Primary science in the UK: a scoping study

Final Report to the Wellcome Trust

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Contents

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1 ABBREVIATIONS USED IN THIS REPORT

ANOVA	Analysis of variance
ASCII	American Standard Code for Information Interchange
CPD	Continuing professional development
DTI	Department of Trade and Industry
HEI	Higher Education Institution
ICT	Information and communications technology
ITE	Initial Teacher Education
LEA	Local Education Authority
KS1	Key Stage 1 (& equivalent in Scotland)
KS2	Key Stage 2 (& equivalent in Scotland)
OFSTED	Office for Standards in Education
QCA	Qualifications and Curriculum Authority
SATs	Standard Assessment Tests
Sc1	Scientific Enquiry in the National Curriculum
SEN	Special educational needs
SPSS	Statistical Package for the Social Sciences
VLE	Virtual learning environment

2 EXECUTIVE SUMMARY

2.1 Purpose of the research

The Wellcome Trust commissioned this research in May 2004. The Graduate School of Education at Queen's University Belfast and the Science Department of St Mary's University College Belfast carried out the work. The Wellcome Trust was seeking to establish an overview of the current status of primary science in the UK with particular reference to strengths and weaknesses in specific focus areas, issues of concern and ways to improve primary science so that children are best supported to develop the sorts of skills that will help them to become active and informed citizens.

2.2 Aims

- To provide a clear, evidence-based, analysis of the current issues facing primary science in the UK with particular reference to the specific areas outlined in the tender documentation.
- To explore primary teachers' attitudes to science and ways in which they support primary students to develop *scientific literacy*.
- To evaluate the impact of the types of science initiatives already taking place in UK primary schools.
- To identify a niche within which the Wellcome Trust could usefully take forward work in this area.

2.3 Methodology

The methodology involved four strands which, when taken together, provided a range of data collection and analyses, both quantitative and qualitative. This approach was adopted to obtain findings which reflected the main challenges and future opportunities for primary science across the UK. The strands were:

- Surveys - in the teacher survey, telephone interviews were carried out to explore teacher attitudes, classroom practice, inclusive science education and additional sources of funding for science teaching. In the HEI survey, an e-mail questionnaire was used to explore the range and impact of science initiatives in primary schools.
- Focus group discussions involving groups of teachers took place in different regions of England (three groups), Scotland (one group), Wales (one group) and Northern Ireland (pilot and one group). These discussions addressed issues arising out of the literature review and telephone survey questionnaire.
- Literature reviews of children's attitudes towards primary science and of science initiatives in primary schools.
- A 2-day conference for primary teachers and other stakeholders in primary science to discuss issues arising from the research and ways forward for primary science.

2.4 Key findings and recommendations

The key findings were that:

- Teachers felt that their overall lack of science background knowledge, confidence and training to teach science effectively was the most significant issue currently facing primary science
- The other main issues were, in rank order: lack of resources, lack of time, overloaded science curriculum, large class sizes and lack of classroom assistance
- There was great inequality between schools in the amount of funding they received for science
- Teachers who had carried out professional development in science were significantly more confident to teach science
- Carrying out science investigation in the classroom was constrained by concentration on preparation for national tests, lack of time and lack of teacher confidence
- Making science more relevant to pupils' experience was considered to be the best way to improve the teaching and learning of primary science
- Other main improvements in primary science teaching which could lead to children becoming more active and informed citizens were suggested as: more training for teachers, more funding for resources, more classroom assistants, more time to teach science, smaller class sizes for science, less science content in the curriculum, more and better use of ICT, involving more science experts in supporting science teaching and using specialised science teachers
- Children really enjoy doing science but it has been recognised in several studies in the UK and beyond that the general level of enjoyment of science decreases in the later primary school years.
- Only about one quarter of the 300 schools sampled received any extra funding for science
- Approximately one fifth of UK ITT providers responded that they had been involved in science initiatives with primary schools in the last five years. None of these were from Wales and only two were from Scotland.

The key recommendations are:

- Policy-makers, teacher educators and CPD providers should work *in partnership* to provide targeted and structured UK-wide CPD provision for primary teachers to develop their science teaching confidence and skills
- Teachers should be facilitated and rewarded to promote their involvement in professional development in science
- Policy makers should provide guidance regarding appropriate levels of funding for science in primary schools
- All stakeholders need to work to make primary school science more relevant to the experience of children
- Research needs to be carried out into the most effective ways of making primary science more relevant to children's lives
- Policy makers and curriculum developers should either keep primary and secondary curricula discrete and non-overlapping or deal with the overlap by promoting more effective links between primary and secondary teachers.

- Teacher educators need to ensure that all primary student teachers are provided with practical expertise in the planning, design and running of simple science investigations
- Effective use of ICT in primary science should be facilitated
- Innovative approaches should be introduced which have been shown to improve teachers' confidence and skills to teach science, such as co-teaching (joint planning, teaching and evaluating lessons) between science student teachers and classroom teachers.

3 FINDINGS AND RECOMMENDATIONS

3.1 Main findings

The main findings from this study are based on the responses of 300 teachers across the UK to the telephone survey and on the focus group discussions which took place in England, Northern Ireland, Scotland and Wales. The findings relating to HEI initiatives in primary science were obtained from their responses to the e-mail survey.

The key findings suggested that primary teachers feel they lack the confidence to teach science effectively, particularly in relation to carrying out simple science investigations. Teacher confidence was increased, however, by their involvement in primary science professional development activities. In addition, despite teachers' agreement that children really enjoy doing science, the general level of enjoyment of science decreases in the later primary school years. There was great inequality between schools in the amount of science funding they receive. Teachers also identified lack of resources, lack of time, overloaded science curriculum, too much concentration on preparation for national tests, large class sizes and lack of classroom assistance as major issues facing primary science.

The most effective improvement in primary science to develop children's skills to become more active and informed citizens was identified as making science more relevant to children's experience.

Only about one quarter of the 300 schools sampled received any extra funding for science Approximately one fifth of UK ITT providers responded that they had been involved in science initiatives with primary schools in the last five years. None of these were from Wales and only two were from Scotland.

3.1.1 Issues of concern in primary science

1. The main issue of concern voiced by the survey teachers and by all the mixed sector workshop groups who attended the conference was teachers' lack of knowledge/expertise/confidence/training (7.1 & 7.2)
2. Survey teachers identified lack of resources and lack of time for teaching science as the next most important issue, whilst the mixed sector groups selected not enough science investigation and concentrating too much on written work (7.1 & 7.2)
3. Male teachers were significantly more likely than females to cite lack of resources as an important issue (7.1)
4. Female teachers were significantly more likely than males to cite lack of time for teaching science as an issue (7.1)
5. The least important issues identified by both survey teachers and those in the mixed sector workgroups were: not enough staff, primary not geared towards science and science being imposed on teachers (7.1 & 7.2)
6. Survey teachers gave higher prominence to the science curriculum being overloaded and classrooms being too small than mixed sector workgroups, whereas the latter gave higher prominence than survey teachers to the issue of not enough investigation (7.1 & 7.2)

3.1.2 Improving children's scientific literacy

1. Almost a third of all teachers in the survey suggested that making science more relevant to everyday life was the way to improve primary science so that children are best supported to develop the skills that will help them become active and informed citizens – i.e. to improve their scientific literacy. This finding is more significant because it was an open question (8.1)
2. The next most important improvements suggested by teachers in the survey were more training for teachers and more funding and resources for science (8.1)
3. The four workgroups at the conference representing teachers, HEIs, CPD providers and policy makers, unanimously agreed that encouraging children to question/investigate was the best way to improve scientific literacy (8.2)
4. The second choice for these workgroups was again unanimous – making science more relevant to everyday life (8.2)
5. The third choice of policy makers was closer work between primary and secondary schools, CPD providers selected more training for teachers, and both teachers and HEIs chose more time for science teaching (8.2)

3.1.3 Confidence to teach primary science - effects of professional development in science and school size

1. The two most important factors affecting teacher confidence in science teaching were:
    - Professional development work in science – teachers who had undertaken any professional development in science were significantly more confident in nearly all aspects of teaching science
    - School size – teachers from larger schools were significantly more confident than those from smaller schools in some aspects of science teaching
2. Teachers in the Northern Ireland sample undertook less professional development work in science and were less confident to teach science than those in other regions, although this could be related to the fact that this sample comprised significantly higher proportions of rural and smaller schools (Appendix 2).
3. Teachers found science more difficult to teach than English and mathematics (6.1.1)
4. In relation to developing children's science skills, teachers were most highly confident to develop children's skills to record data (80% reported high levels of confidence) and least to help them relate science to everyday life (66% higher levels of confidence) (6.1.1)
5. Concerning their own science teaching skills, most teachers had high confidence levels in their science questioning skills (86%) and lowest levels of confidence in using ICT in science teaching (44% higher levels of confidence) (6.1.1)
6. Of the curriculum topics, teachers were most confident to teach the life cycle of a flowering plant (85% higher levels of confidence) and least to teach renewable and non-renewable energy sources (61%) (6.1.1). However, children reported that learning the parts of the flower was one of the most difficult things they did in science (6.2.1)
7. There was little effect of gender, age or school location on teachers' confidence in science teaching (6.1.1)

3.1.4 Use of formative assessment – effects of professional development and extra science funding

1 The two most important factors affecting teachers' use of formative assessment in science were:
- Professional development work in science – teachers who had undertaken any were significantly more likely to include investigations/investigative work, mind mapping and individual target setting as part of their formative assessment in science
- Extra funding – teachers from schools that had received extra funding for science were significantly more likely to use discussion and oral questioning, mind mapping, peer assessment and pre- and post-testing as formative assessment techniques

2. Teachers agreed that formative assessment was more enjoyable than summative assessment for both teachers and children (6.1.2)
3. Fewer than 1% of the teachers surveyed indicated that they assessed children's investigative skills (6.1.2)

3.1.5 Use of creative contexts – effect of teacher gender

1. Female teachers were significantly more likely than male teachers to use role play, stories, developing thinking skills, relating science to everyday life and integrating science with other curricular areas in their teaching of science (6.1.3)
2. Teachers were highly positive about how science learning and teaching helps develop children's thinking skills (6.1.3)
3. Teachers most often used discussion (91% often used) and group work (84%) as creative contexts for teaching science; role play (10%) and drama (8%) were the least used contexts (6.1.3)
4. The use of stories was more prevalent at KS 1 and equivalent in Scotland (6.1.3)
5. Teachers commented that relating science to real life was most effective when science was being taught 'in context', for example outside, during visits, etc
6. Teaching investigative science was considerably constrained by preparation for national tests (6.1.3)
7. Teachers discussed their lack of confidence in facilitating investigations (6.1.3)
8. Doing an investigation properly takes up a considerable amount of time (6.1.3)
9. Children are often upset if they don't get the 'right' result in science investigations (6.1.3)
10. Children carrying out their own investigations was considered more realistic in theory than in practice (6.1.3)

3.1.6 Using history and other subjects in science teaching

1. Children transfer very little across subject boundaries unless teachers make these links extremely explicit (6.1.3)
2. Only 13% teachers often used history in science teaching (6.1.3)
3. Most teachers taught history and science as separate subjects (6.1.3)

4. Curriculum history does not lend itself as a context for teaching science (6.1.3)

3.1.7 Inclusion – gender and special needs

Gender

1. Most teachers (80%) disagreed that girls were less interested than boys in science (6.1.4)
2. Despite this, 47% teachers agreed that they tried hard to get girls more involved in science (6.1.4)
3. Teachers held mixed views about girls' engagement in science; some thought that girls were passive whilst others maintained that it was personality, rather than gender, that determined pupil engagement in science (6.1.4)
4. Teachers agreed that there was no significant difference between girls' and boys' performance on national science tests (6.1.4)
5. The effect of gender on science enthusiasm was less apparent at KS1 than at KS2 (6.1.4)
6. Some teachers commented that girls were more methodical than boys in their approach to practical work (6.1.4)

Special Needs

1. There is a serious issue of maintaining the balance between the needs of a small number of special needs children in the class with those of the whole class, especially in regard to practical science (6.1.4)
2. Children with certain special needs, such as autism or Asperger's syndrome, related well to science activities (6.1.4)
3. Children with learning difficulties frequently performed much better in science than in other subjects (6.1.4)
4. Teachers cautioned that science was not a panacea for children with all types of special needs (6.1.4)

3.1.8 Children's attitudes to primary science

Some of the findings relating to children's attitudes in this section are derived from earlier work by members of the project team (Murphy and Beggs) and other studies.

1. Teachers agreed that children loved learning science (6.2.2) and greatly enjoyed practical work in science (6.2.3)
2. Many children experienced a decline in interest in school science which starts at around the age of 10 (6.2.1)
3. There was little relationship between attitudes to school and attitudes to science - those towards school were more positive and the difference became greater as children got older (6.2.1)
4. There was evidence to show a bigger difference in attitudes towards school science between younger and older primary children (younger more positive) than there was between girls and boys (girls slightly more positive) (6.2.1)
5. The possible reasons for the observed decline in children's interest in science at primary school could include the following:

   a. Lack of experimental work
   b. Preparation for national tests (where applicable)
   c. Difficult science curriculum content

6. Children maintained that learning the parts of the flower was one of the most difficult things they did in science (6.2.1), even though teachers were more confident teaching this than other science topics (6.1.1)

3.1.9 Impact of primary science initiatives

1. A survey of primary science initiatives indicated that most addressed the following areas:
   - Increasing teachers' confidence to teach science
   - Promoting scientific investigation in the classroom
   - Increasing children's enjoyment of science
   - Improving pupil attainment in science
   - Improving continuity between KS2 and KS3 science
2. The most commonly used approaches to support teachers and learners in the development of primary science were:
   - In-class support
   - ICT-based support
   - Use of support materials
   - Out-of-class intensive workshops
   - Production of materials by teachers
3. The areas of the UK which appear to be the most poorly served in terms of primary science professional development are: Wales, Scotland, parts of the north west and south west of England.
4. Whilst many of the initiatives reviewed for this project undoubtedly had a significant impact on children and teachers in the project schools, their impact on the school population as a whole was not nearly as high.
5. The work of the AstraZeneca Science Teaching Trust (ASZTT) since its establishment in 1997 has been pivotal in improving primary science professional development.
6. Gaps in provision are evident in the following areas:
   - Science for children with special needs
   - Integrating science with other curricular areas
   - Relating science to children's everyday lives

3.2 Overall recommendations

3.2.1 Key recommendations

The findings from this project suggest that the key to improving children's scientific literacy lies in making school science more applied to real life and to involve children more in raising questions and carrying out simple science investigations. It has also been shown that teachers feel that their confidence and knowledge relating to teaching science needs to be further developed. There is clear evidence that teachers who had undertaken science professional development work were more confident to teach science.

The study recommends that there needs to be a national, structured programme of professional development in place for primary teachers, which concentrates on making school science more relevant to the everyday lives of the children and using more investigative approaches in science learning and teaching. The curriculum for science needs to be improved to ensure that science learning is meaningful and relevant. In addition, teachers should be given more time to teach investigative science. Where applicable, the amount of time spent on 'cramming' for national tests should be reduced and the nature of the tests should be changed so that children are assessed more on their scientific thinking and less on their memorisation of scientific facts.

3.2.2 Key mechanisms

The key mechanisms enabling such development in primary science involve greater levels of partnership between the various stakeholder groups – with all groups working towards the same goal(s).

Making school science more applied to real life and involving children more in raising questions and carrying out simple science investigations could provide the overall themes for professional development programmes across the UK. The same goals could drive curriculum development and form the basis of assessment programmes. Teachers in schools would also direct their own teaching towards these goals and teacher educators could use these goals as the framework in which to contextualise their primary science training programmes.

The following sections set out the specific recommendations for different stakeholder groups to help achieve these and other important goals. Success in doing so would result in fewer children losing interest in science towards the end of their primary education and could lead to a better uptake of science at secondary and tertiary levels.

3.2.3 Recommendations for policy makers and curriculum developers

Professional development and better classroom resources for primary teachers will help to increase their confidence to teach science. In order for maximum benefit to be derived from professional development, policy makers should endeavour to:

1 Provide guidelines for schools in relation to effective resourcing for science – the findings from this research indicate gross inequality in terms of funding received for science equipment and resources.

2 Reward and facilitate teachers' professional development in science

3 Ensure that professional development provision reaches teachers in *all* schools – this study provides strong evidence that teachers in smaller schools are less confident than those in larger schools to teach science

4 Re-work the primary science assessment programmes to ensure that children's scientific thinking and how they can relate science to their everyday lives form the basis of what is being tested

5 Reduce the amount of content in the primary science curriculum; include aspects of science which are likely to enthuse children, not to confuse them

6 Either keep the primary and secondary science curricula discrete and non-overlapping or deal with the overlap by promoting much more effective links between primary and secondary teachers of science

3.2.4 Teachers

The findings from this study have revealed that the following actions should promote more effective science teaching, particularly in the areas of making science more relevant and increasing the amount of investigative science taught:

1. Promote children's learning of science by relating the material to their everyday lives wherever possible
2. Take advantage of opportunities to attend primary science professional development programmes
3. Find out from children the science topics they find difficult; findings from this study show there could be a mismatch between things teachers have high confidence teaching and those children find hard to learn, for example. Try to scaffold (provide structured support with aspects that children cannot work out on their own) the learning of topics children find difficult.
4. Carefully check the requirements of the level of conceptual knowledge required in different topics – some science taught at primary school is too hard for teachers, let alone children

3.2.5 Teacher educators and researchers

Higher education institutions need to enhance the preparation of new primary teachers to ensure that they are confident and effective teachers of science. They could also increase their partnership work with schools and other CPD providers in relation to primary science. More specifically it is recommended that HEIs:

1. Provide *all* students with a good science background and show student teachers ways to make science more relevant to the lives of the children they teach
2. Ensure that *all* student teachers are provided with practical expertise in the planning, design and running of simple science investigations that they can effectively carry out with children in the classroom
3. Provide science specialist students with the skills they require to become effective science coordinators
4. Work in partnership with other CPD providers to ensure that there is an effective, structured programme of provision of primary science for teachers in the locale

5. Validate and accredit teachers' professional development work as appropriate
6. Increase the provision of courses for classroom teachers in primary science
7. Give science specialist students opportunities to co-teach science with classroom teachers to enhance the experience of the children's science learning. Co-teaching involves the student working *together with the teacher* in the planning, teaching and evaluation of science lessons. This has been shown in previous studies (e.g. Murphy, Beggs et al, 2004) to improve classroom teachers' confidence to teach science and has an important effect on improving students' teaching and professional development skills
8. Increase the opportunities for student teachers to incorporate ICT into their science learning and teaching

3.2.6 Continuing professional development providers

Effective CPD provision in science for primary teachers is probably the most important factor in bringing about improvements in primary science learning and teaching. CPD providers are recommended to:

1. Aim to ensure that provision is UK-wide and targeted towards helping teachers make science more relevant to children's lives and to use more investigative science teaching approaches
2. Liaise with HEIs to ensure that provision within a local area addresses the needs of teachers in all schools, particularly those in smaller primary schools.
3. Specifically address those areas that complement provision by the HEIs, such as science for children with special needs, integrating science with other curricular areas and relating science to children's everyday lives – see the areas outlined in section 3.2.1
4. Ensure that professional development in primary science includes hands-on experience for teachers and promote discussion of how the topics can be adapted to suit participants' individual classroom situations
5. Try to incorporate elements of co-teaching science with primary teachers to improve their confidence. Co-teaching involves the provider working *together with the teacher* in the planning, teaching and evaluation of science lessons – previous studies have shown that it greatly improves classroom teachers' confidence to teach science

4 RECOMMENDATIONS FOR THE WELLCOME TRUST

4.1 Key recommendations

The Wellcome Trust would be well placed to contribute towards improving children's scientific literacy and their enjoyment of science by extending its education programme to include a greater focus on younger audiences. This would also help to enhance the uptake of science by students at secondary and tertiary education levels. Such investment would address the aims of the Wellcome Trust's education programme, which sets out to:

- stimulate interest and excitement in biomedical science among young people,
- increase the number of young people studying science at all levels and the quality of people entering biomedical related careers as a profession of choice,
- create future citizens who are well equipped to understand and take individual and societal decisions about the impact of biomedical science on their lives.

