsider (a university lecturer) with specific expertise to support the teachers in their professional development. I will also be in the school to gather data for my own research where my approach will have to be more structured and rigorous. I wanted the teachers to be truthful and not give responses that they think I would want to hear or my research will lack internal validity. I had to resolve these potential difficulties by visiting ARP School on a regular basis so all teachers accepted my presence and felt at ease when providing data for my research. The tensions and how the teacher researchers have resolved any problem associated with their different roles will be one of the features of my research when evaluating the effectiveness of the action research model of professional development and its impact in ARP School.

In the next chapter I will be discussing my research design and its implementation. As my research lies in the qualitative domain the ideas that will be discussed are:

- the nature of qualitative research as a research paradigm;
- case study as an approach to educational research;
- the nature of validity, triangulation and reliability;
- the different forms of evaluation and how they are applicable to my research;
- how I intend to gather data;
- negotiating access to ARP School;
- any ethical issues which may arise; and
- how I intend to analyse and present the data.

Chapter 3

Research Design

3.1 Introduction

This research is an evaluation of the school based Action Research Project 'Making science more challenging for primary children'. The Primary School in this study has thirteen teachers of which four were involved directly in the action research. In this chapter, I seek to justify the qualitative research paradigm that I have adopted to show how this is compatible with an evaluation. In my research, it would be inappropriate to use quantitative methods, as the number of teachers involved is so small, and I wish to find out what they think and feel and to understand their experiences. Hence my focus will be on qualitative methods of data collection. As only one school is involved in the project, I have used a case study approach or strategy. Collection of data is discussed and the methods used linked to the aims of the research and the research questions.

3.2 Qualitative research

This research lies firmly within the qualitative paradigm as it aims to understand experiences as nearly as possible as its participants feel it or live it (Sherman and Webb, 1988). As Becker (1986), noted, it is the study of people doing things together in the places where these things are done. Qualitative research is concerned with descriptions, explanations and theory development (Hammersley, 1992) whereas a quantitative researcher is generally seeking verification or proof of a proposition (Maykut and Morehouse, 1994). What I am not doing, however, is restricting the research to a description of the teachers' perspectives. I hope to achieve descriptions, explanations and theory development in this research. Denzin and Lincoln (2000: 3) give a clear definition of qualitative research, which summarises many of the ideas of other writers:

> *Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, materials practices (sic) that make the world visible… This means that qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret phenomena, in terms of the meanings people bring to them.*

Qualitative research implies that the researcher will be examining the qualities of processes and meanings (Denzin and Lincoln, 2000). In contrast, quantitative research often takes the opposite idea and is concerned with quantities, measured amounts, the analysis of causal relationships (Denzin and Lincoln, 2000), is indirect and abstract and treats experiences as

similar, adding or multiplying them together (Sherman and Webb, 1988). Qualitative researchers are trying to understand a phenomenon in all its complexity and within a particular situation or environment. In the past quantitative researchers tried to eliminate all of the unique aspects of the environment in order to apply the results to the largest possible number of subjects (Maykut and Morehouse, 1994: 13). Qualitative research is rarely replicable and seeks to claim validity from means such as triangulation, reflexivity, rigour of investigation and reporting. The results cannot necessarily be generalised to other situations. It tends to deal with a small number of cases and aims to provide a deeper understanding of social phenomena (Silverman, 2001) rather than the breadth of the large sample as in quantitative research. Where the population under scrutiny is large, probability sampling (Robson, 1999; Denscombe, 1999) is a popular method used to select subjects from the whole population. This sampling method is often used in a quantitative research project. In qualitative research where numbers are small, the subjects would be selected by non-probability sampling (Denscombe, 1999; Anderson et al, 1994). The respondents are selected because of some characteristic (Patton, 1990) with a purpose in mind. In my research, the respondents who were the teachers form a purposive sample (Denscombe, 1999; Robson, 1999). The important aspect of this type of sampling is the criteria used to select the respondents. My sample was the teachers in ARP School some of whom were undertaking the Action Research Project. In my research it was important for me to explore the range and nature of views and experiences of the teachers to enable a detailed exploration of my research questions (National Statistics Office, 2005). It would be inappropriate for me to use quantitative methods as I wished to find out what the teachers thought and felt and to understand their experiences. Hence my focus will be on qualitative methods of data collection.

3.3 Case studies

Case study is one approach to educational research. As Stake (1994) indicated, a case study is driven by interest in what can be learnt from individual cases rather than generalising beyond. A case study is best judged by the extent to which other teachers working in similar situations can make decisions about their own practice based on the evidence presented to them. The relatability of the case study is more important than its generalisability (Bassey, 1981: 85). As Stake (1995) suggested, case studies often provide data which readers can empathise with and relate to their own experiences. This facilitates a greater understanding of the phenomenon. Robson (1999: 5) defined case study as:

> *...a strategy for doing research which involves an empirical investigation of a particular phenomenon within its real life context using multiple sources of evidence.*

In my research, I have investigated the phenomenon of a school-based action research project and its impact on a group of teachers in one school. Data were collected using a number of methods, for example, interviews and questionnaires. For these reasons, I have used a case study approach in this research. As Hitchcock and Hughes (1995) indicated, a case study should focus on groups of actors and their perception. The advantage of a case study approach is that it allows the researcher to *deal with the subtleties and intricacies of complex social situations* (Denscombe, 1999: 39). In my research, the case under investigation is a group of teacher researchers who are hoping to make science teaching more challenging, especially for the gifted children, by the process of Action Research. This is clearly a complex social situation. A case study incorporates a chain of evidence, which allows for different perspectives and opportunities to corroborate findings which enhances the validity of the data (Denscombe, 1999: 85). Here, the chain of evidence involved the teachers' perceptions and ideas as the teacher-researchers carried out the Action Research Project.

3.4 Validity, triangulation and reliability

Case study is regarded as a triangulated research strategy (Tellis, 1997). The process of articulation and triangulation of the findings help to check the analysis for validity and give evidence to support particular explanations (McNiff et. al, 1996; Cohen and Manion, 1994). In research terms, data are internally valid if they reflect the truth and reality of the situation being studied (Denscombe, 1999) and an accurate picture of what is claimed is being described (Hitchcock and Hughes, 1995: 105). Triangulation has its origins in the triangulation techniques used by sailors to determine their location when out at sea. Triangulation in research attempts to explain what is happening by studying the focus of the research from more than one standpoint (Cohen and Manion, 1994). Triangulation can increase the claim to validity of data if similar findings about the same research focus come from different perspectives or from different methods. Triangulation can give some confidence to the interpretation of the meaning of the data. Each method of data collection or account from different actors using the same method will give a *distinct perspective* (Denscombe, 1999: 84) and can be used as a means of comparing and contrasting different views and interpretations, see for example Cohen and Manion, (1994). Triangulation is not without its problems, as Hammersley and Atkinson (1983: 199) point out:

> *One should not adopt a naively 'optimistic' view that the aggregation of data from different sources will unproblematically add up to produce a more complex picture.*

Hammersley and Atkinson (1983) do not suggest that researchers should avoid generating data in a number of ways but point to the issue of deciding which account is correct if there are discrepancies emerging in the data. Data from various sources should not be given

different values or judged to be of greater worth. Tooley and Darby (1998: 43), in their criticism of qualitative research, reported that many articles they had examined showed a *lack of triangulation.* By gathering data from the perspectives of different teacher researchers, I hope to validate my research and avoid this criticism. Triangulation will enhance the explanatory validity (Hitchcock and Hughes, 1995) as analysis of the data will be justified by evidence collected by a variety of methods and/or from different teacher researchers' perspectives. The findings of my research will be taken back to the teacher researchers. They will then be able to verify (or not) my findings. This is a second way to support the validity of the research finding and is called respondent validity (Silverman, 2001). In my research, reliability will come through the development and use of different research instruments (and trialling them before use to try to reduce bias) and, for example, in a similar way to respondent validity, by providing interviewees with a transcript of their interview and an analysis of my conclusions for checking. The teachers will be able to give their perspectives on the data and have clear input into the way the research is progressing. This will mean that *data collection and analysis are intertwined* (Robson, 1999: 18).

3.5 Evaluation

In my research, I will be examining and evaluating both the products of the action research and the process of action research. The aims of the investigation are therefore:

- to examine the success criteria of the action research project and see if they have been met; and'
- to evaluate the effectiveness of action research as a means of professional development and hence school improvement in the context of this project.

Scriven (1991: 139) defined evaluation as *the process of determining the merit, worth, or value of something, or the product of that process.* Evaluation is clearly value-oriented. As Eisner (1985: 4) indicated, without the notion of worth we cannot evaluate anything, we can only test or measure. Value judgements are made at every step of the process; defining the criteria or objectives, collecting data and in particular putting the two together (Harlen, 1994). This research project actually involves both parts of this definition as I am examining both the process and the product of the action research carried out in ARP School. Robson (1999: 170) indicated that evaluation is not a separate research approach but only the purpose of some kind of research:

> *The purpose... is to assess the effects and effectiveness of something, typically some innovation or intervention...*

Qualitative approaches to evaluation merged in the 1970s (Greene, 2000). At first, interpretive philosophies and qualitative approaches were initially contested on both methodological and practical grounds, but qualitative approaches eventually took root (Greene, 2000). Chambers (2000) described this as applied ethnography as it involves making decisions about the possible consequences of the implementation of changes. Fetterman (1984, 1988, and 1994) indicated that it was possible to link a qualitative approach to evaluation when he introduced the concept of ethnographic educational evaluation. Fetterman (1988) also disputed the myth that ethnography is concerned exclusively with the qualitative domain and educational evaluation with the quantitative paradigm and suggested that there was no conflict in linking the two ideas together.

Fetterman (1984) saw ethnographic educational evaluation as a hybrid of ethnography and traditional evaluation. It is the process of applying ethnographic techniques to the concept of educational evaluation. Robson (1999) indicated that ethnography is an exploratory process, which aims to develop a theory about how participants accomplish the various actions taking place in the group. The group that I am concerned with are the teacher researchers, their actions and their action research project. The key elements of the ethnographic educational evaluation approach are the use of key informants (the teacher researchers), informal and semi-structured interviews and triangulation, but the ultimate aim is still associated with evaluation not ethnographies (Fetterman, 1994). The ethnographic method is suitable for a detailed examination of a small group within a complex setting. In my research the teacher researchers involved in the Action Research Project are the 'small group'. Its strength is that it is naturalistic. As a method, it studies groups and individuals in their natural setting which is ARP School. My research is therefore best described as an evaluative case study.

Evaluators do not just claim to know about something, they claim to know how good it is from selected vantage points (Greene, 2000). It is one type of applied research. It highlights issues to do with change. Evaluation is essentially indistinguishable from other research in terms of design, data collection techniques and methods of analysis (Robson, 2000). As most evaluations are concerned with effectiveness and appropriateness of an innovation or programme in a specific setting i.e. a case rather than a sample, it makes case study strategy appropriate for many evaluations (Robson, 1999). Hitchcock and Hughes (1995) state that a case study should focus on a particular actor or groups of actors and their perceptions. The concern is with the rich and vivid description of events within the case.

The Evaluation Research Society (1980) cited in Robson (1999: 177) in America produced a categorization of types of evaluation, which covered the purpose, and the kind of activity stressed in the evaluation.

Table 3.1: Types of evaluation

Type of evaluation	Kind of activity
Front-end analysis (Pre-installation, context, feasibility analysis)	Takes place before programme starts, to provide guidance in its planning and implementation
Evaluability assessment	Assesses feasibility of evaluation approaches and methods
Formative evaluation (developmental, process)	Provides information for programme improvement, modification and management
Impact evaluation (summative, outcome, effectiveness)	Determines programme results and effectiveness, especially for deciding about programme continuation, expansion, reduction, funding
Programme monitoring	Checks for compliance with policy, tracking of services delivered, counting of clients
Evaluation of evaluation (secondary evaluation, meta-evaluation, evaluation audit)	Critique of evaluation reports, re-analysis of data, external reviews of internal evaluations

(Evaluation Research Society, 1980: 3-4 cited in Robson, 1999: 177)

The first part of my research could be described as a secondary evaluation concentrating on the effect, effectiveness and value of the Action Research Project (Evaluation Research Society, 1980 cited in Robson, 1999; Robson, 1999; Robson, 2000) because the focus is on the results and effectiveness of the action research project (see Chapter 2 for a discussion of action research). Action research has a number of key processes; observation, planning, reflection and implementation. Action research for the teacher researchers in ARP School involved them in evaluating the teaching and learning opportunities that were put into place as a result of their action research project to make science more challenging, particularly for gifted children. In my research, I will be evaluating this evaluation. Within this category of secondary evaluation there are more specific evaluative activities, including criterion-referenced evaluation which examines the extent to which specific objectives have been achieved at the desired level of attainment (Robson, 1999: 178). This part of my research fits more into the research design associated with the democratic model of evaluation (Hopkins, 1989) as the teacher researchers will be participating and collaborating in the research. They will be assessing the impact of the action research project, as part of the action research cycle. This will involve an evaluation of data to find out if science teaching has become more challenging. It is intended that the teacher researchers will take control of all aspects of the action research (Robson, 2000) including this crucial evaluation. However, my status as a

lecturer in science education may have an influence on the teacher researchers. The teachers may look to me to validate, justify and corroborate their findings. I will be examining this in the second part of my research (Chapter 5) where I look at the roles of the different stakeholders in the School Action Research Project. My role in the School Action Research Project should be that of a consultant assisting the teacher researchers and not acting as their director. The teachers will be co-researchers acting as partners, all with an active involvement.

The second section of my research, which is an evaluation of an action research project as a model of staff development, takes a more interpretive approach (Greene, 2000). This involved all of the teachers in ARP School who could be assigned to one of two categories:

- the teacher researchers – the four teachers who carried out the action research project and utilised the key processes of observation, planning, reflection and implementation;
- the other nine teachers who were mainly involved in implementing the findings of the action research with some reflection on ideas for challenging science activities developed during the action research project by the four teacher researchers.

I wish to examine how the four teacher researchers experienced the action research strategy. Sherman and Webb (1988) describe this as illuminative evaluation. The focus is on the collection of data from all of the teacher researchers, who undertook the Action Research Project, in order to evaluate the effect of the innovation, in this case, the process of carrying out the Action Research Project. The evaluation will therefore examine the process of action research as a model for staff development (Hitchcock and Hughes, 1995). The research design will be more bureaucratic (Hopkins, 1989) with teacher researchers and other teachers the subject of the research, not co-researchers. The teacher researchers will therefore take a more passive role.

3.6 Collection and selection of data

In order to discuss the collection and selection of data my research questions need to be examined. These are:

1. To what extent were the expected outcomes and success criteria of the action research project achievable within the time scale?
2. How effective is action research as a means of professional development?

In order to come to conclusions about both questions data were collected from multiple sources (Robson, 1999) to give an in-depth insight (see table 3.2).

Table 3.2: Linking research strategy with research questions

Research Activity	Research question
Brainstorming, with TRs using nominal group technique:	
• What is educational research?	2
• What are the advantages/disadvantages of educational research as a means of staff development?	2
• What are the roles of 'insiders' and 'outsiders' in educational research?	2
Interview TRs to examine (Interview 1):	
• their role in the action research project and the roles of other; stakeholders in the research;	2
• the need for the action research project;	1
• tensions or conflicts that have arisen concerning their roles as teachers and researchers.	2
Examine the data from the Action Research Project to see if the success criteria of the project have been met.	1
Interview TRs + OTs to determine if (Interview 2):	
• they perceive that their science teaching has improved/altered during the year and in what ways;	1
• they feel more confident about challenging children in their science teaching;	1
• children have become more motivated and excited by science;	1
• they feel that attainments in science have improved as a result of the action research project;	1
• they are now challenging gifted children in science.	1
Interview TRs to examine (Interview 3):	
• if action research was seen to be an effective means of staff development;	2
• if they have become more reflective practitioners as a result of the Action Research Project;	2
• if any tensions or conflicts have arisen and if they have, have they been successfully resolved;	2
• if perceptions of education research, as an effective means of staff development, have changed during the year;	2
• if any tensions, conflicts or ethical issues have emerged during the research year.	2
Interview TRs to discuss (Interview 4):	
• if the success criteria of the Action Research Project have been met;	1/2
• if the success criteria of the Action Research Project were realistic.	1/2

TR – teacher researchers

OT – other teachers in ARP School

As Denscombe (1999: 39) suggests in his description of qualitative research, the study reported here tries to capture the *complex reality under scrutiny*. Data based on personal

opinion can tend to be unreliable (Anderson et al, 1994) but refinement of research tools and data from different actors can increase consistency and reduce this problem. Collection of data from a range of sources and perspectives allows for triangulation and helps to establish validity (Denscombe, 1999; Anderson et al, 1994) and corroborate findings. As can be seen in Table 3.2, the main source of data used to address the first research question was information from the teacher researchers' Action Research Project (for example Appendix 1 has a timeline for the Action Research Project, Appendix 3 shows a copy of the teacher researchers' lesson observation schedule and Appendix 5 has a blank lesson planning proforma) the dissemination reports they had written and interviews with all of the teachers at ARP School. When working with the teacher researchers to examine the second research question, interviews and nominal group technique (Delbecq, et al, 1975) were designed to elicit their ideas, understanding and perceptions (see Appendix 4 for an example of an interview transcript with one of the teacher researchers). The aim of each of these methods was to determine teachers' and teacher researchers' beliefs and perceptions. Each method therefore had a semi-structured or unstructured format. A criticism of structured data collection methods has been that the data collected suffer from procedural reactivity (Hammersley, 1979). For example, a procedure which used structured questionnaires or interviews to collect data may distort or bias what the teachers in my study believed by giving unintended cues that guide them to give answers that they think I expect. I hoped to avoid procedural reactivity by using semi-structured or unstructured formats. Teachers were given opportunities to respond to questions in detail and depth to 'speak' for themselves with little direction. The objective was to understand what the teachers' perceptions were, to provide answers to my questions as well as reasons for their opinions and not pre-judge what is and is not important information.

If the data to be collected were likely to be uncomplicated and straight-forward (Denscombe, 1999), with little need for me to follow up ideas with prompts I used an open-ended questionnaire. A questionnaire was chosen for initial data collection because it would be relatively easy to contact all of the teaching staff as I visited ARP School on a regular basis to support the teacher researchers and carry out my role as tutor visiting initial teacher training (ITT) students on their school placements. As teachers are very busy with little time to spare this meant they could answer the questions at their leisure. At the initial meeting with the teacher researchers they brainstormed their ideas concerning the nature of education research. I then used nominal group technique (Delbecq, et al, 1975) to examine their perceptions of the advantages and disadvantages of educational research as a means of staff development and the roles of each person involved in the research process. It is initially similar to brainstorming, as it requires the recording of ideas without evaluating them. Ideas are then listed and clarified and finally evaluated and put into an agreed order of significance. The teachers discussed the data, which allowed tentative categorisations to emerge. The

method that I used to gather most data, however, was the interview (see Table 3.2). Interviews were carried out within the natural settings of the teachers' own school (Hitchcock and Hughes, 1995). A number of semi-structured interview schedules were devised. As I was a regular visitor to ARP School and known by all of the staff, I was able to set up time tables to gather data from all of the teachers on some occasions and just the teacher researchers at other times during the school day. A semi-structured interview format was devised because it would give me the opportunity to develop further questions, to probe for details and clarify ideas and issues raised and facilitate and encourage a two-way communication. It would also provide for greater opportunities for probing new or unexpected areas. Questions were carefully selected and trialled with colleagues at Oxford Brookes University and then modified before being used with the interviewees. This procedure was adopted to try to ensure that the research questions could be addressed, and to try to eliminate ambiguity in the questions. I was the only one involved in the carrying out the interviews, which should have reduced the variability in data collection to some extent (Robson, 1999). It has been argued, however, that there is more chance of bias when only one interviewer is involved (Cohen and Manion, 1994). Hammersley and Gomm, (1997) noted that once a particular interpretation, explanation or theory had been developed by a researcher he or she may tend to interpret data in terms of it, be on the look out for data that would confirm it, or even shape the data production process in ways that lead to error. This can arise in research through the questions asked in an interview, or as a result of the *way* they are asked (Oppenheim, 1966). I tried to eliminate this bias by planning the following precautions into the interview process and so improve the reliability of the data:

- I did not discuss the topic of the interview before it started;
- I gave the same explanation to each of the interviewees to try to eliminate other information which might contaminate their responses;
- I tried to develop an atmosphere of rapport and trust;
- I tried to be open minded and relaxed;
- I triangulated the responses by giving transcripts and conclusions back to the interviewees so I and they could check the data.

I found it very difficult to write down responses during an interview and keep the atmosphere relaxed or respond to answers with follow up questions to clarify ideas. For these reasons, and with agreement of the interviewees, I recorded the interviews onto audiotape. This allowed me to check for bias or misinterpretation of responses (Opie, 2004) and eliminate the possibility of perceiving responses that overlooked or distorted the data (Gall et al, 2005) or presenting results that were in line with any of my prejudgements (Hammersley and Gomm, 1997).

3.7 Negotiating access

There were two research projects taking place in ARP School at the same time; the action research project being carried out by the teacher researchers, in which I was involved as mentor and as well as collaborator, and my evaluative research. Both projects involved me in visiting ARP School on a regular basis which meant that I became well known to the staff and was not seen as a total outsider coming in to carry out research on the school. I had organised staff meetings and supported teachers in their development of more challenging science teaching. I hope this informal relationship facilitated trust between the teachers and me and between the teacher researchers and me. At first, I discussed my study with the head teacher going through an outline of what I wished to do. This was then shared with the whole staff. I felt that this approach helped to solve the problem of access. In order for me to carry out my own research I needed the 'gatekeepers' (Denscombe, 1999) not to see me as such an outsider carrying out research on them even though it could be argued that I was actually doing this. It would allow me to get closer to the actors' perspective (Denzin and Lincoln, 2000); to find out what they really thought.

3.8 Ethical issues

Bassey (1995: 15) suggests three ethical values which should underpin research, *respect for the person; respect for the truth: and respect for democratic values*. The first of these basic ethical principles indicates that no harm should come to the participants in a research project (Oppenheim, 1997). This can be achieved by negotiating access with participants and promising confidentiality (McNiff et al, 1996). This could however lead to tensions for the group of teacher researchers in a number of significant ways. They are involved in two very demanding roles, teacher and researcher, which might lead, for example, to conflicts of time and commitment between the education role of the teachers and the research role of the teachers. Some data might be seen to be critical of colleagues, and in a small school setting it is relatively easy for these individuals to be identified. The other teachers, who were not teacher researchers, may even feel they are being judged by the action research. Thus access to data by teacher researchers may lead them to abandoning or watering down some findings to protect the professional life of colleagues and themselves. This, then, potentially brings into conflict Bassey's (1995) first two principles. By telling the truth we may be harming the individual teacher. The strength of action research, however, is that it is designed to make things better (Macintyre, 2000) and that effective change in practice is only possible in co-operation with all the participants (Altrichter et al, 1993). However, in the Primary School under investigation, only four teachers were fully involved in the Action Research Project and the other nine mainly involved in implementing the findings. It was hoped that the Action Research Project would make an impact in all classes and that science will become more challenging for the gifted children in each of these classes. As Stenhouse (1975) indicated,

the control over the changes resulting from the research is in the hands of those who have to implement them. This may go some way to solve the ethical problem for the teacher researchers, and will also be part of my research. (See Research Questions, Section 3.5)

3.9 Analysis and presentation of data

In the analysis phase of the research the emphasis was on interpreting and coding the data by what Arksey and Knight (1999: 163) described as *producing some manageable, systematic guide*. This approach to analysing qualitative data is described by Maykut and Morehouse (1994: 123) as interpretive-descriptive. My concern was to accurately describe what I have understood and to restructure the data into a recognisable reality (Strauss and Corbin, 1990: 20) for the teachers in the ARP School. This approach to data analysis requires some selection and interpretation of data (Maykut and Morehouse, 1994). The data analysis was undertaken by the constant comparative method (Glaser and Strauss, 1967).

The aims of my research were:

- to examine the success criteria of the action research project and see if they have been met; and
- to evaluate the effectiveness of action research as a means of professional development and hence school improvement in the context of this project.

To achieve these aims I had to analyse and interpret data from a number of sources, which included the data from the School Action Research Project and data collected specifically for my research purposes. This was to ensure that my descriptions were grounded in the reality (Denscombe, 1999) of the experiences of the teachers and teacher researchers in ARP School. To do this I had to *treat the evidence fairly and without bias* (Robson, 1999: 372).

There were a number of steps involved in this method of analysis:

1. Interviews were transcribed and returned to interviewees for checking and modification where necessary.
2. Interview transcripts, questionnaires, notes from the nominal group technique session and information from the Action Research Project were read to identify aspects which may be significant.
3. Segments of data from each part of the whole record were clustered together under common themes related to each research question.
4. Once tentative themes or categories emerged, other data were examined and compared to confirm, extend or refine the existing ideas.
5. If data emerged that did not fit into a theme or category a new theme was formed.

6. Refinement of ideas was continuous; initial themes or categories were changed, merged or omitted; new categories were generated, and new relationships discovered (Goertz and LeCompte, 1981 cited in Maykut and Morehouse 1994).
7. Extracts from data were included in the report to contextualise the data. Care was taken to ensure that the views of all of the teachers and teacher researchers were represented equally in order to avoid a particular bias.
8. A composite summary of the *essence of the phenomenon being investigated* (Hycner, 1985: 296) was then written to explore how the findings related to my original research questions.

A brief description of analysed data associated with the different roles of stakeholders in the Action Research Project should illustrate the steps taken in my analysis. Data from the nominal group technique (Delbecq, et al, 1975) session were coded and used to develop tentative categories for the roles of the teacher researchers, the other teachers and myself. These categories were used to develop an interview schedule which was utilised near the start and end of the Action Research Project (see Appendix 4 for transcript of an interview with one of the teacher researchers). This was a process of deductive analysis as I was incorporating and building on earlier theoretical input provided by the nominal group technique session. Once the interviews had been transcribed they were returned to the teacher researchers for checking and amending as necessary. When all of the data had been collected I was able to finalise my category system of roles. I made sure that my categories included every data segment and were mutually exclusive; they were internally homogenous and externally heterogeneous. These categories were then checked by the teacher researchers to ensure that they thought the descriptions and ideas were correct. Once I had an acceptable description of my data categories I could begin the analysis and interpretation to look for meanings, make inferences and show how the data linked to theoretical ideas concerning action research.

A second more complex system for data analysis involved the first part of my research concentrating on the effect, effectiveness and value of the Action Research Project. There were two sources of data for this research; the teacher researchers' own data from their Action Research Project and my interviews with all of the teachers in the school at the end of the Action Research Project. In my role as critical friend to the teacher researchers, I helped them to describe and analyse their data from interviews, questionnaires, observation of teaching (see Appendix 3 for their observation schedule), examination of teachers' planning (see Appendix 5 for the lesson planning proforma), as well as notes from staff and year group meetings. As they were engaged in action research the teacher researchers always had their success criteria as a focus (see Chapter 1, section 1.5) for any analysis. My own research examined the extent to which the expected outcomes and success criteria of the Action Research Project were achieved within the time scale. In order to accomplish this I collected

the teacher researchers' data and their analysis and used this to develop my own interview schedule (see Appendix 2 for interview times). Once these interviews were transcribed, each transcript was given back to the teacher concerned to allow her to amend and change as she felt necessary. This process of triangulating the teacher researchers' data with interview data allowed me to validate the teacher researchers' findings. Again, I was engaged in deductive analysis as I was incorporating and building on the conclusions and analysis carried out by the teacher researchers.

Chapter 4

The effect of the Action Research Project

4.1 Introduction

This chapter describes a secondary evaluation that concentrates on the effect, effectiveness and value of the Action Research Project (Evaluation Research Society, 1980; cited in Robson, 1999; Robson, 2000) which the teacher-researchers carried out in ARP School. Action Research for the teacher researchers in ARP School involved them in evaluating the teaching and learning opportunities that were put into place as a result of their Action Research Project to make science more challenging, particularly for gifted children. Data were derived from all of the teachers in ARP School. The analysis and discussion in this chapter are related to research question 1 and the three sub-questions:

1 To what extent were the expected outcomes and success criteria of the Action Research Project achievable in the time scale?

   1.1 Did the teachers become more confident in their ability to challenge children in their science lessons?
   1.2 Did teachers' planning and teaching include ideas for providing additional challenge particularly for scientifically gifted children?
   1.3 Did pupils develop a more positive attitude to science and feel more challenged?

To facilitate answers to these sub-questions I will now discuss the audit of teachers' perceptions at the start of the Action Research Project, the interventions that the teacher researchers put into place to address any issues that arose during the initial audit, and finally the impact of the interventions. The teacher researcher will be identified as 'TRs' and the teachers 'Ts'.