The Trust could potentially extend much of their current education work to incorporate more work in school science with younger children, particularly since their current education programme focuses on creativity, testing new ideas and pushing boundaries. Primary teachers, in the main, are not science specialists and use creative approaches to teach other areas of the curriculum. These teachers could benefit enormously from support with creative science teaching.

Specific areas of the Wellcome Trust's education programme that could be extended to address areas of need highlighted in this report include:

1. The Science Learning Centres initiative, which will enable primary and secondary teachers across the UK to spend extended time finding out more about today's science and exploring new ways to enhance the teaching and learning of all science. Part of the work of this initiative could be related to enhancing partnerships between policy makers, CPD providers, HEIs and teachers to provide a programme of professional development for primary teachers aimed at making school science more relevant to children's lives and increasing investigative science teaching approaches.

2. Pulse – this programme currently supports visual and performing arts projects that engage young people with biomedical science. Extension of this programme to include a greater focus on the primary sector would help to address the areas of making science relevant to the lives of the children, increasing children's enjoyment of science and enhancing creative thinking in science.

3. The Wellcome Trust is increasingly looking at how digital media can be used to engage young people in discussing issues in contemporary science. The use of ICT in primary science learning and teaching is increasing at a rapid rate and using digital media to promote discussion of relevant scientific issues is an important aspect of this work.

4. The three themes identified in the Wellcome Trust's Engaging Science grants programme for 2004 – 2006 are all related to making science learning more relevant and meaningful. The Trust could put out a call for project relating to these themes

which are specifically directed towards teachers, children and parents in primary education.

Within these programmes, the Wellcome Trust could support specific areas for development (see below) which have been highlighted in this report.

4.2 Specific areas for development

1. Support for CPD through the Science Learning Centres.

The Wellcome Trust is influential in the direction of the work of the Science Learning Centres. In this role it is recommended that they facilitate:

i. Ensuring that the work of the Science Learning Centres prioritises primary as well as secondary science issues

ii. Professional development in the area of relating primary school science to children's everyday lives

iii. Monitoring teacher confidence in primary science, particularly as a result of science CPD programmes

iv. Hands–on professional development programmes for teachers

v. The development of specific schemes of CPD provision for:

- Science coordinators
- New primary teachers with little science background
- New primary teachers with post-16 science qualifications

vi. Teacher-involvement in developing primary science CPD programmes

vii. Development of the role of science coordinator to audit and organise science CPD in each school

viii. The potential for co-teaching science between:

- Primary classroom teachers and CPD providers
- Primary and secondary classroom teachers

2. Future research areas in primary science

The following research topics are recommended for consideration by the Wellcome Trust to take forward the work of this research project:

i. The relevance of primary science to children's lives and how this can be improved

- Purpose: to inform curriculum developers, teacher educators, teachers and CPD providers

ii. Aspects of science CPD which teachers have found useful and what (and how much) they have incorporated into their practice

- Purpose: to inform and focus CPD programmes

iii. Differences in confidence to teach science between teachers in large and small schools (our findings suggest that teachers in smaller schools are less confident in particular aspects of science teaching)
   - Purpose: to target CPD

iv. Aspects of science primary teachers are most comfortable teaching
   - Purpose: to inform policy makers, curriculum developers and teacher educators

v. Aspects of science children of different abilities find too difficult or boring
   - Purpose: to inform teachers and curriculum developers

vi. Differing levels of engagement of boys and girls in science investigations
   - Purpose: to inform teachers and CPD providers

vii. Concept development in primary science by children of different age groups – where to start teaching different topics and how to progress
   - Purpose: to inform policy makers, curriculum developers, teacher educators, teachers and CPD providers

viii. Children's experience of science as they enter KS3
   - Purpose: to inform policy makers, KS2 and KS3 teachers, teacher educators and CPD providers

ix. Lessons learned from primary science innovations in the UK, Ireland, Europe and worldwide
   - Purpose: to inform all stakeholders in primary science

The project directors have already piloted work in some of these areas, specifically work on children's attitudes and co-teaching.

3. Dissemination of the report and future conferences

It is recommended that the Wellcome Trust disseminates the findings from this report as widely as possible. The report has suggestions which could lead to improvements in primary science at many levels. The Wellcome Trust might produce versions of the report which are tailored to address the various stakeholder groups. More specifically, the following publications and audiences could be considered:

i. A conference report for distribution to all participants and the sectors they represent

ii. A report specifically for teachers, highlighting the most relevant findings and recommendations for enhancing practice

iii. Publication of research papers to address the science education research community in the UK and beyond

iv. An executive report tailored for policy makers which could be used to influence effective decision making in regard to primary science

v. A report to the Science Learning Centres providing an overview of the findings and indicating those areas to which professional development programmes should be directed

vi. Guidelines for other CPD providers who can enhance their own provision by contextualising their courses, promoting links with HEIs and addressing specific needs of teachers

The Wellcome Trust could also facilitate the setting up and running of a series of primary science conferences similar to the one held in Belfast. The evaluations from all respondents were highly positive and recommended that there should be many more opportunities for the different sectors to get together and learn from each other. It is vital, however, that classroom teachers make up a large proportion of the delegate list as they are directly working to develop the skills in children that will help them become active and informed citizens. Teachers attending the Belfast conference were particularly positive about their experience, both during and after the conference.
Ideas for follow up conferences might include:

i. Regional conferences at which the research data are disseminated and the two workshops are focused to suggest ways to enhance primary science locally

ii. National conferences addressing particular themes arising from the Belfast conference, for example:

- Enhancing primary science professional development
- Factors affecting teacher confidence in primary science
- Comparing teachers' and children's views of primary science
- Improving children's scientific literacy
- Designing creative contexts for science teaching
- Promoting inclusion in the primary science classroom
- Using more formative assessment in primary science

5 INTRODUCTION

This research project examines aspects of primary science education provision in all regions of the UK and suggests ways forward to address some of the issues for concern that have been recently flagged up in several publications from the United Kingdom and beyond.

Importance of teaching science at primary level

Most would agree that an aim of primary science is to spark the interest of children in the sciences. In a policy paper from the Royal Society of Chemistry it was suggested that another aim of primary science is to give children a sense of the cultural importance of science in shaping our everyday lives, but also in shaping the way we think about ourselves and the universe (RSC 2001 online).

Young children's natural curiosity can be harnessed in their science lessons. It is during science that they have the opportunities to manipulate materials, ask questions, hypothesise, predict and test their predictions. They can express what they have learnt through drama, writing, talking, drawing and by using ICT.

(a) Development of critical and creative thinking skills

It is by doing science in primary school that children can begin to develop critical thinking skills that can enable them to distinguish between facts and claims. For example, young children can carry out simple tests to determine the validity of a claim that an advertised kitchen roll is the most absorbent. Older children could test a variety of plant growth enhancement products to see which is the most effective.

Learning science also enhances the development of creative thinking skills, such as fluency, flexibility, originality of ideas and imagination. Donnelly (2004) referred to many scientific questions that were raised during 'thinking time' sessions. For example: what did the first people on Earth do?; where do rainbows come from?; how does the sun know it is morning?; where does the tide go? 'Thinking Time' sessions involve the children and teacher sitting in a circle with no designated places. The child opening the discussion makes a statement and then tips the child next to him/ her. If this child wishes to speak she/ he does so, and then tips the next child, if not she/ he passes on the tip. The role of the teacher is to model and scaffold dialogical language and thought processes alongside facilitating and participating as part of a community of enquiry. There is no one conclusion accepted above another nor is there a vote for or against. All thoughts and ideas are accepted and are left to further internal reflection. Donnelly suggests that children are not only capable of but are interested in reflecting on and discussing simple philosophical questions.

(b) Development of scientific skills, concepts and attitudes

Primary science aims to develop scientific skills which will enable children to effectively carry out and communicate scientific approaches. Such skills include: observation, communication, measurement, experimenting, classifying, interpreting data, making hypotheses, inference and prediction. It is also important for children to develop some understanding of scientific concepts, such as: time, life cycles, weight, interdependence of living things, length, change, volume and adaptation. In addition, by doing science at primary school, the following attitudes can be fostered: perseverance, originality, co-operation, responsibility, curiosity, independence of thinking, self-criticism and open-mindedness.

(c) Open-ended investigation

Open-ended investigation in primary science provides perhaps the most important opportunity for children to develop scientific thinking and manipulative skills. Even very young children could carry out simple open-ended investigations with their teachers. An example might be a child or the teacher asking why cress seedlings on the window-sill are bending towards the window. Children could raise hypotheses which could be tested. Typical hypotheses from 4-5 year olds might include that the seedlings are too tall, too tired, lacking water or bending towards the sun. Simple investigations could be planned, such as: stopping watering a sample of seedlings and putting sets of seedlings in each of two shoeboxes which excluded light except for holes cut into different sides of each box and placing a light source close to the hole. For older children, 'choice chamber' investigations with woodlice provide excellent opportunities for children to raise and test hypotheses.

(d) Scientific literacy

Primary science seeks to develop the sorts of skills that will help children to become active and informed citizens. Such skills, together with the conceptual knowledge that underpins their development, is what the authors of this report have previously defined as *scientific literacy* (Murphy *et al* 2001). This notion of scientific literacy is not new. The next section of the report considers a historical perspective of primary science, in which it can be seen that much of the current thinking about ways to improve science learning and teaching for young children has been rehearsed time and again.

What was the provision of primary science before the national curriculum?

Almost one hundred years ago, John Dewey was arguing for improved science education for young learners:

> *One of the only two articles that remain in my creed of life is that the future of our civilisation depends on the widening spread and deepening hold of the scientific habit of mind; and that the problem of problems in our education is therefore to discover how to mature and make effective this scientific habit.* *(Dewey 1910)*

Science in elementary (later called primary) schools in England during the 1920s consisted mostly of nature study. In the early 1930s there was a move to introduce children to physical science and to make the teaching of science more related to everyday life. De Boo and Randall (2001) cite from Savage (1932): '…as far as possible, everyday phenomenon and common experiences should be utilised as the foundation stones of school work in science.' Indeed, a report from the Ministry of Education (England and Wales) (1931) stated that:

> *The aim of the junior school will be to make the fullest use of the lively interest of children at this stage… about the world around them… the curriculum must be thought of in terms of activities and experience rather than knowledge to be acquired and facts to be stored. This will entail a departure from the traditional methods of class instruction in favour of individual work in acquiring skills and in project activities pursued in groups.*

Similarly in Scotland, the Scottish Education Department (1946), cited in de Boo and Randall (2001), in emphasising experiential learning, stated:

> *…the role of the child is that of an adventurer, collector and questioner; that of the teacher to inspire, explain and encourage. The materials of the lesson should, whenever possible, be the real objects. It is very much easier and more real to have a talk about a cow or a potato or the North Star in the presence of these familiar objects. The cow must, however, be seen outside of school, and the North Star out of school hours.*

During the 1950s and 60s, science in primary school did not develop significantly due to constraints such as lack of teacher expertise, lack of resources, large classes and the eleven plus examination. However, there were initiatives for change and perhaps the most important of these was the Nuffield Junior Science Teaching project (1964-66) originally for 7-13 year olds, later for 5-13 year olds. The general educational philosophy of this project was based on harnessing children's natural curiosity and love of asking questions.

During the 1970s and 1980s, the Assessment of Performance Unit (APU) surveyed children's science knowledge at the ages of eleven, thirteen and fifteen and outlined what these children should be expected to do in science. Two other projects were influential. The SPACE (Science Processes and Concepts Exploration) project (1990-98) investigated children's scientific ideas and the STAR (Science Teaching Action Research) project studied classroom practice in relation to process skills. Harlen (p 25, in Sherrington, 1998) has discussed the impact of these projects. In summary, they - together with other international projects - generated major interest in children's own scientific ideas, which has given weight to constructivist approaches towards learning in science.

Post national curriculum primary science

The *National Curriculum for England and Wales*, *5-14 National Guidelines* in Scotland and the *Northern Ireland Curriculum* were all introduced in the late 1980s and early 1990s. These defined for the first time what aspects of science should be taught at primary level. Decisions regarding the content and pedagogy of primary science were made using evidence from the major research projects described above. Science became a compulsory subject in state primary schools in England and Wales in 1989 (and in 1990 in Northern Ireland). In Scotland, science is part of Environmental Studies, one of the five broad areas in the primary curriculum.

There is general agreement that whilst considerable progress with primary science has been made since its introduction as a compulsory primary subject, there is concern that advances made in the early stages are in danger of being lost (Parliamentary Office for Science and Technology [POST], 2003). The POST (2003) briefing summarised these concerns as: declining pupil interest in science during the primary school years, the balance needed between teaching factual knowledge and the skills of scientific enquiry;

the effects of the SATs tests (and equivalents) and the importance of teachers' scientific knowledge and confidence.

Recent inspection reports from England, Wales, Northern Ireland and Scotland indicate that there are UK-wide concerns. The most recent OFSTED subject report for science in primary schools (OFSTED 2004) highlighted the need for more scientific enquiry as an internally and externally assessed component of the science curriculum and to provide more training to address the lack of confidence and expertise of teachers in carrying out scientific enquiry in class. The chief inspector of schools in Wales, Susan Lewis, suggested that teaching in the final year of primary school continues to "concentrate too much on activities in…science that focus too narrowly on questions similar to those in the national tests" (Estyn, 2003). In Northern Ireland, similar concerns were raised in the most recent inspection report of primary science. Priorities for action included the provision of opportunity for children to devise their own investigations, regular formative assessment, the outcomes of which are used to inform subsequent teaching and learning and providing adequate challenge for children across the ability range (Department of Education for Northern Ireland, 2002). A major inspectors' report on science education in Scotland advised head teachers of primary schools to ensure that science is taught systematically throughout the school, adopt a consistent approach to the science content being covered at each stage, ensure appropriate assessment and monitoring of pupils' progress in science and support the teaching of less experienced or less confident colleagues, for example through co-operative teaching (HM Inspectors of Schools, 1999).

Other commentators have also been critical. Audrey Randall, a member of the original working party for the National Curriculum for Science, expressed concern that the recent emphasis of literacy and numeracy has caused science to be marginalized. She wrote of seeing formal science lessons taught in the afternoons which 'were so prescriptive that children were simply following instructions.' There seemed to be 'little opportunity for children to explore, investigate their own questions or further their own intellectual development.' (de Boo and Randall 2001). Gerald Smith, who chaired the DTI Working Party on Primary Science and Technology, highlighted problems such as lack of provision for long in-service practical courses for teachers, lack of sales of primary science equipment indicating the low priority of science in many primary schools, less time in the curriculum for practical activities, and the SATs (Standard Assessment Tests), which test 'children's ability to acquire facts' which can disadvantage many children, particularly those with special needs (de Boo and Randall 2001). de Boo appreciates that nowadays all children now study science and all new primary teachers study science but she emphasises that:

> *We have yet to succeed in persuading all children of the relevance of science to their daily lives and to see themselves as critical guardians against the use and abuse of science and misinformation parcelled out by politicians and the media. Maybe this is the task for the teachers of the new century.* (de Boo and Randall 2001)

There are others however, who feel primary science has been more successful, as indicated by the published results of SATs (for example, see Table 5.1), which show that the attainment of 11 year-olds in the SATs is higher for science than for English and mathematics. There is evidence, however, that primary children are being 'trained' for these science tests and that what is being measured is factual recall rather than scientific understanding (Murphy and Beggs (2003), POST (2003)).

Table 5.1 Attainment of 11-year-olds: percentage of pupils achieving Level 4 or above

	1998	1999	2000	2001	2002	2003
Test						
English	65	71	75	75	75	75
Mathematics	59	69	72	71	73	73
Science	69	78	85	87	86	87

Source 2003 data: Statistical First Release, National Curriculum Assessments 7, 11 and 14-year-olds by Local Education Authority 2003.
1. Includes results from all maintained schools (including Special Schools) and the results for independent schools that made a return.
2. Figures for 2003 are provisional.

There is also evidence to show that some of the science taught at primary school is too difficult for the teachers, never mind the children (Osborne and Simon (1996), Harlen (1997), Murphy *et al* (2001)). If the teacher's understanding is not good, s/he 'covers' the topic from a text and encourages children to 'learn' it. On the other hand, when the teacher has a high level of understanding of a topic, s/he encourages questions from children, explains and promotes active learning.

An issue regarding the Key Stage 2/3 transition is that many secondary science teachers, the majority of whom hold degrees in science subjects, teach science as though children have experienced no prior learning in the subject. This leads to repetition of content, resulting in boredom and disinterest in school science. An Ofsted Secondary Review (1998) referred to children's science experience stating that:

> *In many schools the science curriculum at Key Stage 3 has not been modified to allow for pupils' achievements in primary school so their progress is slow. Much can be gained by improving the interchange of ideas and information across the primary-secondary boundary…*

The problem of lack of continuity in science learning between Years 6 and 7 can only successfully be addressed by the teachers who are best placed to decide which areas of science should be taught at primary and which at secondary levels.

The Wellcome Trust and primary science

The Wellcome Trust initiative to explore whether there is a need to extend its education programme to younger audiences is timely and most welcome in relation to primary science. If adopted, it would enable the Wellcome Trust to have a direct and lasting impact on science education in primary schools, where the current problem of declining interest on school science, if not addressed, will lead to a reduction in the number of scientists and science teachers for the future. The Trust is investigating how children are supported to develop the sorts of skills that will help them to become active and informed citizens. Such skills, together with the conceptual knowledge that underpins their development, is what the authors of this report have previously defined as *scientific literacy* (Murphy *et al* 2001).

In addition, there is a need for co-ordinated, large-scale research into learning in primary science, which the Wellcome Trust would be well placed to contribute to, given its extensive programme of research in many aspects of science learning. Unlike the other core primary subjects, English and mathematics, the primary science curriculum does not present an obvious sequence for the development of concepts and skills. Much of the primary science curriculum is a 'dilution' of the secondary curriculum, as opposed to science 'building blocks' which could be used as a base on which to structure children's progressive development of scientific concepts and skills. There is an urgent need for research into linking children's cognitive development during the primary years with the formation of specific scientific concepts and the acquisition of particular scientific skills.

5.1 Project aims and objectives

The aims of the project were to:

A1. Provide a clear, evidence-based, analysis of the current issues facing primary science in the UK with particular reference to the specific areas outlined in the tender documentation.

A2. Explore primary teachers' attitudes to science and ways in which they support primary students to develop *scientific literacy*.

A3. Evaluate the impact of the types of science initiatives already taking place in UK primary schools.

A4. Identify a niche within which the Wellcome Trust could usefully take forward its work in this area.

In order to address these aims the following objectives were agreed:

O1. Identify current challenges, good practice and opportunities in relation to the following focus areas:

- Children's attitudes to school science
- Classroom practice in primary science
- Use of formative assessment
- Creative contexts for science teaching
- Inclusion in science classrooms
- Relationship between science and other curricular areas
- Additional sources of funding outside mainstream funding

O2. Explore how *scientific literacy* can be best developed in the primary classroom.

O3. Review a range of small and large-scale science initiatives in primary schools and provide an overall assessment of their impact for primary science.

O4. Make recommendations for future primary science education initiatives.

5.2 Methods

It is important to note at the outset that this project was carried out as a *scoping study*, the aim of which was to provide an overview of the key issues facing and opportunities for primary science across the UK. The work does not represent a detailed picture of the exact proportions of teachers and others in the science education community holding particular views.

The methodology involved four strands which, when taken together, provided a range of data collection and analyses, both quantitative and qualitative, following the advice of Cohen *et al.* (2000, p. 112). Cohen *et al* (2000) stated that a multi-faceted approach maps out, or explains, more fully the richness and complexity of human behaviour by studying it from more than one standpoint and by making use of both quantitative and qualitative data. This approach was considered most appropriate for a scoping study which sought to obtain findings that reflected the main challenges and future opportunities for primary science across the UK.

- **Strand A:** **Literature reviews** of children's attitudes towards primary science and of science initiatives in primary schools brought together information from various studies which have been carried out in these areas. This provided a broad framework in which the project findings were discussed.
- **Strand B:** **Surveys** of teachers and HEI personnel were undertaken. In the teacher survey, telephone interviews were used to explore teacher attitudes, classroom practice (including skill development, ICT integration, use of formative assessment, time spent on science and integration of science with other curricular areas), creative and historical science teaching contexts, inclusive science education, and additional sources of funding for science teaching. For the HEI survey, an e-mail questionnaire, which sought to find out about the extent of involvement in primary science initiatives with schools, was sent to all primary initial teacher education providers.
- **Strand C:** **Focus group discussions** involving groups of teachers took place in different regions of England (three groups), Scotland (one group), Wales (one group) and Northern Ireland (pilot and one group). These discussions addressed issues arising out of the literature review and telephone survey questionnaire; participants were also invited to suggest possible ways forward for primary science initiatives.
- **Strand D:** A 2-day **cross-sector consultation conference** in which initial research findings were discussed with teachers and other stakeholders from across primary science education. Representatives from all UK regions attended. There were two keynote speakers and separate mixed-sector and sector-specific workshops to discuss issues arising from the research and ways forward for primary science.

Table 5.2 (below) summarises which methods were used to collect data from each audience group (pupils, teachers, CPD providers, HEI, policy makers) and which methods were qualitative and quantitative.

Table 5.2 Data collection

	Literature Reviews	Telephone survey	E-mail survey	Focus groups	Conference
Primary teachers	✓ 💭	✓# 💭		✓ 💭	✓ # 💭
Children	✓ # 💭				
CPD providers	✓ 💭				✓ # 💭
HEIs	✓ 💭		✓ # 💭		✓ # 💭
Policy makers	✓ 💭				✓ # 💭

Key: data collected from audience group [✓]
qualitative methods 💭
quantitative methods #

5.2.1 Literature reviews

Two literature reviews were undertaken in order to provide a background and context for the work. A review of recent studies into children's perceptions and attitudes to primary science provided a fuller picture of primary science. Part of this review was based on studies by Murphy and Beggs, the authors of this report. The salient findings from the review are included in chapter 6, in which we consider some current areas of strength and weakness in relation to particular focus areas of primary science.

A second literature review was undertaken to explore primary science innovations in the UK. A range of innovations was considered in terms of the nature and impact of such work.

5.2.2 Surveys

Telephone survey

A sample of 300 primary teachers participated: 150 from England and 50 each from Scotland, Wales and Northern Ireland. These numbers were selected to provide samples from each area which were large enough for statistical analysis, whilst retaining an overall sample size of 300. The first part of the telephone survey instrument comprised questions designed to collect data relating to factors which may have some influence on teachers' attitudes towards science, such as gender, length of service, science background, science support and position in school (eg science co-ordinator). The rest of the instrument was designed to collect data relating to school factors, assessment of science, teacher confidence in developing children's knowledge and skills in science, different approaches to science teaching and teacher attitudes towards science learning and teaching. The attitude items were largely adapted from previous surveys of science and ICT attitudes, (for example: Murphy and Beggs 2003b). The instrument was piloted in Northern Ireland and England. Teachers were asked to indicate their response to the attitude items on a Likert 5-point scale. In addition there were two open questions. In the first of these, teachers were invited to express their views relating to what they considered to be the main issues facing primary teachers in their science teaching. In the second, teachers were asked to speculate about how primary science teaching could be improved so that children are best supported to develop the sorts of skills that will help them become active and informed citizens (Appendix 1).

Data from the interviews were coded and returned in ASCII format for analysis by the research team.

The sample characteristics outlining the profile in terms of gender, age profile, position in school, location of school, school size, resources and time spent on science teaching, importance of science teaching relative to other subjects and professional development in science are presented in Appendix 2.

E-mail survey

A survey of Higher Education Institutions (HEIs) which were involved in initial teacher training (ITE) for the primary school sector was carried out to determine their level of participation in and assessment of the impact of various primary science initiatives. All primary ITE providers were targeted. An e-mail questionnaire was designed to collect information relating to the involvement of HEIs in small and large-scale science initiatives in primary schools, including the nature of the work, its funding, any challenges, the outcomes and perceptions of the impact of the initiative. A total of 100 questionnaires were sent out to primary initial teacher education providers via e-mail and 30 were returned. The data collection was followed up with interviews and e-mail communication (Appendix 3).

5.2.3 Focus groups

The focus group discussions were designed to provide feedback on the findings of the telephone survey and literature review. They also provided an opportunity for teachers to discuss primary science issues with each other which had not been addressed in the survey. Teachers were also asked to offer suggestions of ways forward for primary science. Seven focus group discussions, facilitated by the research assistant and one or more project team members, took place in England (three groups, representing Northern, Western and Southern England), Wales, Scotland and Northern Ireland (Belfast – two groups, including the pilot group). As far as possible, one teacher represented one school, although in some groups there was a Key Stage 1 and a Key Stage 2 teacher from the same school. Group size ranged from six to ten. All focus group discussions were fully transcribed for analysis by the research team.

A summary of the main points of each focus group discussion is presented in Appendix 4.

5.2.4 Cross-sector consultation conference

The aim of the conference was to bring together a wide range of expertise in primary science education to consider the key issues arising from the telephone survey and focus group discussions. The focus was on identifying ways forward to enhance the learning and teaching experience of science in primary schools. Participants included policy makers, advisers, teachers, teacher educators, CPD providers and other representatives of the UK science education community. The conference also provided data from a range of stakeholders across primary science education (and across the UK) who had not been otherwise consulted as part of the project, and provided an opportunity for discussion of regional comparisons. For full details of the conference, please see Appendix 5.

5.2.5 Data analysis

The response to the closed questions in the telephone questionnaire were analysed statistically using SPSS. Non-parametric and parametric tests were performed, including analysis of frequencies, factor analysis of the attitude items, correlation analysis and analysis of variance. Reliability analysis of all the attitudinal responses (questions 3-7 and 9-10) was carried out calculating Cronbach's alpha coefficient. This yielded a value of 0.8425, which exceeds the critical value of 0.8, considered to be reliable for social science data (Bryman 2001).

Open responses from the questionnaires were categorised independently by the market research company who carried out the telephone survey (Mori) and by members of the research team. The categories which emerged from this analysis were used to inform both the focus group and conference workshop discussions.

The focus group transcriptions were coded and categorised initially by an independent researcher, who was not a member of the research team. This process avoided any possible researcher bias in the initial analysis since all research team members had been present at one or more focus group interview. The transcriptions and the selected categories were then analysed by the research team, who agreed a set of themes emerging from the discussions.

The qualitative and quantitative data were compared. There were no major discrepancies between overlapping areas, however, many themes emerged from the focus group discussions which had not been evident from the telephone survey. This was expected, since the telephone questionnaire had asked for responses to specific questions by individuals. The focus groups, on the other hand, provided opportunities for more open discussion, and ideas were frequently sparked of in teachers from comments made by others in the group.

6 PRIMARY SCIENCE– FOCUS AREAS

6.1 Classroom practice in primary science

6.1.1 Introduction

For the purposes of this report, classroom practice is used as a term to embrace aspects of the teaching and learning of science in the primary classroom. Specific areas of classroom practice which have been focused on in the research are: teacher confidence, formative assessment, creative contexts for teaching science and inclusion.

6.1.2 Teacher confidence in primary science teaching

Introduction

Lack of teacher confidence, knowledge and expertise in science teaching was identified by all stakeholders involved in the project as being the most significant issue currently facing primary science. Teachers were not as confident teaching science as they were teaching English and mathematics. The main factor influencing teacher confidence was professional development: teachers who had undertaken professional development in primary science were significantly more confident in most areas of their science teaching. School size was also a significant factor – teachers in smaller schools were less confident than those in large schools in many aspects of science teaching. The findings are presented in more detail below.

Findings from the current research

Findings from the telephone survey

In the telephone survey (See Appendix 1), teachers were asked to indicate their level of confidence on a five-point scale (with 5 as the highest level of confidence and 1 as the lowest level) in relation to different aspects of science teaching.

In considering their confidence in science teaching relative to other subjects, the results were as follows:

High confidence (levels 4 & 5 combined):

Maths	95%
English	88
Science	80
History	79
Geography	68
ICT	56

Lower confidence (levels 1-3 combined)

ICT	44%
Geography	31
Science	20
History	19
English	12
Maths	9

Clearly, teachers are not as confident teaching science as they are teaching English and mathematics, but they are more confident teaching science than some other subjects, such as geography and ICT.

Teachers' confidence in developing children's science skills ranged from a high proportion (80%) who were confident in helping children develop the skills to record data to a lower proportion (66%) feeling confident to help children relate science to their everyday lives (see below).

Developing children's skills

Recording data	80% (high confidence level, 4/5)
Observation	78
Fair testing	77
Interpreting findings	67
How science affects everyday lives	66

In relation to confidence in their own science teaching skills, most teachers (86%) were highly confident about questioning. More than three quarters were highly confident in some of the practical aspects of science teaching, fewer (68%) had such a high confidence level in assessing practical work, whilst less than half (44%) reported high confidence in using ICT in science teaching (see below).

Teaching science

Questioning	86% (high confidence level, 4/5)
Deciding skills to be developed	80
Ensuring all children engaged	78
Organising practical	77
Explaining scientific ideas	74
Assessing practical	68
Using ICT in science lesson prep.	46
Using ICT for science teaching	44

Teachers' confidence in developing children's understanding of different aspects of science indicated that most were highly confident about teaching the flowering plant. In a study of children's attitudes, however, Murphy and Beggs (2003a) reported that children perceived 'the flower' as one of the most difficult things to learn in science! A similar trend was observed with the water cycle – easy to teach but difficult to learn. Children complained about all the 'big words', some of which were unfamiliar and some very abstract, when trying to learn these science topics. Teachers, on the other hand, have more difficulty with some of the more conceptually challenging science topics, such as renewable and non-renewable energy, series and parallel circuits and friction (see below).

Developing children's understanding of

Flowering plant	85% (high confidence level, 4/5)
Water cycle	85
Basic life processes	82

Temporary / permanent change	80
Solids, liquids & gases	76
How sounds are produced	74
Insulators and conductors	71
Sound travel	69
Reflection of light	68
How we see things	67
Friction	66
Series & parallel circuits	64
Renewable/non-renewable energy	62

Factors affecting teacher confidence

The survey data were interrogated with respect to determining which, if any, of the characteristics of the sample of teachers might influence their confidence in science teaching. The strongest correlations existed for the relationships between confidence and professional development undertaken in science and that between confidence and the size of the school – teachers from larger schools were more confident. Analysis of variance (ANOVA) for these two factors revealed that there was a significant effect of each ($p < 0.05 - p < 0.001$) on teacher confidence in various aspects of science teaching (see Appendix 6).

Professional development

The most important factor influencing confidence in primary science teaching was professional development. In all cases below, confidence was significantly higher if teachers had carried out some professional development in primary science (see Appendix 6 for significance levels). Items under each heading have been ranked by significance level, starting with the highest:

- Teaching:
  - science
  - history
  - geography
- Confidence in developing children's ability to:
  - develop their observation skills
  - address how science might affect their lives
  - recognise, design, and carry out a fair test
  - interpret findings
- Confidence in:
  - deciding the science skills to be developed in an activity
  - assessing practical work
  - organising and delivering practical work
  - explaining scientific ideas to children
  - using questioning as a tool in science teaching
  - ensuring that all the children are engaged in science learning
- Confidence in developing children's understanding of
  - friction
  - the life cycle of a flowering plant
  - renewable and non-renewable energy sources

- basic life processes, e.g. circulation, respiration, digestion
- insulators and conductors
- the water cycle

School size

To a lesser extent, but still important, school size seems to have an effect on teacher confidence in primary science. ANOVA indicated that the following areas of confidence increased significantly with the number of children in the school (see Appendix 7 for levels of significance). Again, items under each heading have been ranked by significance level, starting with the highest:

- Teaching science
- Confidence in developing children's ability to:
    - recognise, design, and carry out a fair test
    - record data
- Confidence in:
    - explaining scientific ideas to children
    - ensuring that all the children are engaged in science learning
    - organising and delivering practical work
    - deciding the science skills to be developed in an activity
    - using questioning as a tool in science teaching
- Confidence in developing children's understanding of
    - friction
    - basic life processes, e.g. circulation, respiration, digestion
    - the water cycle
    - the reflection of light from mirrors and other shiny surfaces
    - how we see things
    - how sound travels through a variety of materials
    - life-cycle of a flowering plant

Other factors

Correlation analysis indicated very little relationship between teacher confidence in science teaching and gender, age, extra funding for science, urban, suburban or rural location and time spent teaching science. Some relationship between confidence and the age group taught was evident, although this was only manifest in relation to those science topics which are more frequently taught at Key Stage 2. There was a strong correlation between confidence in the practical aspects of science teaching and the presence of a classroom assistant.

Findings from focus groups

Teacher confidence was an issue discussed in all of the focus groups. The following points summarise the aspects of confidence discussed in the various groups:

Experience of teaching

1. Teachers admitted that they were more confident in certain topics than in others, but a school head teacher made the point that having specialists (either within the school staff or external) undermines the existing good work that classroom

teachers are doing. Such teachers must realise that they are not expected to know everything.

2. Teacher confidence could be improved by co-teaching between those who have more confidence and ability and teachers who would benefit from their experience.
3. There was not much evidence of science being related to children's own lives either by children or teachers.

Primary teacher needs

4. More professional development is required to improve teacher confidence. The problems are probably coming from the teachers' own confidence and background in science. There are certain things that they might not have done since primary school or secondary school themselves and may not have even done then. In these aspects teachers may lack confidence maybe adopt rote learning - just simply stick up a picture of a flower and say go and learn it.
5. The odd hour of professional development here and there might not improve teacher confidence. It will take a whole change in mind-set.
6. There appeared to be a lack of confidence on the part of the participants in their own scientific knowledge and an acknowledgment of the need for clear and supportive teaching materials to facilitate the delivery of the curriculum.

The following extracts of conversation from focus groups 1 and 2 illustrate some of these points. In the first extract, teachers are considering which areas of science might teachers have least confidence to teach.

> ***Facilitator*** *(group 1): ...If you are a teacher maybe lacking in confidence in certain areas maybe they don't want to do the practical end of things or they feel that they are maybe not as fully equipped to do it as they…*
>
> ***KS2 Female 1****: It is probably time it is pressure of time rather than not being competent…*
>
> ***Facilitator****: ...or confident.*
>
> ***KS2 Female 1****: ...or confident.*
>
> ***Facilitator****: We also asked the question [in the telephone survey]: how would you rate your confidence in the following areas within science, such as their recording of data, helping children record their data, their ability to recognise, design and carry out a fair test, their ability to address how science might affect their lives, their observation skills or interpretation of findings. Which do you think teachers found the most difficult to develop in children out of those areas?*
>
> ***KS2 Female 1 & KS1 Female 1****: Fair testing.*
>
> ***KS2 Female 3****: I would have thought interpretation.*

The group 2 extracts below illustrate issues about confidence in investigative teaching and confidence with specific aspects of science content:

KS2 Female 1: *...I enjoy the investigating because the children are exploring and I don't have to know all the amazing facts. I enjoy working through the investigative ways rather than teaching content and being asked a question I don't know the answer to.*

KS1 Female 1: *There are certain aspects within science that you feel more confident about than others.*

KS2 Female 2: *I think if you went down the route of saying you need specialists to teach science, then you might lose some of the highly effective primary strategies that primary teachers employ to motivate the children. I don't think it is that important to know all the answers because that way we learn and the children learn. It's not admitting you're a failure by not knowing all the answers rather it's encouraging the children to understand that there are ways of finding out the answers.*

KS2 Female 3: *That's where communication comes in because when I do a lesson and if something is wrong then I can go back, but you have to know how to go back. You can check with your colleagues and hopefully one of them has the answer.*

KS2 Female 4: *It's about finding the time to go back as well and being able to get hold of your science co-ordinator or your colleague and talk to them. That's what I find to be a problem.*

Facilitator: *Are there any sections within those three broad areas [living things, materials and energy] that you feel you lack confidence in or are very confident in teaching?*

KS2 Female 1: *I think microorganisms are very difficult to teach because it's very hard to show practically. We did a yeast experiment and composters and looking in to the microscope but they can't see it so it's very difficult. From an experiment point of view it's not easy to find experiments they can see.*

KS2 Female 2: *Rocks are quite fun in sorting but they are quite difficult.*

KS2 Female 5: *The parts of the plant can be hard to remember each year.*

Findings from cross-sector consultation conference

One of the workshop discussions at the conference gave delegates an opportunity to respond to statements which had been highlighted in the telephone survey (see section 7.1). Delegates were placed in seven cross-sector groups to consider the relative importance of the issues of concern in science identified by primary teachers, to place in priority order the three they considered to be of highest importance and to identify the three they considered to be of lowest importance.

The results from the seven groups were collated and of the issues that emerged as being highly important were placed in rank order. All groups identified 'lack of knowledge/expertise/confidence/training' of teachers as being of highest importance. No other issue was unanimously placed in this category, though some groups attached equal importance to two or more issues.

This finding supports the findings from the teachers in the telephone survey.

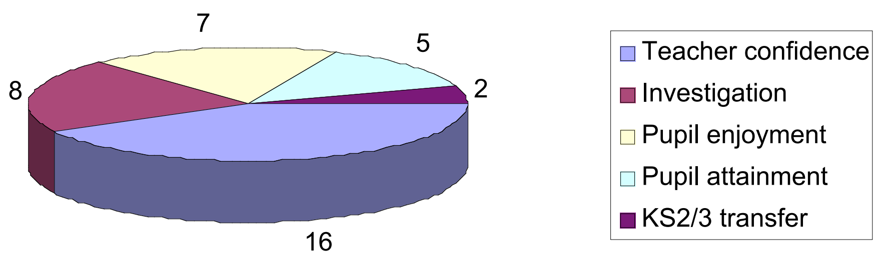
Survey of HEI primary science initiatives

The HEI survey asked providers to categorise the types of primary science initiatives that they were engaged in with schools. The main areas addressed by these initiatives were broadly categorised as follows, although many projects spanned more than one category.

- Increasing teacher confidence
- Promoting investigation in class
- Increasing pupil enjoyment
- Improving pupil attainment
- Improving KS2/3 transfer

Given the findings described above, it is not surprising that the largest number of initiatives in primary schools appeared to be aimed at increasing teachers' confidence in science learning and teaching. Figure 6.2 shows that most of the initiatives were addressing the issue of teacher confidence, indicating that the issue of teacher confidence is recognised at a local level and many initiatives are aimed at improving this problem.

Figure 6.2 Number of projects addressing specific areas



It can be seen from Table 6.3 that professional development aimed at increasing teacher confidence employed a wide variety of approaches. This is particularly important in light of the evidence from Section 6.1 on teacher confidence which revealed that the group of teachers in the survey who had experienced any science professional development, regardless of what type and for how long, were significantly more confident in most aspects of science teaching than teachers who had not carried out science professional development.