4.2 Teachers' confidence in their ability to challenge children in science activities

One of the key success criteria of the Action Research Project was an increase in the confidence of teachers to challenge children, particularly the gifted. The teacher researchers felt that other outcomes could only be achieved if this happened. It was therefore decided to interview teachers early in the project to investigate their initial feelings and identify the factors that might affect their confidence. This process was repeated at the end of the project to determine whether or not teachers had become more confident during the year.

Effective teachers of gifted children need to have a good knowledge and understanding of their subject (Maker and Nielson, 1995), and need to be confident when applying this knowledge in the classroom (Education and Employment Committee, 1999). HMI (1992) reviewed the education of gifted pupils and identified a variety of factors associated with these pupils achieving a high standard of work. One of the factors was the teachers' deep understanding of the subject matter they were teaching (see DfEE, 1998b; Harlen, 1997a; Osborne & Simon,1996; Shulman, 1987; Summers, 1994; TTA, 2002). This is not simply to convey information to children but to have the confidence to ask children questions which allow them to reveal, develop and reflect on their ideas. Teachers with relevant scientific understanding can provide relevant sources of information and identify the next steps that will allow children to progress in their own understanding (Harlen, 1996: 335). Alexander et al. (1992) argued that effective teaching depends on the successful combination of knowledge, understanding and skills. When these are combined, they should *provide pupils with maximum opportunity to learn* (Silcock, 1993: 13). Carré (1998) found that many primary teachers do not have a science background and are concerned about knowing 'right answers'. Symington (1980) found that teachers who lacked confidence to teach science tended to use teaching strategies which allowed them to maintain control of the classroom knowledge flow, but which were not appropriate ways of engaging pupils in science. These teachers underplay questioning and discussion and limit practical work to investigations that are very simple (Harlen, 1996; Harlen and Holroyd, 1997). This would mean not giving children the freedom to explore for themselves and possibly arriving at answers that the teacher does not know or understand. Teachers who are enthusiastic about a subject, however, are more likely to recognise the need to challenge gifted pupils (Carlisle and Phillips, 1984 cited in Parson, 2001; Gross Davis, 1993; QCA, 2001a). This has clear implications for the science teaching in ARP School. The teacher researchers hoped to address the lack of confidence amongst the teachers in ARP School by supporting them in the following ways:

- A number of in-service sessions, which I taught, with a focus on challenging the gifted child. Among other ideas, help was given with questioning, grouping for investigations and recording using quantitative and qualitative data and graphs.

- The LEA has a team of science advisors whose role is to support teachers in making their science teaching more effective. The Team visited Key Stage 1 and Key Stage 2 classes to teach demonstration lessons, to give teachers ideas for questioning, challenge, differentiation, and show how different types of resources could be used to stimulate the children.

- The teacher researchers observed teachers, recognised as being effective in science teaching, within other schools. This provided an opportunity for the teacher researchers to discuss planning and observe challenging science being taught.

- An audit of resources was undertaken and advice taken from the LEA Science Advisory Team to look at and order different types of resources, including ICT. Acting on the advice of the Science Advisory Team, the staff looked at New Star Science (Feasey et al., 2001) and following discussion and approval by the head teacher the school purchased the scheme. This scheme was selected as it has clear links with the QCA Schemes of Work (QCA/DfES, 2000), and provided guidance for challenging activities, as well as assessment of children's learning and background information for teachers on the science topic being taught. (The New Star Science Scheme splits the science National Curriculum (DfEE/QCA, 1999a) into units of work, which are appropriate for each year group. The units are arranged so that scientific topics are addressed on a regular basis allowing for progression in children's understanding of the concepts involved.) All of the teachers were asked to trial and evaluate the scheme. The science coordinator highlighted specific aspects of the scheme including progression, assessment and subject information for teachers.

- A new lesson-planning sheet was developed with an enlarged format to allow space for questions, vocabulary and differentiation. Teachers used these to develop and teach more challenging science lessons.

- A number of staff meetings were organised. These focused on discussion, the evaluation of resources, planning, and training needs.

4.2.1 What impact did the interventions have on the teachers' confidence?

At the end of the project, the teacher researchers were convinced that most of the teachers in ARP School felt more confident about their science teaching. This was exemplified by TR1 who noted how her increased confidence had positively impacted on her science teaching. She summarised her thoughts for the year and what she had achieved when she stated:

> *What we're looking for, is to make science interesting, fun and challenging*
>
> (Interview 1: TR1)

The teacher researchers thought that the interventions had therefore been successful and were seen to be directly related to this increased confidence. The introduction of the science

scheme New Star Science (Feasey et al, 2001) and the staff meetings were seen by most teachers to be the most helpful interventions in extending and reinforcing their science knowledge and understanding. The increase in knowledge and understanding had impacted in a positive manner on science teaching which was seen by most teachers to be more challenging. T5 went on to indicate that her science teaching had improved as a direct result of her increased confidence, and T8 made the direct link between an improvement in her confidence and a more challenging approach to her science teaching. T7 suggested that although all of the interventions had helped to increase her confidence, the important message for her was that the interventions clarified and supported ideas that the teachers already had about science teaching. One intervention that was specifically commented on by a number of teachers was the visit from members of the LEA Advisory Team to teach lessons, whilst being observed by class teachers. After watching the lessons, T12 seemed to realise that developing challenging science was not as difficult as she thought:

> *...they did the investigations from shadows, I thought... I could have managed that.*
>
> (Interview 2: T12)

Not all of the teachers were so positive, T1 felt more secure in her teaching but still thought she did not have enough confidence to try out new things and explore different teaching techniques and to increase the level of challenge.

A major outlay for ARP School had been the purchasing of New Star Science (Feasey et al, 2001). It was hoped that this would allow the teachers to implement the 'acting' part of the action research cycle (Lewin, 1946; Kemmis and McTaggert, 2000; Zuber-Skerritt, 1995; see Chapter 2 for a discussion of action research and Appendix 1 which shows the two action research cycles involved in ARP School's Action Research Project). The teacher researchers were particularly interested in the impact this might have had on teachers' confidence. The teacher researchers would be engaged in observing and reflecting; two further aspects of the action research cycle (Lewin, 1946; Kemmis and McTaggert, 2000; Zuber-Skerritt, 1995). Eleven members of staff indicated that New Star Science (Feasey et al, 2001) had helped their confidence to some extent. It was seen to be a source of information for both teachers and pupils and therefore an aid to teachers' subject and pedagogical subject knowledge. T1 summed up the feelings of many of her colleagues on the issue of subject knowledge when she stated:

> *I'm sure some people whose knowledge is good think, 'Why on Earth are they putting this in?' but from my point of view it's very useful.*
>
> (Interview 2: T1)

The Teachers' Guide to New Star Science (Feasey et al, 2001) was seen as a clear source of information for teachers who were unsure about some aspect of scientific knowledge (Interview 2: T2) and gave details of science that teachers needed to know. T12 went on to develop this idea further when she noted that New Star Science (Feasey et al, 2001):

> *...backs up what I thought needed to be covered in that unit and just filled in any gaps and showed how children's knowledge should progress.*
>
> (Interview 2: T12)

The scheme also helped with the organisation of science teaching by giving ideas for teaching activities and through this helped to increase teachers' confidence. Teachers did not tend to use the scheme as a whole but as a basis from which to develop their own ideas to support their teaching, and, in particular, to develop questions that were more challenging. For example, T10 particularly made use of the teachers' guide and skills sheets which dealt with aspects of scientific investigations.

More than half of the teachers indicated that they felt more positive about science at the end of the Action Research Project. TR1 illustrates this when she said:

> *I really enjoy it* (science). *I want the children to get stuck in and get going.*
>
> (Interview 2: TR1)

T5 admitted that she had not been looking forward to teaching some science topics, and thought that she would not enjoy teaching them. But, when she started teaching, she found this was not the case as her new found confidence meant that her teaching had been better than she had anticipated. This positive attitude was reflected in the way teachers now approached their science teaching. T9 exemplified this when she noted that she now read more around topics before teaching them, looked for different resources to support and extend her teaching, and talked more with her colleagues about how to approach the teaching of particular topics. She now felt confident enough to allow children to explore their own ideas, even when she was unsure of the outcome of the science involved. She was happy to say to the children that she was not sure about the science, but would carry out her own research to fill in her knowledge gaps and then feed this back to her class. The teacher researchers were sure that most of the teachers would not have been confident to do this at the start of the Project. T2, however, gave a contrasting view. Lack of subject knowledge in the physical sciences, particularly forces, gravity and friction (what she saw as the harder science topics), was still an issue for her. She was concerned still about children asking questions where her knowledge was *a bit weak* because her answers were not precise nor clear enough (Interview 2: T2). As Traianou (2006: 1) noted subject knowledge is:

a major component of teachers' expertise, one that underpins the ways in which teachers help children to develop understanding of content of science as well as their ability to inquire.

There has been a clear focus on literacy and numeracy in primary schools over the last few years, which the teacher researchers thought had been to the detriment of science. A significant number of teachers suggested that science had become more high profile during the course of the Action Research Project. TR2 thought that the staff meetings had played a major role in this because they gave teachers time to discuss planning, resources, knowledge and understanding and to share good practice. As T1 indicated, the teachers were thinking more, talking more, and *putting more effort into* their science teaching (Interview 2: T1). She concluded that this was one of the major influences on teachers becoming more confident. The research findings in this section would therefore seem to have congruence with findings in the United States which suggested that primary teachers needed regular updates to their content and pedagogical scientific knowledge to enhance children's learning (NARST NEWS, 2001: 1).

This, however, contrasted with TR3 who thought that she was not putting any more effort into her teaching, nor had it change significantly. Rather, she was thinking more about the reasons for teaching in a certain way, and this was influencing the children's learning. This is a clear example of a paradigm shift in the thinking of the teacher researcher. TR3 was engaged in double-loop learning (Argyris and Schön, 1974) as she was questioning her norms, values and underlying beliefs. She was confident that her theory-in-use did not need to change but through the Action Research Project it had become congruent with her espoused theory.

4.3 Teachers' planning and teaching to providing additional challenge particularly for scientifically gifted children

In this section I have examined the teachers' planning and teaching at the end of the Action Research Project to determine if it included ideas for providing additional challenge particularly for scientifically gifted children. As a result of the initial audit, the teacher researchers felt that the following needed to be addressed to develop the science teaching and make it more challenging for scientifically gifted children.

1 Teachers needed to be more flexible with the timetable, blocking time, in order that children could finish experiments and reflect on their work.

2 Teachers needed to spend more time planning, focusing on ways to challenge the children in their class. In order to address the lack of cross-curricular links, different activities were planned incorporating science and literacy. The research team discussed the important elements in planning necessary to improve teaching. A format for an activity planning sheet was developed which included the following elements:

- clear learning objectives;
- key scientific skills and specific science vocabulary associated with the topic to be taught;
- introductions which include more challenging questions;
- space available to record differentiated activities;
- plenary;
- homework if applicable;
- evaluation.

3 Staff meetings and INSET should be organised in order to address issues concerning identification of gifted children in science, differentiation, planning challenging activities, using resources in the classroom and the use of effective questioning.

4 The key issue of time management needed to be resolved. The teacher researchers decided to address this issue by teaching science in larger less frequent blocks of time so that an investigation and other activities could be carried through to a finish in one session. Extra small amounts of time would be utilised to reinforce key concepts or vocabulary. They would also investigate the introduction of science links with other subjects.

4.3.1 What impact did the interventions have on the teachers' planning and teaching?

One of the key aims of the Action Research Project was for teaching to include additional challenge, particularly for scientifically gifted children. This could only be done by differentiation of some sort. At the end of the project, all of the teachers indicated that they were aware of the need to challenge the gifted children, but had applied this to differing degrees in their science teaching. T4 indicated that there had been a real impact on her teaching which she thought was now more challenging, whereas T1 thought she had not changed her teaching style, but she did feel more positive about science teaching.

There was a belief amongst the teachers that scientifically gifted children had the capacity to learn more quickly and at a more complex level than their class mates (Freeman, 1998; Porter, 1999; VanTassel-Baska, 1998) which had influenced their planning and teaching. The teachers thought that science had a higher profile during the Action Research Project as they

were discussing it regularly at staff and team meetings where planning was discussed. Teachers were therefore, spending more time thinking about and planning science activities, which then impacted on their teaching. This is exemplified by T9 who indicated that the Action Research Project had:

> *...made her think about the way she taught science and focus on teaching style and the content being delivered.*
>
> (Interview 2: T 9)

The new activity planning sheet with its seven elements, however, was greeted with a mixed reception. A particular concern from some staff was about the possible amount of time needed to complete it. It was decided that the Key Stage 2 (KS 2) teachers would undertake the initial trial and that there would be further discussion between the teacher researchers and the Key Stage 1 (KS 1) teachers before they started using the sheets. By the end of the Project the science coordinator (TR1) was confident that there was a greater consistency within planning, and that all staff were more confident when considering differentiation and challenge. The different sections of the planning sheet had made teachers think *deeply about the activities which would be more challenging* (Interview 2: TR2) to meet the learning needs of gifted pupils (Van Tassel-Baska, 2000). One of the key changes had been to develop different learning objectives for gifted pupils. (In the past, all groups would have had the same learning objectives.)

The move to make science more challenging for gifted children through questioning seemed to be a major theme that resulted from the new planning sheet. There was change in emphasis to take more time to ask 'What if?' questions and *actually making them think and explain a little bit more* (Interview 2: T9). The majority of teachers realised that much of their questioning in the past had been closed and now they thought it had become more open and challenging. Questioning was sometimes organised in different ways and directed at particular children to probe their ideas and make them think deeply about a topic and require them to *apply information in a different context* (Interview 2: TR2). This meant that *they all need to be thinking* (Interview2: TR1) as anyone might be asked or be expected to explain something.

Questioning was developed for whole-class sessions, as well as to target individuals when they were engaged in practical or other tasks. In whole-class sessions, teachers planned for the use of questions *to structure the introduction of lessons and to challenge and develop children's ideas in the discussions at the end of the sessions* (Interview 2:T2). Questions targeted at individuals allowed teachers to assess a child's understanding of a topic to allow the teacher to move his/her understanding further. Questions were also used to explore children's ideas and perhaps draw out information from the child which they maybe had not

thought of (Interview 2: T1). Targeted questions in whole-class discussions was a strategy used to keep individuals involved and to keep them thinking about the science under discussion (Interview 2: TR3). There seemed to be a move from closed questions to more open questions targeted particularly at the gifted children (Interview 2: T3). The reasons for doing this are clearly explained by TR4 when asked to describe how she challenged gifted children:

> *I am asking the 'What if?' questions and actually making them think and explain a little bit more. Perhaps some of my questioning in the past, without realising, was may be a bit closed. I was looking for an answer, I had got something specific in my mind that I want them to give back to me if you like, whereas now I am perhaps a little bit more open to pushing them to think things through, and putting it into another context too and make it more real for them.*
>
> (Interview 2: TR4)

The development of gifted children's thinking skills was therefore the key aim of the open questioning and this led to a number of different outcomes:

- an expectation of quality thinking in the explanations or answers to the questions;
- the development of science investigations where children had to make decisions about the variables to investigate, how to carry out the investigation, and the conclusions that could be drawn from the data;
- setting tasks where children are asked to apply the knowledge they had gained to new situations;
- grouping children by their responses and planning differentiated work to take forward all children's learning.

Although the staff initially expressed concern with regard to the amount of time required in using the planning sheets, at the end of the project their value was recognised by the majority of teachers. As one teacher said:

> *We have done much more planning in much more detail. What is interesting is, and I would be honest and say I was one of the ones in Key Stage 1 who felt that we didn't need a huge planning sheet ... I have managed to use most of it.... The more you put down in detail the more it makes you gather your thoughts properly.*
>
> (Interview 2: T13)

For a minority of teachers, the activity planning sheet was still an issue at the end of the Action Research Project. It was seen to be one more layer of unnecessary paperwork. It was

thought to be bureaucratic and cumbersome, and a way for outsiders to check on the science teaching. These teachers were spending more time planning their science activities, but as one of the teachers said, she wrote down the key points but not in great detail. In particular, KS1 teachers, who undertake detailed planning for multiple year groups and accommodate two sets of objectives (Foundation Stage and KS1 National Curricular), felt that this would add to their already lengthy planning meetings. (Before a child is five, planning and teaching at ARP School are structured around the non-statutory Foundation Stage Curriculum (DfEE/QCA, 2000c). After a child's fifth birthday they need to be taught the statutory KS1 Curriculum (DfEE/QCA, 1999)). However, each Curriculum had to be planned for as there were children from each stage in the classes. These two curricular have different learning objectives, curriculum emphases and organisation. (Science in the Foundation Stage is taught as part of 'Knowledge and Understanding of the World' but is a discrete subject at KS1.)

Although filling in the new planning sheet was seen as a step too far for some teachers, they were planning more challenging science activities at the end of the project than at the beginning. This is exemplified by T2 who noted:

> *We've just been analysing the structure of the lesson really and the differentiation more than we would have done previously.*
>
> (Interview 2: T2)

There was more use of formative assessment in teachers' planning for challenge which led to the development of extension activities and differentiated tasks for the scientifically gifted. Formative assessment at the start of a topic was undertaken to determine children's understanding of the area of science that is to be taught (Black and Wiliams, 1998; Assessment Reform Group, 2002). If this formative assessment is linked to planning, it should allow all children to make progress in their understanding of science.

If the children understood the science concepts that were being discussed they were *moved on to the next thing* (Interview 2: TR4) or made to apply what they knew to a different context. TR1 justified this by suggesting that:

> *If they* (the gifted children) *have already covered what the majority of the class are covering, if they have done it all before and they have got that understanding then* (the lessons) *all becomes boring and it is that repetition thing, so I think it is appropriate to give them something different.*
>
> (Interview 2: TR1)

A theme that emerged for the Action Research Project was that extension activities were not simply more of the same but were activities that the children would find fun and interesting as

well as challenging. The activities would not achieve their aim if the gifted children were not motivated to push themselves *to develop their thinking further* (TR3) in order to meet the challenge. As she indicated:

> *If it seems like a fun thing or it has an interest to them then yes they will push themselves forward and enjoy doing that.*
>
> (Interview 2: TR3)

Organisation of science was seen to improve during the project. This was clearly linked to the improved planning, both formally and informally, which meant there was more discussion, which focused in on aspects of class management and organisation. Feedback from the teacher research team, staff meetings, and INSET helped all of the staff develop questioning techniques and provided an opportunity for open discussion regarding progression and continuity within the school. For the first time, teachers looked at science topics to examine how concepts should develop throughout the school. This allowed teachers to see where there might be repetition or where they could cover the work at a faster pace because aspects of the topic had been taught in previous years. The primary curriculum can be thought of as a spiral that widens from Year 1 to Year 6 as it is designed to give progressively deeper understanding and greater competence (DES, 1985). This means that children are taught topics, for example electricity, up to three times during their career in a primary school. This has the potential for repetition, lack of continuity and no real progression if teachers do not know what and how a topic has been covered in previous years.

The issue of time and time management had obviously been a key issue for the majority of staff. Addressing this concern was therefore one of the features of the interventions that were trialled. Teachers looked at the allocated time for the science curriculum and decided to block longer periods of time, rather than allocate a set time each week, so that the objectives of the lessons could be achieved more easily. If science is taught in one-hour sessions, some practical science activities will not be completed and will have to be continued at a later date. This can potentially waste time and decrease children's motivation. This flexibility did not necessarily increase the amount of time devoted to science but did mean that teachers thought the time was more efficiently used. Some teachers did teach science for a small amount of extra time for consolidation of work and ideas. This is exemplified by TR3 who stated that:

> *The extra quarter of an hour provided an opportunity to extend their* (gifted children's) *thinking. It provided a visual stimulation, visual reminder, and mental reinforcement of vocabulary with lots of questions. It really motivated the children and there is evidence within the questioning of the children of extension of thinking skills.*
>
> (Interview 2: TR3)

Another teacher (TR2) of older children trialled an extra half hour a week during the Spring Term for consolidation of facts to meet the Standards for the Key Stage 2 Standard Assessment Tests (SATs). TR2 stated that:

> *I really looked at how I could make this half an hour enjoyable yet challenging. The time given to planning was worthwhile as the children really enjoyed these half-hours and consolidated their previous learning.*
>
> (Interview 2: TR2)

TR3 had realised that the time allocated to science was not sufficient to develop challenge, and through that, children's thinking. She therefore was implementing her science teaching with additional quarter-of-an-hour lessons *to back up areas that they have not understood properly, to consolidate ideas or when we have not had time to really talk through the conclusions (*Interview 2: TR3). (In her conversations with T9 she had learnt about the literacy links with science and the quizzes and she intended to develop science quizzes in these short lessons.)

For the majority of teachers, the organisation of science investigations was no longer an issue at the end of the project. It was still seen to be difficult but manageable. Teachers felt confident enough to allow children to explore their own ideas from more open ended tasks rather than the closed teacher directed tasks of previous years. This had a major impact on science investigations where teachers said they were trying to make them more interesting and varied (Interview 2: T3). When the class carry out a science investigation (DfEE/QCA, 1999), T6 had her gifted children dealing with complex variables, continuous rather than categoric, or, in some, more than one variable. (Variables are the factors that need to be managed in an investigation. Continuous variables are measurable, for example, height and time; categoric variables involve simple classifications, for example, eye colour or type of seed.)

Three teachers were still concerned about managing groups carrying out practical work and in particular investigations. These teachers had groups of children engaged in different subject based activities throughout the day. This would mean that different groups of children would be carrying out science tasks during the week. For them the issue was one of logistics. Ideally, they wanted to spend time with each of the science groups to challenge all children's thinking. In reality, this was not the case. Some children had their science time squeezed by other school activities; sometimes the teacher had to deal with other children engaged in other subjects.

Managing a number of groups during science lessons had become less of an issue for the majority of teachers. Teaching had become more group focused with less whole class teaching. This enabled teachers to *focus on the more able* (gifted) *and challenge them* (Interview 2: T3). During science lessons, groups of gifted children could be found in strange places around the school, for example, the cloakroom, carrying out their investigations whilst the teacher talked to the rest of the class. As T12 indicated, *it is really plate spinning* (Interview 2: T12). When questioned further she stated that this meant science teaching to challenge gifted pupils was not without difficulty but was very satisfying when it went well.

Teachers therefore, tried to achieve challenge in their science teaching through the use of ability groupings combined with modification of the standard curriculum. Research evidence suggests that gifted children do need opportunities to work with each other (Education and Employment Committee, 1999). The principle, which underpins this organisation, is part of Vygotsky's (1962) theory of the 'zone of proximal development'. He suggested that children benefit from working in collaboration with more capable peers, but more importantly that the only meaningful learning is that which is in advance of development (Vygotsky, 1962). Ability grouping therefore allows gifted children to be brought together for social and intellectual support (Davis and Rimm, 1998) in a gathering of like minds (Teare, 1997).

Working in groups was seen to have a number of advantages. The children were given autonomy to try out their own ideas, to carry out their own research, and to create displays of their work that they had designed. The teachers thought that group work and less whole class teaching allowed them to carry out more targeted questioning. This facilitated much discussion, and improved assessment of each child's scientific knowledge and understanding. The advantage was that it allowed the teachers time to talk to and challenge individual children as they went around the groups; through these discussions they could make effective assessments. The main impact of this group work on children was to increase enthusiasm for and enjoyment of science amongst the top third of the class. This was particularly noticed by T6 who thought that this was having a positive impact on the achievement of the gifted children in her class.

Giving groups of gifted children different activities did, however, seem to have a down side. Sometimes, the more challenging activities were seen by other children to be much more interesting, particularly practical work. This was an issue because it was thought by the teacher researchers that the less able children did not have the level of understanding, or even basic knowledge, to cope with the challenge of the differentiated activities; they may end up not learning anything at all if they were given them to carry out. All children were not seen to have the same potential or innate ability in science. Gifted children needed opportunities to reach their potential and achieve as highly as possible by being given challenging activities. The concepts within these activities were often too difficult for the rest of the class to

understand. To try to address this, teachers sometimes took the gifted children to another place outside of the classroom to carry out their science activities. However, the issue still arose at plenary sessions when each group told the rest of the class what they had been doing.

The demonstration lessons given by the Science Advisory Teacher clearly gave the impetus to a number of teachers to try out ideas for themselves. As T7 indicated:

> *I always feel, 'good heavens', how can you juggle all these balls even with an LSA* (Learning Support Assistant). *But you know, the way she* (the Advisory Teacher) *did it did help and it is working.*
>
> (Interview 2: T7)

TR3 thought that the organisation of her science teaching had not altered during the project, *I am still putting in as much effort as I did before* (Interview 2: TR3). What had changed for her was that she had become more aware of the reasons why she was doing something. She stated that her focus had changed from her teaching to the children's learning. It would appear that TR3 was challenging scientifically gifted children in her science lessons before the Action Research Project started. The real change for her was to examine the underlying beliefs and values to determine why she did things in a particular way. She had engaged in both reflection-in and reflection- on-action. Other teacher researchers had also engaged in reflection-in-action which had resulted in changes their science teaching, coupled with reflection-on-action which changed their beliefs and ideas about teaching. All of the teacher researchers showed a paradigm shift in their thinking from a focus on teaching to a focus on the children's learning. The teacher researchers had been involved in double-loop learning. This clearly shows how the Action Research Project impacted on the teacher researchers.

A small minority of teachers thought that changing the organisation to allow for more group work had had a negative effect on their science teaching. T2, who was convinced that her teaching had not improved because children were spending more time discussing and talking and less on carrying out practical work, exemplified this viewpoint. The timetable for science was seen to be quite strict, which meant that within the time available, once discussion was complete, she indicated that she only had time for a group or teacher demonstration.

TR2 organised a number of visitors and experts to come into the school, with clearly very positive results. A secondary school teacher of physics and biology attended one half-day a week to teach science skills to a group of gifted Year 6 children. This was seen to be extremely successful by both the teachers and pupils. TR2 indicated that the pupils enjoyed the experience because they were dealing with more challenging ideas, and using more sophisticated equipment, which was not normally associated with the primary science

curriculum. She saw this as a means of challenging the gifted children's thinking and increasing their motivation. She noted that the children said that they looked forward to the morning and really capitalised on their time, writing up their experiments for display and sharing their findings with the rest of the class. TR1 also had expert visitors talking to her children about the Earth and space, and rocks and soil. She was convinced that this increased the children's motivation by making the science more interesting and challenging. I believe that as long as challenge in science is associated with science equipment there is a potential problem for primary schools where there is a limited budget. I suggest that challenge can be achieved in other ways that are manageable by all primary teachers without the need to resort to sophisticated equipment. This is exemplified by the challenge activities developed by the other teacher researchers.

TR4 examined the links between science and literacy, using role play, drama, poetry and story. She found that adopting this cross-curricular, creative approach raised enthusiasm for science within her class and extended scientific thinking by making the children apply their knowledge to everyday situations. TR3 allocated additional periods of time within the day to science. She utilised the time in the format of a quiz; the children were able to develop their own questioning techniques and take more responsibility for their own learning by carrying out their own scientific research prior to acting as quiz masters. TR4 sent groups of her gifted scientists from her Year 4/5 class to work with gifted scientists in the Year 6 class of teacher 6. This resulted in the sharing of their knowledge with the rest of the Year 4/5 class. This was one of the factors which caused a noticeable increase in the children's enthusiasm for science, as noted by TR4.

For logistical reasons associated with the number of pupils in any given year group, most children were taught in classes with two year groups together. In ARP School, science is taught on a two year cycle, which means all children in a particular class are taught the same topic. Thus, in any class there are children with differing scientific abilities, age and experience, and levels of understanding. T12 who had a class of Year 3 and 4 children exemplifies this issue. Within the class, there were children who could not write mixed with others who were above the level in writing expected for children when they leave the primary school. This arrangement therefore brings with it a number of problems for the teacher. With some children, T12 said that she had to repeat things a number of times before a child understood a concept (Interview 2: T12). This was a dilemma for the teacher because children that were gifted could very well have a clear understanding of the concepts under discussion or grasp them after being taught once (Rogers, 1999). Keeping doing the same thing may cause stagnation (Interview 2: T13), boredom or even disruptive behaviour (Interview 2: TR1). T1 had a clear solution to this dilemma; she gave all of the children activities which she thought would be challenging for all of the children in her class at the start

of a topic. She examined their responses and was able to differentiate her teaching to meet the needs of the gifted children who demonstrated mastery. This is an ideal way of operating which other colleagues working in the same planning teams began to use. This was a clear demonstration of identification through provision (Freeman, 1998).