Table 6.3 Approaches used in professional development aimed at improving teacher confidence

Issue Specifically Addressed	Professional Development Approach	Number
Improving teachers' scientific knowledge and confidence	In-class support	7
	ICT-based support	3
	Increasing pupil interest in science	2
	Out-of-class intensive workshops	3
	Production of materials by teachers	1

Science Students in Primary Schools

Most projects aimed at improving teacher confidence also concentrated on professional development taking place *in the classroom*. The *Science Students in Primary Schools* (SSIPS) project was a collaboration between three initial teacher education institutions (Queen's University Belfast, St Mary' University College and Stranmillis University College) and 65 teachers in 18 primary schools in the Greater Belfast area and Bangor. The aim of the project was to increase classroom teachers' confidence to teach investigative science. Phase 1 of the project involved science specialist student teachers and class teachers co-teaching investigative science for _ day per week over 10 weeks. The students worked alongside the teachers to prepare, teach and evaluate practical investigative lessons in science and technology. Throughout their time in school the student teachers were not supervised or assessed; they worked as 'equals' with the teachers. Phase 2 involved the primary teachers attending workshops run by science educators and advisors to develop their skills in teaching investigative science and technology. Phase 3 focused on school development; with science educators and advisors supporting schools to devise school development plans for their provision of science and technology.

Teachers who participated in the project gained in their confidence and expertise to teach investigative science. Previously many teachers did not think investigations covered enough ground in the time available. After working with the students, teachers saw that children doing practical investigations were talking more about their work and seemed to be retaining at lot more of the associated knowledge. The students reported very positively on their own increased levels of confidence. After the second year of co-teaching, the school experience grades of students who had experienced co-teaching were higher than those who had not been co-teaching. Another benefit of the working partnership between students and teachers was the measurable increase in children's enjoyment of science. Attitudes surveys of children who had and had not been involved in this project showed significant differences, with children who had taken part much more positive towards science. The survey was carried out 6 months after the students had left to test whether the effect had been longer term (Murphy *et al* 2004).

Evidence Based Teaching

A self-funded project in the School of Education of Nottingham Trent University involved a small group of primary teachers working with university tutors to improve their science teaching. This action research project called the *Evidence Based Teaching (*EBT) project supported teachers in their own professional development. Each teacher developed their own piece of action research to meet their own personal professional development aims, while the tutor's role, as well as supporting the teachers' action research, was to develop ways of understanding evidence based teaching. The project assumed that, given the appropriate kinds of (inexpensive) support and encouragement, teachers can play a pivotal role in addressing professional problems in their own teaching, problems which are of importance to teachers widely, and can successfully work collaboratively to achieve worthwhile improvements in both understanding and in practice, which improve the learning of their children.

Science through Telematics

Some of the projects involved the use of ICT to enhance teacher confidence in the teaching of science. The AstraZeneca-Exeter *Science through Telematics* (AZEST) project based in the Department of Education and Lifelong Learning at Exeter University involved teachers in six local primary schools investigating the potential of the Internet to offer curriculum support materials and as a discussion forum for primary science. It attempted to utilise the Internet to develop primary teachers' knowledge, understanding and teaching of science, focusing on the topic 'Forces and Motion' and 'Science Subject Leadership'. Those teachers involved in the project demonstrated some innovative approaches to the teaching of 'Forces and Motion' and in the use of concept mapping to explore pupils' knowledge and understanding of a topic.

Science in the New Curriculum

The Queen's University / St Mary's University College *Science in the New Curriculum* (SiNC) project used e-conferencing using a virtual learning environment (VLE) to support the work of science specialist student teacher/classroom teacher teams who co-taught science in geographically distant schools. They were concentrating on working together to try and integrate aspects of science, history and geography. In the new Northern Ireland curriculum, these three subjects will be subsumed into the larger area of the World Around Us. Students and teachers also attended intensive workshops based in the university. Primary science advisors, curriculum developers and science teacher educators collaborated to provide joint workshops for the students and teachers. Time was also made available for student-teacher teams to work together on preparing teaching materials. The VLE facilitated exchange of materials as well as on-line support from curriculum, ICT and science specialists. The VLE also enabled teachers and students in geographically distant schools to build up a bank of shared resources which they could adapt for their own use. Teachers and students used the VLE for peer support, although this facility was very much dominated by the students, who knew each other well.

Partnership in Primary Science (PIPS)

The *Partnership in Primary Science (PIPS)* project was set up by the University of Stirling's Institute of Education to promote continuing professional development within a community of approximately 40 primary teachers. The teachers, along with educators and scientists, met for one-day programmes in which they shared their ideas and helped develop workable strategies and resources for implementing practical science and ICT in the classroom. Online communication was also encouraged to provide mutual support and the sharing of practice. The project produced resource materials created by and for teachers for the full primary spectrum. Participant primary teachers were more confident and became actively involved in providing CPD for colleagues.

Canterbury Christ Church University Department of Education developed science teaching and learning through the *Partnership in Primary Science* project. The project paired science coordinators with newly qualified teachers to develop good practice and increase confidence in investigative science teaching. The project aimed to combine NQT enthusiasm, subject knowledge and up to date ICT skills with the science coordinators experience, expertise and familiarity with the working of their school.

Promoting Excellence in Primary Schools

Other projects have used a higher proportion of university-based training to develop teachers' confidence. Liverpool John Moores University worked with at least 35 local schools in the *Promoting Excellence in Primary Schools* project. It involved university tutors, research associates, teachers and science coordinators, all working in close liaison with the local LEA. Its main focus was the professional development of teachers in terms of improving their confidence in teaching science. They did this by organising professional development twilight sessions run by the college tutors with inputs from partner secondary schools. A central aim of the project was to support teachers in employing active, innovative teaching and learning strategies where children's conceptual understanding is developed by encouraging them to talk about their ideas and then test them in practical ways. The tutors and research associates planned and co taught science investigations. The project team reported an improvement in teacher confidence in teaching science and greater enthusiasm and motivation for science in both teachers and pupils.

Teachers and Children Exploring their World

Another approach to improving teacher confidence was to engage teachers in the production of materials. A recently set up project in the University College Winchester, School of Education called *Teachers and Children Exploring their World* aims to support teachers in investigating and reporting their practice. It is an action research project designed to develop a set of case studies of teaching science / knowledge of the world in the Foundation Stage. The project team are working with 18 primary schools in the Wessex (Southampton) area. They anticipate increased confidence, knowledge and understanding in using a wide range of strategies especially open-ended approaches. Case studies will illustrate new models of classroom practice in primary science, cross curricular work, creative contexts for science teaching and CPD in primary and foundation science.

6.1.3 Formative assessment

Introduction

'Formative assessment' describes that which uses the evidence gained to adapt the teaching work to meet learning needs (Black *et al* 2003). The term has become almost synonymous with *assessment for learning*, which is usually 'informal, embedded in all aspects of teaching and learning, and conducted by different teachers as part of their own diverse and individual teaching styles' (Black *et al* 2003).

An essential part of formative assessment is feedback to the learner, both to assess their current achievement and to indicate the next steps in their learning 'trajectory'. Black *et al* (2003) review some of the research on formative assessment. Kluger and DeNisi (1996) concluded from their review of the effectiveness of feedback, that feedback only leads to learning when it includes guidance on how to improve. Butler (1988) researched types of feedback. Her findings showed that of the types: marks alone, marks with comments and comments alone, the learning gains were greatest when comments alone were given as feedback. This finding is quite surprising to many teachers, although some who have tried it have reported that the mark was often all that was read by students and that they focused more on feedback comments and targets when no marks were given (Black et al 2003, p43 *et seq*).

In addition to providing written feedback Black et al (2003) describe other techniques which can be used in formative assessment, including:

- Questioning (when the questions explore issues that are critical to the development of understanding, when respondents are afforded 'wait time' to frame their answers and when follow-up activities provide opportunities which extend student understanding).

- Marking (when students are encouraged to show and develop understanding, when comments show how to improve and when opportunities for students to follow up on comments are planned as part of the overall learning process).
- Peer and self-assessment (when clear and explicit criteria are given for evaluating learning achievements, when peer assessment is used to help the objectivity required for self assessment and when students are encouraged to bear in mind the aims of their work and to assess their progress to meet these aims.
- Formative use of summative tests (when students engage in reflective review of their work, when the students set and mark questions and when students, through peer and self-assessment, apply criteria to improve their own work.

Formative 'lessons', according to Black et al (2003) are those which create opportunities for students to reveal their own understanding of the criteria for success to their peers and then to improve it (p65).

Findings from the current research

The findings from the current research showed that, against this background, the teachers in our survey and focus groups might have had very diverse views of the nature of formative assessment. The main factors affecting survey teachers' use of formative assessment were professional development and extra funding for schools. The teachers who were much more likely to use formative assessment in their science teaching were those who had carried out science professional development and those whose schools had received extra funding for science. Teachers taking part in the focus group were generally positive about the use of formative assessment in science teaching. The importance of formative assessment in science was also underlined at the cross sector conference by keynote speakers and in workshop discussions and one of the HEI primary science initiatives in the email survey was focused on improving formative assessment practice.

Use of formative assessment

Two types of questions were included in the survey to determine the extent of teachers' use of formative assessment in science.

Firstly, teachers were asked to respond as to whether or not they used specific formative assessment techniques. The majority of teachers in the sample responded that they used the formative assessment methods stated in the question. Almost all teachers (96%) indicated that they provided feedback with advice for improvement to children as part of their science teaching. A very high percentage (90%) responded that they evaluated children's pictures, graphs, etc which showed their scientific reasoning Almost three-quarters of teachers (70%) said they used checklists to record observations of children

The second type of question was an open question in which teachers were invited to say which types of formative assessment of children they used in their science teaching. When the question was asked in this way, the proportion of teachers using each method reduced significantly:

- Formal tests (30%)
- SATS (14%)
- Observation (13%)
- None (11%)
- Informal tests, quizzes, etc (10%)
- Oral questioning and discussion (6%)

- Assessment sheets (6%)
- Monitoring written work (5%)
- Continual assessment (4%)
- Peer assessment (4%)
- QCA assessment (4%)
- Web/ICT-based assessment (2%)
- Pre/post testing (2%)
- Teacher assessments (2%)

Very few teachers (1% or less) indicated they used the following methods:

- Mind/concept mapping
- Targets for every child
- Investigative work

It was very interesting to note that, apart from the very small numbers of teachers who indicated they assessed investigative work, there was no mention of assessing children's practical science skills.

Factors affecting teachers' use of formative assessment

Correlation analysis indicated that only two factors seemed to be related to teachers' use of particular types of formative assessment: professional development in science and whether or not their school had received extra funding for science. With regard to professional development, those teachers who had carried out some form of professional development in science were significantly more likely to use the following methods of formative assessment (See Table 6.1a):

- Mind mapping
- Setting targets for every child
- Investigations / investigative work

The responses were identical in each category for these three factors (Table 6.4a), unlike those for the effect of extra funding (see Table 6.4b).

Table 6.4a ANOVA table showing a significant effect (at $p < 0.05$) of teachers' professional development in science on the use of the specific formative assessment methods

		Sum of Squares	df	Mean Square	F	Sig.
What, if any, other types of assessment are used? Mind mapping	Between Groups	.051	1	.051	3.920	.049
	Within Groups	3.895	298	.013		
	Total	3.947	299			
What, if any, other types of assessment are used? Targets for every child	Between Groups	.051	1	.051	3.920	.049
	Within Groups	3.895	298	.013		
	Total	3.947	299			
What, if any, other types of assessment are used? Investigations/investigative work	Between Groups	.051	1	.051	3.920	.049
	Within Groups	3.895	298	.013		

Total	3.947	299	

Whether or not a school had received extra funding for science also seemed to impact on teachers' use of formative assessment methods. Table 6.4b shows those methods which appeared to be used significantly more by teachers in such schools, namely:

- Discussion and oral questioning
- Mind mapping
- Peer assessment
- Pre and post-testing

Table 6.4b ANOVA table showing a significant effect (at p < 0.05) of additional funding for science on the use of the specific formative assessment methods

		Sum of Squares	df	Mean Square	F	Sig.
What, if any, other types of assessment are used? Discussion/oral questioning	Between Groups	.243	1	.243	4.129	.043
	Within Groups	17. 553	298	.059		
	Total	17.797	299			
What, if any, other types of assessment are used? Mind mapping	Between Groups	.061	1	.061	4.679	.031
	Within Groups	3.886	298	.013		
	Total	3.947	299			
What, if any, other types of assessment are used? Peer assessment	Between Groups	.268	1	.268	7.721	.006
	Within Groups	10.329	298	.035		
	Total	10.597	299			
What, if any, other types of assessment are used? Pre/post testing	Between Groups	.093	1	.093	4.814	.029
	Within Groups	5.787	298	.019		
	Total	5.880	299			

Findings from focus groups

There were several discussions about formative assessment practices in the focus groups. In one group, Key Stage 1 and Key Stage 2 teachers were exploring the different formative different assessment methods they used with children of different Key Stage groups. Key Stage 1 teachers seemed to make more use of checklists and pictures, whereas Key Stage 2 teachers used more oral assessment methods, such as questioning and discussion. One novel technique mentioned was (group 3):

> ***Key Stage 2 Female 1**: …yes. In my class at the start of the topic we put all their misconceptions up on the wall and then at the end they killed themselves laughing saying that's what we thought you know it is really…but we asked why have we changed what we think and they have to be able to say why they don't think that anymore. So it is quite interesting.*

Teachers agreed that the use of more formative assessment techniques was more enjoyable for both the teacher and the children. Most of the discussions about formative assessment were highly positive. However, some aspects were criticised, for example the use of checklists. One teacher's comments about checklists (group 4) illustrated the tension between teaching the children and keeping records of evidence of the teaching:

> ***Key Stage 2 Female 1**: Well I don't think personally a checklist would work for me but it might work for somebody else. I hate ticking boxes, a personal thing. It is just another sheet that gets buried on my desk whereas if I am going round working with a group I will mentally take note of whose coping, who's not, who's doing well whose leading the group, who's taking a back seat and that sort of thing. But if there is no evidence of that having occurred, you know, that's the problem, and I understand that is where the checklist could come in handy. But you are back to why you are teaching. What are you doing? Are you teaching for somebody to come in and say have you assessed these children or are you actually teaching?*

Many teachers related the challenges of assessing practical work, as illustrated by the following extract from group 5:

> ***Key Stage 2 Female 1**: And it is the specific language you must use. You know the scientific experiments must be done in a certain way, they must be talked about in a certain way and that is why again the Science SATs are marked so hard because some children, you know what they mean but scientifically it is not viable and they lose marks on that and you have to try and bring them up to that standard without teaching them to the test. Unfortunately this is what is happening too.*
>
> ***Key Stage 2 Female 2**: Assessing practical work is very difficult actually. I think assessing any practical work is very difficult.*
>
> ***Key Stage 2 Female 3**: But it is the one thing that when it comes up in assessments, they just…they get sepals and petals mixed up and of course the diagrams vary in the degree of detail. They just find it very, very hard. I do revisions in Year 6 before the SATs on that and I ask the children to give me a list of the things you want me to revise over the next couple of weeks and parts of the flower is always top of the list - always.*
>
> ***Key Stage 2 Male 1**: In some schools they do very little investigation in the last year because they are always pumping this knowledge into the children all the time.*

Most of the discussions on formative assessment led to a discussion of SATs (England) and the transfer test (Northern Ireland). Teachers were, on the whole, negative about effects of the national tests on children's enjoyment of science and the 'training' aspect of teaching to the test. They were appreciative, however, that including science in these tests raised the profile of the subject in school.

Findings from cross-sector consultation conference

The nature of assessment of primary science was discussed in cross-sectoral workshops. There were strong feelings in some groups that assessment practices were crucial. It was pointed out by more than one group that the assessment dictates pedagogy and that in some parts of the UK, assessment militates against innovation within science teaching. It was recognised, however, that it is up to teachers to strike a balance between their own pedagogy and ensuring that what and how they teach matches the assessment requirements for external tests.

Survey of HEI primary science initiatives

One of the initiatives identified by the survey of HEIs focused specifically on formative assessment of Sc1 – Scientific Enquiry. This was the *Improving Science Together* project, (Bath Spa University).

Improving Science Together project, (Bath Spa University).

This was a collaborative venture involving 20 primary schools, four secondary schools, local LEAs and Bath Spa University College. The project arose out of concerns that the status of scientific enquiry had been reduced as a result of the pressure on schools to focus on teaching for the SATs tests. The view of the project team was that by focusing on Sc1 it would not only develop children's practical skills but their higher order thinking skills as well. The team of university tutors and LEA advisors worked with primary teachers to develop lesson plans and accompanying assessments. In addition several bridging projects were developed for better KS2/3 continuity and progression. Primary and secondary teachers worked together to plan practical projects that children could begin in the summer of their final year in primary school and complete in the autumn term of secondary school.

It was reported that children participating in the project carried out more practical work and subsequently enjoyed the more practical aspect of their science lessons. They also reported better continuity and progression between KS2 and KS3 programmes of work.

6.1.4 Use of creative contexts for primary science teaching

Introduction

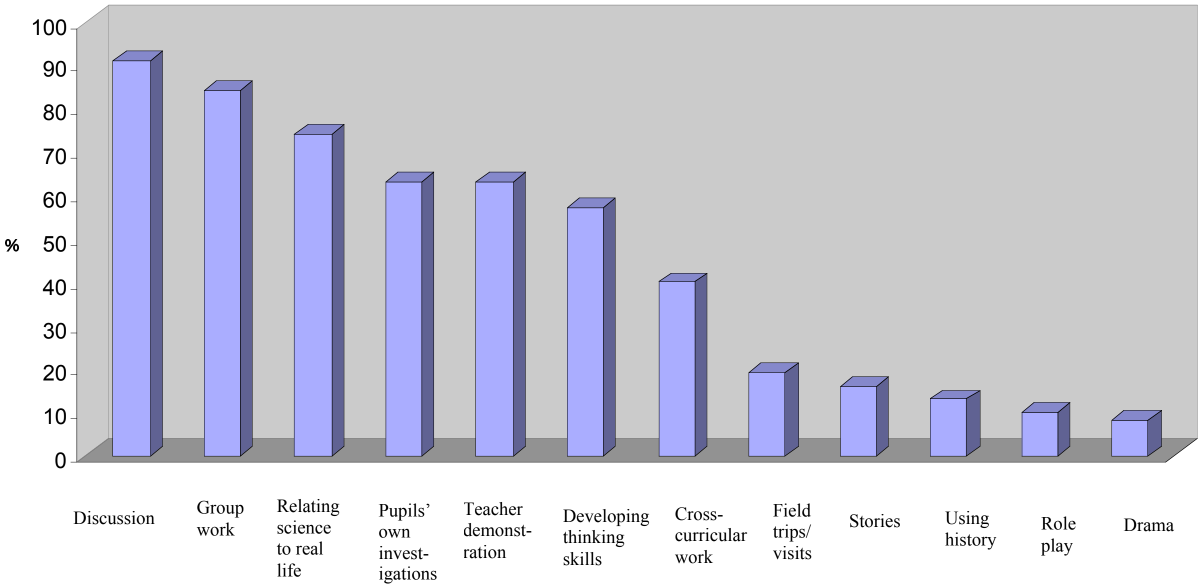
For this research we included a set of 'creative contexts' which may be used for teaching science in the telephone survey. These ranged from contexts which were most commonly used, such as discussion and group work through to those which were probably not employed as frequently, such as role play and drama. Much research has been carried out regarding the value of providing creative contexts for teaching science in both primary and secondary settings. Not only do children enjoy science more when it is taught creatively (for example: Williamson 2004), but there is evidence that creative science teaching can also have positive outcomes in relation to children's learning in science (Coates and Wilson 2003). There is a case also to include interactive teaching and the use of ICT as creative contexts for science teaching. Murphy (2003) and Osborne (2003), respectively, have recently reviewed the use of ICT in science teaching in primary and secondary settings.