A number of strategies were used to try to overcome this issue of meeting the needs of gifted children. Some teachers used open-ended tasks to allow children to explore ideas to the depth they wished (Interview 2: T3), and/or used the gifted children to support other children in the class to explaining scientific ideas and concepts to the other children (Interview 2: TR1). A number of teachers differentiated tasks with learning objectives that were appropriate for the gifted children working in their own group (Interview 2: TR3). The most common method was the use of questions that challenged children's thinking. This is not surprising as questioning was one of the aspects of teaching that the teacher researchers wanted to focus on and which therefore featured on the new activity planning sheet. Differentiating science to make it challenging for the gifted was not without problems. T1 highlighted the case of one of her children who did not want to be singled out as gifted. She was described as *outstandingly able* and her understanding was way beyond the rest of the children in the class (Interview 2: T1). Unfortunately, the teacher thought she was lazy and did not want to be given activities which would challenge her thinking because this would mean she was on her own working at a science task when other children had finished. This was a dilemma for T1 because she was attempting to give the child opportunities to build on her ability, but the child lacked the motivation to achieve her full potential.

This has clear resonance with the idea that children will not convert their innate ability into achievements without being intrinsically motivated (Gagné, 1991, 1995; Eyre, 1997) or committed to the task (Renzulli, 1995). TR3 taught a class of Year 5 and 6 children. She had a number of children who were gifted scientists but had poor literacy skills. Most of these children could cope with this situation, but one boy was having great difficulties and felt *swamped* by the other children. He was not able to cope in a group of the *most able* (gifted) where he was expected to verbalise exactly *what he should be doing* (Interview 2: TR3). It would seem that this boy came into the group of gifted children who have a learning disability (Porter. 1999). Baum (1989) described this child's type of disability as recognised learning disabled. The results can be low self-esteem plus low achievement (Porter: 1999). Whether to place the boy in a group where he could cope socially, but not be challenged to make the most of his ability, was a quandary for the teacher. Baum et al. (1991) suggested that children who are recognised learning disabled should be allowed to present their work in a non-verbal form or taught in a non-traditional manner. The scientifically gifted boy in question would therefore be challenged during science activities. This might have been the solution to the problem for both the teacher and pupil.

At the end of the project, only one teacher indicated that resources were an issue for her when teaching science. Additional books and materials, including videos and CD Roms, formed the basis of a small library of science resources to enable teachers to obtain ideas for differentiation and different ways of accessing the science curriculum. Purchasing the New Star Science Scheme (Feasey et al, 2001) had been the major financial outlay for ARP School. This scheme examines all aspects of the primary science curriculum. Throughout the life of the project, the scheme had been trialled in all of the classes. At the end of the research project, teachers were asked, by the teacher researchers, how this major resource had influenced their science teaching. One of the main benefits the teachers highlighted was that the scheme gave them a base on which to plan and develop their knowledge and understanding. The data indicated that the scheme had helped to develop the science teaching in ARP School. The areas that the teachers said the scheme had improved included:

- planning more challenging science lessons;
- teaching science lessons which offered more challenge;
- support with more open-ended, challenging questioning in science lessons;
- differentiation for gifted children;
- creating more positive attitudes in children;
- children's attainment in science;
- teachers' ability to assess.

The teachers in KS1 were particularly positive about the big books (Feasey et al, 2001). These acted as a real visual stimulus for the children and created great interest in science. The teaching style was seen by the KS1 teachers to be very appropriate for this age group as the ideas are presented in a visual format. The scheme provided a structured approach for teachers when planning and assessing, and reinforced the need for specific questioning. The assessments built into the scheme at regular intervals had been used effectively by teachers. There was some thought, however, that the scheme might overload the pupils with the same layout of worksheets which could become repetitive and off putting for children. This would then have a negative effect, as the activities would be the same from lesson to lesson (Interview 2: TR1).

4.4 The development of children's attitude towards science

In this section, I will be examining the teacher researchers' third success criteria; pupils would have a more positive attitude towards science and feel more challenged. The teachers saw the need to make the work exciting and stimulating for gifted children lest they could become bored with the science lesson. Gifted children were seen to have knowledge beyond the rest

of the class and knew many of answers to the teachers' questions. This became an issue at times when the class was taught all together, especially at the beginning and end of sessions where they had to sit still. Here the teachers felt that the work was not difficult enough for the gifted children. This has implications for gifted pupils, as lack of interest and motivation could lead to behavioural problems. Again, the issue of the teachers' own knowledge came into play. This was summarised by TR2 who said:

> *My knowledge has to be secure and I have to know what the next stage in the process is really to get them interested, because if it's more of the same thing they know that straight away. Especially for more able* (gifted) *children...*
>
> (Interview 2: TR2)

The classroom environment plays a key factor in transforming gifted children's innate ability into academic performance (Gagné, 1991, 1995). Teachers have a key role in this as they provide activities which motivate gifted children (Eyre, 1997) and support and encourage them to succeed (Freeman, 1991).

The teachers in the research conducted by Eyre et al (2002) believed it was important for gifted children to be challenged to the point where they might risk failure. The teachers in ARP School went on to develop this idea, summarised by T7's comments:

> *You don't push them so far that it becomes hard and it becomes off-putting for them. You want to hit the right spot, I suppose don't you? But you do want it to be exciting. The children want to do it. They want to question. They want to find out for themselves. It's finding out for themselves, and being excited by it... that makes science challenging.*
>
> (Interview 2: T7)

4.4.1 Children's attitudes towards science at the start of the project

The teacher researchers tried to establish children's attitudes to science using a questionnaire with KS 2 children and discussion groups covering the same information with KS 1 children. The teacher researchers analysed their data and established that most KS 1 children had a positive attitude towards science in school, but that there were no specific areas which proved especially popular. The majority of the children in KS 1 looked forward to their science lessons, finding them fun, interesting and challenging. However, there did appear to be a number of gender issues, with more girls not looking forward to their science lessons, boys spending more time carrying out scientific investigations at home, and boys taking part more frequently in discussions involving science. For the most part, the children thought that they worked hard and that their teachers enjoyed teaching science. Science was seen to be part of their lives, as they talked about science at other times of the day and

watched videos about science at home. There was no indication in the data to suggest that pupils associated the science work in ARP School with the science experienced in the children's homes. The teacher researchers however did make this assumption when analysing their data.

As the children moved through KS 2, attitudes towards science altered. Although science was still viewed in a positive way there appeared to be specific aspects of science which were less popular, in particular, forces and materials. Most children in KS 2 still felt science was important to their everyday lives although by the time the children reached Year 6 the emphasis was more on future requirements. Many of the children in KS 2 felt they could work harder and were not being fully challenged.

4.4.2 What impact did the research project have on children's attitudes?

The teacher researchers gathered data through questionnaires at the start and end of their research project. Analysis of these data suggested to the teacher researchers that the interventions which had been put in place had been positive, and that the objective of raising pupils' motivation, enthusiasm and developing positive attitudes towards science had been achieved. The findings can be summarised in the following way:

- More children, in particular girls, looked forward to science.

  ...when it is science they say 'Oh great' so they (the children) *obviously enjoy it far more.*

  (Interview 2: T13)

- There was an increase in the number of children thinking science was interesting.

  They do not get bored in my class.

  (Interview 4: TR3)

- More children perceived that their teachers enjoyed teaching science.

The teachers thought that a number of factors had been involved here but three in particular had made a significant impact. Firstly, the introduction of a wider variety of resources; secondly, different teaching styles; and thirdly, the introduction of a wider variety of tasks. From their observations during science lessons, the teachers thought the children greeted the books in New Star Science (Feasey et al., 2001) with interest and enthusiasm. This they credited to the format and page layouts. There were, however, some criticisms of the scheme, as teachers thought there was a significant amount of repetition of ideas and

worksheets for the children to fill in. T2 suggested that this had caused problems in terms of children's attitudes at the start of the year because she had followed the scheme too rigidly then; now she was more relaxed and flexible in her approach. It was thought that the worksheets in the scheme could get children *bogged down* because some children might lack the literacy skills needed to fill them in (Interview 2: T2). As TR3 indicated, it could be potentially *death by paper work* (Interview 4: TR3). With increased confidence, teachers were replacing these sheets with class discussions, which were viewed by the children in a much more positive way. Repetition of similar ideas and activities in the scheme was a second issue, also identified by TR1, which might affect children's attitudes towards science. This was seen to be a particular issue for the gifted scientists. The teachers realised that there was a need for recapping of some ideas to reinforce children's thinking, but the gifted children did not need to do this as much as other members of the class. For example, children were expected to make model parachutes in Years 4 and Year 6 when investigating forces. The science coordinator (who was TR1) reviewed the scheme to try to eliminate these repetitions. Overall, individual teachers indicated that they thought they had changed their organisation and style of teaching to accommodate the needs of the gifted.

Making science more fun and challenging was the second key factor in increasing interest in science identified by the teacher researchers. As T12 noted, if children are interested they want to learn more (Interview 2: T12). A key factor in this was to make the science more relevant and related to the everyday lives of the children. The majority of teachers achieved this by moving to a style of teaching which was less teacher directed and allowed children more time to explore their own ideas. Children were involved in more practical work and less writing. Two teachers in particular talked about how they now *pulled children up rather than pushed them.* This meant setting activities which would challenge their thinking which would require effort to achieve a solution, and challenging children to the point where they might fail (Eyre et al., 2002), but supporting them if this became a possibility. The activities would be slightly beyond their grasp and require significant effort to master them (Davis and Rimm, 1998). The children would be in their zone of proximal development (Vygotsky, 1962) engaged in activities which had greater depth. It also allowed for the possibility of previously unidentified gifted scientists revealing themselves when engaged in challenging activities (Geake et al, 1996). This was seen by the teachers to be a more effective way to challenge and motivate children and was particularly important for the gifted children who had not been well catered for in the past. T12 discussed how well motivated, organised and conscientious her gifted children were because she believed her teaching had changed to challenge their thinking and ideas.

Teachers talked about activities being *really good* because they were more fun and exciting for the children. This meant that children were more likely to be motivated by the activities, a key aspect in actualising gifted children's innate ability (Gagné, 1991, 1995; Eyre, 1997).

Equally important, the teachers indicated that they were now having more fun teaching science. This meant that the teachers were more likely to repeat this way of teaching. The number of practical tasks and those involving visual images increased as they were seen to be more effective in helping children to learn science concepts. At the start of the year extension tasks were not seen to be motivating for the children, but during the year some teachers thought they had developed tasks which were both interesting and challenging, and which allowed gifted children to push themselves forward and enjoy the experience (Interview 2: TR1). This involved the children in more open-ended investigation and research questions (Teacher 14). As TR4 indicated:

> *If they* (scientifically gifted children) *are challenged, they are involved and more enthusiastic so their approach to the subject has got to be more positive.*
>
> (Interview 4: TR4)

The teacher researchers thought that the introduction of a variety in teaching methods, for example, linking science with literacy, and providing opportunities for consolidation of ideas and vocabulary during the day, enhanced the children's learning and helped raise motivation and enthusiasm.

The issue of boredom was the main reason that TR2 used to justify her use of acceleration rather than broadening the curriculum to challenge gifted pupils. Some children had parents who taught them lots of science. This meant that these children were *very knowledgeable in science* so broadening the curriculum was not enough (Interview 4: TR2). These children needed to be *stretched* beyond the primary curriculum. One child was a particular concern as TR2 thought he could probably pass a GCSE examination in science; he is:

> *...phenomenal in the knowledge and understanding so it has been very difficult to keep him motivated.*
>
> (Interview 4: TR2)

TR2 gave this child work from the Key Stage 3 curriculum to challenge him because, if she did not, he quickly became bored and frustrated.

The attitudes of many Year 6 children however, did not appear to be as positive at the end of the research as at the beginning, which was of real concern to the teachers involved. The second survey was carried out at the same time as the KS2 SATs. The format of the science SATs is two 45 minute examinations. Before these examinations, the Year 6 children spend much time revising and preparing in a formal, less practical way with an emphasis on the learning of facts and science content knowledge. The teachers still had the perception that science is a body of knowledge to be taught in the final year of primary school (Murphy and

Beggs, 2003). The teacher researchers thought this could have influenced Year 6 pupils' attitudes to science in a negative manner. As T3, a Year 6 teacher, indicated:

> *... the KS2 SATs at the moment are content driven. It is necessary to revise in order that the children achieve their potential. However the children can view this as boring.*
>
> (Interview 2: T3)

So, although revision lessons were not greeted with any enthusiasm by the children, the teachers thought they were a necessity. The Parliamentary Office for Science and Technology noted that focusing on the factual content of science:

> *...can leave little time to build on children's interests, engage pupils in discussion on scientific ideas and issues: and teach scientific enquiry.*
>
> (POST, 2003: 2)

The teachers at ARP School were aware of the issues identified by POST (2003) as they had similar concerns. The Year 6 teachers were clearly aware that revision lessons impacted on their teaching style and children's learning. This resonates with ideas expressed in Excellence and Enjoyment: a strategy for primary schools (DfES, 2004a) which indicated that children will learn better when they are excited and engaged. The classroom environment plays a key factor in transforming gifted children's innate ability into academic performance (Gagné, 1991, 1995). Teachers have a key role in this as they provide activities which motivate gifted children (Eyre, 1997) and support and encourage them to succeed (Freeman, 1991). As T3 indicated:

> *it is imperative that different teaching methods are employed to ensure children's interest in science.*
>
> (Interview 2: T3)

Although there seemed to be an underlying belief in this philosophy, the Year 6 teachers still did not feel empowered to teach for challenge throughout the year. Teaching for challenge takes time and would not allow the Year 6 teachers to revise all aspects of the science curriculum. It would have needed a leap of faith for these teachers to continue teaching for challenge, which neither they nor the Headteacher was willing to take, as there was still the imperative that PANDA grades needed to improve. A mid-year survey of children's attitudes

to science might have given different results as the Year 6 children were also engaged in more challenging science activities at that time. The Action Research Project had resulted in improved attitudes to science in the rest of the school as challenge had become an integral part of science teaching throughout the time of the Project.

For some children their perception of challenge remained an issue. Although many felt they worked hard, some felt they could work harder and that they were not being fully challenged. The teacher researchers considered this and thought it could have been a fault of the survey instrument rather than the children's actual perceptions; most children seemed to feel they could work harder in many areas of the curriculum.

4.5 Chapter summary

In answer to the first research question: to what extent were the success criteria of the Action Research Project achievable in the time scale? This question refers to all teachers at ARP School at the end of the Action Research Project. My research indicated a positive response for the following reasons:

- All of the teachers indicated that they felt more confident in their ability to challenge children in science through their own increased knowledge, more structured planning and the use of different types of resources which were purchased as a result of this Project.
- The teachers have sufficient scientific and pedagogical knowledge to deliver a more challenging science curriculum.
- Teachers were adopting a variety of teaching styles and integrating science within other curriculum areas; this had resulted in increased interest and motivation amongst both staff and children.
- The Action Research Project raised the profile of science in ARP School with science becoming one of the focuses for discussion and staff development through the year.
- Differentiation improved with a different format for planning and a more focused approach providing additional challenge for children.
- Teachers recognised the importance of providing opportunities for children to carry out more conceptually challenging investigations. The benefits of this increased reflection and development of more challenging teaching had an impact on the attitudes and enthusiasm of the children.
- Observation of teachers from other schools who were seen to be effective at challenging children in their science teaching was seen as a valuable source of information, ideas and strategies. The value of this was that the teachers who were observed were classroom teachers who laboured under the constraints of everyday teaching.

- Observation of the Science Advisory Team working with classes in the school also proved to be effective in providing ideas for differentiated recording, challenge and classroom management.
- The teachers thought the role of the science coordinator was enhanced, allowing time for reflection and insight into what was happening throughout the whole school.
- By carrying out the Action Research Project the teacher researchers thought they had been able to address important issues in a systematic way which has had a positive impact on professional and curriculum development.

Chapter 5

An evaluation of the process of action research

5.1 Introduction

This chapter presents an evaluation of an action research project conducted by some teachers at ARP School, with a view to developing a model of professional development (Hitchcock and Hughes, 1995), which takes a more interpretive (Greene, 2000) or impact evaluation (Evaluation Research Society, 1980: 3-4) approach. I wished to examine how the teacher researchers experienced the action research strategy. Sherman and Webb (1988) describe this as illuminative evaluation. The focus is on the collection of data from all of the participants in the Action Research Project (see Methodology Chapter 3) in order to evaluate the effect of the innovation (in this case, the process of carrying out the Action Research Project). The research design was more bureaucratic (Hopkins, 1989) with teacher researchers the subject of the research, not co-researchers. The teacher researchers took a more passive role. This research ran in parallel with the teacher researchers' own Action Research Project.

Ainscow (1998) has pointed out, that a research perspective is particularly important in trying to understand the different theories and points of view about, for example, meeting the needs of gifted primary children in science lessons. Action research has the potential to be turned into a vehicle for effective in-service education and training for teachers (Stenhouse, 1975; Elliott, 1974; Hustler et al, 1986; McKernan, 1996; Peters, 2004). As described in Chapter 1, the Best Practice Research Scholarships (DfEE, 2001b) supplied funding for the teacher researchers to carry out the research. Through action research, teachers could investigate their own practice in order to enhance the quality of teaching and learning experiences (Clark, 1997). This funding was mainly used by the teacher researchers to employ supply teachers to cover the classes of the teacher researchers when they were engaged in the research, and thus provide the time for the teacher researchers to carry out research activities. The time provided was used to; visit other schools, visit colleagues' classrooms, *find out what is really going on* (Interview 3: TR1) in science lessons, reflect on their own practice, discuss issues with colleagues, and focus on a specific aspect of teaching and learning through the collection and analysis of their own data. The funding allowed time to *examine what was happening* (Interview 3: TR3). Time allowed them to plan how to make science teaching more challenging and then:

- *Look – building a picture and gathering information.*
- *Think – interpreting and explaining.*
- *Act – resolving issues and ideas.*

(Stringer, 1999: 18)

After completion of the initial action research cycle to determine how challenging science teaching was at the start of the Action Research Project, the teacher researchers planned interventions to try to improve the situation and then complete a second action research cycle (Lewin, 1946; Kemmis and McTaggert, 2000; Zuber-Skerritt, 1995).

Action research can be described as the pursuit of action (or change) and research (or understanding) at the same time (Kemmis and McTaggert, 2000). It is often community based, as in the case of the teacher researchers, and carried out by a practitioner or practitioners in the field (Stringer, 1999: 9); in this project, ARP School. The primary purpose is to produce practical knowledge that is useful to people in the manner in which they conduct of their lives (Reason and Bradbury, 2001). The action research discussed in this thesis began as other action research projects have with a general idea that an improvement or change in the participants' area of work was desirable, i.e., science teaching was not challenging enough. The action research was undertaken because there were concerns about the science teaching which needed to be addressed. Changes to classroom practice were seen by the teacher researchers to be an inevitable part of being a professional (Altrichter et al, 1993). Professional development in this form assumes that teachers are reflective practitioners. A group of interested teachers, who were keen to make the necessary changes to their classroom practice, was formed to clarify this mutual concern. The group then worked together and focused its improvement strategies on making science teaching more challenging (Hart and Bond, 1995; Kemmis and McTaggert, 2000). The characteristics of action research are summarised in the CRASP model developed by Zuber-Skerritt. Action research is:

- ***C**ritical collaborative enquiry by*
- ***R**eflective practitioners being*
- ***A**ccountable and making the results of their enquiry public,*
- ***S**elf-evaluating their practice and engaging in*
- ***P**articipative problem-solving and continuing professional development.*

(Zuber-Skerritt, 1995: 15)

In order to evaluate action research as a means of professional development, a number of research questions were devised (see Chapter 1 for more information). For convenience, these questions are reproduced below:

- To what extent is action research an effective means of professional development?
- How did the teacher-researchers view the roles of different stakeholders in the Action Research Project?

- Are there tensions, conflicts and ethical issues associated with the Action Research Project for the different stakeholders? If there are tensions, how did these arise? How might they be resolved?

5.2 The teacher researchers' thoughts about action research as a means of professional development

This section deals with the research question: To what extent is action research an effective means of professional development? At the end of the Action Research Project, all of the teacher researchers believed that the project could provide a model for professional development beyond the context of ARP School, and the specific focus on science and gifted pupils. The teacher researchers thought that imposed changes were less likely to be effective, or as permanent as changes brought about by staff within ARP School. This evidence is supported by wider research findings, which suggested that some professional development had not met teachers' expectations as the context in which they were working was not taken into account (Clark and Callow, 1998). Action research was, therefore, seen by the teacher researchers as the ideal vehicle for professional development as it allowed them to participate in and go through the action research cycle of planning, acting, observing and reflecting (Lewin, 1946; Kemmis and McTaggert, 2000; Zuber-Skerritt, 1995).

An overarching theme that emerged was that the teacher researchers viewed the Action Research Project as an essential instrument for the implementation of meaningful changes to make science teaching more challenging in their school. The teachers would become more effective (Hargreaves, 1998). There was a clear feeling from all four teachers involved that they were now more than *teachers* and had become *teacher researchers*. This is a rejection of the technical rational view (Schön, 1983; Doerr and Tinto, 2000) of professional development that is operationalised in the research-development-dissemination (RDD) model (Altrichter et al, 1993: 201) and a belief in the reflective rational approach (Schön, 1983). The teacher researchers were challenging the common assumption that knowledge for and about classroom teaching should be firstly generated in a university then used in schools (Brown and Macatangay, 2002). Two of the teacher researchers had been involved in other research projects, which were not action research but fitted into the RDD model. TR2 indicated that she had developed as a researcher, in gathering data, when involved with previous projects but had not been part of the team that developed the theories nor dissemination of the findings. Both teacher researchers thought that action research was the most effective in changing practice of the teachers involved as they could be *more proactive* (Interview 3: TR1) in identifying problems and developing solutions to solve them. TR4 felt more confident in her ability as a researcher and indicated that she would be keen to undertake another research project. She contrasted her experiences of research when she was a literacy coordinator. She talked about being *on the other side* when researchers came into her school to *do*

research with the children (Interview 1: TR4). She had seen the research process in action but was an outsider being researched on. No feedback was given after the research was completed which made TR 4 feel even less positive about education research. Being a teacher researcher was seen to be:

> *... more fun and much more satisfying...it was not just research for the sake of research, it is research for the sake of actually doing something to improve your own practice.*
>
> (Interview 4: TR 4).

This supports the contention that teachers researching their own schools and classrooms have found the process of carrying out the research to be a highly satisfying and energising professional activity (Hargreaves, 1998; Handscomb and MacBeath's, 2005).

There are three assumptions in reflective rationality that the teacher researchers applied to their Action Research Project. These are:

- *Complex practical problems demand specific solutions.*
- *These solutions can be developed only inside the context in which the problem arises and in which the practitioner is a crucial and determining element.*
- *The solutions cannot be successfully applied to other contexts but they can be made accessible to other practitioners as hypotheses to be tested.*

(Altrichter et al, 1993: 202)

The complex problem related to making science more challenging in the context of their own school. I could direct the teacher researchers to theory and practice from my own and others' research but they felt that it was necessary for them to try out ideas for themselves with the children in their school. Through the process of action research, the teacher researchers began to know their own knowledge (Lytle and Cochran-Smith, 1994) as the approach was immediate, direct and relevant to their needs (Day, 1991) and geared to their own practice (Ponte, 2005). This process enabled the teacher researchers to move beyond simply changing their science teaching to reflecting on and changing the underlying beliefs which underpinned their teaching. Two key aspects of traditional research are replicability and generalisability (Robson, 1999). The research is thought to be of good quality if other people can do the same thing with the same results, and if the method and its findings can be generalised to all situations. These criteria are inappropriate for action research as it is not possible nor desirable to aim for replication or generalisation. The teacher researchers carried out the Action Research Project to understand and improve the science teaching in

ARP School. It was this shared learning that led to the construction of their collective knowledge (McNiff et al, 1996). As TR2 indicated:

> *By carrying out the Action Research Project we have been able to address important issues in a systematic way which has had a positive impact on professional and curriculum development.*
>
> (Interview 3: TR2)

Action research by its very nature requires time to implement as it is research into actions which by their very nature were long term. The teacher researchers were hoping to make science more challenging throughout ARP School, to influence practice in all classrooms by the end of the research year. Time could have been given quite independently of the Action Research Project for other forms of staff development but the teacher researchers thought that action research was the most effective means of knowing if they had really made a difference. This was because they could engage in *reflection and improvement based on information they had systematically gathered and analysed* (Ponte, 2005: 278).

The teacher researchers were agreed that, in their view, the action research model adopted was applicable in most curriculum areas and for many issues related to whole-school development. They indicated that there should be more teacher research linked to ARP School's staff development plan to investigate how they could improve teaching in all subjects. This supported the ideas of Hitchcock and Hughes (1995) who thought that it was a part of a teacher's responsibility to carry out research. The teacher researchers were in essence validating the CRASP model (Zuber-Skerritt, 1995) of action research as the most effective means of professional development as it integrates teaching with curriculum development, research and reflective practice (Elliott, 1991).

Enabling groups of teachers to be involved in such projects was thought by the teacher researchers to have the potential for enhancing and enriching the school culture way beyond the specific content area under consideration. The Action Research Project stimulated teacher researchers' interest and gave them ownership of the teaching and learning process. Much of the professional development that the teachers had been involved in previously was simply concerned with classroom practice. The action research project enabled the teacher researchers to think beyond the immediate classroom and examine their ideas and theories about gifted children. This process offered the real possibility of a paradigm shift in the teacher researchers' ideas. The development of the process of reflective practice was seen by the teacher researchers to be a powerful tool for helping teachers improve children's learning. As TR1 indicated:

> *The benefits of taking part in the research project were many; it allowed time for us* (the teacher researchers) *to be reflective in our teaching, and test out new initiatives and interventions.*
>
> (Interview 3: TR1)

The teacher researchers thought that the opportunity to look into an aspect of education in detail and having the time to do this was a very significant feature of their own personal development. This is illustrated by TR3 who stated:

> *It has to be a good thing professionally, because you are actually gaining another skill.*
>
> (Interview 3: TR3)

For TR1, personal development was particularly apparent in the increased status and enhancement of her role as science coordinator. The research had given her the opportunity to have a higher profile in ARP School, and to reflect and gain insight into what was happening throughout the school. The Action Research Project gave a picture of science teaching at the start and end of the Project. She (TR1) could be confident that teaching of science had become more challenging because she had evidence and data to support this. This enhanced status, which was an indirect consequence of the Action Research Project, emerged during staff meetings, year group meetings, the organising of in-service training meetings for the whole staff, and organising observations of colleagues when they were teaching science to their classes. The teacher researchers were, however, conscious that the profile of science, both in terms of children's perceptions and in terms of teacher's enthusiasm, was enhanced more in their classrooms compared with the classrooms of the other teachers. This could be similar to the effect noted by TR4 when 'outsiders' came into her classroom. She did not have ownership of the research and therefore was detached from it. The other teachers in the school had opinions which echoed the idea that research was carried out by outsiders who wanted to influence teachers' practice. This is illustrated by T1 who stated:

> *They* (external researchers) *always try to implement changes too quickly, they do their research and then they want it* (classroom practice) *changed instantly.*
>
> (Interview 2: T1)

Teachers' thoughts and ideas about education research do lend support to Hargreaves' (1998) view that education research is the best form of continual professional development and that it should involve all concerned.

For the teacher researchers, working as part of a team with the same goals in mind was a significant feature of the research. TR3 and 4 particularly enjoyed the concept of being an 'educational researcher' and sharing ideas and disseminating findings at the county's teacher research conference. Even though the teachers found being a teacher researcher challenging, they thought the research had developed them professionally as they had gained confidence to question ideas, which were previously accepted without thinking. As TR4 indicated:

> *I think it* (carrying out research) *is a very valuable thing to do, because it makes you think about your practice in the classroom. Not just with what you are researching, but you actually start to think deeply about a lot of other areas as well.*
>
> (Interview 3: TR4)

The aim of the Action Research Project was professional development of all teachers in ARP School, to make science teaching more challenging. What the teacher researchers wanted was all of their colleagues to reflect on their teaching to examine how challenging it was and then look to develop challenge where it was not apparent. The Action Research Project helped to define the CPD as the development of teachers' practice rather than compensating for teachers' deficiencies (Huberman and Guskey, 1995).