Findings from the current research

The most frequently used creative contexts

The data from the survey showed that the most frequently used creative context in science teaching was discussion, followed by group work and relating science to everyday life. Figure 6.4 below indicates the percentages of teachers who responded that they 'often used' each of these contexts:

Figure 6.4 Creative contexts used in science teaching



Factors affecting the use of particular creative contexts

The correlation analysis indicated that one factor might influence the use of creative contexts in science teaching. This was gender. Women tended to use particular creative contexts significantly more than their male counterparts. The data in Table 6.4c confirms that the effect of gender on the response to these items was highly significant in all cases ($p<0.01$). (Each result quoted in Table 6.4c is also highly significant using both the Welch and Browne-Forsyth tests which take into account the different sample sizes). It appears, then, that female teachers are more likely than males to make use of some of the more creative contexts in their science teaching.

Table 6.4c ANOVA showing the significant effect of gender on the use of creative contexts in science teaching

		Sum of Squares	df	Mean Square	F	Sig.
Role play	Between Groups	3.082	1	3.082	6.739	.010
	Within Groups	136.265	298	.457		
	Total	139.347	299			
Teaching science from stories	Between Groups	10.402	1	10.402	22.431	.000
	Within Groups	138.185	298	.464		
	Total	148.587	299			
Developing thinking skills in science	Between Groups	2.160	1	2.160	6.841	.009
	Within Groups	94.090	298	.316		
	Total	96.250	299			
Relating science to real life	Between Groups	2.407	1	2.407	11.504	.001
	Within Groups	62.340	298	.209		
	Total	64.747	299			
Integrating science with other curricular areas	Between Groups	5.607	1	5.607	16.552	.000
	Within Groups	100.940	298	.339		
	Total	106.547	299			

Focus on Specific Creative Contexts:

Pupils' own investigations

Findings from telephone survey

In the two open response questions in this survey (see Appendix 1) teachers were asked about the main issues facing primary teachers in their science teaching and how primary science may be improved to enhance pupils' scientific literacy. Responses to these questions are discussed more fully in chapters 7 and 8 of this report, but in relation to pupils' own investigations, the responses from the telephone survey indicated that teachers felt there was not enough time, resources or training for them to carry out more effective investigations with children. Some responses to the question regarding issues facing teachers were:

> *… delivery of the children thinking of their own investigations; because of time and size of class its more practical to give answers.*
>
> *Teachers need to have more assistance in the class to allow them to do more investigations…*
>
> *Lack of confidence in teaching science - need for more professional development in teaching the skills of investigation and assessing science.*
>
> *Developing children's investigative skills.*
>
> *Developing attainment target one with the children - this is teaching the children to investigate an experiment properly and get it working.*

In response to the question on improving primary science, the following comments were made relating to pupil investigation:

Less focus on reaching SATS targets more topic investigation in areas where the children's interests lead them we don't have time to do it because the curriculum is too rigid there is no leeway.

That children have to have more freedom to follow their own investigations so need more trying so that they are happy with open ended questioning.

Through more investigations and projects that get pupils to think for themselves.

Narrowing the curriculum to only concentrate on certain aspects / have more investigating work as opposed to written work / process should be more important as opposed to right answer / develop thinking skills more money for resources.

Focus groups

The focus groups included a lot of discussion of pupil investigations, ranging from its practicality in the classroom to constraints due to lack of time, to national testing requirements and to lack of teacher confidence.

Allowing the children to carry out their own investigations in science was considered to be less realistic in practice than in theory. One of the ways teachers cope with this is exemplified by the following excerpt (group 4):

> ***Key Stage 2 Female 1**: From a personal point of view I pretend to use that strategy where I would get the kids to come up with their ideas for possible investigations but then I would lead it… But it is more teacher-led to be perfectly honest it is not just away you go and test that out. I mean I do go through the pretence of letting them have an input [laughs].*
>
> ***Key Stage 1 Female 1**: But then again you can get them to join in, for example, if you are making jelly or something, you could get them to come up and stir and put it in the fridge and that sort of thing, so they can get involved. But I find it's hard when you have a whole class watching. For example, making Rice Krispie buns, you know, the poor children at the end of the queue are fed up waiting by the time they come up and scoop out their chocolate Rice Krispie mixture.*

The constraints on investigative science caused by preparation for national tests dominated some discussions. In Northern Ireland, the following dialogue illustrated the issue (group 1):

> ***Key Stage 2 Female 1**: I think in P7 and in P6 we are bound by the dreaded Transfer. There is just no getting away from it and you end up giving them information, not having time to necessarily do the practical work…. The problem is that the content becomes boring for the children at end of P6 and the beginning of P7…*
>
> ***Key Stage 2 Male 1**: Investigative work stops halfway through P6 and it doesn't start again until halfway through P7.*
>
> ***Key Stage 2 Female 1**: Exactly, exactly because there just isn't the time.*
>
> ***Key Stage 2 Male 1**: I found that as well. The kids get involved in things they like to do. It is following something from start to finish that seems to be the*

problem. To do an investigation properly it would probably take say a week, a couple of weeks to follow it up, to plan it, to carry it out and evaluate it and go through it and do the write ups and all the rest of it. So I think a lot of the teachers plan it and actually do it - and it is the follow through bit that sort of gets lost.

Key Stage 1 Female 1*: Because it doesn't mean anything to them unless they are involved practically in something, it doesn't mean anything.*

The aspects of lack of teacher confidence in facilitating investigations and of investigations taking a long time to be carried out properly with the children were also discussed very widely. The following extract combines both (group 6):

Key Stage 2 Female 1*: […]I think this probably has implications for teacher training, the teaching staff themselves really because not everyone is au fait with the investigative work that needs to be going.*

Deputy Head Female 1*: Well we do all ours through investigation wherever we can. But there are topics that lend themselves more to it […]But if you looked at science as a skills-based curriculum then you would have more children actually developing those skills so it wouldn't matter what topic that you were actually doing.*

Head Teacher Female 1*: … Let's face it, if you were doing an investigation and you wanted to learn something from it, there is no guarantee that you are going to learn it in that 45 minutes. You might need to do it again or go and have a little think about it and come back. I run my class sometimes like that if we are doing an investigation we will do that for the whole day because then we have time to talk about it and I have asked the children do they prefer working like that and they have said yes, because you can actually show somebody else what you are doing and talk to somebody else.*

The final extracts in this section relate to a couple more important aspects of teaching investigative science at primary school. In the first, the teacher is critical of the difference between what she learned about investigative science teaching as a student and the reality in the school (group 6):

Key Stage 2 Female 2*: …but I was going to say the way we were taught at college last year was all through investigation. We were all doing these investigations that children would be doing, but we were learning as we were doing them, and that is the way in my head it was always to be taught in schools. Then I went into a school and I might have six topics a year to cover … and I found time to be a problem… I want to teach through investigations - that is how I was taught in my teacher training but it's time …we will set it aside and we will just talk about it or I will do it [as a demonstration] at the front, I have done that once rather than allowing the children to get involved and you are a bit gutted by it but it is…the time is just not available to do it.*

A more experienced teacher highlighted another problem when carrying out investigative science with young children – their need to be 'right' (group 6):

Head Teacher Female 1*: And … children thinking they have always got to be right and there is always going to be a right outcome to that or a wrong outcome, when in science particularly that is just absolutely never the case. One avenue of investigation will lead to other avenues of investigation and I* *think to me, particularly the upper end of Key Stage 2, that is the thing. Children think there should be a right answer outcome to every scientific experiment you get. I try to encourage them to think 'well why did you have that [set] of results and I've had this and I am only five yards down the table from you?' It is actually developing them more scientifically than if we all got the same answer.*

Findings from cross-sector consultation conference

Lack of pupil investigation was ranked as the second most important issue (after lack of teacher confidence/expertise/training) by the cross-sector group discussions. However, when sectoral groups discussed ways to improve primary science to enhance pupil scientific literacy, all four sectors (teachers, HEI, CPD providers and policy makers) ranked more pupil investigation as the most important, both in terms of its potential and its feasibility (Appendix 5).

Survey of HEI primary science initiatives

More than one fifth (21%) of the HEI initiatives surveyed were aimed at improving teachers' skills at facilitating investigations in the classroom. These initiatives employed various approaches: both in-class and out-of-classroom support were found to be effective, as was ICT and the use of a variety of published support materials. (Table 6.5)

Table 6.5 Approaches used in professional development aimed at promoting science investigation

Issue Specifically Addressed	Professional Development Approach	Number
Promoting scientific investigation in primary classrooms	In-class support	3
	ICT-based support	2
	Use of support materials	1
	Out-of-class intensive workshops	3

Science Investigations in Schools

The ASE-King's *Science Investigations in Schools* (King's College London) project, funded by the Wellcome Trust, aimed to improve the quality of scientific enquiry by developing innovative teaching strategies. They reported on how teachers implemented Programme of Study 1 of the National Curriculum for Science (Sc1) and explored the influence of Sc1 on the nature of investigative work done. They identified successful practice and its benefits for pupils, problems facing teachers in using investigative work and suggested ways of overcoming them. The project team worked with groups of teachers to identify current practice and concerns. They obtained detailed descriptions of investigations using teacher diaries, videos of lessons, samples of pupils' work and pupil questionnaires. They also collected teachers' opinions through group discussions and individual interviews. They worked with individual teachers to improve pupils' performance in investigations.

The project produced teaching materials and research reports for teaching specific aspects of enquiry and made recommendations for the QCA based on an exploration on how enquiry was implemented in schools by using focus groups and a national questionnaire survey. The findings of this project informed policy making and design of the 1999 Science National Curriculum.

Children Challenging Industry

The *Children Challenging Industry* project based in the Chemical Industry Education Centre at York University also focused on engaging children in scientific enquiry. It was funded from various sources (such as company donations, contributions from Excellence in Cities, Education Action Zones, Regional Development Agencies, participating schools and education business partnerships) and covered schools across the North of England. The rationale was the desire to improve both the skills and motivation of children regarding primary science (and specifically scientific enquiry) and to improve children's and teachers' perceptions of the chemical and allied industry. A team of advisory teachers delivered classroom based INSET to teachers and children of 9-11 year olds. The INSET focused on 'motivating investigations set within industrial contexts'. The advisory teacher also trained suitable manufacturing companies in their region on organising and conducting effective site visits for 9-11 year olds. Each advisory teacher worked with 35 schools and up to 20 companies each year. The project began in 1996 and has continued to expand, working with over 5000 children and 1700 teachers from 175 schools each year. The project team found an increase in positive perceptions of industry by teachers and children, improved enjoyment of and motivation for science from pupils (and some teachers), improved confidence of teachers to carry out classroom based investigations and, from anecdotal evidence, improved children's skills in carrying out science investigations.

Partnership for Continuing Professional Development

The *Partnership for Continuing Professional Development* project aimed to raise pupils' achievement in science and encourage a culture of success in science by developing an infrastructure of expertise and a climate of innovation and good practice within schools. (AstraZeneca Science Teaching Trust, 2004). Tutors from the University of Durham worked closely with Redcar and Cleveland LEA and all the primary schools in the Redcar and Cleveland LEA. They had four specific objectives: to develop an infrastructure of expertise; a positive scientific culture in the schools; introduction of a range of teaching and learning approaches; and the raising of pupil attainment. They set up a programme of INSET course and cluster group meetings, based on the needs identified by the schools. These began with a focus on classroom investigations in science. A university science team worked with the science coordinators and teachers in the schools and visits were set up to develop school action plans and to give advice on resources and provide twilight INSET with whole school staff. The project has provided participant schools with a 'kickstart' to radically improve their quality of science teaching and raise the profile of science.

Partnership Teaching Project

The *Partnership Teaching Project* was set up in 1997 in Bretton Hall, University of Leeds. (AstraZeneca Science Teaching Trust, 2000). The project began in Barnsley with 25 schools and spread as cluster projects to 16 schools in Wakefield and a further 15 schools in York. The project focused on partnership teaching and the planning of lessons for teaching and assessing specific science process skills. The premise behind the partnership project was that pupil underachievement in Sc1 limits their broader knowledge and understanding of science. Teachers will only address it if they understand the purposes and nature of practical scientific work and are confident to manage pupils' science investigations in class. Science coordinators from each school were partnered with a non-specialist teacher and each team planned taught and observed lessons together. The initiative also held 15 INSET days for the partnered teachers in year one. This was then followed up with regular visits from a university tutor. In the second year each school nominated a new partner teacher to strengthen the support for the science coordinator and again the teams were supported with college based INSET. Baseline and end of project confidence audits confirmed that project teachers viewed the process of partnership teaching as having significantly improved their confidence in teaching science. Other benefits included raising the profile of science in the school, greater teacher awareness of progression across the age ranges and lessened anxiety about being observed.

Developing thinking skills

Developing children's thinking skills has become an important aim in primary education. In science, children are intended to develop thinking skills such as classifying, grouping and sequencing, in the context of science related content. Teachers use a range of questioning skills and strategies for facilitating group work to encourage effective participation, discussion and collaboration by all pupils. Links are made to prior learning and pupils are encouraged to reflect on how they have learnt and worked together (Adey et al 2003).

Findings from the telephone survey

Despite the fact that virtually all science learning and teaching develops children's thinking skills, only just over half (56%) teachers in the survey responded that they often used the development of thinking skills in their science teaching. Thinking skills were referred to only very rarely by teachers in the open questions. Three teachers mentioned the development of thinking skills as a way to improve children's scientific literacy.

Findings from focus groups

Teachers were highly positive in their views on how science learning and teaching helps to develop thinking skills. One teacher remarked (group 6):

> ***Key Stage 2 Female 1****: ...I think it [Science] is brilliant for developing thinking skills because I think the science topics help to put the thinking skills in context. I think it is giving the thinking skills relevance.*

Teachers discussed ways that science helped develop children's thinking skills, such as 'you are always asking them to tell you their opinion and to think about things'. One teacher described a card-sort of living and non-living things: 'we didn't give them any input, so they were thinking themselves and giving suggestions why they thought something was living or why they didn't and I think it just gave them…it is amazing what they came out with and their ideas. I think it is very important to give them the time to think.' She went on to say that: 'I think a lot of children will sit back and they will not think, they are quite happy to let other people do it for them.' The same teacher remarked on her own development as a result of using thinking skills approaches: 'I know I have completely changed the way I teach Science in the last two or three years'.

Some teachers talked about the difficulty of using thinking skills approaches (group 3):

> ***Key Stage 2 Female 2****: I think it is actually changing, letting go and taking risks. My deputy at the time just came in and asked me to have a go with the children. We were trying the Concept Cartoons at the time and I let them…we put up the four ideas and I said right how are you going to prove your answer to make up your own experiments? Now that takes building up from nursery you know to…and they found it, they came up with some good ideas but it was hard for them. And actually for the kids when it didn't go right they actually you know that sort of failure, they almost felt a sense of failure oh it hasn't worked so…*
>
> ***Key Stage 2 Female 1****: I think probably down the school they don't feel like that but they like to be right.*
>
> ***Key Stage 2 Female 2****: It is getting all teachers into that mode isn't it? I am sure for a lot of teachers it is quite kind of difficult to go from that.*
>
> ***Key Stage 2 Female 1****: It is quite interesting that one of our Primary Five teachers came and said I have to teach electricity, I've never done it before what will I do? Well I said why don't you just give them some wires, a battery and a bulb and see what they do with it and she went can I do that and I went yes just say…*
>
> ***Key Stage 2 Female 2****: And you do it as well.*
>
> ***Key Stage 2 Female 1****: …just say I want you to see if you can get the bulb to light and don't say anything else. She came back after it and she said [gasp] it was brilliant - and she said they were doing things like parallel and series circuits, that she hadn't anticipated and the kids go much further. If you let them, if you just say to them today we are going to learn how to make a simple circuit, this is how you are going to do it and then let them get on with it. It was really good to see someone else trying it and seeing it was really good. But it probably is leaving your comfort zone and letting go of that I am in control and I am going to make sure that everyone knows the right answer.*

Another discussion revolved around some interesting developments which have been taking place in Scotland:

> ***Key Stage 1 Female 1****: All schools have been invited to do it because it is what the Fife Science Development Team is promoting for the next year: Let's Think Through Science.*
>
> ***Key Stage 2 Female 1****: They have been doing peer coaching and things. I have had the Development Team come in and first of all they sort of demonstrated a lesson with a group with you and then they would come back and do a peer-support doing a lesson together and come back and watch you and sort of feedback afterwards…this is, that's working well, you need to try and do this and again it is stepping back and letting the children talk to each other. You are just really there giving a gentle prod if they get stuck in a discussion. It is amazing how much they communicate with each other. At first they want to go through you for everything but eventually they get used to saying oh maybe that is not what you should have done, could you try that, and they have to explain why they want it done a different way and it is really interesting and they are only six, seven years old. But it needs to be built on.*

***Key Stage 1 Female 1**: I did an evaluation with the class on what did they thought about what Let's Think Through Science was and I got some quite interesting comments. One boy said 'Let's Think Through Science is all about developing your brain…' …what they felt they got better at doing, it was things like' listening in groups' and 'listening to others', 'sharing ideas'…*

The Welsh group discussed the possibility of the SATs being replaced with some assessment of thinking skills:

***Key Stage 2 Female 1**: There is another one, is it inside the black box or…*

***Facilitator**: Yes, that was mentioned in Scotland.*

***Key Stage 2 Female 1**: …it is really looking at self-evaluation, where you sit children down and I wondered about this but having seen and read quite a bit on it recently how children tell other children, point things out, oh you have got this wrong. Some children explain it better to each other in their own terms and a lot of children's thinking and learning has apparently come on exceptionally well and really what [name] the regional Science Advisor, was saying that day was that in the place of SATs this might come into school as a form of assessment because what we don't want to do is to replace SATs with another form of SATs…*

***Facilitator**: With a different name.*

Key Stage 2 Female 1:…but training children to think and evaluate their work for themselves. I think that is quite an exciting way to go.

Findings from the cross sector consultation conference

Whilst workshop discussions highlighted the importance of developing thinking skills through science, the development of thinking skills *per se* was not selected by groups as a key factor in relation to improving primary science.

Survey of HEI primary science initiatives

Whilst developing children's thinking skills in science was a feature of many of the projects described in this survey, only one of the projects was specifically aimed at developing children's scientific thinking.

The *CASE@KS2* project involved collaboration between King's College London's Centre for the Advancement of Thinking, 11 schools in the Borough of Hammersmith and Fulham and 10 schools in Harrow. The aims included developing scientific thinking amongst year 3 pupils, devising and testing CASE-based curriculum materials and training teachers in their use in the classroom. The project was unique among CASE (Cognitive Acceleration through Science Education) projects in that it was developed through the context of science within the National Curriculum with the lessons based on topics in the QCA schemes of work. CASE@KS2 is grounded in the learning theories of Piaget and Vygotsky's social construct theory.

For the teachers involved in the project, professional development was provided by a combination of days outside school and support coaching in the classroom. Teachers were introduced to Piaget's and Vygotsky's work and its relevance to CASE. Teachers and tutors explored how theory could link with work in the classroom. In the first term, project tutors went into schools and modelled two CASE lessons. In spring the project tutors and teachers team taught together in class. In the summer term teachers ran the CASE lesson on their own, observed by the university tutor and feedback about pedagogical aspects of CASE immediately after the observation.

The project team wanted to see whether CASE@KS2 had an impact not only on children's thinking but also on their science learning. The project results to date show no significant difference between experimental and control groups. However long term effects have been observed in earlier CASE interventions at year 7 and 8 where groups who had experienced CASE achieved significantly higher GCSE grades in science, English and maths compared with those that had not. The project team reported that the work had an effect on children's ability to think of themselves as independent thinkers particularly those children with special needs.