The Action Research Project encompassed the aspects of CPD which the synthesis of research findings indicated would produce positive outcomes (Cordingley et al. 2003; DfES, 2004b); for example:

- The teachers decided on the focus for their CPD.
- There was a sharing of good practice. Staff meetings were organised to discuss and try out methods for challenging gifted scientists.
- External expertise was provided. Members of the Science Advisory Team gave demonstration lessons and the teacher researchers visited other schools to watch teachers who were seen to teach science in a challenging manner. I talked about challenge in science at staff meetings.
- Teachers tried out ideas in their own classrooms and had opportunities to examine their successes and failures at subsequent meetings. This sustained practice in the classroom was necessary for the transfer and incorporation of skills, strategies and curriculum patterns into teachers' active teaching repertoires (Buzzard and Jarvis, 1999) and to decrease the possibility of science teaching returning to the status quo as it was before the Action Research Project started (Desforge, 1995).
- Showers et al (1987) suggest that nearly all teachers need social support and 'follow-up' provided by expert or peer coaches during the transfer process to enable them to sustain their practice. This was provided in two ways, by the teacher researchers

supporting their colleagues, and by my visits to the school to help organise and lead staff meetings and discuss ideas with the teachers.

A key feature of action research is the notion of praxis (Grundy,1995); theory is derived from practice (Elliott, 1991) and involves reflection and self-evaluation (Zuber-Skerritt, 1995; McNiff et al, 1996). This contrasts with the technical rationalist view that sees practice as an application of theories and principles that are known before engaging in the practice (Doerr and Tinto, 2000). According to Schön (1995) action research has its foundation in the rejection of the technical rationalist approach and a valuing of 'knowing-in-action' where professional practice flows smoothly and appears simple to outsiders (Altrichter et al, 1993). The teacher researchers were all experienced and showed the characteristics of this type of professional action:

- thinking and acting were not separate (the teacher researchers taught science lessons skilfully, with fewer problems than most of their colleagues);
- many were unaware of the source of their practical knowledge or how it was learnt.

Before the project started, there was a realisation amongst the teacher researchers that they were not meeting the needs of gifted children in science lessons. This disrupted the smooth flow of routine actions, and the questioning of assumptions about teaching instigated another type of action; reflection-in-action (Schön, 1983, 1987, 1995). The teacher researchers realised that the routines they had developed needed to be changed to make their science teaching more challenging. This reflection occurred within the action of teaching science lessons (thinking and doing are not separated) and led to the rethinking of aspects of the knowing-in-action (Schön, 1983, 1987, 1995). The teachers were trying out new ideas which started the process of generating new understanding and began to change their science teaching (see Chapter 4). As TR1 indicated:

> *Everybody's looked in greater depth at their own teaching of science. They've tried out different things... there has been a lot more discussion about what's going on, and what things we might like to consider to make science more challenging.*
>
> (Interview 4: TR1)

This reflection-in-action would have had an impact on the science teaching but the concern for many teachers was that they did not have the skills or knowledge themselves to really make a significant impact to solve the problems associated with developing more challenging science lessons. Staff meetings, visits to other schools and the purchasing of the science scheme Ginn New Star Science (Feasey, et al, 2001) provided exemplar material to allow teachers to develop the necessary knowledge and skills.

A major part of the Project was time for the teachers to develop the skills and knowledge necessary to challenge gifted children, but more importantly to reflect on their practice and evaluate their teaching (Kinder and Harland, 1991) and its *contribution to children's learning* (DfES, 2004b: 6). This would facilitate the teacher researchers' own reflection-on-action (Schön, 1983, 1987, 1995). This was necessary as the teacher researchers were developing their own knowledge. Time away from teaching gave them the opportunity to distance themselves from action and allowed them to reflect on it away from ARP School context. The teacher researchers were conscious that reflecting-on-action was a slow process which could disturb the smooth running of routines in their classrooms, but it facilitated careful analysis and allowed them to plan the changes they wished to make to their teaching. Reflection-on-action can therefore, make explicit the strategies, assumptions and problems associated with reflection-in-action (Doerr and Tinto, 2000). This allowed them to examine critically the strategies and ideas discussed and introduced during the staff meetings and visits to other schools. This in itself began to generate new problems which once solved created knew knowledge for the teachers. A second key feature of reflection-on-action is that it makes knowledge communicable (Altrichter et al, 1993). The knowledge gained about challenge could be communicated to colleagues in ARP School. It was hoped that through reflection, both on and in action, teachers would solve the problems associated with meeting the needs of able scientists by developing their knowledge-in-action. Challenge would therefore become part of the routine in science lessons (see Chapter 4). The changes to classroom practice for teachers who were not teacher researchers were achieved through single-loop learning. For the teacher researchers there was a paradigm shift as they focused beyond changes to science teaching to the beliefs and values which underpinned the new teaching strategies. They were engaged in double-loop learning as their focus changed from teaching to learning and meeting the needs of scientifically gifted children.

The Action Research Project was seen to be successful because it moved the teachers from the process of knowing-in-action to reflecting-in-action and the teacher researchers to the process of reflecting-on-action, which incorporates all aspects of the CRASP ((Zuber-Skerritt, 1995) model of action research. This reflective process is an integral part of effective CPD (DfES, 2004b). Prior to starting the Action Researcher Project, all of the teacher researchers thought of themselves as reflective practitioners (Schön, 1983, 1987, 1995). This had entailed evaluating their teaching to look for improvements in children's learning (reflecting-in-action). TR4 exemplified this when she indicated that she constantly reflected on what had happened in her classroom during the day to look for improvements or alternative ways of teaching in order to enhance the children's learning. TR3 took this view further as she thought reflection might be influenced or facilitated in different ways through staff meetings, key stage meetings, meetings of subject teams or on a personal level examining *how a*

lesson went and how it could be improved (Interview 3: TR3). She saw the significance of reflection-on-action for improving practice.

For all of the teacher researchers, the project allowed them to move away from the individual system of reflective practice to a more collaborative process of reflection through the action research in a research team. TR2 explained this clearly when she stated:

> *Reflective practice is when you are actually reflecting on your own practice, and then you are improving your own practice. Action research is when you are reflecting on your own and others' practices, and then extending it out to help other teachers in the school.*
>
> (Interview 3: TR2)

This definition clearly has all of the characteristics of the CRASP (Zuber-Skerritt, 1995) model of action research. In order to reflect on their own and others' practice, the teacher researchers had to *bring together action and reflection, theory and practice, in participation with others in pursuit of practical solutions to issues of pressing concern* (Reason and Bradbury, 2001: 1); that is, make science more challenging. The teacher researchers were involved in the action research cycle of looking, thinking and acting (Stringer, 1999).

The systematic gathering and discussion of data was viewed as key factors in the success of the Action Research Project and was seen by the teacher researchers as one of the features which distinguished the two processes, reflective practice and action research. The action research provided *evidence to back up why you are doing something or why you should change your practice* (Interview 3: TR3) – or what the change should be/could be. This evidence or data went beyond the teacher researchers' own classrooms to an examination of what went on in all of the classes in ARP School to find out both teachers' and pupils' perception of challenge in science. Data were gathered at the beginning and end of the Research Project *to see whether the strategies put in place had been successful* (Interview 3: TR2). As TR4 indicated:

> *Action research is looking at what is happening, analysing it, and taking suggestions forward from there, in a process like a cycle. You start from where you are and you place some interventions and then you see where you're going from there.*
>
> (Interview 3: TR4)

This has clear resonance with the concept of the action research cycle of planning, acting, observing and reflecting (Kemmis and McTaggert, 2000; Zuber-Skerritt, 1995).

Action research was viewed as practitioner research with teachers involved in developing their own practice and influencing the practice of colleagues. This would allow them to develop their own teaching and take ownership of the research agenda, which was very important to the team of teacher researchers. They saw the importance of being able to *speak the language, and to be able to know the difficulties and the successes* (Interview 3: TR2) as an essential feature of successful action research. For the teacher researchers, any research project that involved teaching and learning had to involve teachers:

> *...because they are the ones who are teaching every day and developing the children's learning.*
>
> (Interview 4: TR 1).

Whereas reflective practice was seen as a general approach to the improvement of teaching and learning, action research was seen by the teacher researchers as more specific and focused. Action research:

> *...means identifying something that you'd like to find out more about and actively going out and finding out what else there is, and trying to make a difference bringing things, bringing new things to the school, or to the, the subject.*
>
> (Interview 3: TR1)

The teacher researchers had achieved their aim to make science teaching more challenging. In terms of the action research processes, they had brought together action and reflection; *developed practical solutions to issues of pressing concern* (Reason and Bradbury, 2001: 1) and participated in problem-solving and continuing professional development (Zuber-Skerritt, 1995: 15).

TR4 went so far as to indicate that she thought it was not possible to carry out an action research project alone to examine your own practice (Carr and Kemmis, 1986). The teacher researchers thought this would be simply the normal thing that effective teachers would do after teaching a science topic and would therefore be classified as reflection-in-action. This resonates with models of effective CPD where the emphasis was on peer support, working with colleagues and sharing practice (Cordingley et al., 2003; DfES, 2004b).

For TR3 the research involved her in thinking through what she was doing more than she would have been normally. She thought that she was more aware of how she was *challenging the brighter* (gifted) *children* (Interview 4: TR3). This belief is supported by TR2 who used this to help her show how action research developed out of reflective practice:

> *The* (action) *research is going one stage further, it is extending my thinking ...as a teacher, I would be reflecting on most of my lessons in the week. Whereas, as a researcher, I was looking at science and the more able* (gifted) *child.*
>
> (Interview 3: TR2)

Action research involves strategic action with a deliberate planned intent to solve a problem (McMahon, 1999). If we combine this with systematic gathering of triangulated information, rigorous analysis of data, we move from reflective practice to action research (Denscombe, 1999; Shafer, 2000; Pereira, 1999). The teacher researchers did have a real problem to solve and were concerned to triangulate their data. The data allowed them to reflect-on-action in a systematic manner to increase the validity of their findings as they wished to influence science teaching in the whole school. This meant that the teacher researchers were involved in action research not simply reflective practice.

Reflection-on-action is therefore a key feature of the action research cycle and the teacher researchers were convinced that this process was facilitated by being in a research team who could discuss ideas together. As they indicated, it was the sharing and working in a team which actually moved it from the realms of reflective practice and into a process of action research. This again mirrors the notion that participation and dialogue with other colleagues was a necessary feature of action research (for example, Zuber-Skerritt, 1995; Sachs, 1999; Reason and Bradbury 2001; Ponte, 2005). Other writers in the field (for example, McNiff, 1988) however, suggested that individual teachers can engage in action research *through self-reflective enquiry undertaken ... in order to improve the rationality and justice of their own practice* (Carr and Kemmis, 1986; 162). The teacher researchers in this project were adamant that they would not have been successful in developing challenging science activities without the shared process of reflection-on-action. The importance of the group was stressed by TR3 who stated:

> *One of the good things about research is that you are able to discuss and get ideas and then formulate it as a group, not just one, one individual. I think it was a joint effort.*
>
> (Interview 3: TR3)

I feel that the Action Research Project was an example of educational research as it was systematic critical inquiry made public (Stenhouse, 1975). Working as a team helped the teacher researchers to be more systematic and critical in their data analysis and through triangulation increased the validity and reliability of their findings. A teacher working on her/his own could carry out an action research project but I feel they would have to have had experience of other research projects before they could attempt this.

Working as a group allowed the research to have a greater depth by focusing on the whole school. As the teacher researchers indicated, working alone within the time scale would mean the research might not be so wide-ranging as it would only be able to focus on the teacher's own class or year group. It was thought that one teacher researcher would have much less impact on her colleagues and the aim of the Action Research Project, to make science teaching more challenging across the school, would not be achieved. The Project would not have been effective professional development for the whole staff of ARP School. For the teacher researchers, teamwork allowed them to move from being reflective practitioners who were examining their own classroom practice through reflection-in-action, to action researchers investigating science teaching in the whole school through both reflection-in-action and reflection-on-action. To summarise, it was thought that working alone would not have *helped the school as much* (Interview 3: TR4) and would not have had the same impact and would therefore be less effective professional development.

Reflection and discussion within the group was seen as an integral part of their research (Interview 3: TR1). As TR2 indicated, it allowed them to *see the wider picture* (Interview 3: TR2) beyond what went on in their own classrooms. This was significant because the aim of the Action Research Project was to make science teaching more challenging in all classrooms, not just those of the teacher researchers. For the teacher researchers *seeing the wider picture* meant working through the action research cycle twice during the lifetime of the Project to eventually gather data which would indicate if the interventions they had put into place had been successful, and science had become more challenging throughout ARP School.

The Action Research Project achieved its aim in ARP School as the success criteria were met (see Chapter 4). The teacher researchers thought the Action Research Project was effective CPD for all of the teachers in ARP School. An analysis of the Action Research Project showed that it incorporated the factors which are associated with effective CPD (DfES, 2004b) that were established by the Evidence for Policy and Practice Information and Coordinating Centre review (Cordingley et al, 2003). Action research is therefore an effective form of professional development as it has the potential to change not only classroom practice but also the fundamental values and principles which underpin this practice. Action research has the potential to change teachers' theories about how children learn and through this have a long term impact on the children in their care.

5.3 The roles of the different stakeholders in the Action Research Project

This section relates to research question: How did the teacher-researchers view the roles of different stakeholders in the Action Research Project? The stakeholders that were discussed

were myself, the teacher researchers, and the other teachers in the school. Data were gathered from the teacher researchers at the beginning of the Action Research Project to determine the roles of the different stakeholders. At the end of the Action Research Project, the teacher researchers were interviewed to determine how the initial ideas about the roles of different stakeholders might have developed.

All of the teachers in ARP School had a role in the development of challenge in their science teaching. Only the teacher researchers however, would be involved in a self-reflective spiral of planning, doing, analysing and re-planning (Clark, 1997) where they examined what they did implicitly and perhaps took for granted, and made this information explicit. It was the teacher researchers who had ownership of the research, who developed the research plans, decided on which interventions should be put into place and were intimately involved in gathering data to build up a picture of what was happening in science lessons, interpreting and explaining what the data meant, and resolving issues as they emerged (Stringer, 1999: 18).

The teacher researchers made it very clear that they were the only ones who were researchers; the other teachers had various roles in supporting this. The other teachers, who were pro-active within their own classrooms, were seen to be active reflective practitioners but not teacher researchers. The teacher researchers, who were pro-active within the whole school, thought that their role was a much more active one in developing challenging activities compared with their colleagues. TR1 exemplified this when she suggested:

> *They* (the other teachers) *are supporting our research by co-operating and being willing to talk with us openly…they have been quite open to supporting the research.*
> (Interview 1: TR1)

Other roles were not directly associated with being a researcher per se but were concerned with the situation in the school where four teachers acting as a researcher team were trying to change the practice of the whole teaching staff. They were keen not to be seen as experts in the field of science education but colleagues who were interested in taking a more direct part in the Action Research Project. The teacher researchers were keen to keep their colleagues informed at every step of the research process. The group dynamics allowed the teacher researchers to share and evaluate ideas in a more effective way, share expertise, and through this develop *a better project* (Interview 3: TR3). On a more mundane level, they thought that working as a team was less stressful.

The teacher researchers met regularly to decide the timetable for the research and the interventions that they instigated. My role was to act as a critical friend to help the teacher

researchers to 'look' and 'think'. The teacher researchers did however, think that the group had become more dynamic and self-sufficient as the research progressed. As TR3 indicated:

> *We worked very closely together. There was lively interchange of ideas with different people taking the lead on aspects of the research for which they had particular skills or aptitude.*
>
> (Interview 3: TR3)

The teacher researchers were engaged with all three elements of the Stringer (1999) model whereas all of the other teachers in ARP School were only involved in acting to resolve issues and ideas. During a brainstorming session, at the start of the Action Research Project, the teacher researchers set out the roles they thought each of the stakeholders would assume.

All of the teachers, including the teacher researchers would be:

- Learners;
- Reflectors;
- Open to change;
- Implementers of change;
- Providers of information;
- Open to scrutiny.

By taking on these roles, they would be involved with the components of effective CPD (DfES, 2004b).

All of the teachers in ARP School would need to take on these roles as the Action Research Project aimed to make all of the science teaching in the school more challenging. As TR1 indicated, the Action Research Project:

> *...gave an answer for the whole school...science was an area of weakness, we were taking that on and we were deciding what to do about it.*
>
> (Interview 3: TR1)

An understanding of challenge in primary science and how to implement this was therefore a key element in the roles of all teaching staff. The list also implied that all teachers would be open to the idea of changing their teaching and being trained how to do this. Indeed one of the key factors that the teacher researchers thought contributed to the success of the Action

Research Project was the co-operation and willingness to talk openly and reflectively which the other teachers demonstrated. As TR4 noted, the initial 'look' highlighted areas that needed to be improved. TR3 even noted that her colleagues were willing to *take on board unpalatable stuff* (Interview 3: TR3). They were willing to admit that some of their teaching was not challenging and needed to be improved, and sometimes they were *getting things wrong* (Interview 3: TR3). There was therefore a readiness to implement changes to classroom practice amongst most teachers by trialling new teaching methods and ideas. Some of the changes were, however, first trialled in the teacher researchers' classrooms; for example, the use of stories, plays and poems by TR4. The impact of these was analysed and fed back to the rest of the staff. Some teachers did have worries and concerns (see Chapter 4) but these seemed to have been mainly overcome by the end of the Action Research Project. There were times when the teacher researchers *made mistakes because they were learning about research* (Interview 3: TR1). This meant the rest of the teachers had to be patient and supportive of the research team particularly when they were out of their classrooms carrying out the research.

For the teacher researchers to instigate the 'look' element of Stringer's (1999) model, the teacher researchers had to gather information and data from all teachers and their children through interviews, surveys and classroom observations. Teachers in England have their classroom practice scrutinised on a regular basis by both external and internal agencies. For example, TR2 gathered data annually in her role as assessment coordinator and OFSTED inspectors are required to observe teaching, so it was hoped that the research would be viewed simply as an extension of this process. There was therefore an assumption that all of the teachers would be open to the prospect of having their teaching examined to determine how effective they were at teaching science in a challenging manner. At first, some teachers were unwilling to talk about their planning and were reluctant to allow a teacher researcher to observe their teaching but they eventually became more relaxed and supported the research to a lesser or fuller extent as all were keen to make their science teaching more challenging. This was because there was a realisation that the research would help them to improve their science teaching. As TR1 said, the research *gave an answer* (Interview 3: TR1) for the whole school. The teacher researchers saw support as an integral feature in the success of the Action Research Project. This support was a multifaceted process. By the end of the Project, the other teachers became more important in a non-research way as, in the minds of the teacher researchers, they offered support to the research team and helped them to remain focused and *moving forward* (Interview 3: TR3) to meet the time scale for finishing the research within the academic year. The other teachers were supported in various ways to develop more challenging science activities. Interviews and less formal discussions also helped all of the teachers to move from the processes of knowing-in-action to reflecting-in-action. They were not left there on their own, and knew they could count on the support of the research team. The teacher researchers also supported each other to carry out all aspects of

the research and keep each other motivated and on track to complete the research. To be effective, the Project needed, and had in place, teacher researchers who were:

- *Committed to systematic questioning of their own teaching;*
- *Committed to the study of their own teaching;*
- *Concerned to question and test theory in practice.*

(Stenhouse, 1975; 143)

The list of roles associated with being a teacher researcher is obviously longer and more complex compared with the list for the other teachers in the school. This was because the teacher researchers were insiders in the Action Research Project and were engaged directly in gathering and analysing data (Stringer, 1999: 18); looking to build a picture and thinking to interpret and explain. They were engaged in self-reflection, collaborator reflection and discussion (Borgia and Schuler, 1996).

The roles the teacher researchers associated with acting as a researcher included:

- Data gatherers;
- Data analysers;
- Thinkers and reflectors;
- Planners of a way forward;
- Disseminators of information.

The teacher researchers were the main researchers, problem identifiers and investigators (Brown and Macatangay, 2002) who would be reflecting on information they had systematically gathered and analysed (Ponte, 2005: 278). They indicated that they would be engaged in all aspects of the action research cycle; planning, acting, observing and reflecting (see Table 5.1), but in reality, they found the process of action research was not quite as neat as this because on some occasions all aspects took place concurrently (Gummesson, 1991).

Table 5.1: Links between the action research cycle and teacher researchers' descriptions of their roles in the Action Research Project

Research cycle activity	Teacher researchers' description
Planning	Planners of a way forward
Acting	Learners Reflectors Open to change Implementers of change Providers of information Open to scrutiny Dissemination of information
Observing	Data gatherers
Reflecting	Data analysers Thinkers and reflectors

TR1 summarised the role that the teacher researchers had as gatherers of data when she indicated that they would have to:

> *... find out what is happening at the moment in our school. To find out where we are. To find out where we need to go. To find out what is happening in other schools and put some suggestions forward to improve standards in our own school.*
>
> (Interview 1: TR1)

Once the data had been collected, the teacher researchers worked as a team to analyse and interpret the findings to determine the implications for the project and for ARP School. As there were four teacher researchers, they could each examine the data and bring their own thinking and ideas to the discussions. As the project progressed, different teacher researchers took the lead in the gathering and the initial analysis of specific data; for example, TR4 was very interested in children's attitudes to science so she took the lead is this aspect of their research. After the initial analysis, the whole team would meet to continue the process of analysis and interpretation. This was a form of triangulation which validated the teacher researchers' conclusions.

For the teacher researchers, thinking and reflecting on data was one of the keys to the success of the Action Research Project. This was seen to be a very active role where heated discussions and questioning of other's assumptions and ideas was the norm. This was viewed as a positive process which could only benefit the Action Research Project as it was expected that increased reflection and challenge of assumption would eventually impact in a positive manner on classroom teaching. The teacher researchers were engaged in a form of internal triangulation of their data to increase the validity of their conclusions. TR3 went so far as to say she could be quite *belligerent and antagonistic* in her challenging of other teacher researchers' *thoughts and ideas* (Interview 3: TR3). The teacher researchers did not simply accept ideas but were keen to question and discuss them in detail as in the past it was thought that colleagues had been less willing to share and discuss ideas. Again, working as a team was seen to enhance this reflective, questioning aspect of their role because the discussions allowed them to clarify and refine their ideas.

At the start of the Action Research Project, the teacher researchers needed clear guidance about how to proceed and develop all aspects of their research. As they became more confident and assured, they needed less support from me as they were able to wholly take over the *decision-making and planning* (Interview 3: TR1) to move the research forward to achieve their aims. They felt that this was a change from a passive to a more active role with them in control of the research agenda. This was seen to be a natural, inevitable progression as they became more confident in *what they were doing and where they wanted to go* (Interview 3: TR4) and took on the role of researchers. Again, the team of four was seen to be significant in the pace of this development. The mutual support they could offer allowed the teacher researchers to take over and plan how the research would progress.

5.3.1 The teacher researchers' perceptions of my role as a stakeholder in the Action Research Project

One distinctive element of this project was my role as an external mentor. The aim was to give the chance for all aspects of the research to be seen in a more objective way. This is often quite difficult in a relatively small institution like a primary school where the focus involves insider researchers. I saw my role as the provider of a more sound theoretical base to help teacher researchers to build on teaching which is often approached very pragmatically. I was to offer the external expertise necessary for effective CPD (Cordingley et al., 2003; DfES, 2004b). My involvement hopefully eased the transition from being a reflective practitioner to being a teacher researcher who bases her conclusions on systematically gathered data and evidence. My ultimate aim was to act as 'critical friends' to the teacher researchers. Costa and Killick (1993: 50) offered the following definition of a critical friend as:

> *A trusted person who asks provocative questions… takes time to fully understand the context of the work presented and the outcomes that the person or group is working towards… an advocate for the success of that work.*

This definition contains four elements commonly understood as central to the role (MacBeath et al, 2000; Doherty et al, 2001) which I hoped to put into place during my time with the teacher researchers. These are that the critical friend should:

- Be trustworthy;
- Ask demanding and pertinent questions;
- Find out about the school;
- Actively support its development.

One further element is also acknowledged as being crucial to the role of critical friend, that of providing: *An outside perspective, a reference point and connection with a wider field of knowledge* (MacBeath et al, 2000: 158). As I had carried out research and development in the field of science education and the development of challenging science activities for primary aged children I felt able to take on this role.

At the start of their Action Research Project, what was of paramount importance to the teacher researchers was my expertise in research methods and tools, and knowledge of how to develop challenge in science for gifted children. As the research developed through the aspects of the action research cycle, my role as a critical friend became more pertinent. I interviewed the teacher researchers to gather data relating to their thoughts about my role in their Action Research Project. There was obviously a danger of researcher bias through the use of leading questions is this aspect of my research as I was essentially the research instrument (Denzin and Lincoln, 2000: 368) asking questions about myself. I was very careful to treat the interviews as a two way communication to try to set the teacher researchers at ease. During the interviews, I engaged in member checking (Creswell and Miller, 2000) by restating and summarising information received from the teachers. After the interviews were transcribed the teacher researchers were sent transcripts which they could examine critically and change where they wished. I feel that member checking (Creswell and Miller, 2000) meant that the teacher researchers' comments about my role were what they actually thought.

Data gathered from interviews indicated that the teacher researchers thought that my role was to act as a support in two distinct ways, one associated with carrying out the process of action research and secondly to act in a more personal effective manner if and when issues or problems arose. The lists were:

- Supporting the process of action research
    - Leader;
    - Focuser;
    - Organiser;
    - Keeper on task.

- Personal support to carry out the action research
    - Advisor;
    - Calmer;
    - Encourager;
    - Being positive.

When I interviewed the teacher researchers at the end of their Action Research Project, it was still possible to identify these two aspects of my role in the teacher researchers' comments. Interestingly, in models of effective CPD the emphasis is on peer support rather than on leadership by a supervisor (Cordingley et al., 2003; DfES, 2004b). Taking on the role as a leader at the start of the Action Research Project was not surprising as the teacher researchers were not too confident about carrying out research activities. As expected, however, my role as leader was seen to be less important as the research developed during the lifetime of the Project.

The teacher researchers thought they had become more autonomous and my role took on more of the features of the critical friend. This is not unsurprising as the teacher researchers became much more confident in their ability as researchers and I did not have the situated knowledge which is necessary to implement changes to classroom practice (Bryant, 1996). At the start of the year, the teacher researchers:

> (did) *not know what was expected...it was important that there was someone other than teacher researchers involved...to help pull it* (the research) *together, and keep us focussed.*
>
> (Interview 1: TR 1)

In this context, initially I was part of the research team with particular expertise and knowledge that could be drawn upon when needed. There were times when the teacher researchers needed someone, who had experience of action research projects, to help keep this project on track to finish by the end of the year. They admitted that it would have been easy to let this timescale slip as the everyday role of class teacher was a clear priority. There was a conflict between the roles of teacher and researcher for the teacher researchers (Atkinson,1994; McTaggert et al.,1997). I visited ARP School on a regular but informal basis

to offer encouragement and support where it was needed, but also to try to force their hands to keep to the research schedule. This was not viewed in a negative way but, on the contrary, was seen as a means of motivating the teacher researchers to keep working to achieve the desired aims (see Chapter 1). The teacher researchers were keenly aware that the research was designed to influence the teaching of science in all classes in the school. My role was viewed as integral in supporting them in this development as I had expertise in the development of challenging science activities and could share this with the teachers at staff meetings. I could share my knowledge with the teachers, in an advisory capacity, to allow them to develop their own classroom practice in the 'act' aspect of the action research cycle. The teacher researchers thought I gave structure to the project, which may not have been in place if I had not been involved to help keep them on task and focussed when necessary. As TR3 suggested, I became the hub of the project and was able to give an objective point of view when needed on all aspects of research. TR3 summarised this role when she said:

> *...sometimes if you're in amongst it all the time, especially working with colleagues in a school, you tend to get bogged down by the same sort of language and the same sort of style, whereas somebody coming in can give fresh ideas and fresh input.*
>
> (Interview 3: TR3)

Some of the initial data were quite sensitive and could have been viewed as critical of colleagues and their practice. Without my support, the teacher researchers indicated that they might have been reluctant to discuss contentious aspects of science teaching. These needed to be examined and discussed openly before improvements could be made to facilitate more challenging science teaching. The teacher researchers thought my comments and advice gave legitimacy to these research findings, which allowed them to approach colleagues with more confidence and assurance. I was not thought of as an authority figure who gave the 'correct' answers but someone who could support and legitimise the conclusions that the teacher researchers had already drawn from their data.

Initially, I helped them to design their research tools and to analyse data, to help the teacher researchers sort out and *organise their ideas* (Interview 3: TR4), but as they became more confident and in control of the direction the research was taking they needed and asked for less guidance from me. This view was exemplified by TR2 who indicated:

> *We have all become more actively involved* (in the research). *To begin with we were talking a lot but later we were actually going out and doing things and making changes and making plans.*
>
> (Interview 3: TR2)

The teacher researchers thought that one of my essential roles was to ask questions to provoke their thinking and *challenge ideas and assumptions* (Interview 3: TR3) about the science teaching in the school and how it could become more challenging. Some of these questions were critical of the teaching processes as they were asking teachers to reflect on their own and colleagues' embedded practice. The questions were often hard for the teacher researchers to resolve as class teachers, because they were involved with the practice of their colleagues. This move from being a teacher who is concerned with science teaching in her class to a teacher researcher who is examining science teaching across the school was difficult for the teacher researchers as the role of internal researchers had not been part of their responsibility in the school. They saw part of my role as therefore to help keep the research focussed, to help them ask the unpopular questions, to guide them in this unfamiliar role and to help make the transition from teacher to teacher researcher.

5.4 Tensions, conflicts and ethical issues for teachers involved in action research

This section relates to research question: Are there tensions, conflicts and ethical issues associated with the Action Research Project for the different stakeholders? If there are tensions, how did these arise? How might they be resolved? The Action Research Project was managed to allow teacher researchers time to carry out all aspects of research. Without this time for reflection-on-action, the Action Research Project might not have been as successful. This time for analysing and reflecting on data was made available because all of the teacher researchers had been awarded a Best Practice Research Scholarship. This time was appreciated by the teacher researchers but they still had to carry out some aspects of the research in their own time. What was clear, however, was that without classroom release the research would have been very *difficult to complete* (Interview 3: TR4) and would have been:

> *...squeezed in a few meetings after school and that would have been very difficult to organise, to get all members* (teacher researchers) *together.*
>
> (Interview 3: TR 3)

The teacher researchers were committed to the Action Research Project and realised this would take up a large amount of their own time as they were wanting to influence all science teaching in ARP School (Interview 1: TR2). As TR4 indicated, there was a *balancing act between her role as teacher and her role as researcher* (Interview 3: TR4). When deadlines approached for each aspect of her work, teaching or researching, she made that her priority. For TR2, however, there was already a greater commitment of time outside of her classroom than her colleagues as she was deputy head of ARP School. She was already working long hours, starting work at 7.30am and working in the school until 6.00pm and had within this, non-contact time from her class, to carry out her duties. The research meant she had to carry

out the tasks associated with her role as deputy head in the holidays, as the research used up much of her non-contact time. This showed real commitment on her part as the roles of deputy head and class teacher on their own are very stressful and time consuming. The type of thinking needed for action research *sits somewhere uncomfortably between the quick intuitive judgments of the teacher and the more rational and explicit analysis of the researcher* (Atkinson,1994: 398). What the Action Research Project provided was time and opportunity away from the classroom for the teacher researchers to engage in knowledge generation and understanding through the action research process alongside their teaching roles. Essentially, the available time eased the teacher researchers' 'discomfort'. Other teachers were not given this opportunity and their focus stayed clearly on teaching and the improvement of children's learning through knowledge transfer.

One of the distinctive features of this Action Research Project was that it aimed to influence and change the teaching of science in all classes in ARP School, not just the classes taught by the teacher researchers. The teacher researchers were fully committed to this aim and its implications for their practice but other colleagues did not all have this degree of enthusiasm or dedication to try to achieve this through action research. Staff meetings could provide the theory and demonstration (Joyce and Showers, 1984) aspects of effective professional development but the Action Research Project gave all teachers the impetus to practice ideas in their own classrooms, and gave them feedback to indicate how effective they had been (Joyce and Showers, 1984; Cordingley et al., 2003; DfES, 2004b).

At various stages in the Research Project, tensions arose between the teacher researchers and the other teachers. These arose when the other teachers were asked to help the teacher researchers to generate data for the Action Research Project. There was a clash between the roles of teacher and researcher and for the other teachers the needs of their pupils came uppermost. The other teachers did not have the opportunity or the time to see how the data they generated would help resolve the Action Research Projects aims. Their decisions were based on their *quick intuitive judgments* (Atkinson,1994: 398). The emphasis for the other teachers was on *techniques and making techniques more efficient* (Usher and Bryant: 1989: 87). They were involved in single-loop learning (Argyris and Schön, 1974). In contrast, the teacher researchers were given time and opportunity to engaged in the process of reflection-on-action, which incorporated all aspects of the CRASP (Zuber-Skerritt, 1995) model of action research. They were engaged in double-loop learning (Argyris and Schön, 1974) as they were *questioning the role of the framing and learning systems which underlie actual goals and strategies* (Usher and Bryant: 1989: 87).

The first issue involved the initial audit of children's attitudes to science. The teacher researchers thought this had been discussed fully at a staff meeting and all teachers would be happy administering it. In reality, the Key Stage 1 teachers thought that this would be too

difficult for their classes to complete without taking a considerable amount of their time and in reality was *not worth doing* (Interview 4: TR3). At the meeting, the Key Stage 1 teachers expressed their reservations about making their classes complete a questionnaire as they thought that simply talking to their classes would be a more effective means of determining their children's attitudes to science. In reality, they were still asked to get their classes to complete the written questionnaire that was designed and *only suitable for Key Stage 2 children* (Interview 4: TR4). This was obviously very difficult for young children, as many did not have the skills to read the questions or to write answers to them. The class teachers or their classroom assistants had to spend time with individuals or small groups to get the questionnaires completed by each child. This took a considerable amount of time and patience. In retrospect, the teacher researchers thought this had such a negative impact on their colleagues to cause them to have reservations about the whole research project and had made them feel resentful because their ideas had apparently not been taken into consideration. This did not have a major impact on the initial action research cycle as the teacher researchers could analyse the data on attitudes for all of the children in ARP School (see Chapter 4).

After the initial audit to determine how children were being challenged in science lessons and what the children thought about science (see Chapter 4) the teacher researchers decided that more formal planning for challenge was needed by all teachers. They subsequently devised a new science activity planning sheet which had a specific section dealing with challenging activities. At the staff meeting where this was introduced the teacher researchers experienced tensions between themselves and the rest of the staff. As TR1 indicated, *there was a gasp at the staff meeting* and a comment; *We are never going to be able to write all that down* (Interview 3: TR1). The teachers could see the value of the planning sheets and *were not daunted by them* (Interview 3: TR3) but thought there was already time pressure on them to complete the work they had to do without adding to this burden. As Bush and Middlewood (2005) noted, teachers must feel ownership of a change if it is to be implemented effectively. The Key Stage 1 and Reception/ Year 1 teachers felt again that this was a particular issue for them as they had to plan for mixed age groups and in some cases mixed Key Stages (Foundation Stage and Key Stage 1). This meant they had different learning objective for the different age groups as well as new children coming into their classes each term from the Nursery. They were subsequently *feeling very stressed* about increasing their workload in science (Interview 3: TR3).

This staff meeting was hard for the teacher researchers to manage as they had thought carefully about how to develop challenge in science teaching and the development of effective planning was one of the cornerstones of this development. Some teachers were very antagonistic and at first refused to implement a change to their planning because of a perceived increase in their workload. This was partly resolved by TR1 (the science

coordinator) and TR2 (the deputy headteacher) meeting with small groups of teachers to talk through their planning and the new sheets. All of the teacher researchers also acted as models for their colleagues and showed how it was possible to adapt and modify planning to make it more challenging. As TR2 indicated, *it has taken a lot of persuasion for them to see the good of doing that* (implement the new planning sheets) (Interview 4: TR2). By the end of the Action Research Project, all of the teachers in ARP School had adapted their planning to make science more challenging and as TR1 reported, the changes *were not as bad as they* (the other teachers) *thought* (Interview 4: TR1). One of the beneficial consequences of the new planning sheet was that teachers were thinking and talking more about their science teaching to build in challenge. The subsequent transference to paper was seen by the teachers in the school to be less time consuming than was originally thought. All teachers eventually saw the planning sheet as a beneficial part of the whole process of making science more challenging. This was achieved partly through discussions between the teacher researchers and their colleagues but mainly by the teacher researchers acting as models who successfully implemented change and trialled ideas in their own classrooms.

The research was designed by all of the teacher researchers as equal partners with the same responsibilities and commitment. At the end of the research, however, they concluded that there needed to be one person who would take the overall lead in a project involving the whole school and with more than one teacher researcher. This person would be a teacher in the school who had experience of action research. She would need to be in a position to see the whole picture and deal with issues as they arose. In reality, the attitude survey and lesson planning structure were introduced by one of the team with little consultation between her and her research colleagues. The lesson for future research projects was summarised by TR2 when she indicated:

> *...in the future, it has given us the lesson that we do have to as a group talk more about what actually we are going to say* [to other staff] *and about the implications for the staff and not hurry it through.*
>
> (Interview 3: TR2)

An insistence that there should be a Key Stage 1 teacher on the research team, or at least more involved with the research, might have alleviated the problems that this group of teachers had. As TR3 indicated, the problems were caused by lack of clear communication between the teacher researchers and the other staff (Interview 3: TR3). Mistakes had happened but this was to be expected with teachers who were new to the role as teacher researcher.

At the start of the research, the PANDA data that came into ARP School indicated that science results were better than those for mathematics. This led to comments and the questioning of science being the focus of the Action Research Project as some teachers thought the priority should have been mathematics. This became even more of an issue when it was suggested that one mental mathematics session a week should be replaced by a science activity designed to develop children's thinking. This issue was only resolved in the teacher researchers' classrooms where developing thinking was a focus. Other teachers were still reluctant to move away from the pattern of numeracy teaching they had developed through the national training schemes (DfEE, 1999b).

Part of the research involved TR1 visiting classrooms to observe science teaching. As this was part of her normal role as science coordinator it was thought that teachers would find her visits less stressful. As she indicated *perhaps if I had gone in as a researcher in their eyes, it may have been different* (Interview 3: TR1). She had indicated that data would be anonymous and confidential and each teacher had the opportunity to view her comments before they were introduced to the whole data set. This was good research practice as the data would be more valid and reliable, and it seemed to three teacher researchers to alleviate any problems or concerns. Interestingly, this contrasted with TR3's point of view. She thought many teachers had felt *insecure, uneasy and hesitant* about classroom observations and were concerned about how the data would be used (Interview 3: TR3). For her, this had caused tension between the members of the research team and their colleagues. This had not been apparent to TR1 who had perhaps been sheltered from negative comments by the kind nature of her colleagues. Teachers have had to get more used to being watched whilst teaching in recent years, but this does not seem to make the process less stressful for the teacher being observed.

One of the problems for the teacher researchers was that they had to leave their own classes at times to carry out some aspects of the research, for example the analysis of data and writing the report for the Best Practice Research website (DfEE, 2000b). This seemed to cause tension in a number of distinct ways. Every time one of the teacher researchers was not in the classroom, a supply teacher was employed to teach the class. The teacher researchers, however, still had to prepare the work to be covered, discuss this with the supply teacher, and follow up the activities to *maintain continuity* (Interview 3: TR3). The teacher researchers were aware that the research involved more of their time but were convinced that the benefits to their teaching through the *analysis your own practice and thinking about challenging children* (Interview 3: TR 4) made this justifiable.

The school tried to employ supply teachers that knew the systems in the school and were known to the children. This was to try to minimise disruptions so as to allow the normal timetable to continue as far as possible. A supply teacher new to ARP School might not be

left with activities like design and technology because it was known that some disruptive children would cause problems in those lessons that had a less formal structure. The teacher researchers were convinced that the pupils in their classes were disturbed if there were changes to the normal routine. This caused problems with behaviour and disruption for the supply teacher, which had to be resolved by the teacher researchers on their return to the classroom. The school had a reputation for being effective in dealing with disruptive pupils. This meant that the Local Education Authority asked that children who have been excluded from neighbouring schools could be admitted. Many of these children were in the teacher researchers' classes and were badly behaved when being taught by supply teachers. This issue is summarised by TR2 who indicated:

> *...last year I had a particularly volatile Year 6...it was difficult to get the right calibre of supply teacher to cover me in order that they* (the class) *did not explode.*
>
> (Interview 3: TR2)

This problem was exacerbated because all four teacher researchers were from the same Key Stage as it was sometimes difficult to find this number of supply teachers for the same days. For the Headteacher the prime function of teachers is to teach the children in their classes, rather than carry out research projects. In the final stages of the Action Research Project, the conflict of roles between being a teacher and researcher became such an issue that the Headteacher decided that only two teacher researchers could be released at a time. Fortunately, this did not affect the Action Research Project as by then much of the time was spent writing reports for the Best Practice Research website and the National Primary Trust (refs needed?). Only two Teacher Researchers released at a time coupled with support by the Headteacher who made himself 'more visible' on the research days went some way to resolve the behaviour problem. This however, placed the onus on the teacher researchers to use their own time to complete the writing of the research report. They thought that this was an expedient solution to the problem as they would have had to spend extra time dealing with the consequences of children's bad behaviour on their return to their classroom.

5.5 Chapter summary

This chapter has examined data from only the four teacher researchers and not the other teachers at ARP School. In answer to the research question 'To what extent is action research an effective means of professional development?

- Action research was seen as an ideal form of professional development as it allowed teacher researchers to participate in and go through the action research cycle of planning, acting, observing and reflecting.

- Professional development in this form assumes that teachers are reflective practitioners.
- Action research was seen by the teacher researchers to be the most effective means of professional development as it integrates teaching with curriculum development, research and reflective practice

In answer to the research question 'How did the teacher-researchers view the roles of different stakeholders in the Action Research Project?'

- Working as a research team was a significant factor in the success of the Action Research Project.
- The move from being a class teacher concerned with her/his own teaching to a teacher researcher concerned with science teaching across the school was a difficult transition to make which needed support from peers and a critical friend.
- The teacher researchers became more autonomous as the Action Research Project progressed and they became more confident in their own ability to carry out research activities.
- My role as critical friend was significant for the success of the Action Research Project. This support had two components; support for the process of action research, and personal support to help the teacher researchers to carry out the action research.

In answer to the research question 'Are there tensions, conflicts and ethical issues associated with the Action Research Project for the different stakeholders?' If there are tensions, how did these arise? How might they be resolved?

- There were few really significant tensions or conflicts which went unresolved as all teachers were committed to making their science teaching more challenging.
- The teacher researchers experienced tensions between their roles as class teachers and teacher researchers. Funding to support the research went part way to alleviate this problem as it paid for supply teachers to cover for teacher researcher time.
- There were some tensions between the teacher researchers and other teachers when the teachers thought they were being asked to implement aspects of science teaching which they viewed as unrealistic or collect data which was seen to be difficult or inappropriate to gather.

Chapter 6

Conclusions

6.1 Introduction

In my research, I have examined and evaluated both the products of the action research and the process of action research. As discussed in Chapter 1 the aims of the investigation were:

- to examine the success criteria of the action research project, designed to make science teaching more challenging for gifted pupils, and see if they have been met; and
- to evaluate the effectiveness of action research as a means of professional development and hence school improvement in the context of this project.

In this chapter, I will discuss the implications of my findings and the wider implications of the research. The areas discussed are:

- The issues involved in making science teaching more challenging,
- The action research process;
- The limitations of my research; and,
- Implication for changes to professional practice:
    - My model of professional development;
    - Lessons for the future.

6.2 The issues involved in making science teaching more challenging

Clark and Callow (2002: 25) suggested that teachers could make progress in their professional development in three ways:

- *the development of knowledge and skills to improve children's learning;*
- *the development of teachers' self understanding; and,*
- *the development of changes in the workplace which put the needs of the school first.*

Clark and Callow (2002) suggested that the best professional development, which changed teachers' thinking and classroom practice, integrated all three elements. This research showed that the process of working together in their own school helped the teacher researchers to monitor their own personal learning and the collective learning of their colleagues. All of the teachers indicated that they had learnt new teaching techniques and developed their scientific knowledge to allow them to challenge gifted children more effectively. This information came mainly from interviewing teachers and from pupils'

questionnaires. What these data seemed to indicate is that all teachers' theory-in-use (Argyris and Schön, 1974) had developed during the year. The data did not however, explore what impact the research had on the teachers' espoused theory concerning challenge and gifted children. The aim of the Action Research Project was professional development of all teachers in the school. What the teacher researchers wanted was all of their colleagues to reflect on their teaching to examine how challenging it was and then look to develop challenge if and where it was not apparent. The Action Research Project was seen to be successful because it moved all of the teachers in ARP School from the process of knowing-in-action to reflection-in-action (Schön, 1983, 1987, 1995). This resonates with Hargreaves' assertion that:

> *Innovation must be disciplined enough to create high leverage practices: it is pointless to disseminate poor practice or even good practice that makes impossible demands to implement.*
>
> (Hargreaves, 2003: 12 cited in Holmes, 2004: 143)

One of the innovations introduced was a new activity planning sheet (see Appendix 5). The KS1 teachers thought that their planning needed to be developed but that the planning sheet would take up too much time for them to implement. The teacher researchers were aware of this issue and were adaptable enough in their ideas to make allowance for this concern. As a result the teacher researchers thought that their data from the Action Research Project would indicate that the planning and teaching across the school had become more challenging for scientifically gifted pupils.

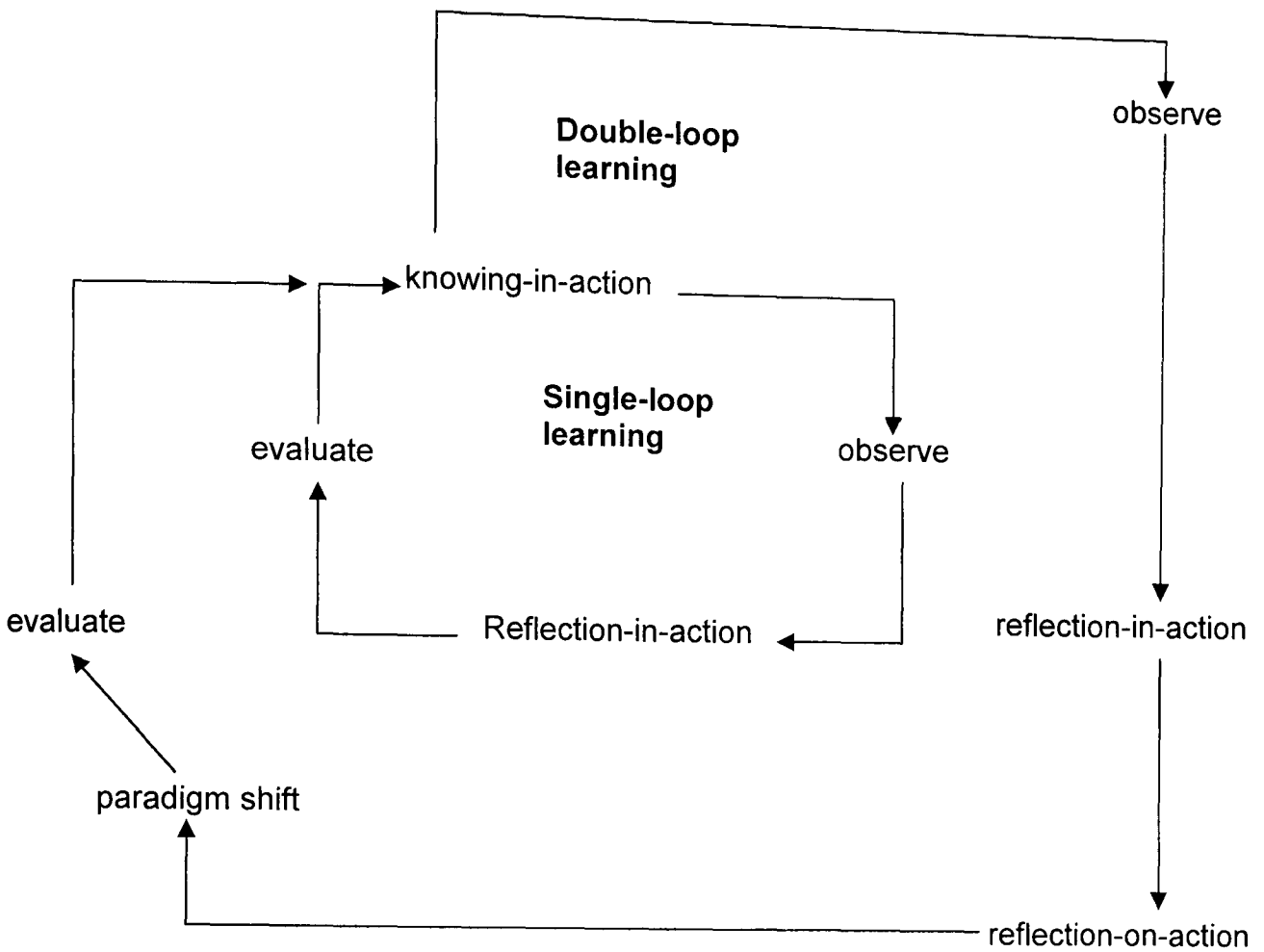

Figure 6.1: My model of single and double-loop learning

Figure 6.1 shows the relationship between knowing-in-action, reflection-in and on-action and single and double loop learning. The classroom work of a teacher is revealed in the skills, judgments and actions which indicate a pattern of tacit knowing-in-action. This makes up the bulk of what teachers do everyday in their teaching. Schön (1983, 1995) discussed the difference between reflection-in-action and reflection-on-action. Reflection-in-action is when a competent practitioner learns to think on her/his feet and is able to improvise as s/he takes in new information and/or encounters the unexpected. We all have a capability for reflection on what we know as revealed by what we do (Schön, 1995). The process of reflection-in-action begins when the teaching of a lesson is interrupted by the observation of something that was unexpected. The observation triggers reflection directed both at the unexpected observation and the knowing-in-action that led to it. Through reflection and evaluation of the results s/he has achieved the teacher will turn her/his thoughts back to the knowing-in-action. In reflection-on-action, however, the teacher reflects on the tacit understandings and assumptions s/he holds and subjects them to scrutiny in order to achieve deeper understanding of pupils' roles, motivations and behaviours that are implicit in reflection-in-action (Schön, 1995). Schön emphasized the importance of educators' thinking about the dilemmas of their teaching and the social outcomes of education. Through reflection on knowing- and reflection-in-action there can be a paradigm shift in teachers' ideas.

There did seem to be a greater impact in the teacher researchers' classes, as the profile of science, both in terms of children's perceptions and teachers' enthusiasm, was enhanced more when compared with their colleagues. Only the teacher researchers engaged in the process of reflection-on-action, which incorporated all aspects of the CRASP (Zuber-Skerritt, 1995) model of action research. This may be because the teachers in ARP School who were not directly involved as teacher researchers were engaged in single-loop learning (see figure 6.1). Their focus was on changing teaching strategies in the classroom to see what impact they had. The reflection-in-action was directed towards making the new strategies more effective. The teacher researchers were engaged in double-loop learning which involved reflection-on-action and an examination of beliefs and systems which underlie the teaching strategies. This can potentially lead to a paradigm shift which involves higher level learning (Fiol and Lyles, 1985). For the teacher researchers, there seemed to be congruence between their theory-in-use and their espoused theory concerning scientifically gifted pupils. There were no data to suggest that this is the case for their colleagues.

The work of Habermas (1971), and in particular his concept of technical, practical and emancipatory knowledge interests, has been used to understand different levels of reflective practice (Van Manen, 1977). All of the teachers in ARP School were working at the technical and practical levels where the function was to improve practical skills and enhance practice to identify and solve problems (James and Jules, 2005) in relation to teaching more challenging science lessons. Only the teacher researchers however, were engaged in reflection at the emancipatory level as they felt empowered by the Action Research Project.

The differences between teachers and teacher researchers might explain why the impact of the Action Research Project was greater in the teacher researchers' classrooms than in the classrooms of their colleagues. A group of teacher researchers can therefore have an impact on other colleagues in a school if they all understand the aims of an action research project (see Chapter 4). But if there is a desire to have deep impact teachers must engage in action research themselves. This will involve them in double-loop learning. As Hargreaves (1998: 1) suggested, teachers who are involved in research will find their professional practice to be *more effective and satisfying.*

6.3 The action research process

Some professional development did not meet teachers' expectations, as the context in which they were working was not taken into consideration (Clark and Callow, 2002). If specific innovations are imposed on schools, there is a tendency to reduce teachers' coping power and problem-solving capacity and to increase their dependence – because their existing potential is not encouraged but ignored (Altrichter et al, 1993: 203). Professional development, therefore, has less chance of success unless it involves teachers in exploring

the implications of the changes for their own educational values, and finding out how to alter the routine of their practice (Stenhouse, 1975). In the Action Research Project, the teachers were questioning the common assumption that knowledge for and about classroom teaching should be firstly generated in a university then used in schools (Brown and Macatangay, 2002). This technical rational approach (Schön, 1983; Doerr and Tinto, 2000) that is operationalised in the research-development-dissemination (RDD) model (Altrichter et al, 1993: 201) of professional development translated developments outside of schools into teachers' action by means of publications and training. This has clear resonance with other developments in primary education. For example, when the Science National Curriculum was introduced in 1989 there was a sense of disquiet amongst my primary colleagues as they felt that they were being told to teach a watered down secondary school science curriculum. The model utilised by the teachers (see Chapter 5) was based on the reflective rational approach (Schön, 1983) to professional development. The teachers had control; a key factor in determining whether the professional development will make an impact in the classroom.

There is evidence to suggest that effective models of professional development are characterised by groups of individuals working together as a community of learners via collaborative enquiry (DfES, 2004b: 5). The teacher researchers decided that an action research approach would be the best way to operationalise their model of professional development. The definition of action research which best resonates with their ideas comes from Ebbutt (1985). The teacher researchers carried out a systematic study as a group with the aim of improving their and their colleagues' education practice. Essentially adopting an action research approach involved the teacher researchers in actively examining their current teaching of science to the gifted children in order to change and improve it. They hoped to achieve this by engaging in critical reflection. The driving force behind this was the teachers' 'need to know' in order to bring about the desired changes (Wadsworth, 1998). One of the main reasons for adopting an action research approach was the degree of empowerment it gave the teacher researchers. They were involved in evaluating data in the initial audit to examine the state of science teaching at the beginning of the Action Research Project before deciding on appropriate interventions from those that had been demonstrated, for example during staff meetings and visits to other schools, and finally evaluating the outcomes of these interventions (Gabel, 1995).

One criticism of action research is that it is not question-driven but outcome-driven (McNiff, 1988). This can be a particular problem when the 'outcome' is value laden and an assumption is made that the interventions which led to the particular outcome are a good thing, which will be 'proved' by the action research. This could lead to a report, which discusses the effects of a change on professional practice or an evaluation of a teaching intervention, but is not action research. What indicated that the teacher researchers' study adopted an action research approach was the collection of evidence in relation to their

research question, i.e., how can we make science teaching more challenging for gifted pupils? Two key aspects of some 'traditional' research e.g., those adopting a scientific or a quantitative approach are replicability and generalisability. The research is thought to be of good quality if other researchers could obtain the same results if they carried out the research activities in the same manner, and if the method and its findings can be generalised to all situations. These criteria are less important for action research (Robson, 1999) as it is neither possible nor desirable to aim for replication or generalisation. This is because schools and pupils within them are often very different. What works in one context may not be appropriate to another. The teacher researchers carried out the Action Research Project to understand and improve the science teaching **in their school**. It was this shared learning that led to the construction of their collective knowledge (McNiff et al, 1996). The rigour of action research can be ensured by checking findings and interpretations to a point of saturation. The data analysis in the Action Research Project became sounder because all of the teacher researchers and myself, as a critical friend, agreed on the interpretations. The trustworthiness of the data was ensured through triangulation. The teacher researchers and their colleagues tried out ideas in their classrooms, they checked that their findings were practical and ethical, and they shared their findings with colleagues at staff meetings. This was a way of 'publishing' what they had learned and of opening it to scrutiny of their peers (Feldman and Minstrell, 2000). In action research, the 'facts' are therefore checked with the 'people'. As McCarthy (1982: 255) noted:

> *Communication that is orientated towards reaching understanding inevitably involves reciprocal raising and recognition of validity claims. Claims to truth and rightness, if radically challenged, can be redeemed only through argumentative discourse leading to rationally motivated consensus.*

This communication introduces a reflexive dimension to the analysis that is one of the distinctive feature of action research. Winter (1989) described reflexivity as bending back into one's subjective system of meaning. It can be construed as a never-ending process of questioning interpretations, understandings and conclusions (Clark, 1997: 98). The teacher researchers wanted to make the solutions found in their action research project accessible to other teachers who could then explore the findings in the context of their own school to develop hypotheses of their own to be tested (Schön, 1983). This was achieved by publishing details of the project through the National Primary Trust (Coates et al, 2003c). If we accept Stenhouse's (1984:77) definition of research then the Action Research Project was an example of educational research as it was *systematic critical inquiry made public.*

6.4 Limitations of my research

I have used an evaluative case study (Stenhouse, 1988) approach in this research. In order to facilitate this data were collected using a number of methods, for example, interviews and questionnaires. As Hitchcock and Hughes (1995) indicate, a case study should focus on groups of actors and their perception.