Stories

Some teachers use stories in their science teaching. These stories can be directly related to science, such as the story of Edward Jenner and the discovery of vaccination, or can be only indirectly related to science. The *Science through Stories* series has been written in line with the curriculum to help teachers to introduce their KS1 pupils to Science. Once read and discussed, each story can be developed through both practical science and drama. The work in science requires only simple equipment; the drama can be carried out in the classroom (Hendy and Sparks Linfield 1996).

Findings from the telephone survey

The survey revealed that teachers of younger children made more use of stories in their science teaching than teachers of older children (Table 6.6).

Table 6.6 Use of stories in science by teachers of different age groups

Using stories in science teaching				
	4-6 years	**7-9 years**	**10-11 years**	**It varies**
Never	14.9%	32.1%	39.8%	23.6%
Occasionally	46.8%	54.7%	51.6%	59.4%
Often	38.3%	11.3%	7.5%	16.0%

Findings from focus groups

The use of stories for science teaching seemed to be dominated by Key Stage 1 teachers in the focus groups. It was interesting that a Key Stage 2 teacher felt that Key Stage 2 teachers needed to be educated to use stories effectively in science teaching (group 4):

Key Stage 2 Female 1: *Yes. I think it is a lack of education, a lack of teacher training. I know there was a big push recently with all the big books and poems and chocolate or* *whatever but I just think that [using stories in science teaching] hasn't filtered through yet to the majority of the Key Stage 2 teachers.*

Survey of HEI primary science initiatives

One of the projects in the survey of primary science initiatives fostered by HEIs included an approach which involved the use of storylines.

The ***STAY (Science Transition AstraZeneca York)*** project was a 2-year initiative involving 5 high schools and 8 primary schools in the York area. Project teachers from these schools attended 5 days of CPD during the autumn term 2001. Their training focused on Sc1 and particularly the *considering and evaluating* evidence strand. The project teachers worked in four development groups. Each group produced a unit of work representing 6 hours teaching in year6 and four hours in year7. Each unit included a science storyline based on a commercial/real-world context within which the science concepts and scientific enquiries are set. The units also include a unique and transferable self-review and diagnostic assessment scheme that is used by pupils and teachers. The four units were trialled in the project schools in the Spring Term 2002. Following evaluation and review two units were launched; 'Fizzy Drinks' and 'Bread'. They were made available to all schools in York. Year 6 pupils were to be taught 'Fizzy Drinks' and to complete work on this unit when they transferred to Year 7 classes. The 'Bread' unit was to be taught a year later - thus avoiding repetition for Year 5 pupils in mixed age classes.

Using history in science teaching

The use of history in science teaching has been found to be very effective in terms of enhancing the learning of science (Fowler 2000, online, Duschl (2000), online). However, the practice of using history to teach science in UK primary schools is not common.

Findings from telephone survey

Whist 50% primary teachers in the survey responded that they occasionally used history in their science teaching, only 13% used it often (Table 6.7). These proportions were similar for teachers of children of different age groups.

Table 6.7 Frequency of use of history in science teaching

	Frequency	Percent
Never	108	36
Occasionally	150	50
Often	40	13
Don't know	2	1
Total	300	100.0

Findings from focus groups

Most groups agreed that they taught history and science as two separate subjects. When discussing the reasons for this, they talked about the fact that much of the 'curriculum' history did not lend itself to teaching science, but there were aspects of non-curriculum science that added a lot of interest to science teaching. The following extract illustrates these points (group 6):

> ***Facilitator***: *[…] Would you find History particularly conducive to teaching scientific topics?*
>
> ***Key Stage 2 Female 3***: *I did a course on the History of Science and Technology and that was really, really interesting.*
>
> ***Facilitator***: *And then did you use that in the classroom in terms of giving children a background, if you were doing electricity or something like that?*
>
> ***Key Stage 2 Female 3***: *Well yes, that is always there, but I am thinking they are more riveted by the medical details and things like that, aren't they? Like blood and guts…*
>
> ***Head Teacher Female 1***: *We taught microorganisms and we started with Jenner and stuff like that and you can actually bring in a whole lot…*
>
> ***Key Stage 2 Female 3***: *We do science with Florence Nightingale with healthy living.*
>
> ***Deputy Head Female 1***: *But not history as it is set in the National Curriculum is it? You know scientists - my children knew everything about Galileo doing Earth and Space - it was amazing they were just so interested they have researched…*
>
> ***Facilitator***: *Independently but not from the history component.*
>
> ***Deputy Head Female 1***: *…but it is the science that brought in the history not the history that brought in the Science.*
>
> ***Key Stage 2 Female 1***: *But they are not developing any Science skills by doing that.*
>
> ***Facilitator***: *Perhaps it is just background about where the context in which this scientific knowledge is set.*
>
> ***Head Teacher Female 1***: *It is just to increase the interest really.*

6.1.5 Inclusion: gender, special needs and ethnicity

Inclusion

'Schools have a responsibility to provide a broad and balanced curriculum for all pupils. The National Curriculum is the starting point for planning a school curriculum that meets the specific needs of individuals and groups of pupils' (National Curriculum, online).

This statutory inclusion statement on providing effective learning opportunities for all pupils outlines how teachers can modify, as necessary, the National Curriculum programmes of study to provide all pupils with relevant and appropriately challenging work at each stage. It sets out three principles that are essential to developing a more inclusive curriculum:

A. Setting suitable learning challenges
B. Responding to pupils' diverse learning needs
C. Overcoming potential barriers to learning and assessment for individuals and groups of pupils.

The advice from QCA for teachers of primary science is that children should be taught to view positively differences in others, whether arising from race, gender, ability or disability. Science teachers can achieve this by using materials that reflect social and cultural diversity and by providing positive images of race, gender and disability, for example by explaining that there were successful methods of immunising against smallpox used in Asia, Africa and China several centuries before Edward Jenner's work on vaccination took place in England (QCA online).

Gender

Findings from the telephone survey

Teachers in the survey did not respond that gender was a major issue in teaching primary science. The majority (80%) disagreed that girls were less interested than boys in science. Despite this, almost half of the teachers (47.4%) responded that they tried hard to get girls more involved in science; 28% were neutral and 23% disagreed. When asked about what were the main issues facing primary teachers in their science teaching, only one teacher out of 300 mentioned that gender was an issue. In the other open question in which teachers were asked to comment on how primary science can be improved so that children are best supported to develop the sorts of skills that will help them to become active and informed citizens, no teacher mentioned anything to do with gender.

Findings from the focus groups

There was some evidence from the focus group discussions that gender issues in science surfaced as children got older. Many of the Key Stage 1 teachers commented that the response of boys and girls to science was with equal enthusiasm. The view among many of the Key Stage 2 teachers was, on the other hand, that girls were more passive and lacked confidence in practical activities when working in mixed groups. There were teachers who disagreed, however, and suggested that it was personality and not gender that was the important factor underlying the level of children's participation in active science. Another observation was that girls were more methodical and organised in their approach to science practicals, whereas boys just 'got stuck in'. Despite the varying views in regard to the importance of gender in relation to participation in science, however, most teachers agreed that there was little, if any, observed difference between girls and boys in their performance in science tests. The extracts below give a flavour of some of these discussions.

> ***Facilitator*** *(group 1): What about ensuring equal participation between girls and boys? Are there any issues there? I mean there is this popular idea…*
>
> ***KS2 Female 1****: This myth that…*

Facilitator*: …that boys take over.*

KS2 Female 2*: I agree I think they do. I think the girls are really passive; not all of them of course, but if you put them in a group the boys do seem to enjoy the practical hands-on whereas the girls sort of let them get on with it sometimes. You have to encourage them.*

KS2 Female 1*: Sometimes it depends on the girls' personalities. I went on one of those Science days, it was in one of the grammar schools and my girls were really competitive against the boys, you know connect stuff and making things.. So maybe it kind of depends on what kind of a personality…*

KS2 Male 1*: I would agree with what [KS2 Female 2] said there. I would say every personality is different…but you would see that in most classes each year. The girls would sit back.*

Facilitator *(group 3): Would there be any gender differences you would notice?*

Key Stage 2 Female 2*: I think the girls… the girls really lack confidence with practical activities and I think the boys tend to dominate. Your dynamics within your groups you have to be very, very careful with, but definitely in gender terms I would say that girls lack confidence with the practical activities … but that might just be my context.*

Key Stage 2 Female 1*: I would say that is fair actually, experiments and stuff, the boys just get stuck in and the girls actually think things through and are organised and a bit scared to…*

Key Stage 1 Female 1 *(group 3): I don't think they make any differences in Primary One I think they all just get on.*

Facilitator*: They just all get stuck in.*

Key Stage 1 Female 1*: But you will have the odd one but it is not particularly a boy or a girl I think it is just…*

Facilitator *(group 2)****:*** *One of the questions related to … boys and girls, do you find that they are equal in their participation an d interest in science?*

Key Stage 2 Female 1: *The girls get stuck in here just as much as the boys really.*

Key Stage 2 Female 6: *It can be a personality thing with some children because they step back and let others do it and it may not be anything to do with their gender.*

Key Stage 2 Female 2: *In analysis there hasn't been any significant difference between the performance of boys and girls within the school.*

Facilitator *(group 5): In terms of inclusion as well what about boys and girls? How do you find the involvement there? Equal…?*

***Key Stage 2 Female 2**: I really don't find that any different.*

***Key Stage 2 Female 1**: No difference, I don't find a difference.*

***Key Stage 2 Male 1**: Well going back to what I said earlier, girls are better at organising themselves than boys. Boys need a lot more direction. They need to sort themselves out into groups and sort out the jobs you know whereas girls have done it and have sorted themselves out and are all busy…*

Special Needs

Pupils with special educational needs

The following advice for teachers of children with special needs is offered on the National Curriculum website:

> *Curriculum planning and assessment for pupils with special educational needs must take account of the type and extent of the difficulty experienced by the pupil. Teachers will encounter a wide range of pupils with special educational needs, some of whom will also have disabilities. In many cases, the action necessary to respond to an individual's requirements for curriculum access will be met through greater differentiation of tasks and materials, consistent with school-based intervention as set out in the SEN Code of Practice. A smaller number of pupils may need access to specialist equipment and approaches or to alternative or adapted activities, consistent with school-based intervention augmented by advice and support from external specialists as described in the SEN Code of Practice, or, in exceptional circumstances, with a statement of special educational need. Teachers should, where appropriate, work closely with representatives of other agencies who may be supporting the pupil.*

Findings from the current research

The survey did not ask questions relating directly to teaching science to children with special needs. The only comments relating to children with special needs were made by teachers from special needs schools and only to the question asking what were the main issues facing teachers of primary science, for example:

> *We are a special needs school so the investigative side of science is difficult.*

> *It is probably differentiation and modification to suit the needs of this school because it is a special needs school.*

> *Communication as it is a special school.*

There was no specific discussion of science and children with special needs during the focused workshops at the stakeholder conference. There was, however, a lot of discussion of special needs issues in the focus groups and one of the projects in the HEI survey reported positive effects on science for special needs children.

Findings from the focus groups

All teachers in the focus groups had experience of teaching children with special needs. This ranged from one child in a class (which may not be their current class) to a teacher who had taught in a special needs school. The issues discussed related to the value of science for teaching children with learning difficulties, the need for balancing the needs of one or two against those of the whole class and strategies teachers have used to enhance their teaching of science to children with special needs. There was overall agreement that science was important in motivating and engaging children with special needs and several instances in which such children achieved better levels in science than some other subjects evidenced this view. There was awareness, however, that despite science being effective in the engagement of children with certain needs, for instance autism and Asperger's syndrome, it was not going to be the case that science might be as effective in these areas in teaching children with other special needs. The following extracts illustrate these discussion areas.

> ***Key Stage 2 Female 2*** *(group 5): Well I've just got one little boy who can hardly write anything down come out with a Level 4 in this SATs through the scribe; …that's the skill of the teacher to keep them interested all the way through without having to write anything down. It's fine actually.*
>
> ***Key Stage 2 Female 1****: I have got a little girl who will draw what she has found out and she will scribe to her supporter systems. She did the low level Science SATs and got a three, which was absolutely superb for her…*
>
> ***Key Stage 2 Female 2****: Some children may be dyslexic and there is this particular little boy who used to love his science lessons but he just couldn't write any of it down. But we kept him there but I don't know what will happen when he goes to secondary school, it will probably all fall apart but he was very keen [...]*

> ***Key Stage 1 Female 1*** *(group 1): We do team-teaching so I take all Primary Three for Science and I have a little boy with autism but he just sometimes finds…he will sort of go off and is not paying attention but anything practical gets his attention straight back. As soon as it is over, that is it, he is gone again. It is trying to keep him there to do it and even if we were getting him to fill in the science, saying what we wanted to find out - it would take quite a while…but it takes up a lot of time… I am trying to organise and make sure everyone else is still staying on task, doing what they are supposed to be doing and that nobody is going to injure themselves or you know the safety aspect of it all if you are doing something involving… Last week we were making Rice Krispie buns - you have to be really careful with them because you can end up worrying are they OK are they enjoying themselves and then you think 'oh right how many other children have I in the class to look after'?*
>
> ***Key Stage 2 Female 3****: Yes. Well I have an Asperger's boy but I have a classroom assistant as well and I must say I do Science in the afternoons and it is brilliant. He absolutely loves Science. It is brilliant for me. I have another boy, very badly dyslexic, does no English and Maths and in all his Science things he has got four A's in all his assessments. Fantastic. So in my case it is very positive, they love science they love it they can't wait to get their hands on it. It suits those two types of children that have got special needs. But with other ones I don't know…*

> ***Key Stage 2 Female 1*** *(group 3): I was in Special Education for a year… teaching science within the Special Ed. Department rather than integrating them into mainstream. Certainly you had much more focus on the actual practical activity and not so much focus on the discussion… They liked the instant result, doing something and there was an effect but they got very good at explaining things like the rockets with the vinegar and bicarbonate of soda. They were able to explain that the gases filled the tube and then it popped. They loved things that were visual and that they could do. We didn't focus on anything like recording observations, it was all hands-on, watch what happens …the enjoyment was a huge factor and they did all learn to use a digital microscope. We took photographs of fruits, we were looking at how they looked with the light from above and below and all we wanted them to say was which one they liked best… But they could all by the end put a piece of fruit under the microscope and take a photo on the screen - it was all one-to-one that kind of thing. But they loved doing it and I certainly…that was the first time I had ever taught science to special needs children and it was really rewarding. I absolutely had a ball and they always knew it would be the thing that would be messy or [laughs] but they loved it, they really did.*

> ***Key Stage 2 Female 1*** *(group 3): I have found that the brighter children are much more reluctant to say why they think something because they are scared they are wrong. They have this fear already when they are 7, that it may not be the right answer whereas the children who are maybe not so good at reading or writing are more than happy to give their ideas and they will say no this is why I think that. I found that especially with the 'Lets Think Science'. The brightest children in my class sit there and are terrified to answer a question in case they get it wrong whereas the other kids are just like to have a go…*

Survey of HEI primary science initiatives

The project team of one of the projects (described earlier in Section 6.1.4) reported that the work had an effect on children's ability to think of themselves as independent thinkers particularly those children with special needs.

Ethnicity

The Primary Science area of the QCA website also provides advice for teachers regarding children who have English as an additional language.

> *The collaborative nature of practical work in school science, plus the subject's use of visual models and analogues, make it an ideal subject for integrating new arrivals who may have English as an additional language (EAL).*
>
> *Teachers should plan work that is accessible for children with EAL and that also extends their language skills. Teachers need to plan appropriately challenging work for those whose ability and understanding of scientific concepts are in advance of their language skills.*

> *Difficulties might arise in science for EAL children because of the use of words that are common both to science and everyday usage but have different meanings in each of these two contexts, for example 'control', 'cell' and 'force'. As other children may also be confused by these words the opportunity should be taken to explore the issue and to share strategies for remembering the science meanings, for example, adding a new word to a wall chart or shared file on a computer network, together with a strategy for remembering the science meaning.*
>
> *Teachers may wish to provide vocabulary lists but children need to engage with these actively, for example through games or quizzes, if they are to use them effectively.*
>
> *Teachers may wish to provide lists of scientific terms with definitions. If using the DfES/QCA schemes of work the key words can be drawn from the vocabulary section in the key stage 1 and 2 units. Children could build their own bilingual dictionary of key words.*

Findings

The survey did not ask questions relating directly to teaching science to children who have English as an additional language, nor to other questions relating to ethnic background. No comments regarding ethnic background were found among the responses to open questions about issues facing teachers of primary science and ways to improve scientific literacy. There was no specific discussion of science and ethnic background during the focused workshops at the stakeholder conference, nor was there any specific mention of issues relating to ethnic background in the HEI survey of primary science initiatives.

Findings from the focus groups

There was great variety amongst the groups in relation to children who spoke English as an additional language, ranging from classes with no such children (mainly in Northern Ireland) to those with a high proportion. The discussions mainly centred around strategies for helping these children, although in one group, teachers considered whether the problem was just the language or whether it was the science as well. The following extracts reflect the amount of discussion given over to this area, which was relatively small.

> ***Key Stage 2 Female 2*** (group 2): *We have a high proportion of children with English as their additional language ... a lot of effort is put into making sure they can articulate their findings and observations. We have to do a lot of work scaffolding for our children so that they have got the vocabulary and the confidence ... to try and make observations, particularly in Year 6.*
>
> ***Key Stage 1 Female 2:*** *We do stretch ourselves so that they can understand, like using terms like the bigger the bang the louder the noise.*
>
> ***Key Stage 2 Female 1:*** *It's like bringing it down so they have something they can latch onto. Making things relate for them so they don't just need all this language.*

***Facilitator** (group 2): Do you think it's a language problem rather than a science problem?*

***Key Stage 1 Female 1:** I think it is initially a language problem particularly for the children that are here. As an adult you know what's going on and you can express it but it's difficult for them.*

***Facilitator:** So that's a problem for the teachers too?*

***Key Stage 2 Female 4**: We have learning objectives and by the end of the lesson we look back on these and reflect on what we have learnt. We then get the children to say what they have learned and how they have done it. So this reflects what I think and gets them to reiterate and articulate what they have learnt through things like paired talks where they have to explain to their partner. So we use different methods of getting them to verbalise.*

6.1.6 The Relationship between science and other curricular areas

The geographer, Sir Halford John Mackinder, summed up one of the problems of unitising knowledge in the following quotation:

Knowledge is one. Its division into subjects is a concession to human weakness.
(*Sir Halford John Mackinder, 1861-1947*)

Findings from the current research

Most teachers in the telephone survey responded that they integrated science with other curricular areas at least occasionally (Table 6.8).

Table 6.8 Percentages of teachers who integrated science with other curricular areas

	Percent
Never	6
Occasionally	54
Often	40
Total	100.0

However, no mention of integrating science was made by these teachers in response to it being a major issue and only two teachers commented that integrating science with other curricular areas was a way to improve children's scientific literacy.

Findings from focus groups

In discussions of how science was integrated across the curriculum generally, focus group teachers were of the opinion that there was lots of potential for cross-curricular teaching through science. However, the aspects of the other subject areas covered, for example, history and geography, were not necessarily those that matched the 'curricular' areas of those subjects. In regard to literacy and numeracy, teachers were of the opinion that there was little transfer across subject boundaries unless the teachers made explicit links obvious to the children. It could be the case that the very act of introducing 'subjects', each with its own discrete programme of study, into the primary curriculum has, in fact, made linking these areas more difficult for teachers.

Findings from cross sector consultation conference

Both keynote speakers at the stakeholder conference commented on the need for more integration of science with other curricular areas (Appendix 5). Group discussions at the workshops suggested that there was not enough time for such integration and that there is a need for more explicit links between science and other subjects.

Survey of HEI primary science initiatives

One of the projects in the HEI survey aimed to support the integration of science with other curricular areas. This was the Science in the New Curriculum (SiNC) project (described earlier in Section 6.1.2). Teachers and science specialist student teachers were concentrating on working together to try and integrate aspects of science, history and geography. In the new Northern Ireland curriculum, these three subjects will be subsumed into the larger area of *The World Around Us* (CCEA 2004).

6.1.7 Sources of funding and support from primary science initiatives

Findings from telephone survey

The second most important issue facing teachers of primary science identified by teachers in the telephone survey was the lack of resources and funding for school science (See Section 7.1). The data in Table 6.9 shows that there were regional differences in regard to teachers' perceptions of their science resources. Northern Ireland teachers were the most negative, with only 20% teachers describing the resources for science as 'good'.

Table 6.9 Teachers' perceptions of their school science resources

	Wales	**NI**	**Scotland**	**England**
Good	42.0%	20.0%	50.0%	50.7%
OK	50.0%	66.0%	42.0%	41.3%
Poor	8.0%	14.0%	6.0%	8.0%

There were also regional differences in regard to teachers' knowledge of extra funding which their school had obtained for science (Table 6.10). Again, the highest proportion of teachers who knew of no extra funding received was in Northern Ireland. A very high proportion of teachers in the Scottish sample responded that they have received extra funding for science.

Table 6.10 Teachers' knowledge of extra funding for science

	Wales	NI	Scotland	England
Yes	24.0%	14.0%	74.0%	17.3%
No	76.0%	86.0%	26.0%	82.7%

Findings from Focus groups

The focus group discussions revealed that there seemed to be great disparity between funding for science in different schools and between science and different subject areas. This can be illustrated by the following extracts:

> ***Facilitator**: You are looking worried M. Do you know whether you have any money to spend?*
>
> ***Male, KS 2 (science coordinator)**: Everybody else seems to be quite well resourced. Our Science budget for last year was £120.*
>
> ***Facilitator**: What size of a school have you?*
>
> ***Male, KS 2 (science coordinator)**: About 240 in the school…*
>
> ***Facilitator**: Two-form entry.*
>
> ***Male, KS 2 (science coordinator)**: …about one and a half but as you've said it needs to come to cross-curricular otherwise we cannot possibly get the money out of £120 that you need for Science. It really is…*
>
> ***Female, KS 1**: You couldn't even pay for batteries could you?*
>
> ***Male, KS 2 (science coordinator)**: No, no. Torches and batteries just take that and it is like looking ahead to what you need next year and we are in a similar situation where you have to bid for money and you don't usually always get it because it is not in the school development plan it is not a high priority in the school. So as Science Co-ordinator you do have to try and get on the back of other people and get some of their money as well.*
>
> ---------------
>
> ***Female KS 1**: I agree. I think there are great resources out there that you can buy but often principals don't feed the money into Science, it is more English and Maths but they are where the money goes, most of it. I think they could attribute more money to Science.*
>
> ***Female KS 2 (science coordinator)**: Like this year in our school … I got £500 for Science, they got £10,000 for English…*
>
> ***Female KS 1**: Yes, I think they could do with more money.*
>
> ***Female KS 2 (science coordinator):** …£10,000 to £500 and yet you are doing English through your Science, you are doing so much, you are getting so much English out of your Science as well …*
>
> ***Facilitator**: Dreadful.*

***Female KS 2 (science coordinator)**: There are so many…like you would think of the things now that you can get you wouldn't believe it, the stuff is fabulous, videos everything is fabulous. We are all running around trying to do double the work because you don't have the resources. If you had the resources sitting there then everybody would teach it.*

***Male KS 2**: It is the price of the things as well. The price of things has gone up in the last few years.*

***Female KS 2 (science coordinator)**: The price is dear yes but if you look around. There was a life cycles catalogue or a thing on life cycles like the butterfly and you put them in order. In one catalogue it was £32 and in another it was £21. so you have to know where to look and know what catalogues because that all comes into it as well when you are planning and make sure that you are on the mailing list for those catalogues.*

***Male KS 2 (science coordinator)**: But when you get a budget of £500 can you afford to buy four of those, one for each class? You are expected to share…*

***Female KS 2 (science coordinator)**: Exactly.*

***Male KS 2 (science coordinator)**: And it can be very difficult when you have 100 children split among four classes and you are trying to teach all the same thing and you are having to get someone to go and get this and someone to go and get that from the other rooms, that can be quite difficult.*

***Female KS 2 (science coordinator)**: Excuse me, I would like so much for Science but it is a preparatory department, which has no money at all. We never have money left over.*

***Female KS 1 (science coordinator):** My allowance in science is minimal for the year and I really struggle to do anything with it and as a result our resources are very ancient and we just have to make the best with what we've got because we can't actually afford to replace anything.*

***Female KS 1 (science coordinator):** I don't have an allowance so I just have to go on bended knee really.*

***Female KS 1 (science coordinator):** I get £150 a year*

***Female KS 1 (science coordinator):** That doesn't do anything really does it?*

***Female, head teacher:** Its £50 more than somebody else gets.*

***Female, KS 2:** Some people think they don't get a really big budget but they get more than £150 a year. I think that I will go along with H in saying that the consumables eat up a lot of and what I am trying to this year is put a consumables budget so that the things that we buy are the things that last. I asked everyone to make a list of the things that they really needed and to make a wish list and I have to say that people didn't get everything on the wish list, they got what we could afford. For example the set of science equipment for experiments within a particular year group, two sets would* *have been ideal but we could only afford one. Teachers are always having to prioritise.*

Facilitator: *So do you tend to look for things that come in kits specifically for teaching a topic or a unit rather than…?*

Female, KS 2: *Yeah, well what we have got is, I'm not quite sure when the suitcase things came out but that's what we inherited when I came here but we have got resources stored according to the areas of science that they address. The thing that S was looking at were actually packs designed specifically for year three so rather than rummaging through all of the cupboards to make up exactly what you need these came ready prepared.*

Facilitator: *Do you get much support from the county, from the advisory service or not?*

Female KS 1 (science coordinator): *With resources or in general? I know they have resources but we haven't got any of them.*

Findings from cross sector consultation conference

It was interesting that, whilst the teachers in the survey highlighted lack of resources and funding as the second most important issue in primary science, the cross sector groups at the conference identified this as only the fifth most important issue. In the discussions regarding improving children's scientific literacy which were carried out by single sector groups, no group (teachers, HEIs CPD providers and policy makers) selected resources or funding among their top three ways to improve children's scientific literacy.

Survey of HEI primary science initiatives

Overview

This section provides a summary of primary science initiatives undertaken by UK higher education institutions. Information was gathered via two main sources: an e-mail questionnaire and a literature search. The survey identified 23 initiatives, ranging from very small-scale self funded work with one local school to large-scale (national) funded projects. Seven responses suggested that their institutions were not currently involved in science initiatives being carried out with primary schools. A summary of all the initiatives considered for this report, which also includes some from non-survey sources, is presented in Appendix 8.

The main areas addressed by these initiatives were broadly categorised as follows, although many projects spanned more than one category.

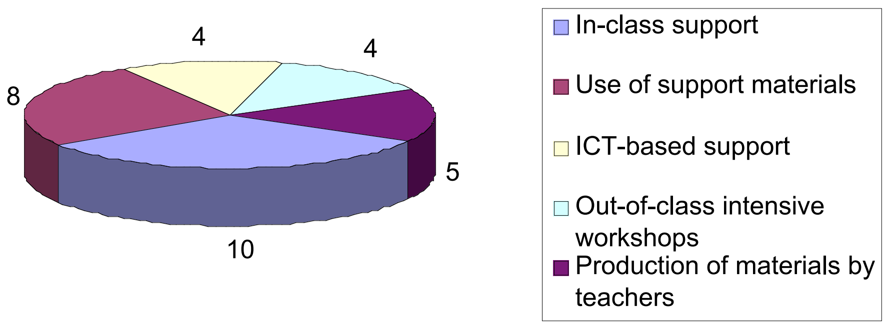
- Increasing teacher confidence
- Promoting investigation in class
- Increasing pupil enjoyment
- Improving pupil attainment
- Improving KS2/3 transfer

The initiatives involved a variety of professional development approaches which were categorised as follows:

- In-class support
- Use of support materials
- ICT-based support
- Out of class intensive workshops
- Production of materials by teachers

The number of initiatives principally using the different approaches is shown in Figure 6.11.

Figure 6.11 Number of projects principally using specific approaches



The relationship between the approaches used and the purpose(s) of each initiative were complex since most initiatives were multi-layered.

Where appropriate, the information regarding specific projects which has been included in the relevant areas of this report. However, there were some projects which did not directly fit into these categories and these are included here:

Improving pupil attainment in science

Several initiatives were primarily aimed at improving pupils' attainment in science. The primary approaches used for these were in-class support and the use of support materials.

Enhanced Advisory Services project

The *Enhanced Advisory Services project* set up by the Northamptonshire Inspection and Advisory also aimed to support teachers professional development in science teaching and learning (AstraZeneca Science Teaching Trust, 2000). This project was set up to support 21 rural primary schools in Northamptonshire, most of them with fewer than 150 pupils. Many of the teachers in these schools had been unable to participate in science based professional development activities previously because of their distance from central LEA training. The Northamptonshire Education and Community LEA provided 4 advisors from its science team to give direct support to each school. The advisers worked with the science coordinator and head teacher to carry out a science audit in each school to identify development priorities and set targets for improvement. Each school's training needs were identified and a training programme (through workshops and courses at a central venue in the local market town) developed in response to this. A key objective for the project was to provide high quality professional development of science coordinators. This aimed at updating their own professional knowledge and understanding, developing their ability to lead and support colleagues and improve their ability to evaluate the quality of science education provided.

The provision of science equipment to the rural schools using the equipment grant provided by AZSTT was a great bonus for the schools. This improvement in materials, equipment and books benefited both the teachers and children. Verbal feedback from staff and confidence audits of teachers highlighted that teachers' confidence in teaching science was a major factor in improving pupils' attitudes towards science. This increase in confidence also fed into the raising of the profile of science in the schools. Phase 1 of project: At KS1 in 1997, 19% of pupils' in AZSTT schools reached Level 3 in their science SATs. By 1999 this had risen to 31% (a 12% increase compared to a 4% increase for other schools in the county) At KS2 the striking rise in attainment of project schools was less marked, but individual schools demonstrated some dramatic rises in attainment and all schools achieved their targets for attainment during the period of the project. Phase 2: Between 1999-2000 the percentage of pupils in KS2 science gaining level 4 or more rose from about 74% to more than 85%, while those gaining Level 5 rose from about 18% to 30%. Head teachers saw the project as a means of institutional self-evaluation and this model is now used across a number of other subjects in some of these schools. Beyond the duration of the project, higher levels of attainment have been sustained and now project schools are in line with county averages. Resources developed during the project have been given back to schools across the country either by website or paper based products.

Making Sense of Science

The *Making Sense of Science* project was a collaboration between Software Production Enterprises (SPE), The Open University, Goldsmith's College (University of London) and Lewisham LEA (AstraZeneca Science Teaching Trust, 2004). It initially involved science coordinators from 18 local schools and was extended to 12 schools in Kent. The project focused on the professional development of the science coordinator. The project used distance learning INSET materials combined with tutor support in developing the role of subject leader, and the opportunity for coordinators to carry out focused in school development. Each science coordinator was offered 4 core INSET days. These days provided support for the participants' distance learning using the Making Sense of Science materials and how this resource could be used for INSET in project schools. Science coordinators identified three main areas of focus for their in-school project: a curriculum focus identifying an area of science to be developed with children; a teaching and learning focus to be addressed with colleagues; and a coordination focus for their own professional development. Each coordinator was allocated £1000 to spend on resources and these resources together with the Making Sense of Science materials were vital to the success of the school-based projects. They enabled coordinators to carry out high quality professional development with their colleagues and then to follow through by applying new ideas in the classroom with proper resources.

Interviews with science coordinators highlighted a greater awareness of their role as science coordinator and greater confidence in carrying out their role. Many were running science-related INSET within their school, were working in partnership with other teachers in the classroom and were recognising positive changes in their own and colleagues' teaching of science and in pupils' learning.

Performance Indicators in Primary Schools (PIPS)

The *Performance Indicators in Primary Schools* (PIPS) project in the University of Durham CEM Centre is a UK wide monitoring project involving over 3000 schools, designed to give feedback to school on how well they are doing by providing performance data. Schools and teachers find it hard to get a perspective on how successful they are with their own pupils compared with teachers in other schools. The project aims to support teachers and children by improving the education of children by giving high quality information to teachers. The project provides performance data for the schools to use to improve the provision for science in the last few years of primary schools.

Improving KS2 / KS3 transfer

The professional development initiatives which were aimed at improving KS2/3 transfer used a combination of approaches involving support materials, some of which were developed by the teachers.

North Yorkshire AstraZeneca Science Pedagogy and Progression (NYASPP) Project

The *North Yorkshire AstraZeneca Science Pedagogy and Progression (NYASPP) Project* draws on findings and best practice resulting from the 'STAY' project. The project responds to current debate on the need to concentrate on curriculum and pedagogical aspects in transfer between primary and secondary schooling. This is particularly important in the area of teaching the process skills of scientific enquiry since this is work that underpins the science that pupils do either side of transition, irrespective of the topic studied. The central idea of this project is to address the needs of year 7 pupils through the development and teaching of 'Science Enquiry Mini-tasks' (SEMs). The aim is to develop a number of SEMs and relate these to the QCA schemes of work and the national curriculum programmes of study. SEMs will use harmonious pedagogical approaches and will be focussed on teaching in Y5/6 and Y7/8 thereby enhancing the transition between key stages at a deeper and more sustainable level than through the use of bridging units alone.

Impact of primary science initiatives

The projects described in this chapter have undoubtedly had a highly positive influence on primary science in the schools involved. The work of the AstraZeneca Science Teaching Trust has been pivotal in this respect. The Trust has funded 17 HEI projects since 1997 in various parts of the UK and has enabled a significant amount of in-school support for teachers. A condition of receiving AZSTT funding is that a substantial proportion of the money goes directly to schools to support teacher cover, the purchase of extra science resources etc. In addition, these projects have facilitated vastly improved links between the HEIs and the schools; particularly in cases in which the project has been sustained once the funding has ended. An example of this is the Queen's University / St Mary's University College Belfast Science Students in Primary Schools (SSIPS) project. The AstraZeneca Science Teaching Trust supported this work for two years, which pioneered co-teaching primary science in the UK. Lessons learned from the two years have enabled the providers to continue with co-teaching as a highly successful component of the preparation of BEd science students. Co-teaching benefits not only the students, but the classroom teachers also gain in confidence to teach investigative science and the children enjoy science a lot more.

Geographical Impact

However, all of the science initiatives described together only reach a small fraction of the UK primary school population. Much of the valuable work from these projects is not widely disseminated, particularly to schools which are geographically distant from universities. Many such schools are small and the data in section 6.1 of this report indicate that teachers in smaller primary schools are less confident to teach science than those in large schools. The AZSTT has addressed the dissemination issue by creating CPD materials that are available online and are free. Each unit can be viewed online or ordered on CD-ROM for use during professional development activities.

The establishment of the regional and national Science Learning Centres should offer a lot more regarding the wider dissemination of good practice in science professional development to primary schools. The evidence in this report demonstrates clearly that there is a need for *substantially increasing* science professional development for primary teachers. It also shows that such professional development could be effectively targeted at specific aspects of science teaching which are more challenging for teachers. Further, the report shows that professional development in science works, in that teachers who have experienced science CPD are more confident to teach science than those who have not.

The map in Figure 6.12 shows the geographical areas covered by the initiatives cited in this report. There was no available evidence for HEI projects in Wales and only one from Scotland (although this is quite a big project). Parts of the North West and south west of England also seem to be less well represented.

It should be noted however, that as the study only looked at HEI initiatives, it is not making comments about geographical gaps in other CPD provision

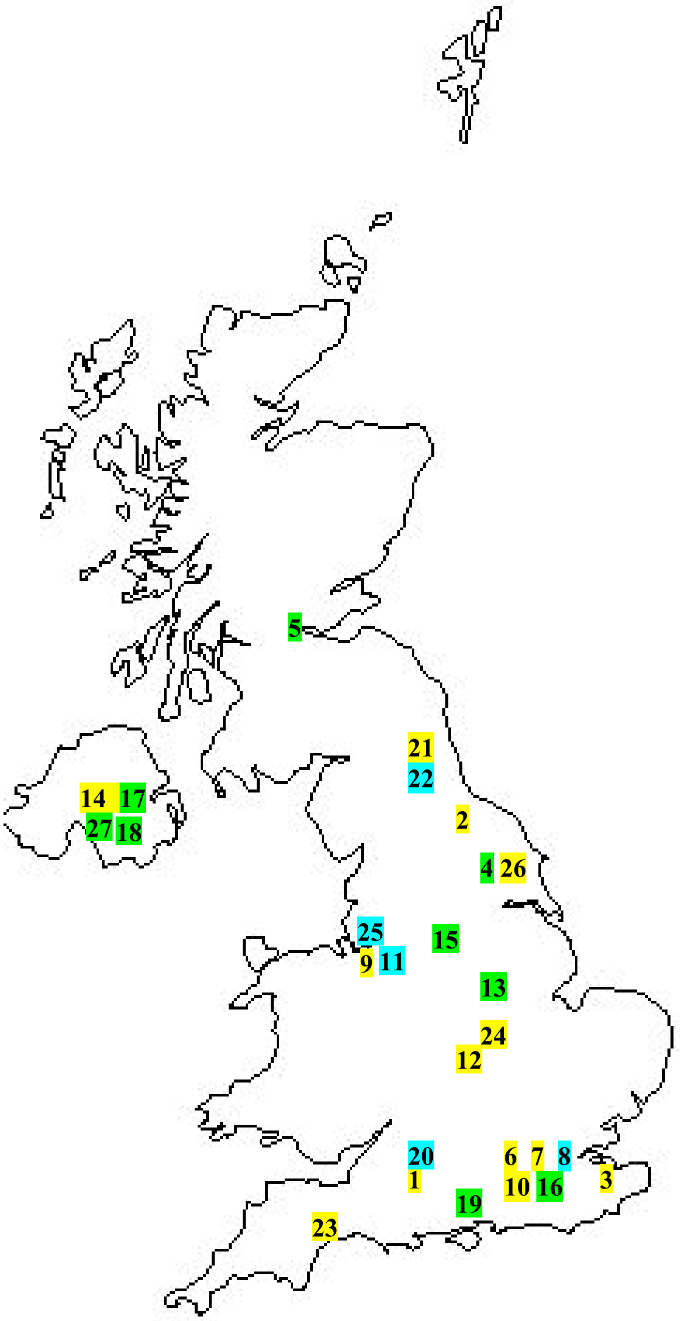
Non-geographical gaps in provision

The projects cited in this report reflect some of the important primary science professional development work taking place in the UK. There appears to be a gap in provision regarding HEI initiatives aimed specifically at science for children with special needs. Many of the initiatives described referred to special benefits for special needs children. Focus group discussions in section 6.1.4 indicated that many children who have learning difficulties in some subjects achieve particularly well in science. There is a need to address professional development in primary science to enhance the experience for teachers and children in special schools and for those children with special needs in mainstream schools.

One of the other areas which seems to be under-represented in the HEI initiatives considered for this report is the integration of science with other curricular areas. Evidence from the focus group discussions (6.1.3) indicates that children have difficulty transferring between subjects – even between maths and science – unless the teacher makes explicit links. This is a consequence of the introduction of subject programmes of study into the primary curriculum. Teachers also find difficulty making such links due to the nature of content bound up in various programmes of study. For instance, the programmes of study for primary history in the UK do not include many aspects which teachers might use to enhance their science, for example, topics such as disease and immunity, changing ideas about how the world works, etc. There is more evidence of the history of science being addressed in the KS3 programmes of study, for example, Unit 21: *From Aristotle to the atom: scientific discoveries that changed the world?* (QCA Scheme of Work for KS3 History).