The concept of validity for the two evaluations discussed in this thesis can be regarded as the comparison of the data I collected and analysed to see if it matched with what I professed to collect and analyse. Collection of data from a range of sources and perspectives allows for triangulation and helps to establish validity (Denscombe, 1999; Anderson et al, 1994) and corroborate findings. The data from the Action Research Project indicated that there was an increase in challenge in science lessons after the interventions were introduced but this does not necessarily indicate that challenge increased because of the interventions. Flecknoe (2002) suggested that teachers who are willing to engage in professional development are likely to be concerned about improving the teaching and learning in their classrooms. The impact reported could merely be a report of what would have happened anyway (Flecknoe, 2002: 133). This is a threat to what Robson (1999) refers to as internal validity. The teacher researchers had invested much time and effort into the Action Research Project. An evaluation of this as an effective means of professional development might therefore be subject to concerns about validity. The threat to validity here is a concern to know if the teachers were telling the truth or giving responses that they thought I would expect. This is known as concurrent validity (Oppenheim, 1997). As Hammersley and Atkinson (1986: 196) indicated:

> *We cannot assume that any actor is a privileged commentator on his or her own actions, in the sense that an account of intentions, motives, or beliefs involved are accompanied by a guarantee of their truth.*

I tried to overcome threats to concurrent validity by comparing data from all of the interviews, questionnaires and nominal group technique to check for respondent validity (Hammersley and Atkinson, 1986). For example, when examining the roles of the different stakeholders in the Action Research Project I had data from the four teacher researchers in the form of the initial brainstorm and interviews 1 and 3 to analyse.

A case study can be viewed as an in-depth study of interactions of a single instance in an enclosed system (Opie, 2004). A measure of the external validity of a case study is the degree to which the findings can be generalised from the specific sample in the study to some target population (Robson, 1999:46). The value of the research findings was often determined by whether the study was generalisable to the wider population. External validity

can be endangered if the findings are specific to the group being studied, or the findings being specific to the context in which the study took place (LeCompte and Goetz, 1982 cited in Robson, 1999). An alternative to external validity is trustworthiness which has transferability as a key feature. A case study will be viewed as trustworthy if an audience can be persuaded that the findings are worth paying attention to (Lincoln and Guba, 1985: 200), and there is rigorous analysis of data (Bassey, 1999). I have tried to achieve this in this thesis by giving a thick description of the case which will allow others access to this data to allow them to compare with their own situation. Findings are therefore, not generalised but transferred from a sending context to a receiving context:

> *If there is to be transferability, the burden of proof lies less with the original investigator than with the person seeking to make an application elsewhere. The original inquirer cannot know the sites to which transferability might be sought, but the appliers can and do. The best advice to give to anyone seeking to make a transfer is to accumulated empirical evidence about contextual similarity; the responsibility of the original investigator ends in providing sufficient descriptive data to make similarity judgements possible.*
>
> Lincoln and Guba, 1985: 298)

When I started the research I was not looking to generalise my findings. I chose to carry out a case study of ARP School because it was of interest to me. The school was not chosen as a *'typical' example in the sense that typicality is empirically demonstrated, and so issues of external validity are not meaningful* (Bassey, 1999: 75). This does not deny the potential for the generalisability of my findings. Case studies however, are not easily generalisable except where other readers/researchers see their application (Nisbet and Watt, 1984). A case study can provide the reader with vicarious experience (Anderson et al., 1994). As in this thesis I have for example described the context of the research and the planning of the study. This will allow readers to explore the relevance of my research for their own research or context.

In the case of transferability, readers need to know as much detail as possible about a research situation in order to accurately transfer the results to their own. However, it is impossible to provide an absolutely complete description of a situation, and missing details may lead a reader to transfer results to a situation that is not entirely similar to the original one. For example, there is no discussion of gender or science education background of the teacher researchers.

6.5 Implications for changes to professional practice

In this section I will discuss a model of professional development which has stemmed from my work with teachers and teacher researchers in ARP School. In the second section I will examine how action research can fit into the demanding lives of primary school teachers.

6.5.1 My model of professional development; the Three Ring Model

The Three Ring Model of professional development utilises the ideas of Day (1991), Winter (1989) and Feldman and Minstrell (2000) and has three inter linking and necessary components; external knowledge, creating knowledge and knowing-in-action (see figure 6.2). It is founded on the principle that professional development should be the enhancement of normal practice and addresses the issues associated with professional development through action research. The model incorporates three of the key assumptions concerning action research, conducted by teachers, which have been identified from the literature:

- *Action research is geared to teachers' own practice and the situation in which they work;*
- *In action research teachers engage in reflection and improvement based on information they have systematically gathered and analysed;*
- *Action research is carried out through dialogue with colleagues within and outside the school.*

(Ponte, 2005: 278)

The Three Ring Model of professional development is aimed at teachers who are extended professionals and seeks to encourage restricted professionals (Hoyle, 1980) to take on this role. It builds on the core dimensions of the Teacher Learning Academy (TLA) (GTCE, 2005) which was set up by the General Teaching Council for England in 2004. The TLA is designed to offer professional recognition for teachers' learning, development and improvement work (GTCE, 2005). There are four levels within the Academy each of which must address the core dimensions (GTCE, 2005):

- Engagement with an appropriate knowledge base (e.g. research evidence, school data, the experiences of teachers in other institutions).
- Accessing peer support, coaching and/or mentoring.
- Planning of professional learning and change activity (i.e. a teacher learning project).
- Carrying out a change activity (i.e. implementing the teacher learning project).
- Evaluating the impact of the change activity on practice and on own learning.
- Disseminating what has been learned (e.g. through written report, web-based dissemination, hosting a meeting).

Extended professionals seek to improve by learning from other teachers and from professional development. They constantly question and try to link theory and practice. Action research is often the approach used for school-based teacher inquiry because it aims to give teachers practical methods to develop knowledge from their experience and to make a contribution to the shared knowledge of the profession (Altrichter et al, 1993). Teachers investigating or researching their own practice can/might be able to provide a new perspective on the development of knowledge (McNiff, 1988). By utilising an action research approach, teachers can develop their knowing-in-action as the approach would be immediate, direct and relevant to their needs (Day, 1991). The development of knowing-in-action is not achieved by simply gathering data *but is always the outcome of a process in which researchers explore, organise and integrate their own and other's theoretical resources as an interpretive response to data* (Winter, 1989: 261). This process will bring tacit knowledge to the surface as teachers think through their actions as they carry them out. In this model the reflective practitioner can be viewed as a researcher as they are researching their everyday practice as they practise (Campbell et al, 2004). My model of professional development takes the ideas (Day, 1991; Winter, 1989) further as it has three inter linking and necessary components; external knowledge, creating knowledge and knowing-in-action (see figure 6.2).

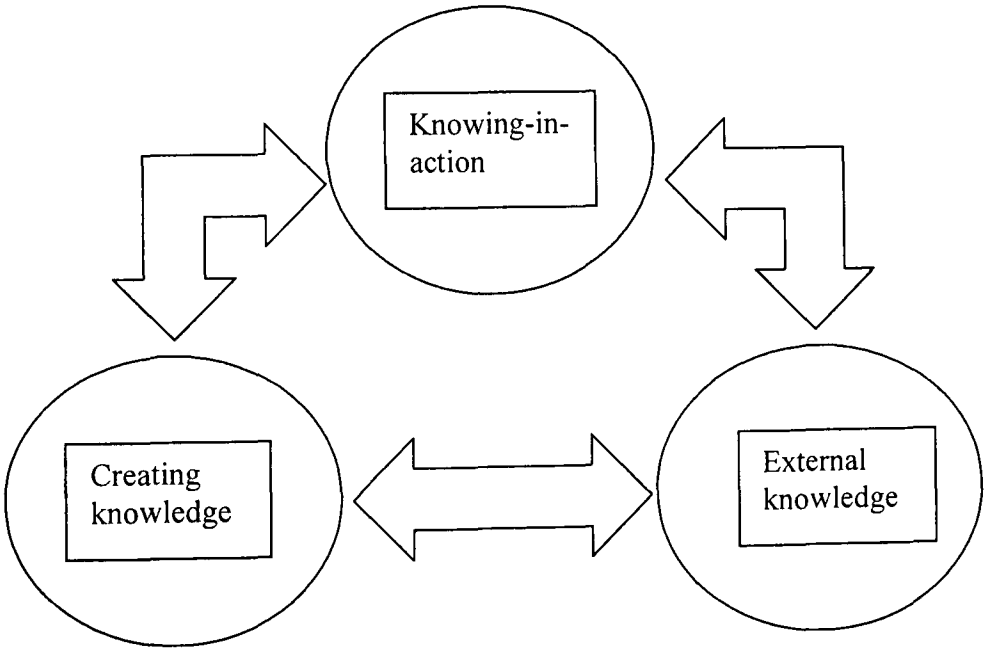

Figure 6.2: Links between different types of knowledge

The model builds on Feldman and Minstrell's (2000) model which viewed action research as an enhancement of normal practice that relies on sustained conversations in a collaborative setting. A group of teachers, from one or a number of schools, would come together in a learning community with an ethos in which it was acceptable to reveal areas of concern or

perceived weaknesses. At the heart of my model is reflection-in-action which is usually triggered by some dilemma within teaching which is habitually guided by knowing-in-action. The dilemma is faced when actions do not produce the usual expected results (i.e. defined by previous experience). The creation of knowledge and external knowledge are then combined, as needed, to bring about a paradigm shift in the teacher's knowing-in-action.

In the model, teachers who engage in action research through knowing-in-action, reflecting-in-action, and reflection-on-action will be reconstructing their theories of action, both in terms of their theory-in-use and their espoused theory (Argyris and Schön, 1974). This will involve making explicit formulations of their action strategies and then opening them to criticism. The teachers will be engaged in *self-reflective inquiry* (Carr and Kemmis, 1997: 162). This means they will be reflecting on their own practice as a basis for researching their own practice (Ponte, 2005). They will in essence be engaged in double-loop learning (Figure 6.1).

External knowledge

Teachers do not necessarily have the pedagogical knowledge, content knowledge, or knowledge of learners (Shulman, 1987) to achieve the aims of their professional development. Outside agencies for example university lecturers, or colleagues from their own or other schools, with the given expertise (Cordingley et al., 2003) could be utilised to help the teachers concerned achieve this goal to engage with and develop an appropriate knowledge base (GTCE, 2005). As Garet et al. (2001) noted, for professional development to have a real impact there needs to be a content knowledge focus. Borko (2004) established that professional development was enhanced when teachers engaged in a reflective dialogue with colleagues within a learning community. The learning community would offer peer support (GTCE, 2005) to facilitate the development of external knowledge. A key principle in teachers' utilisation and development of external knowledge is the process of accessing the experiences of other teachers (GTCE, 2005) through anecdote telling (Feldman and Minstrell, 2000: 450):

> *One teacher may tell an anecdote; the others listen. The listeners respond with their own anecdotes, with questions that ask for details, or with questions that take a critical turn and explore the nature of teaching and learning in schools in the context of the anecdote…ideas about practice are exchanged and generated in the anecdote telling process.*

These anecdote telling sessions would be useful in a number of ways; the development of other teachers content and pedagogical knowledge, giving colleagues feedback (Cordingley et al, 2003), and peer support (Cordingley et al, 2003; GTCE, 2005). Colleagues listening to the anecdotes would act as critical friends who helped each other to reflect on what they were doing and why, mainly by asking questions (Ponte, 2005: 278). In their work on research-

engaged schools, Sharp et al. (2005) found that teachers emphasised the benefits of collaborative learning and the value of collaborative research as professional development. Smith and Sela (2005) and the teacher researchers in ARP School found that sharing knowledge with each other added to the professional validity.

Creating knowledge

Hargreaves (1998) explored ways in which a knowledge creating school could be fashioned. He identified classroom and school based research carried out by teachers as critical elements in the creation of knowledge. Teachers create their own knowledge by planning, carrying out and evaluating a change to their practice (GTCE, 2005). Teachers go back to their classrooms to try out ideas gleaned from the external knowledge and return with more anecdotes to tell (Feldman and Minstrell, 2000). This will hopefully negate the criticism that the professional development is not taking into account the teacher's context (Hargreaves, 2000). By creating knowledge in this manner teachers are adopting a constructivist philosophy. New knowledge is accepted when there is a consensus reached by all teachers in the CPD group (Berninger et al., 2004). Knowledge about teaching and learning has traditionally been divided into theoretical knowledge which has been developed by universities and practical knowledge which is intuitively understood by teachers (Smith and Sela, 2005). In the past this dichotomy has alienated teachers from research (Gore and Gitlin, 2004). Through the utilisation of an action research approach, teachers can create their own knowledge as *it blurs the boundaries between teachers and researchers, knowers and doers, and experts and novices* (Cochrane-Smith and Lytle, 1999: 22).

Reason (2001) noted the primary purpose of action research is the production of practical knowledge that is useful to teachers at all levels: in their classrooms, with the curriculum, other teachers and theoretical knowledge (Altrichter et al., 1993). Through action research teachers can therefore develop their understanding (Carr and Kemmis, 1997). By 'understanding' Carr and Kemmis (1997) mean the knowledge that teachers create themselves. External knowledge is an important source of information, but the creation of their own knowledge is the teachers' own responsibility (Ponte, 2005). Teachers can create knowledge when they are willing to try out and evaluate new ideas (Feldman and Minstrell, 2000). This will involve them in reflection-in-action; *self-evaluating their practice* (Zuber-Skerritt, 1995: 15) and reflection-on-action; *thinking, interpreting and explaining* and *acting to resolving issues and ideas* (Stringer, 1999: 18).

Knowing-in-action

At the heart of any professional development is the desire to change teachers' knowing-in-action. In the past, brief one stop workshops where teachers were told what to do have had little effect (Hawley and Valli, 1999), because teachers cannot change their practice, their knowing-in-action, in a meaningful way simply by being told to do so (Ponte, 2005). For

professional development to be effective teachers need to *identify their own focus and embed the practices in their own classroom settings* (Cordingley et al, 2003: 5). According to Schön (1983), knowing-in-action is tacit knowledge which enables us to execute tasks fairly automatically. Schön noted that our spontaneous knowing-in-action usually gets us through the day. The experienced practitioner is knowledgeable about the theory involved and is skilled in the task. If this is something done on a regular basis it does not have to be thought through – it is just done. Knowing-in-action is often the tacit information that we know about doing something and is often left unexplained or unmentioned when we describe what we do. In most situations tacit knowledge will remain implicit but in the Three Ring Model there is an expectation that teachers will make explicit their knowing-in-action. Knowing-in-action needs to be seen as dynamic not static. A critical feature of the model involves teachers questioning their actions and, equally importantly, questioning what their actions indicate they know.

6.5.2 Lessons for the future

Rather than adopt a case study methodology in the future I would use a more systematic method such as the Concerns Based Adoption Model (CBAM) (Hall and Hord, 1987) to study the implementation of an educational change. The model is concerned with:

> *...measuring, describing and explaining the process of change experienced by teachers involved in attempts to implement new curriculum material and instructional practices, and with how that process is affected by interventions from persons acting in change-facilitating role.*
>
> (Anderson, 1997: 331)

From this definition, it is clear that the CBAM model could allow me to address my two research questions. The model is a conceptual framework that describes, explains and predicts probable teacher behaviours throughout the process of change. The three principle diagnostic dimensions of CBAM (Loucks-Horsley, 1996) are:

- Stages of Concern – Seven different reactions that teachers experience when they are implementing a new programme.
- Levels of Use – Behaviours teachers develop as they become more familiar with and more skilled in using an innovation or adopting a change.
- Innovation Configurations – Different ways that teachers adapt innovations to their own situation.

There are several assumptions about classroom change in curriculum and instruction that underpin CBAM: (1) change is a process, not an event; (2) change is accomplished by individuals; (3) change is a highly personal experience; (4) change involves developmental growth in feelings and skills: and (5) change can be facilitated by interventions directed

towards individuals, innovations, and contexts involved (Anderson, 1997: 333). The model maintains that people considering and experiencing change evolve in the kinds of questions they ask and in their use of the change (Loucks-Horsley, 1996). Early questions are self-oriented: How will I cope with different ability groups in science? When these are resolved questions become more task-oriented: How do I make science investigations more challenging? Finally, when self- and task- concerns are resolved, the individual can focus on impact: Are gifted children being challenged in my science lessons?

One of the aims of the Action Research Project was to foster research practices in the teacher researchers when they were working in their school. Co-operative inquiry came through the sessions when they worked on the action research together as there was a mutual concern for the needs of gifted children. The teacher researchers had opportunities for collaborative inquiry and the learning related to it, they were able to develop and share a body of wisdom gleaned from their experience. As Stenhouse (1975: 144) indicated, they had developed their professionality which he defined as:

> *A capacity for autonomous professional self-development through systematic self-study, through the study of the work of other teachers and through the testing of ideas by classroom research procedures.*

By their involvement in the Action Research Project, the teacher researchers were able to monitor their own personal and the collective learning of the whole staff. The Action Research Project had resulted in all of the teachers learning new teaching skills and techniques and developing their knowledge: pedagogical, content knowledge, and knowledge of learners (Shulman, 1987), to allow them to challenge more effectively in their science teaching. Their knowing-in-action (Schön, 1983, 1987, 1995) had developed to encompass more challenge in their science teaching. The teacher researchers indicated that they thought they had in the process become more reflective practitioners, not only in their science teaching but across the curriculum. Their capacity for reflection-in-action (Schön, 1983, 1987, 1995) had been further developed and enhanced. However, the time spent directly on the Action Research Project allowed the teacher researchers to develop their reflection-on-action (Schön, 1983, 1987, 1995) as they discussed and evaluated the science teaching of all teachers. A key feature here was colleagues in the research team acting as critical friends to support the reflection-on-action to allow it to become more analytical and systematic. What evolved from this Action Research Project was a professional learning community made up of teachers and teacher researchers working together on a collaborative CPD project. The case studies of effective CPD suggest that a school learning community is a beneficial means of implementing, supporting and developing teachers' knowledge. (DfES, 2004b: 7). Senge (1990: 3) identified the characteristics of such a community as a place:

where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together.

It was hoped that the knowledge created and acquired by the teachers in this professional development activity could support other teachers as the findings of the research were disseminated to groups throughout the country. The issues addressed in their research were not unique to their school. The teacher researchers hoped that groups of teachers in other schools could take ownership of their own professional development. This would entail these teachers using the conclusions from the Action Research Project as hypotheses to be tested in their own schools. They would develop their own knowing-in-action by the use of an action research approach to create their own knowledge. The teacher researchers did have funding which gave them time to carry out almost all aspects of their research. Unfortunately, this is not always available, but I believe that professional development through action research is achievable by most teachers if they utilise Feldman and Minstrell's (2000) ideas which emphasised the enhancement of teachers' normal practice, and my Three Ring Model. This view is echoed in the document 'The Core Principles; Teaching and Learning School Improvement System Wide Reform (DfES, 2004b: 6) which states that schools need to:

- *base all improvement activity on evidence;*
- *build collective ownership;*
- *create time for staff to learn together;*
- *embed the development throughout the school;*
- *collaborate with other organisations.*

In this way, action research could be incorporated into the planning of teachers' professional development which takes into consideration the needs of the school (Figure 6.3; Edwards and Talbot, 1994: 67). Teachers might be given more support for professional development if this was linked to the schools' needs (Figure 6.3). Senior managers in the school would be more likely to react in a positive manner to give teachers time to carry out research if this was the case.

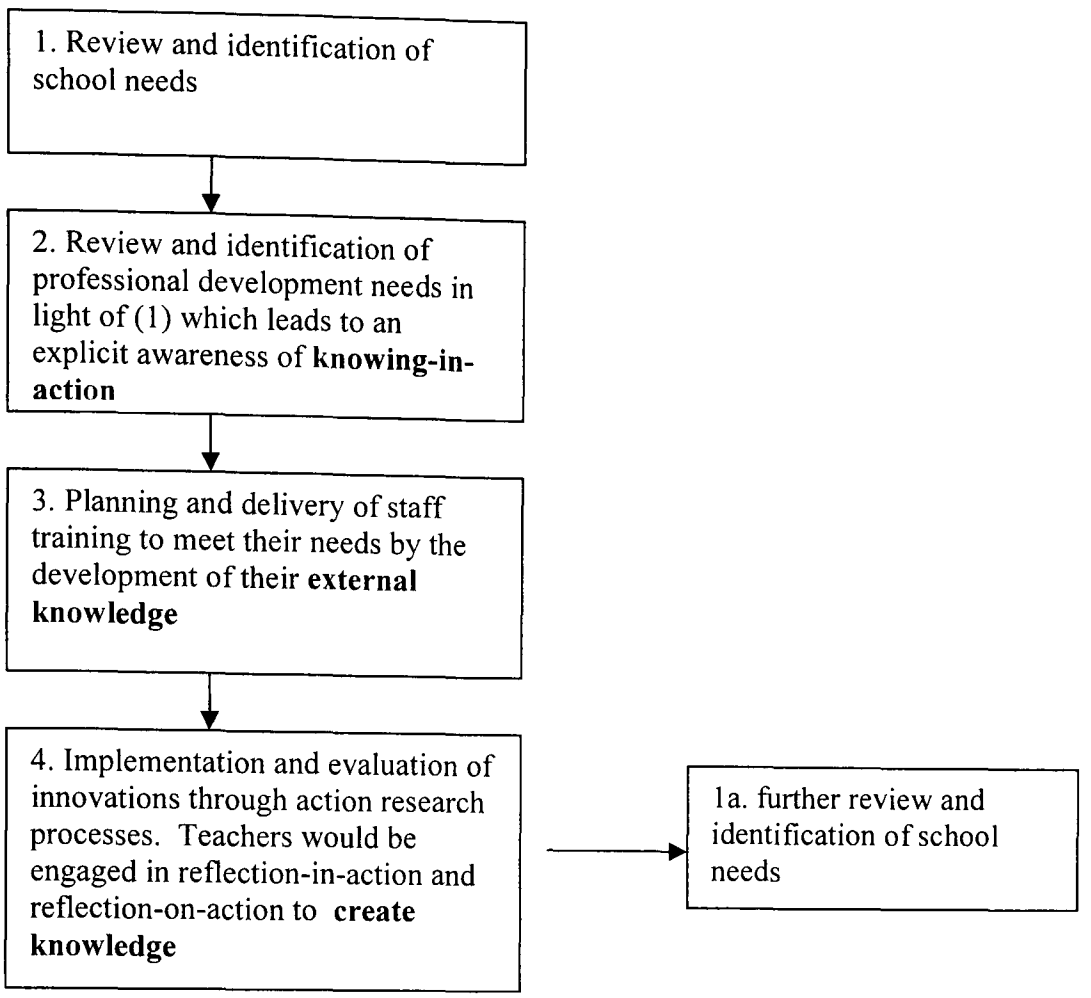

Figure 6.3: Links between professional development and school needs and the Three Ring Model

Essentially, professional development aims at changing teachers' knowing-in-action. For professional development to be really effective and embedded in classroom practice, I believe that it needs to start from the school and the teacher. It needs to involve teachers in double-loop learning (Argyris and Schön, 1974; Fiol and Lyles, 1985) in which teachers can utilise external knowledge to create their own knowledge. In this way both theory-in-use and espoused theory can be changed which in turn could have a long term impact on teachers' knowing-in-action.

References

Ainscow, M. (1998) 'Would it work in Theory? Arguments for Practitioner Research and Theorising in the Special Needs Field.' In C. Clark, A. Dyson and A. Millward (Eds) *Theorising Special Education.* London: Routledge

Alexander, R., Rose, J. and Woodhead, C. (1992) Curriculum Organisation and Classroom Practice in Primary Schools. London, HMSO

Allebone, B. (1998) 'Providing for able children in the primary classroom', *Education 3-13* March 1998

Altrichter, H., P. Posch and Somekh, B. (1993). *Teachers Investigate their Work. An introduction to the methods of action research.* London: Routledge

Anderson, G.L., Herr, K. and Nihlen, A.S. (1994) *Studying Your Own School. An Educator's Guide to Qualitative Practitioner Research.* Thousand Oaks: Corwin Press

Anderson, S. (1997) 'Understanding Teacher Change: Revisiting the Concerns Based Adoption Model'. *Curriculum Inquiry,* 27(3): 331-367

Archer, T., Maccauley, A. and Kendall, L. (2003) *Primary school headteachers' views on participating in research.* Slough: NFER

Argyris, C. and Schön, D.A. (1974) *Theory in Practice.* San Francisco: Jossey-Bass

Argyris, C. (1982) *Reasoning, learning, an action: Individual and organizational.* San Francisco: Jossey-Bass

Arksey, H. and Knight, P. (1999) *Interviewing for Social Scientists.* London: Sage

Assessment Reform Group (2002) *Assessment for Learning: Ten Principles for Guiding Classroom Practice.* Cambridge: Assessment Reform Group

Atkinson, S (1994) 'Rethinking the Principles and Practices of Action Research: the tensions for the teacher-researchers.' *Educational Action Research.* Vol. 2 No. 3 p. 383-401

Australian Government, Department of Education, Science and Training Senate Employment, Workplace Relations, Small Business and Education References Committee Report (2001) *The Education of Gifted Students.* www.aph.gov.au/senate/committee. 12/3/04

Bartlett, S. (2002) 'An Evaluation of the Work of a Group of Best Practice Teacher Researchers.' *Journal on In-Service Education,* 28(3): 527-540

Bartlett, S. and Burton, D. (2003) 'The Professional Development of Teachers through Practitioner Research: a discussion using significant cases of Best Practice Research Scholarships.' *Teacher Development,* 7(1): 107-120

Bartlett, S., Burton, D. and Buckley, S. (2005) 'A Case Study of the Importance of Practitioner Research for Teacher Development.' Education 3 – 13, October: 15 - 19

Bassey, M. (1981) 'Pedagogic Research: on the relative merits of a search for generalizations and study of single events.' *Oxford Review of Education.* 3(1): 73-93

Bassey, M. (1995) *Creating education through Research: A Global perspective of Educational Research for the 21st Century.* Newark. Kirklington Moor Press

Bassey, M. (1998) Action Research for Improving Educational Practice, in R. Halsall (Ed.) *Teacher Research and School Improvement. Opening Doors from the Inside.* Buckingham: Open University Press

Bassey, M. (1999) *Case Study Research in Educational Settings.* Buckingham: Open University Press

Baum, S. (1989) 'Gifted but learning disabled: a puzzling paradox' *Preventing School Failure..*34(1): 11 – 14 cited in L. Porter (1999) *Gifted Young Children.* Buckingham: Open University Press

Baum, S., Owen, S.V. and Dixon, J.(1991) *To be gifted and learning disabled: from identification to practical intervention strategies.* Hawker Brownlow Education: Melbourne cited in L. Porter (1999) *Gifted Young Children.* Buckingham: Open University Press

Becker, H.S. (1986) *Doing Things Together.* Evanston: Northwestern University Press

Berninger, V.W., Dunn, A. Shin-Ju, C.L. and Shimada, S. (2004) 'School Evolution: Scientist-Practitioner Educators Creating optimal Environments for All Students.' *Journal of Learning Disabilities.* 37(6): 500 - 508

Black, P. and Wiliams, D. (1998) *Inside the Black Box.* London: School of Education, King's College, London

Bloom, B. (1956) (Ed) *Taxonomy of Educational Objectives Vol 1.* Harlow: Longman
Cheshire County Council (2002) *Thinking Skills.*
http://www.salt.cheshire.org.uk/MFL/thinking/intro.htm 15/9/02

Bogdan , R.C. and Biklen , S.N. (1992) *Qualitative Research for Education: an introduction to theory and methods.* 2nd edn. Boston: Allyn and Bacon

Bolan R. (2000) 'Emerging policy trends: some implications.' *Journal of In-Service Education* 26: 267 - 280

Borgia, E. T. and Schuler, D. (1996) *Action Research in Early Childhood Education.* http://carbon.cudenver.edu/~mryder/itc/act_res.html 11/11/03

Brause, R. and Mayher, R. (eds) (1991) *Search and Re-search: what the enquiring teacher needs to know.* Basingstoke, Falmer

Brown, M. and Macatangay, A. (2002) 'The Impact of Action Research for Professional Development: case studies in two Manchester schools.' *Westminster Studies in Education,* Vol. 25, No. 1, 2002, p. 35-45

Bush, T.and Middlewood, D. (2005) *Leading and Managing People in Education.* London: SAGE publications

Buzzard, B and Jarvis, T. (1999) Optimising INSET Approaches in Primary Science and Design Technology, *Journal of In-service Education,* 25(2): 337 - 352

Bryant, I. (1996) 'Action Research and Reflective Practice', in D. Scott and R. Usher (Eds) *Understanding Educational Research.* London: Routledge

Campbell, A. and Jacques, K. (2004) 'Best Practice Research: teachers' expectations of the impact of doing research in their classrooms and schools.' *Teacher Development,* 7(1); 75-90

Carlisle, C. and Phillips, D.A. (1984) 'The effects of enthusiasm training on selected teacher and student behaviour in preservice physical education teachers.' *Journal of Teaching in*

Physical Education. 4: 64 – 75 cited in M. Parson (2001) *Enthusiasm and Feedback: A winning Combination!* www.pecentral.org/climate/monicaparsonarticle.html 20/4/06

Carr, W. and Kemmis, S. (1986) *Becoming Critical - Education Knowledge and Action Research.* London: The Falmer Press

Carr, W. and Kemmis, S. (1997) *Becoming Critical.* London: Falmer Press

Carré C. (1998) 'Invitations to Think in Primary Science Lessons.' In . R. Burden and M. Williams (Eds) *Thinking Through the Curriculum*. London, Routledge

Cervero, R. M. (1988) *Effective Continuing Education for Professionals.* London: Jossey-Bass

Chambers, E. (2000) 'Applied Ethnography' in N. K. Denzin and Y. S. Lincoln *Handbook of Qualitative Research.* London: Sage Publications, Inc.

Clark, C. (1997) 'Using Action Research to Foster a Creative Response to Teaching More Able Pupils.' *High Ability Studies,* Vol. 8, No. 1, 95 – 111

Clark, C. and Callow, F. (1998) *Educating Able Pupils.* London: David Fulton Publishers

Clark, C. and Callow, F. (2002) *Educating the Gifted and Talented: Resource Issues and Processes for Teachers.* London: David Fulton Publishers

Coates, D. and Eyre, D. (1999) 'Can encouraging the use of higher order thinking skills in science help young able children achieve more highly?' paper prepared for the fourth Summer Conference for Teacher Education in Primary Science, University of Durham, July

Coates, D. and Hazell, S. (2002) 'How can teachers identify able scientists in year one?' *Educating Able Children* 6(2) 28-34

Coates, D. and Wilson, H. (2000) 'Science Masterclasses for Able Children in Year 2.' *SCICentre 2000 and ASET Conference Report,* compiled by Frankie McKeon, SCICentre, University of Leicester, Leicester: SCICentre

Coates, D. and Wilson, H. (2001) 'Science' in D. Eyre and L. McClure (Eds) *Curriculum Provision for the Gifted and Talented in the Primary School.* London: David Fulton Publishers

Coates, D. and Wilson, H. (2003a) 'Science Masterclasses for Able Children in Year 2' *Education 3-13* June 2003: 9- 15

Coates, D. and Wilson, H. (2003b) *Challenges in Primary Science: meeting the needs of able young scientists at Key Stage 2.* London: David Fulton Publishers

Coates, D., Brennan, J., Gove, F., Hayes, F. and Trigg, M. (2003c) *Meeting the Challenge: raising achievement in primary science.* Birmingham: National Primary Trust

Cochran-Smith, M. and Lytle, S.L. (1992) 'Communities for Teacher Research: fringe or forefront?' *American Journal of Education,* May: 298-324

Cochran-Smith, M and Lytle, S.L. (1993) *Inside/outside: Teacher Research and Knowledge.* New York: Teachers' College Press

Cochran-Smith, M and Lytle, S.L. (1999) 'Relationships of knowledge and practice. Teacher learning in communities. *Review of Research in Education.* 24: 249 - 306

Cohen, L. and Manion, L. (1994) *Research Methods in Education (2nd Edn).* London: Routledge

Colangelo, N. and Davis, G.A. (1997) 'Introduction and overview' *Handbook of gifted education* 2nd edn, eds N. Colangelo and G.A. Davis. Boston: Allyn & Bacon

Collinson. V. and Ono, Y. (2001) 'The Professional Development of Teachers in the Unites States and Japan'. *European Journal of Teacher Education,* 24(2): 223-248

Columbus Group (1991) Unpublished transcript of the meeting of the Columbus Group, Columbus, Ohio in Kearney, K. (1996) *Highly Gifted Children in Full Inclusion Classrooms.* http://www.hollingworth.org/fullincl.html 18/01/2002

Cordingley, P., Bell, M., Rundell, B. and Evans, D. (2003) 'The Impact of Collaborative CPD on Classroom Teaching and Learning.' In: *Research Evidence in Education Library.* London: EPPI-Centre, Social Science Unit, Institute of Education

Costa, A.L. and Killick, B. (1993) Through the lens of a critical friend, *Educational Leadership,* 51 (2): 49-51

Cousins, G. (2000) *Strengthening Action-Research for Educational Development.* http://legacywww.coventry.ac.uk/legacy/ched/research/strengthar.htm 10/6/05

Creswell, J.W. and Miller, D.L. (2000) 'Getting Good Qualitative Data to Improve Educational Practice.' *Theory into Practice.* 39 (3): 124-130

Cross, T.L. and Coleman, L.J. (1992) 'Gifted high school students' advice to science teachers.' *Gifted Child Today,* 15(5): 25- 26 cited in J. Van Tassel-Baska (1998) Planning Science Programs for High-Ability Learners. http://ericec.org/digests/e546.html 7/6/2006

Dadds, M. and Hart, S. (2001) *Doing Practitioner Research Differently.* London: RoutledgeFalmer

Davis, G. A. and Rimm, S. B. (1998) *Education of the Gifted and Talented.* London: Allyn and Bacon

Day, C. (1991) Primary teachers' professional development: a pilot project for primary schools in L. Bell and C. Day (Eds) *Managing the Professional Development of Teachers.* Milton Keynes: Open University Press

DeHaan, R. F., & Havighurst, R. J. (1957). Educating gifted children. Chicago, IL: Chicago University Press

Delbecq, A.L., Van de Ven, A.H. and Guslafson, D.H (1975) *Group techniques for program planning: a guide to Nominal and Delphi Processes.* Scott: Foresman

Denscombe, M. (1999). *The Good Research Guide for Small-scale Social Research Projects.* Buckingham, Open University Press

Denzin, N. K. and Lincoln,Y.S., (2000). *Handbook of Qualitative Research.* London, Sage Publications, Inc.

Department of Education and Science (DES) (1985) *Science 5 – 16: A Statement of Policy.* London: HMSO

Department for Education and Employment (DfEE) (1998) *The National Literacy Strategy, Framework for teaching.* London: HMSO

Department for Education and Employment/ Qualifications and Curriculum Authority (DfEE/QCA) (1999a) *Science. A Scheme of Work for Key Stage 1 and 2.* London: QCA/DfEE

Department for Education and Skills DfEE (1999b) *The National Numeracy Strategy, Framework for teaching mathematics.* London: HMSO

Department for Education and Skills DfEE (1999c) Excellence in Cities: the gifted and talented strand. www.standards.dfes.gov.uk/excellence/policies/GiftedandTalented 12/3/04

Department for Education and Employment/ Qualifications and Curriculum Authority (DfEE/QCA) (1999) *The National Curriculum. Handbook for primary teachers in England.* London: DfEE/QCA

Department for Education and Employment (DfEE) (2000a) *Professional Development: support for teaching and learning.* London: HMSO

Department for Education and Employment (DfEE) (2000b) *Best Practice Research Scholarships. Guidance Notes for Teacher Applicants.* London: HMSO

Department for Education and Employment/ Qualifications and Curriculum Authority (DfEE/QCA) (2000c)*Curriculum Guidance for the Foundation Stage.* London: DfEE/QCA

Department for Education and Employment/ Qualifications and Curriculum Authority (QCA/DfEE), (2000d) *The teacher's guide update to the Science Scheme of Work.* London: DfEE/QCA

Department for Education and Skills (DfES) (2001a)*The autumn package of pupil performance information.* London: HMSO

Department for Education and Skills (DfES) (2001b) *Learning and Teaching: a Strategy for Professional Development.* London: HMSO

Department for Education and Skills (DfES) (2002) *Schools Achieving Success.* http://www.dfes.gov.uk/achievingsuccess. 10/9/03

Department for Education and Skills DfES (DfES) (2004a) *Excellence and Enjoyment: learning and teaching in the primary years. Introductory guide: continuing professional development.* London: HMSO

Department for Education and Skills (DfES) (2004b) *The Core Principles; Teaching and Learning School Improvement System Wide Reform.* www.standrds.dfes.gov.uk/seu/coreprinciples1/core-principles.doc 13/10/05

Department for Education and Skills (DfES) (2005) *Higher Standards, Better Schools for All.* London: HMSO

Desforge, C. (1995) 'How does experience affect theoretical knowledge for teaching?' *Learning and Instruction.* 5: 385 - 400

Dick, B. (1999) *What is action research?* http://www.scu.edu.au/schools/gcm/ar/whatisar.html 2/4/03

Doerr, H.M. and Tinto, P.P. (2000) 'Paradigms for Teacher-Centered Classroom-Based Research', in A.E. Kelly and R.A. Lesh (Eds) *Handbook of Research Design in Mathematics and Science Education.* London: Lawrence Erlbaum Associates, Publishers

Doherty, J., MacBeath, J., Jardine, S., Smith, I. and McCall, J. (2001) 'Do schools need critical friends?', in J. MacBeath and P. Mortimer (Eds) *Improving School Effectiveness.* Buckingham: OUP

Dudley LEA (1998) *Meeting the Needs of the More Able Pupil.* Dudley: Dudley Publication

Gott. R. and Duggan, S. (1995) 'The place of investigations in practical work in the UK National Curriculum for Science'. *International Journal of Science Education, 17, 2, 137 –147*

Ebbutt, D. (1985) 'Educational Action Research: Some General Concerns and Specific Quibbles', in R.G. Burgess (Ed.) *Issues in Qualitative Research: Qualitative Methods.* Lewes: Falmer

Education and Employment Committee (1999) *Highly Able Children* London: HMSO

Edwards, A. and Talbot, R. (1994) *The Hard-pressed Researcher: A research handbook for the caring professions.* London: Longman

Egan, D. and James, J. (2002) *An Evaluation for the General Teaching Council for Wales of the Professional Development Pilot Project 2001-2002.* PPI Group, Bristol (accessed from GTCW website at www.gtcw.org.uk/welcome.html 30/4/03

Eisner, E. W. (1985). *The Art of Educational Evaluation.* London, The Falmer Press

Elliott, J. (1974) *Implementing the Principles of Inquiry/discovery Teaching.* University of East Anglia, Norwich, CARE Publications

Elliott, J. (1991) *Action Research for Educational Change.* Milton Keynes. Open University Press

Elliott, J. (1999) Evidence-based Practice, Action Research and the Professional Development of Teachers. Paper given at Manchester Metropolitan University Staff Development Day, May cited in A. Campbell and K. Jacques (2004) 'Best Practice Research: teachers' expectations of the impact of doing research in their classrooms and schools.' *Teacher Development,* 7(1); 75-90

Evaluation Research Society (1980) 'Standards for Evaluation', Washington DC: ERS cited C. Robson (1999). *Real World Research.* London: Blackwell

Eyre, D. (1997) *Able Children in Ordinary Schools.* London: David Fulton

Eyre, D., Coates, D., Fitzpatrick, M., Higgins, C., McClure, L., Wilson, H., and Chamberlain, R. (2002) 'Effective Teaching of Able Pupils in the Primary School: The Findings of the Oxfordshire Effective Teachers of Able Children Project.' *Gifted Education International.* Vol. 16: 158 - 169

Eyre, D. (2004) *Gifted Education: The English Model.* Warwick: The National Academy for Gifted and Talented Youth (NAGTY)

Feasey, R., Goldsworthy, A., Phipps, R. and Stringer, J. (2001) *New STAR Science Series.* Oxford: Ginn

Feldhusen, J.F. (1996) 'Talent as an alternative conception of giftedness' *Gifted Education International.* 11(3): 124 - 127

Feldman, A. and Minstrell, J. (2000) 'Action Research as a Research Methodology for the Study of Teaching and Learning in Science.' In A.E. Kelly and R.A. Lesh (eds.) *Handbook of Research Design in Mathematics and Science Education.* Mahwah, New Jersey and London: Lawrence and Erlbaum Associates, Publishers.

Fetterman, D.M. (1984) (Ed.) *Ethnography in Educational Evaluation.* London: Sage

Fetterman, D.M. (1988) (Ed.) *Qualitative Approaches to Evaluation in Education.* London: New York: PRAEGER

Fetterman, D.M. (1994) 'Ethnographic educational evaluation' in T. Husen and T. N. Postlethwaite (eds.) *The International Encyclopaedia of Education.* Oxford: Pergamon

Fielding, M. (2003) The Impact of impact. *Cambridge Journal of Education,* 33(2): 289-295

Fiol, C.M., and Lyles, M.A. (1985) 'Organizational learning.' *Academy of Management Review,* 10(4): 803-813

Flecknoe, M. (2002) Measuring the Impact of Teacher Professional Development: can it be done? *European Journal of Teacher Education,* 25(2/3): 119-134

Foster, P. (1999) Never Mind the Quality, Feel the Impact: a methodological assessment of teacher research sponsored by the Teacher Training Agency. *British Journal of Education Studies,* 47: 380-398

Freeman, J. (1991) *Gifted Children Growing Up.* London: Cassell

Freeman, J. (1998) *Educating the Very Able: Current International Research.* London: HMSO

Furlong, J., Salisbury, J. and Combe, L. (2003) *Best Practice Research Scholarships: An Evaluation.* Cardiff University: School of Social Sciences

Gabel, D. (1995*) An Introduction To Action Research* http://physicsed.buffalostate.edu/danowner/actionrsch.htm, 30/4/03.

Gagné, F. (1991) Towards a differentiated model of giftedness and talent. In N. Colangelo and G.A. Davis (Eds) *Handbook of gifted education.* Boston: Allyn and Bacon

Gagné, F. (1995) 'From giftedness to talent: A developmental model and its impact on the language of the field.' *Roeper Review.* 18(2): 103 - 111

Gall, M.D., Gall, J.P. and Borg, W.R. (2005) *An Introduction to Educational Research.* Boston: Allyn and Bacon

Gallagher, J.J. (1985) *Teaching the Gifted.* Newton: Allyn and Bacon

Gardner, H. (1983) *Frames of mind: The theory of multiple intelligences.* New York: Basic Books

Garet, M.S., Porter, A.C., Desimone, L., Birman, B.F. and Yoon, K.S. (2001) 'What makes professional development effectice? Results form a national sample of teachers.' *American Educational Research Journal,* 38(4): 915 – 945

Geake, J., Cameron, S., Clements, D. and Phillipson, S. (1996) 'Science for Gifted Students: Learning from the Lorax.' In M. McCann and F. Southern *Fusing Talent. Giftedness in Australian Classrooms.* Adelaide: The Australian Association of Mathematics Teachers

General Teaching Council for England (GTCE) (2005) *Teacher Learning Academy. Briefing Paper* http://www.gtce.org.uk/TLA/tla_publications/ 13/11/05

George, D. (1997) *The Challenge of the Able Child.* London: David Fulton Publishers

Glaser, B.G. and Strauss, A.L. (1967) 'The Discovery of Grounded Theory'. Chicago: Aldine cited in P. Maykut and R. Morehouse (1994) *Beginning Qualitative Research. A Philosophic and Practical Guide.* London: Falmer Press

Goertz, J.P. and LeCompte, M.D. (1981) 'Ethnographic research and the problem od data reduction', *Anthropology and Education Quarterly,* 12: 51-70 cited in P. Maykut and R. Morehouse (1994) *Beginning Qualitative Research. A Philosophic and Practical Guide.* London: Falmer Press

Gorard, S. (2000) 'Political Control: A Way Forward for Educational Research? *British Journal of Educational Studies,* 50(3): 378- 389

Gore, J.M. and Gitlin, A.D. (2004) '(Re)Visioning the academic-teacher divide: power and knowledge in the educational community.' *Teachers and Teaching: Theory and Practice,* 10(1): 35 – 58

Greene, J. C. (2000). 'Understanding Social Programs Through Evaluation' in Denzin, N. K. and Lincoln, Y. S. (Eds.) (2000) *Handbook of Qualitative Research.* London, Sage Publications, Inc.: 981 - 999

Gross Davis, B. (1993) *Tools for Teaching.* http://teaching.berkley.edu/bgd/motivate.html 20/4/06

Grundy, S. (1995) *Action Research as Professional Development.* Occasional Paper 1 for the Innovation Links Project. Perth: Murdoch University

Gummesson, Evert. (1991). Qualitative Methods in Management Research. Newbury Park: Sage Publications

Habermas, J. (1971) *Knowledge and Human Interest.* London: Heinemann

Hall, G. and Hord, S (1987) *Change in Schools: Facilitating the process.* Albany: SUNY Press

Hammersley, M. (1979) 'Data collection in ethnographic research', in *research Methods in Education and Social Sciences,* DE304, Block 3, Part 3, Milton Keynes: The Open University

Hammersley, M. and Atkinson, P. (1983) *Ethnography: Principles in Practice,* London: Routledge

Hammersley, M. and Atkinson, P. (1986) *Ethnography Principles in Practice.* London: Tavistock Publications

Hammersley, M. (1992) *What's wrong with Ethnography?,* London: Routledge

Hammersley, M. and Gomm, R. (1997) 'Bias in Social Research.' *Sociology Research Online.* 2(1) www.socresonline.org.uk/socreonline/2/1/2 .html 12/3/06

Handscomb, G. (2003) 'Learning and developing together, An LEA approach.' *Professional Development Today.* 6(1): 17 - 22

Handscomb, G. and MacBeath, J. (2005) 'Professional development through teacher enquiry.' *Topics* 33 April 2005 p.15 – 22

Hargreaves, A. (1994) *Changing Teachers, Changing Times: teachers' work and culture in the postmodern age.* London: Cassell

Hargreaves, D. (1998) *Teaching as a Research-based Profession: Possibilities and Prospects.* London, Teacher Training Agency Annual Lecture

Hargreaves, A. (2000) 'Four Ages of Professionalism and Professional Learning'. *Teachers and Teaching.* 6(2): 151-182

Hargreaves, D. (2003) From a presentation to the Annual Network Learning Communities Conference, Birmingham, June cite in D. Holmes (2004) 'Nuts, bolts, levers and cranks: designing enquiry-based learning in Hartlepool' *Improving Learning*, 7, 2, 139 - 146

Harlen, W. (1994) *Evaluating Curriculum Materials.* Edinburgh: The Scottish Council for Research in Education

Harlen, W. (1996) *The Teaching of Science in Primary Schools.* London: David Fulton Publishers

Harlen, W. (1997) Primary Teachers' Understanding in Science and its Impact in the Classroom. *Research in Science Education.* 27(3): 323-337

Harlen, W. and Holroyd, C. (1997) 'Primary Teachers' Understanding of Concepts of Science: Impact on Confidence and Teaching.' *International Journal of Science Education.* 19(1): 93 – 105

Hart, E and Bond, M. (1995) *Action Research for Health and Social Care: a guide to practice*, Buckingham: Open University Press

Hawley, D.W. and Valli, L. (1999) The Essentials of Effective Professional Development: a new consensus, in L. Darling-Hammond and G. Sykes (Eds) *Teaching as the Learning Profession.* (San Francisco, Jossey-Bass)

Her Majesty's Inspectors (HMI) (1992) *The education of very able children in maintained schools.* London: HMSO

Hitchcock, G. and Hughes, D. (1995). *Research and the Teacher: A Qualitative Introduction to School Based Research.* London: Routledge

Hopkins, D. (1989). *Evaluation for School Improvement.* Milton Keynes: Open University Press

Hopkins, D. (1993). *A teacher's guide to classroom research.* Buckingham: Open University Press

Hoyle, E. (1980) Professionalisation and Deprofessionalisation in Education, in E. Hoyle and J. Megarry (Eds) *World Yearbook of Education 1980: professional development of teachers.* London: Kogan Page

Huberman, M. and Guskey, T.R. (1995) The diversity of professional development, in T.R. Guskey and M. Huberman (Eds) *Professional Development in Education.* New York: Teachers College Press

Hustler, D., Cassidy, T. and Cuff, T. (Eds) (1986) *Action Research in Classrooms and Schools.* London: Allen and Unwin

Hycner, R.H. (1985) 'Some Guidelines for the Phenomenological Analysis of Interview Data', *Human Studies,* 8 (2): 279-303

James, C. and Jules, A. (2005) *The Collaborative Practitioner.* Paper presented to the Annual Conference of the British Educational Research Association

Johnson, D., Boyce, L. and Van Tassel-Baska, J. (1995) 'Evaluating curriculum materials in science', *Gifted Child Quarterly* 89(1): 35 - 43

Joyce, B. and Showers, B. (1984) 'Transfer of Training: The contribution of coaching' in D. Hopkins and M. Wideen (Eds) *Alternative Perpectives on School Improvement.* Lewes: Falmer Press

Kemmis, S. (1981) *The Action Research Planner.* Geelong: Deakin University Press

Kemmis, S. and McTaggert, R. (2000) Participatory Action Research, in N.K. Denizen and Y.S. Lincoln (Eds) *Handbook of Qualitative Research.* Thousand Oaks: Sage

Kinder, K. and Harland, J. (1991). *The Impact of INSET: the Case of Primary Science* . Slough: NFER

LeCompte, M.D. and Goetz J.P. (1982) 'Problems of Reliability and Validity in Ethnographic Research. *Review of Educational Research.* 52: 31 – 60 cited in C. Robson (1999) *Real World Research.* London: Blackwell

Leitch, R. and Day, C. (2000) 'Action Research and Reflective Practice: towards a holistic view'. *Educational Action Research*, 8(1): 179- 193

Lewin, K. (1946) 'Action Research and minority problems.' *Journal of Social Issues.* Vol 2

Lewis, A. and Smith, D. (1993) 'Defining higher order thinking.' *Theory into Practice* 32(3): 131 - 137

Lieberman, A. and Grolnick, M. (1997) Networks, Reform and the Professional Development of Teachers, in A. Hargreaves (Ed.) *ASCD Yearbook: rethinking educational change with heart and mind.* Alexandria, VA: Association for Supervision and Curriculum Development

Lincoln, Y. and Guba, E. (1985) *Naturalistic inquiry.* London: Sage

Lomax, P. (1990) 'An Action Research Approach to Developing Staff in Schools' in P. Lomax (Ed.) *Managing Staff Development in Schools.* Clevedon. Multi-Lingual Matters

Loucks-Horsley, S. (1996) 'Professional Development for Science Education: A Critical and Immediate Challenge' in R. Bybee (Ed.) *National Standards and the Science Curriculum.* Dubuque: Kendall/Hunt Publishing Co.

Lynch, S.J. (1992) 'Fast-paced high school science for academically talented: A six-year perspective. *Gifted Child Quarterly* 36(3): 147 -154 cited in J. Van Tassel-Baska (1998) Planning Science Programs for High-Ability Learners. http://ericec.org/digests/e546.html 7/6/2006

Luxford, H. (1997) 'Where do I go from here? An approach to planning for enrichment in primary science.' *Journal of NACE* Spring Issue 1: 3 - 9

Lytle, S. and Cochran- Smith, M. (1994) 'Inquiry, knowledge and practice', in S. Hollingsworth and H. Sockett (Eds) *Teacher Research and Educational Reform.* Chicago: University of Chicago Press

MacBeath, J., Schratz, M., Meuret, D. and Jakobsen, L. (2000) *Self-evaluation in European Schools: A Story of Change.* London: Routledge Falmer

Macintyre, C. (2000). *The Art of Action Research in the Classroom.* London: David Fulton Publishers

Maker, C. J. (1982) *Curriculum Development for the Gifted.* Rockville: Aspen Systems Corporation

Maker,C.J. and Nielson, A.B. (1995) *teaching Models in Education of the Gifted.* Texas: pro-ed

Marland, S. P. (1971) *Education of the Gifted and Talented.* Report to the Congress of the United States by the U.S. Commissioner of Education. Washington, DC: U.S. Government Printing Office

Marsh, G., Boulter, C. and Litson, S. (2001) *Starting research in the classroom: How children learn about Earth in space from CD-ROM and books.* Paper presented at BERA 2001, University of Leeds

Maykut, P. and Morehouse, R. (1994) *Beginning Qualitative Research. A Philosophic and Practical Guide.* London: Falmer Press

McCarthy, T. (1982) Rationality and Relativism, in: J. B. Thompson and D. Held (eds) Habermas—Critical Debates. London: Macmillan

McKernan, J. (1996) *Curriculum Action Research.* London: Kogan Page

McMahon, T. (1999) 'Is Reflective Practice Synonymous with Action Research?' *Educational Action Research.* 7(1): 163 - 168

McNiff, J. (1988) *Action Research: Principles and Practice.* London: Routledge

McNiff, J. (1995) *Action Research for Professional Development: Concise Advice for New Action Researchers.* Dorset: Hyde Publications

McNiff, J., Lomax, P. and Whitehead, J. (1996). *You and Your Action Research Project.* London: Routledge

McNiff, J. (2002) *Action Research: Principles and Practice.* London: RoutledgeFalmer

McTaggert, R., Henry, H. and Johnson, E. (1997) 'Traces of Participatory Action Research.' *Educational Action Research*, 5(1): 123 - 139

Monks, F. J. (1992). Development of gifted children: The issue of identification and programming. In F. J. Monks & W. Peters (Eds.), *Talent for the future.* Assen/Maastricht: Van Gorcum

Morelock, M.J. and Feldman, D.H. (1997) 'High IQ children, extreme precocity and savant syndrome. in N. Colangelo and D.A. Davis (Eds) *Handbook of gifted education.* Boston: Allyn & Bacon

National Academy For Gifted and Talented Youth (NAGTY) (2006) *An Overview.* www.nagty.ac.uk/about/index.aspx 5/3/06

National Association for Research in Science Teaching (NARST) (2001) *NARST News* http://wwww.sci.sdsu.edu/CRMSE/NARST_News44_Abell.html 4/5/02

National Statistics Office (2005) *Purposive Sampling.* www.statistics.gov.uk 12/03/06

Nisbet, J. and Watt, J. (1984) Case Study. In J. Bell, T. Bush, A. Fox, J. Goodey and S. Goulding (eds) *Conducting Small-scale Investigations in Educational Management.* London: Routledge

O'Brien, P. (1998) *Teaching Scientifically Able Pupils in the Primary School.* Oxford: NACE

Office for Standards in Education (OFSTED) (1999a) *Consultation on targets for English and mathematics at Key Stage 2 in 2004.* London: HMSO

Office for Standards in Education (OFSTED) (1999b) *Annual Report of HMCI 1997/1998.* London: HMSO

Office for Standards in Education (OFSTED (2000) *Handbook for Inspecting Primary and Nursery Schools, with guidance on self-evaluation.* London: HMSO

Office for Standards in Education (OFSTED (2003) *Improving city schools: how the arts can help.* London: HMSO

Opie, C. (Ed.) (2004) *Doing Educational Research.* London: Sage Publications

Oppenheim, A. N. (1997). *Questionnaire Design, Interviewing and Attitude Measurement.* London: Pinter

Osborne, J. and Simon, S. (1996) 'Primary science: past and future directions.' *Studies in Science Education,* 26: 99 – 147

Osterman, K. F. (1990) 'Reflective Practice: A New Agenda for Education.' *Education and Urban Society* .22(2): 133-152

Padilla, M.J. (1990) *The Science Process Skills.* http://www.narst.org/publications/research/skill.htm 12/4/04

Parliamentary Office for Science and Technology (POST) (2003) *Primary Science.* London: Parliamentary Office for Science and Technology http://www.parliament.uk/post/pn202.pdf 25/1/06

Patton, M. Q. (1990). *Qualitative evaluation and research methods* (2nd ed.). Newbury Park, CA: Sage Publications

Pedretti, E. (1996) Facilitating Action Research in Science Technology and Society: an experience in reflective practice. *Educational Action Research,* 4(3): 307-327

Pereira, M.A. (1999) 'My Reflective Practice as Research.' *Teaching in Higher Education.* 4(3): 339 – 354

Peters, J. (2004) 'Teachers Engaging in Action Research: challenging some assumptions. *Educational Action Research,* 12(4): 535-555

Pirrie, A. (2001) Evidence-based Practice in Education – the best medicine. *British Journal of Education Studies,* 25: 124-136

Poncini, A. and Poncini, L. (2002) 'A qualitative Assessment of Gifted and Talented Students Undertaking Research Science Projects.' In W. Vialle and J. Geake (Eds) *The Gifted Enigma. A Collection of Articles.* Cheltenham: Hawker Brownlow Education

Ponte, P. (2005) 'A Critically Constructed Concept of Action Research as Tool for the Professional Development of Teachers.' *Journal of In-service Education,* 31(2): 273 - 295

Porter, L. (1999) *Gifted Young Children.* Buckingham: Open University Press

Qualifications and Curriculum Authority/Department for Education and Employment (QCA/DfEE) (2000) *A Scheme of Work for Key Stages 1 and 2. Science Teacher's Guide Update.* Sudbury: QCA

Qualifications and Curriculum Authority (QCA) (2000) *Standards at Key Stage 2: English, Mathematics and Science. Report on the 1999 National Curriculum Assessments for 11 Year Olds.* Sudbury: QCA Publications

Qualifications and Curriculum Authority (QCA) (2001a) *Guidance on Teaching Gifted and Talented Pupils.* http://www.nc.uk.net/gt/general/05_assessment.htm December 2002

Qualifications and Curriculum Authority (QCA) (2001b) *Working with Gifted and Talented Children. Key Stages 1 and 2 English and mathematics.* London: QCA

Qualifications and Curriculum Authority QCA (2004) *Guidelines for working with the more able.*http://www.qca.org.uk/2623_3437.html 14/2/05

Rakow, S. J. (1988). 'The gifted in middle school science.' In P. Brandwein and A. H. Passow (Eds) *Gifted young in science.* Washington, DC: National Science Teachers Association.

Reason, P. (2001) 'Learning and Change through Action Research.' in J. Henry (Ed.) *Creative Management.* London: Sage

Reason, P. and Bradbury, H. (Ed.) (2001) *Handbook of Action Research.* London: Sage

Renzulli, J.S. (1995) 'The three-ring conception of giftedness: A developmental model for creative productivity.' in R.J. Sternberg and J.E. Davidson (Eds) *Conceptions of Giftedness.* Cambridge MA: Cambridge University Press

Robson, C. (1999). *Real World Research.* London: Blackwell

Robson, C. (2000). *Small-Scale Evaluation.* London: SAGE Publications

Rogers, K.B. (1999) *Research Synthesis Regarding Gifted Education Provision.* http://www.nsagtc.org.au/info/articles/RogersResearchSynthesis.html !2/5/02

Rudduck, J. (1991) *Innovation and Change.* Buckingham: Open University Press

Sachs, J. (1999) Using Teacher Research as a Basis for Professional Renewal, *Journal of Inservice Education,* Vol. 25, No. 1, p. 39 – 53

Sagor, R. (1997) Collaborative Action Research for Educational Change, in A. Hargreaves (Ed.) *ASCD Yearbook: rethinking educational change with heart and mind.* Alexandria, VA: Association for Supervision and Curriculum Development

Schön, D. (1983) *The Reflective Practitioner.* London: Temple Smith

Schön, D. (1987) *Educating the reflection practitioner: Towards a new design for teaching and learning in the profession.* San Francisco, CA: Josey-Bass Publishers

Schön, D. (1988) *Educating the Reflective Practitioner.* San Francisco: Jossey-Bass

Schön, D. (1995) 'Knowing-in-action: The new scholarship requires a new epistemology.' *Change.* November-December: 27-34

Scriven, M. (1991) *Evaluative Thesaurus.* Newbury Park: SAGE Publications

Senge, P. M. (1990) *The Fifth Discipline.* New York: Currency Doubleday, cited in Smith, M. K. (2001) 'Peter Senge and the learning organization', *the encyclopedia of informal education,* www.infed.org/thinkers/senge.htm 19/10/2005

Shafer, L. (2000) *Teacher Research Continuum Chart.* http://gse.gmu.researh/tr/TRprofessional.shtml 23/7/01

Sharp, C., Eames, A., Sanders, D. and Tomlinson, K. (2005) *Postcards from Research-engaged Schools.* (Slough, NFER)

Sherman, R.R. and Webb, B.W. (1988) *Qualitative Research in Education: Forms and Methods,* Lewes: Falmer Press

Showers, B. Joyce, B. and Bennett, B. (1987) 'Synthesis of research on staff development: a framework for future study and a state-of-the-art analysis. *Educational Leadership,* 45: 77 – 87

Shulman, L.S. (1987) 'Knowledge and teaching: Foundations of the new reform.' *Harvard Educational Review,* 57(1): 1-22

Silcock, P. (1993) 'Can We Teach Effective Teaching?' *Educational Review* 45(1): 13 - 19

Silverman, D. (2001) *Interpreting qualitative Data,* London: SAGE Publications

Smith, M. K. (1996; 2001) 'Action research', *the encyclopedia of informal education*, www.infed.org/research/b-actres.htm 1/4/03

Smith, M. K. and Sela, O. (2005). 'Action research as a bridge between pre-service teacher education and in-service professional development for students and teacher educators.' *European Journal of Teacher Education,* 28(3): 293 - 310

Smutny, J.F. (2000) *Teaching Young Gifted Children in the Regular Classroom. ERIC Digest E595.* http://www.ed.gov/databases/ERIC_Digests/ed445422.html 1/5/2002

Stake, R. (1994) 'Case Studies' in N. Denzin and Y. Lincoln (1994) *Handbook of Qualitative Research,* London: SAGE Publications

Stake, R. (1995) *The art of case research.* Newbury Park: SAGE Publications

Stenhouse, L. (1975) *An Introduction to Curriculum Research and Development.* London: Heinemann

Stenhouse, L. (1984) 'Action Research and the Teacher's Responsibility for the Educational Process.' In J. Ruddock and D. Hopkins (Eds) *Research as a Basis for Teaching.* London: Heinemann

Stenhouse, L. (1988) 'Case Study Methods. In J.P. Keeves (ed.) *Educational Research. Methodology, and Measurement: an International Handbook,* 1st edn. Oxford: Pergamon

Strauss, A.L. and Corbin, J. (1990) *Basics of Qualitative Research: Grounded theory procedures and techniques.* California: Sage

Stringer, E. T. (1999) *Action Research: a handbook for practitioners.* Thousand Oaks: Sage

Summers, M. (1994) 'Science in the primary school: the problem of teachers' curricular expertise.' *The Curriculum Journal,* 5(5): 179 - 193

Symington, D. (1980) 'Elementary school teachers' knowledge of science and its effect on choice between alternative verbal behaviours.' *Research in Science Education.* 10: 69 - 76

Taylor, C.W. (1988) 'Various Approaches to Definitions of Creativity.' in R.J. Sternberg (Ed.) *The Nature of Creativity.* New York: Cambridge University Press

Teacher Training Agency (TTA) (1999) *Teacher Research Grant Scheme. www.tda.gov.uk 6/8/02*

Teacher Training Agency (TTA) (2000) *Patterns and issues emerging from the third year of the TTA funded Teacher Research Grant Scheme 1999.* London, TTA

Teacher Training Agency (TTA) (2002) *Qualifying to teach: handbook of guidance.* London: TTA

Teacher Development Agency (TDA) (2006) *Training and Development Agency for Schools* http://www.tda.gov.uk 6/5/06

Teare, B. (1997) *Effective Provision for Able and Talented Children.* Stafford: Network Educational Press Ltd.

Tellis, W. (1997) 'Application of a Case Study Methodology', *The Qualitative Report,* Vol.3, No.2. http://www.nova.edu/ssss/QR/QR3-3/tellis2.html 6/8/02

Tolan, S.S. (1992) 'Only a parent: Three true stories.' *Understanding Our Gifted,* 4(3), 1 8-10

Tooley, J. with Darby, J. (1998) Educational Research: A critique – A survey of Published Educational Research, London: Office for Standards in Education

Traianou, A. (2006) 'Understanding teacher expertise in primary science: a sociocultural approach.' *Research Papers in Education.* 21(1): 63 - 78

Usher, R. and Bryant, I. (1989) *Adult Education as Theory, Practice and Research.* London: Routledge

Van Manen, M. (1977) 'Linking ways of knowing with ways of being practical. *Curriculum Enquiry.* 6: 205 – 288

Van Tassel Baska, J. (1998) *Planning Science Programs for High Ability Learners.* http://ericec.org/digest/e546.html 10/4/02

Van Tassel Baska, J (2000) 'Theory and Research on Curriculum Development for the Gifted.' In K.A. Heller, F.J. Mönks, R.J. Sternberg and R.F. Subotnik (Eds.) *International Handbook of Giftedness and Talent (2nd Edition)* Oxford: Elsevier

Vygotsky, L. S. (1962) *Thought and Language.* New York: Wiley

Wadsworth, Y. (1998) 'What is Participatory Action Research?' *Action Research International, Paper 2.* http://www.scu.edu.au/schools/gcm/ar/ari/p-ywadsworth98.html 24/02/05

Waters-Adams (2004) *Action Research in Education.* http://www.edu.plymouth.ac.uk/resined/actionresearch/arhome.htm 7/7/06

Whitehead, J. (1989) Creating a Living Educational Theory from Questions of the Kind 'How Do I Improve My Practice?' *Cambridge Journal of Education*, 19: 41–52.

Whitehead, J., (1993*) The Growth of Educational Knowledge: creating your own living educational theories.* Bournemouth: Hyde Publications

Wilson, R., Hemsley-Brown, J. Easton, C. and Sharp, C. (2003) *Using Research for School Improvement: the LEA's role* (LGA Research Report 42). Slough: NFER

Winner, E. (1996) *Gifted Children: Myths and Realities.* New York: Basic Books

Winter, R. (1989) *Learning for Experience.* Lewes: Falmer Press

Zeichner, K. M. (1993). 'Action Research: personal renewal and social reconstruction.' *Educational Action Research*, 1(2), 199-219

Zohar, A. (1999) 'Teachers' metacognitive knowledge and instruction of higher order thinking.' *Teaching and Teacher Education,* 15: 413 - 429

Zuber-Skerritt, O. (1995) *Action Research in Higher Education: examples and reflections.* London: Kogan Page

Appendix 1

Time Line for the School Action Research Project – September 2001 – July 2002

Research Activity	When it happened
First Action Research Cycle	
Planning	Autumn term 2001
Analysis of questionnaire filled in by all teaching staff to find: • training need; • classroom practice; • understanding of the concept of challenge in science.	Autumn term 2001
Interview all teachers to examine confidence in their ability to challenge children in science.	Autumn term 2001
Staff meeting to discuss the project.	Autumn term 2001
Full day meeting of the research team to: • discuss the present position in the school; • discuss the nature of Action Research; • develop observation schedule and attitude questionnaire.	Autumn term 2001
Full day visit to other schools	Autumn term 2001
Teacher researchers trial observation schedule and attitude questionnaire within their own classes	Autumn term 2001
Classroom observations to examine how teachers challenge children	Autumn term 2001
Questionnaire for children to find out their attitudes to science	Autumn term 2001
Staff development on challenge in science.	Autumn term 2001
Full day meeting of the research team to discuss all audit data.	Autumn term 2001
Teacher researchers trialling of activities in lessons, with children's self assessment of their success.	Autumn and Spring terms 2001/2
Second Action Research Cycle	
Feedback to staff on challenging activities the teacher researchers have trialled in their lessons	Spring term 2002
Classroom observations to examine how teachers implemented strategies for challenging children in science or not.	Spring/ Summer terms 2002
Staff meeting for all teachers to share good practice	Summer term 2002
Questionnaire/ interviews with children to find out if their attitudes to science have changed	Summer term 2002
Interview (all teachers to examine if their confidence in their ability to challenge children in science has changed.	Summer/ Autumn terms 2001
Two half days to draw conclusions and write up the report.	Summer term 2002

Appendix 2

Time tables for my interviews

18th September 2001

Interview 1: Teacher researchers to examine:

- their role in the action research project and the roles of other; stakeholders in the research;
- the need for the action research project;
- tensions or conflicts that have arisen concerning their roles as teachers and researchers.

TR1	9.15
TR2	10.00
TR3	11.00
TR4	13.00

30th /31st May 2002

Interview 2: All of the teachers in ARP School to determine:

- they perceive that their science teaching has improved/altered during the year and in what ways;
- they feel more confident about challenging children in their science teaching;
- children have become more motivated and excited by science;
- they feel that attainments in science have improved as a result of the action research project;
- they are now challenging gifted children in science.

T1	9.15
T2	10.00
T3	11.00
T4	11.45
T5	13.15
TR2	14.00
T7	14.45

T8	9.15
TR4	10.00
T10	11.00
TR3	11.45
TR1	13.15
T13	14.00

18th June 2002

Interview 3: Teacher researchers to determine:

- if action research was seen to be an effective means of staff development;
- if they have become more reflective practitioners as a result of the Action Research Project;
- if any tensions or conflicts have arisen and if they have, have they been successfully resolved;
- if perceptions of education research, as an effective means of staff development, have changed during the year;
- if any tensions, conflicts or ethical issues have emerged during the research year.

TR1	9.15
TR2	10.00
TR3	11.00
TR4	13.00

2nd July 2002

Interview 4: Teacher researchers to discuss:

- if the success criteria of the Action Research Project have been met;
- if the success criteria of the Action Research Project were realistic.

TR1	9.15
TR2	10.00
TR3	11.00
TR4	13.00

Appendix 3

Teacher researchers lesson observation schedule (the right hand column was bigger to allow comments to be written in during the observation.)

Year Group	
How does the teacher encourage children to bring their own scientific experiences and existing knowledge and understanding to the lesson in a non-threatening way?	
How does the teacher clarify, build or develop pupils' ideas? e.g. Explaining and using subject specific vocabulary	
Where is the whole class lesson pitched? To the less able children? To the average children? To the more able children?	
How does the teacher show a clear knowledge of the science topic? e.g. use of vocabulary, building stages of understanding.	
How does the teacher ensure pace and momentum are maintained?	
In what ways does the whole class lesson include interaction with children e.g. : Targeted questions Pupil's ideas Open and closed questions	
What resources are used to promote learning?	
How does the lesson challenge able children?	
In what ways does the teacher engage the children in intellectual discussion and debate, e.g. praise, jokes, questions, examples in everyday use, industrial use, fun activities, world/ethical issues.	
How is the lesson differentiated to meet the needs of able pupils?	
Are there different objectives for gifted children? How are these objectives taught?	
At the plenary do the children evaluate, interpret and share their science findings? If so, how?	
Is there evidence that children have made progress in their scientific knowledge and thinking and have achieved the learning objectives?	

Appendix 4

Tape transcription of Interview 3 with TR2 with initial coding of themes

		Theme
Interviewer	These questions are about educational research for the end of the project. What do you think of educational research as a means of staff development?	Action research as professional development
TR2	I think it is invaluable. It allows you time to visit other schools, it allows you time to reflect on your own practice. It allows you time to discuss issues with colleagues, and it allows you time to focus on a specific area.	
Interviewer	Right. Did you develop any skills or expertise during…is that something else that comes into it?	
TR2	Well yeah, In mean, I'm just starting my third one, my third research project and, and I've developed as a, as a researcher through every single one. And I mean, the first one it was on a low quantity, so you know, I was being led by people, but this time I've been able to take more of a proactive part. And the next one is, I'm going to do as an individual, so I'll be able to then organise myself and organise my own research project. I wouldn't have been able to do that if I hadn't undertaken the two I've already done.	
Interviewer	Right. Do you think other colleagues in the, in the school can develop, can, can benefit from a research project?	
TR2	Yes, I think so. I mean, because the staff meetings and the inset meetings that we've undertaken throughout this research project have helped other staff look at their own practice and develop it. For example, we've done different types of planning, we've looked at questioning skills, we've looked at developing the skills of the more able children. That was on the SDP anyway, but it's been highlighted through this research project.	
Interviewer	So, all in all, research, research is an effective means of staff development?	
TR2	Yes, it is, extremely effective.	
Interviewer	Who, do you think, had control of the research agenda during this past year?	The roles of different stakeholders
TR2	Oh, I think it was a joint, a joint issue with Oxford Brookes and the school. I don't think it was anyone individual. I think the, one of the good things about research is that you are, you are able to discuss and get ideas and then formulate it as a group, not just one, one individual using it, really. So I think it was a joint effort.	
Interviewer	Do you think this, there were, the balance changed or anything, through the year or was it the same all the way throughout the year?	

TR2	I think the balance has obviously got to change, because some people within the group are more experienced than others. And certainly the input given by Oxford Brookes, on the technical side of the writing and how to develop the research project, pointing us in ways that we haven't thought. Because of course, they have done a lot of research projects and they know exactly the format and how to write it. And, certainly within the research project, to keep it on track. Sometimes a member who is more experienced than the others has to call a meeting and, and clarify where it's going instead of going laterally 'It needs to go forward'. But, so the balance is bound to shift throughout the project.	
Interviewer	Right. So...do you think someone working externally from the school is important?	
TR2	Yes, I do think it is, because I think it gives another view on the project. Sometimes, it's like anything, sometimes if you're in amongst it all the time, especially working with colleagues in a school, you tend to get bogged down by the same sort of language and the same sort of style, whereas somebody coming in can give fresh ideas and fresh input, and lead you in a different direction. And that's, and that's, I think that's an invaluable part.	
Interviewer	So, what does, what does the term action research mean to you now?	The nature of action research
TR2	I think action research is, is being able to access different areas of research, for example by going out of the classroom into other schools, by you know, spread it, going and having a look at books in the university. By, you know, by spreading your wings outside of just the classroom and the school environment.	
Interviewer	So, what's the purpose of action research?	
TR2	Well, I think the purpose of action research is to help teachers to, help teachers to progress their own teaching and learning. If teachers are doing it themselves, there is of course a relationship, you know, between the teachers and the people reading it. If just university people are writing it, sometimes they haven't got the ground level knowledge and understanding, which ordinary teachers who are teaching it on a daily basis have. So, you know, we are able to speak their language really, and to be able to know the difficulties and the successes that they'll have as well as we have. And I think that's, that's really invaluable.	
Interviewer	So, action research really needs to have, involve teachers?	
TR2	Yes, I think so. It depends what kind of research it is. Sometimes it has to be more academic.	
Interviewer	If it's looking at teaching and learning?	
TR2	Yes, I think if it's looking at teaching and learning it has to involve teachers, because they are the ones who are teaching every day and developing the children's learning.	
Interviewer	Right. I mean, there are examples of development of teaching and learning, like literacy hour and things. Do you think that's a research based project?	

TR2	Yes, I would've thought that that was a research-based project, a wider research-based project. It probably took a long time over a long, a big spectrum of schools, to be able to come up with the formula.	
Interviewer	So, is, is sharing ideas important?	
TR2	I think that's extremely important. I mean, because during the research projects itself people, you know, they tend to be positive or negative depending on their viewpoint of how it's going. And sharing ideas and bringing the project forward really helps to clarify and extend and just, and just points the way to where you are going. And if you don't share idea's, you can become too tunnelled in what you're thinking. And you could be going off in the wrong tangent all together.	The roles of the different stakeholders
Interviewer	So, all of the things you talked about, I could say that that's reflective practice?	The nature of action research
TR2	Yeah, this is reflective practice.	
Interviewer	How does reflective practice differ from action research?	
TR2	Well, reflective practice is when you are actually reflecting on your own practice, and then you're improving your own practice. Action research is when you're reflecting on your own and other's practices, and then extending it out to help other teachers in other schools.	
Interviewer	So you can't do action research in your own classroom on your own?	
TR2	You, yes, if you're going to write it up you can, but it's...it's very singular. I mean, you could, you can test out some of the action research in your own classroom. But I still think it is, still think it's better if you can go out and see other, other practitioners.	
Interviewer	So what makes it, what moves from reflective practice to research, what's the difference between the two things?	
TR2	Reflective practice is what you normally do on a day-to-day, and one-to-one basis. I mean, a good teacher reflects on every lesson that she does, and you know, sees how she can make it better and or whether, you know, whether it's been a success. The research is going one stage further, it is extending it to looking at a specific focal point. I mean, I, as a teacher, would be reflecting on most of my lessons in the week. Whereas, as a researcher I was only looking at science and the more able child.	
Interviewer	So action research is more focused?	
TR2	Is more focused. Yes, it is much more focused.	
Interviewer	So, how have your ideas about action research developed during the time of this project?	
TR2	I've, I've, my ideas have been more structured now. You know, I've been able to structure my ideas on how I'm going to go about it, what are the, you know, more geared up to the aims of the project, without going as a tangent bred wise, and more thinking about the conclusions, and the data, and the analysis part of it. So, it, you know, my ideas have become a lot more structured.	
Interviewer	So, is data important to an action researcher?	

TR2	Yeah, I think it is. I think data...data can be an important point depending on, really, what the action research is, but I think you have got to have some data to be able to proof a point. Or, or as a starting block, you know starting data, finishing data. To be able to show that something has been successful or not.	
Interviewer	So, to go back to reflective practice... Does reflective practice involve gathering data or proving points that you talked about? See if they've been effective or not?	
TR2	Yes, I mean, reflective practice can, but then again, it doesn't necessarily need to be. I mean, if I'm looking at my literacy lesson, I could just look at that one lesson and not look at data. If I'm looking at myself as being a, say for example writing throughout the whole year then I would need data at the beginning of the year and at the end of the year to see whether the strategies I've put in place have been successful. But on a day-to-day basis it wouldn't need data.	
Interviewer	Right. How might the research have differed if I had not been involved?	
TR2	I think it wouldn't have been as focused. And I think that when we'd got into difficulties about knowing the next step, we would've had to, we would've, I think we would've been floundering and I think we probably would've asked for outside help anyway. It is just the focus and it is the next step forward, really, that we need an experienced, you know, somebody who's done it before.	
Interviewer	Right. What do you mean by focused, then?	
TR2	Well, you know, sometimes you can go off at a tangent, and be thinking, you know, and be looking at different things that really are not the aim of the project. You know, you get, the aim of the project was the more able child, so you put, you know, you, with all the best hounds in the world you could be looking at the lower able child, the medium, and, and, you know, and not focusing on the actual aim of the project, and I think the focus has got to be in your mind all the time, and I think an outside person helps to keep that focus.	
Interviewer	OK. How might the, the research have differed if you were working on your own?	The roles of different stakeholders
TR2	That would've been lonely. Probably not a great deal, really, except that it would have been a lot more, a lot more stressful, really, a lot. You know, because the sharing and the, the sharing in the discussions and the allocation of jobs relieves a lot of the pressure.	
Interviewer	Right.	
TR2	If you would've been doing it on your own, it would've taken twice as long probably, and it would've been twice as pressure, twice as much pressure and it would've mean, meant a lot more time out of the classroom, which would've been unsatisfactory.	
Interviewer	Do you think you would've made as much impact?	

TR2	I don't know, I don't know. I mean, I think, I think, yes, if you're very enthusiastic I would've had the same amount of staff meetings and in some respect maybe, you know, some people do good staff meetings, other people don't. Some people are experienced. And, you know, and maybe it might have, some of the inset in staff meetings might have actually improved in quality. But, it would've been a lot, a lot more work.	
Interviewer	Right. What effects has this taking part in the research project had on you personally?	
TR2	I felt a sense of achievement, I have felt a sense of achievement. When you first feel the, the finished document and you look at your name on it, it's a sense of achievement that you have actually achieved something, you know, that your name is on a piece of work that is going out and that is going to be read by, you know, a broad band of people. And I think, you know, and also a sense of pride in the fact that you've undertaken a project, you know, that is maybe going to have an influence on somebody else's teaching practice.	
Interviewer	Right. Do, do you think you're more reflective now?	
TR2	No.	
Interviewer	Always was?	
TR2	Hm.	
Interviewer	OK. The, the next question is about tensions and conflicts. Just see whether, or even ethical issues, whether they, whether those have arisen during the year. Do you think there were any, any tensions, conflicts, ethical issues between you and, as a teacher-researcher, and the other teachers?	Tensions associated with the Action Research Project
TR2	The other teachers in the, the other teachers in the research project, no, but the other teachers in the school, yes. Certainly because, you know, teachers view that they've got a big workload, which is absolutely right. We all have a big workload and for somebody to come along and say 'We want you to add different layers to this workload', it's taking a lot of persuasion for them to see the good of doing that in the end. You know, and that has, you know, that has created tensions, because I've had to –and so has Fiona- I've had to go and meet teachers after school and talk to them and had a look at their planning, and...It's, it's given them extra work to do, which, teachers don't want extra work to do, they've got enough as it is. So in that respect, yes.	
Interviewer	So how, how were those resolved?	
TR2	They were resolved, because they saw that it, it, the, the project would be of benefit from the, for the school, you know, that teacher-researchers were actually doing it within the school. That it would develop their scientific knowledge and understanding and that hopefully in the end it would develop the children's teaching and learning in science. So they saw the, they saw the positive side of it. It was just an initial sort of, you know, stepping back against the extra workload.	
Interviewer	What about tensions between your different roles as a teacher-researcher and a deputy-head, I suppose, I mean that...?	

TR2 Yeah. No, there wasn't any tensions, really, about that. I mean, no, it's very compartmentalised. The only tension, I think, there was ever is that sometimes I gave up my non-contact time to do the research project, which meant that I wasn't doing the other jobs that I should be doing. So, which meant that in the holidays I had to spend another couple of days of my own time catching up on my own jobs, but beyond that, I don't think there was anything.

Interviewer What about in your class? Effects in your class when you weren't there, really?

TR2 Yeah, I mean, last year I had a particularly volatile year 6. And, and it was difficult to get the right calibre of supply teacher to cover me in order that they didn't, you know, explode. I was looking really, and I deliberately did it this way, that I had a good year 3 student, and so, and that helped, because, you know, she was very secure. She'd been with me for about four weeks, so in the June-July, the writing up time, when she was here for the first three weeks in June, I was able to take time off. With just a supply teacher, you know, viewing her, and, you know, and I'd already planned that in. And, you know, I was just very lucky that I got a good one. I had asked, I wanted a good student. So, you know, that, that was easier. But, it, it does take forward planning, really. And I'd also planned different activities for a time when I knew I will be writing up the project. I had language in evidence week when I knew I'd have those three days off when my presence wasn't necessarily required, because the police were here taking off the whole week.

Interviewer Right.

TR2 So, I'd, I'd looked at the year as a whole, and planned it, so that the times when I knew I would have to take days off were covered, really.

Interviewer Right. What about you as teacher-researchers and me? Conflicts, tensions?

TR2 Well, I don't think there was any conflict or tensions between ...

Interviewer I am only asking the question now.

TR2 Well, as far as I'm concerned, there wasn't any conflicts or tensions between us, because, as far as I'm concerned, I was the learner, and you were more the expert in regards to how to go through the process.

Interviewer Right.

TR2 And, and, I was, you know, I'm quite keen to learn the process, because I want to do more of these projects, so, as far as I'm concerned, I was wanting to learn as much from you as I possibly could.

Interviewer Right. What about other teachers and me? Could you, could you see any issues for them?

TR2 No, no I didn't, I didn't particularly see any issues. The only issues that there were sometimes is that the issues of after-school meetings when, you know, when we've got a lot on after school. But beyond that, you know, but the actual days when we could actually concentrate on the project were beneficial.

Interviewer Right. You've already said this, but would you like to be involved in another action research project?

TR2	Yes, I would. Yes, I'm going to.
Interviewer	Why? Why?
TR2	Because I really really find it very, very interesting and challenging. And I find it helps my own teaching. And I like going around, I like looking at other teachers teaching, I like going around at the schools, I like reading, specifically scientific books. And I like, I like being involved in the whole process.
Interviewer	Right. It helps you in teaching, how does it help you in teaching?
TR2	Well, it helps me in that, you know, like when we were doing the challenging science projects and you were saying about using different types of books, using different types of methods, I tried them out in my own teaching. I mean, there were, you know, there was a few that I picked up that I hadn't been using before. And that wouldn't have come, you know, except for this project. And when I went out and saw somebody else teaching, I saw a different style of teaching and you pick up pointers. You naturally do, I mean, it's a natural reflective process.
Interviewer	Couldn't that have happened in a staff meeting?
TR2	Not necessarily, because you don't often see teachers, other teachers teach at a staff meeting, it's just discussion. And you're discussing the style that your school has really adopted. You need to go and spread yourself out to see how other schools are, you know, dealing with it, to, to see a different method of teaching.
Interviewer	Right. What area would you like to look at next, then?
TR2	Well, at the moment, I'm just starting and I've read upon details on advanced mentoring qualification, which is going to involve a lot of my own study. And a lot of my own writing up.
Interviewer	Who's that with?
TR2	That's with Oxford Brookes, Jenny? Yeah, so I'm just starting that now and I like, I have to actually read the documentation and see when that finishes. I think, probably I would like to do something on maths, because, that's a specific interest of mine.
Interviewer	OK. Thank you very much. Anything else?
TR2	No, that's fine.

Appendix 5: Planning sheet developed by the teacher researchers (boxes were bigger on the original sheet)

Subject	
QCA unit	
Objectives	
Key science skills	
Vocabulary	
Introduction (including questions)	
Activities Include challenge and extension activities where appropriate.	
Plenary (including questions)	
Resources	
Evaluation	