Finally, there seems to be a significant gap in provision in the area of making science more relevant to the children's everyday lives. Survey teachers indicated strongly that this is the key to improving primary science to help children become active and informed citizens (section 8.1) and yet it is an area in which their confidence was not high (6.1).

Figure 6.12 **Geographical areas of primary science initiatives**



1. Bath Spa University College
2. Bretton Hall , Leeds
3. Canterbury Christ Church
4. Chemical Industry Education Centre
5. Institute for Science Education, Scotland
6. Institute of Education, University of London
7. King's College, London
8. King's College London/Dept of Education and Professional Studies
9. Liverpool John Moores University
10. Middlesex University
11. Millgate House Publishing and Consultancy Cheshire
12. Northamptonshire Inspection and Advisory Services
13. Nottingham Trent University
14. Queen's University Belfast /St Mary's University College with Stranmillis University College
15. Sheffield Hallam University
16. Software Production Enterprise Ltd.
17. St Mary's University College (2)
18. Stranmillis University College/St Mary's University College/Queen's University, Belfast
19. University College Winchester
20. University of Bath
21. 21.University of Durham/Redcar and Cleveland LEA
22. University of Durham/CEM Centre
23. University of Exeter
24. University of Leicester
25. University of Liverpool
26. University of York
27. Queen's University, Belfast and St Mary's University College

Denotes a local initiative Denotes a regional initiative Denotes a national initiative

Conclusion

HEI primary science initiatives in the UK have been significantly boosted since the establishment of the AstraZeneca Science Teaching Trust in 1997. There have been some important and high quality projects which have demonstrated significant improvements in teacher confidence, especially in facilitating science investigation in the classroom, children's attitudes and attainment, and in KS2/3 transfer. However, the impact is geographically limited. There is huge potential for the national and regional Science Learning Centres to capitalise on the work already started. In addition, there needs to be a focus on some gaps in provision, such as special needs science, integrating science with other curricular areas and in helping teachers to help children relate science to their everyday lives.

6.2 Children's attitudes to science

6.2.1 Background

The literature review revealed that many children show a decline in interest and enthusiasm for science from a young age. A study by the Institute of Electrical Engineers (1994) showed a decline in the level of interest in science by children in England between the ages of 10 and 14. Osborne, Driver and Simon (1998) found that positive attitudes towards school science appeared to peak at or before the age of 11 and decline thereafter by quite significant amounts, especially in girls. They revealed that science attitudes and interests are developed early in primary school and these are carried into secondary school and adulthood. Morrell and Lederman (1998) reported that many studies have shown very little, if any, relationship between overall attitudes to school and to science. They concluded from their own study carried out in the United States that attitudes to school were more positive than attitudes to science and that the difference became greater as the pupils got older.

The problem of declining interest in school science is international and many reasons have been put forward to explain it, including the transition between primary and post-primary schooling, the content-driven nature of the science curriculum, the perceived difficulty of school science and ineffective science teaching, as well as home-related and social-related factors.

Murphy and Beggs (2003a) carried out an extensive survey of primary children's attitudes to science and found that most of the older pupils (10-11 years) had significantly *less* positive attitudes than younger ones (8-9 years) towards science enjoyment, even though the older pupils were more confident about their ability to do science. The effect of age on pupils' attitudes was far more significant than that of gender. Girls were, however, more positive about their enjoyment of science and were a lot more enthusiastic about how their science lessons impacted upon their environmental awareness and how they kept healthy. There were also a few significant differences in the topics liked by girls and boys – generally girls favoured topics in the life sciences and boys preferred physical science topics. In an attempt to improve children's experience of science in primary school, Murphy *et al* (2004) report that increasing the amount of practical, investigative work in science had a marked, positive effect on their enjoyment of science. They demonstrated a highly significant reduction in the effects of age and gender on children's attitudes to school science.

The current primary science curriculum and the way it is taught and assessed have been criticized as constraining children's science learning as a body of facts rather than as a method of enquiry which requires innovation and creativity. Ponchaud (2001) was concerned that scientific enquiry has diminished in many primary schools. He pointed out that teachers should capitalize on the flexibility of the primary curriculum to carry out longer-term experiments, which would be more difficult to do in the timetable-constrained post-primary school. Campbell (2001) and Ponchaud (2001) also found that, when asked about what they liked best in science, primary children most frequently replied 'doing experiments' and 'finding out new things'. Bricheno (2000) cited the importance of small group practical work and using ICT in promoting positive attitudes to science. The Murphy and Beggs (2003a) study also found that what children liked best in science was doing experiments. The reasons given included that doing experiments was fun, that they found out things and that they were learning whilst enjoying themselves. One eleven-year-old boy commented that when doing experiments he could do things for himself, which helped him remember 'new things'. A girl of the same age stated that practical science was 'a better way to understand things rather than just writing them down'. Even an eight-year-old suggested that doing experiments 'encourages your mind'. Children, therefore, were telling us how important practical, experimental science was for their learning.

In the UK it has also been recognised that there is still an over-emphasis on content in the school science curriculum. Much of this content is isolated from the contexts which could provide relevance and meaning. Further problems include the lack of an agreed model for the development of pupils' scientific capability from the age of 5 upwards, and the fact that assessment in science is geared towards success in formal examinations (Reiss, Millar and Osborne 1999). A 2-year study, *'Beyond 2000'* (Nuffield Foundation 1998), made 10 recommendations regarding the implementation of the Science National Curriculum in England and Wales. Essentially, it was suggested that the curriculum should be re-designed to enhance general scientific literacy as opposed to the current curriculum which is geared towards the small proportion of pupils who will become scientists. A report from OFSTED (1996) stated that:

> *'Most pupils acquire a sound factual knowledge of the material in the Programme of Study but their understanding of the underlying scientific concepts often remains fragmentary…as the content of science becomes conceptually more demanding, there is a progressive polarisation of pupils' achievement, with the least able often becoming confused and holding incorrect ideas'*

Harlen (1997) was also concerned about international findings which report pupil difficulties within certain concept areas. She summarised findings from a large number of studies and concluded that pupil difficulty is chiefly due to the insufficient explanations given by primary teachers. It is interesting to note that much of the published evidence cites difficulties with the physical sciences, whereas in the Murphy and Beggs (2003a) study 'the flower' was frequently cited as the most difficult part of science. This could be due to a concentration on 'learning the parts' as opposed to learning about the process. Osborne and Simon (1996) demonstrated that primary pupils' explanations of 'how we see' were considerably better when a science specialist had taught them.

Preparation for national science tests in primary school could also impact negatively on children's learning in science. Ponchaud (2001) reported that anxiety about performance in national tests sometimes leads to excessive routine test preparation in the final years of primary school. Children have reported the boring and repetitive nature of such preparation (Murphy and Beggs 2003a) and commented negatively on aspects of curriculum content which they found difficult, such as:

> *'The flower – remembering parts, like ovule and ovary – I kept getting these terms mixed up' (11 year old girl)*
>
> *'Forces – pushing, colliding, hard to understand where the force is acting from' (10 year old boy)*
>
> *'Evaporation – I was confused by all the long words, like evaporation, condensation' (11 year old girl)*

Murphy *et al* (2001) showed that even third level students, including those who experienced compulsory school science from the ages of 11-16 and some with post-16 science qualifications, could not correctly answer questions in some primary science topics in tests which had been written for eleven year olds. Science is frequently being taught as facts or as a 'body of knowledge' in the final two years of primary school. Teachers feel the need to prepare children for the tests by ensuring that they can recall the required content knowledge. Attention to constructivist theories of learning science and to scientific enquiry has diminished by this stage.

The project team sought to explore some of these issues further by considering teachers' perceptions of children's attitudes to science. Teachers' responses to items on the questionnaire and questions in the focus group provided evidence of how well teachers' perceptions matched those of the children.

6.2.2 Findings from the current research

Generally, teachers seemed to agree that children generally enjoyed science lessons. This was not always the case when the children were revising for national tests, nor when they were writing up an experiment following completion of the practical work. Teachers did not feel there was a strong difference in enjoyment of science between girls and boys. Several HEI initiatives identified in the survey addressed the issue of increasing children's enjoyment of science.

Findings from the Telephone Survey

Two questions on the teachers' survey instrument (Appendix 1) related to their perceptions of pupil attitudes. Teachers were asked to rate their agreement on a scale of 5 to 1 (5 being the strongest agreement to 1 being the strongest disagreement) with the statements: 'children love learning science' and 'girls are less interested than boys in science'. Figure 6.13(a) shows that teachers indicated strongly that children loved science (89% scored 4/5). There was a significant difference between male and female teachers in the response to the statement 'children love learning science', with male teachers answering even more positively than female teachers. There was no significant effect, however, of age group taught, region of the UK, teachers' perceptions of their science resources, how many hours they spent teaching science per week, whether teachers perceived their school as urban or rural or the size of the school on this result.

Teachers also generally disagreed that girls were less interested than boys in science (80% scored 1/2), with no significant effect of any of the factors mentioned above (see Figure 6.13(b)).

Figure 6.13 (a)
Children love learning science

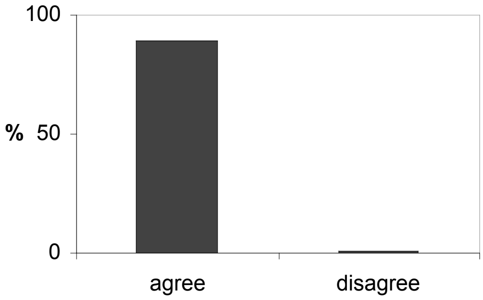
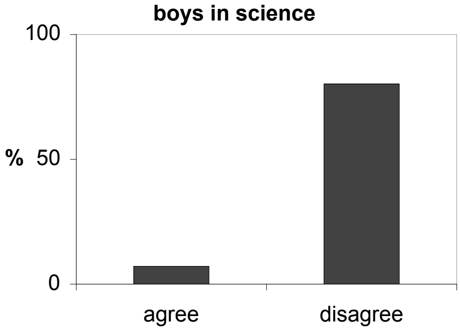


Figure 6.13 (b)
Girls are less interested than boys in science



Teachers related to children's attitudes in their responses to the two open questions. In considering the main issues facing primary teachers in their science teaching, responses ranged from '*children don't take science lessons seriously enough'* to '*all children enjoy science'*. Some comments illustrating these views are:

> *'... getting children to behave so that they're safe/ getting children to be positive about science - not to view it as a subject for messing about'*

> *'children seem to be a bit negative about science, so I have tried to reduce writing in class'*

When responding to the question about how primary science can be improved so that children are best supported to become active and informed citizens, teachers were more positive about children's enjoyment of science, for example:

> *'... I think science is one the subjects which all children enjoy and it should be give more prominence.'*

Findings from the focus groups

Teachers in all of the focus groups alluded to children's attitudes to science, although this was not a major theme. All agreed that children enjoyed practical work, and that this enjoyment often ends when children are asked to write up their work. This can be illustrated by a short extract from the Northern Ireland main discussion group:

> ***KS1 Female 1***: *That's the one thing I have to say about our school, the scheme is very good and it is all practical. P3 (6-7 year olds) - all I have done this year are practicals with the children and they love it! We went so far with electricity, they loved it that much that I brought in circuits and they made circuits in groups and lit the bulb themselves. They weren't supposed to do it but because they loved it so much I thought well sure why not?*

> ***Facilitator***: *Was this a scheme the school made up or one you bought in?*

> ***KS1 Female 1***: *I think it is actually part of the (Education and Library Board) scheme. I am not entirely sure but it is all six-weekly and it has themes. At the minute we are doing the Teddy Bears' Picnic so we are looking at materials of Teddy Bears, the children are making them, making sacks and trying different sorts of peas and rice inside. What is the best for a Teddy Bear? Then we have*

been then working on the other side of it, food. We have made Rice Krispie buns and melted ice-cubes. What is going to keep our drinks cool on our picnic? It has all been practical using like a Science plan house including is it fair, has it been fair, what did we discover? They love it. They just sit down and they know to start at the bottom of the house and that is how we are going to work from it.

***KS1 Female 2**: I agree I think children absolutely adore doing practical work in science…*

***KS1 Female 1**: Yes, they love it.*

***KS1 Female 2**: … but I feel that they detest when you say right we are going to write a report now about what we did but teachers are also under pressure to provide evidence of what they have done and that is the problem. I feel after I have done something really good and the children have had fun and they have learned a lot … oh no they have to go and write this down now…*

This discussion continued with Key Stage 2 teachers talking about the greater emphasis on the 'write-up' and then on to a discussion of the transfer test (the test of English, mathematics and science which is taken in the final year of primary school by all children who wish to attend a grammar school). Very little practical work takes place during the preparation for this test, which usually starts in earnest during their P6 (9/10 years) class.

Survey of HEI primary science initiatives

The HEI initiatives reported here attempt to address issues relating to declining interest in school science by older primary pupils, and engage children in primary science in a way which will be sustained into their later schooling years.

Concept Cartoons in Primary Science Education

One of the initiatives describing work which addressed children's interest in science was the work carried out by Brenda Keogh and Stuart Naylor from Manchester Metropolitan University (now at Millgate House Publishing and Consultancy Limited). They found that teachers had difficulty putting constructivist principles into practice. Teachers recognised that pupils held a wide range of ideas but could not see a manageable way of taking these into account. The *Concept Cartoons in Primary Science Education* project provided teachers and children with a non-threatening approach to dealing with this. The underlying intention was to influence pedagogy by providing materials which are very straightforward for teachers to use, do not require substantial changes to their teaching approach but through their use might have some impact on the way that pupils experienced teaching and learning in science.

The *Concept Cartoons* project was funded by GlaxoSmithKline (GSK) and operated across the UK. Local Education Authorities also ran their own programmes and it is estimated that over 4000 teachers took part. The long-term impact of the project has seen *Concept Cartoons* now appearing as part of the science experience in many schools. *Concept Cartoons* have also been built into various materials used for schools and the take up and positive response to them continues to be very high.

Murder in the Classroom?

A joint initiative in St Mary's University College and Queens' University attempted to increase the engagement of children with science by running DNA fingerprinting investigations in primary schools in a project called *Murder in the Classroom?* The project was funded by Science Year and involved student teachers carrying out DNA investigations with 10-11 year old primary children. Children were very excited about the prospect of looking at DNA fingerprinting and engaged well with both the students and the tasks they were set. They were asked to be crime scene detectives and by using DNA fingerprinting they would solve the crime. The children came up with scenarios for the crimes and the suspects and in many schools they set up a courtroom scene where the suspects were questioned by the rest of the class.

In total over 250 children and students and 17 teachers took part in the DNA investigation. The children were surveyed and the results clearly showed that those who took part really enjoyed it. They reported that they understood the DNA investigation. Over 90% of children responded that they enjoyed the investigation. The primary schools that took part welcomed the additional support and resources provided by the university and university colleges. Furthermore, the success of the BEd students carrying out the investigations led many of the teachers and principals to request that they be considered for other similar projects.

Changing Children's Attitudes to Science

The SCI centre's project *Changing Children's Attitudes to Science* (University of Leicester), working with Leicester City LEA and Leicestershire EBP, aimed to create a cohesive science network through pairs of focus schools in the city of Leicester (AstraZeneca Science Teaching Trust, 2004). The project initially worked with 16 schools and this was extended to include another 15 schools. All the schools received children from socially deprived areas of the city. The project team worked with the head teacher and science coordinator from each of the schools to identify key issues and problems with their science provision. The team then created INSET around the issues identified. A peer mentoring or buddy system was employed where the science coordinator and at least one other teacher from each project school worked collaboratively. The SCI centre team offered a 10-day core course on 'Developing and Assessing Investigations'. During this course teachers built up a sound knowledge base on difficult topics such as friction, electricity, change of state and dissolving. From that teachers were shown how to promote children's questioning in open-ended investigations and how these investigations could be used to develop children's conceptual understanding of the topic areas. Other courses were also available in Literacy and Science, ICT and Science and Science Subject Knowledge. The project had an overall positive impact on children's understanding and achievement in science, many school reported a marked improvement in SATs scores and Ofsted inspections revealed positive changes within project schools. Where teachers' confidence, enthusiasm and expertise in science had increased, children were enjoying investigative science more.

7 ISSUES OF CONCERN IN PRIMARY SCIENCE

7.1 Background

The recent Parliamentary Office for Science and Technology briefing (POST 2003) discussed issues of concern in regard to primary science, including: how schools can both develop pupils' interest in science and prepare them for secondary school; the balance needed between teaching factual knowledge and the skills of scientific enquiry; the effects of the SATs tests; and the importance of teachers' scientific knowledge and confidence

It was suggested in this briefing that possible ways forward include: providing training for primary teachers to improve their scientific knowledge and confidence; reviewing the primary science curriculum; acting to reduce or change the impact of SATs testing on primary science teaching and encouraging school managers to see science as a priority area so that, for example, teachers are encouraged to adapt the curriculum to match the interests of pupils in their school.

One challenge alluded to is the potential conflict between preparing pupils for secondary school science while also maintaining and developing their interest in exploring the world around them (POST 2003).

The findings of the current research tend to agree with some of the issues identified in the POST briefing, apart from the fact that teachers also identified lack of funding for resources as a major issue.

7.2 Findings from the current research

Teacher Perspectives

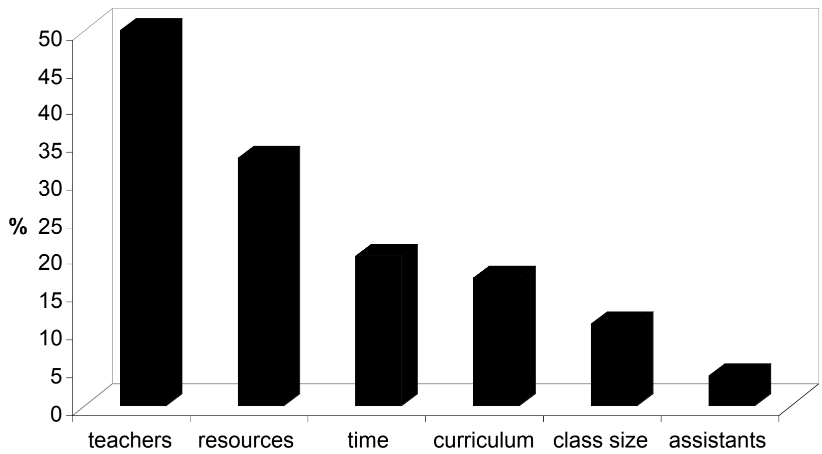
One of the open questions in the telephone survey asked teachers: 'What do you think are the main issues facing primary teachers in their science teaching?' The response was varied and a list of the main issues (in rank order) is given in Table 7.1.

Table 7.1 Rank order of issues identified by teachers

ISSUE	RANK
Lack of knowledge/expertise/confidence /training of teachers	1
Lack of resources	2
Not enough time	3
Classrooms too small	4
Concentrating too much on written work over practical	5
Other (combination of all issues identified by 1 or 2 issues)	5
Overloaded science curriculum	7
Lack of money/funding	7
Difficult to make classes practical/fun	7
Classes too large	7
None	7
Lack of classroom assistants	12
Not enough investigation	12
Primary not geared towards science	14
Science imposed on teachers	15
Not enough staff	15
Need to keep up to date with research	15
Integrating ICT	15

Of these issues, teachers' lack of knowledge/expertise/confidence/training in science occurred in half of all the responses (see Figure 7.1). The next most frequent responses highlighted lack of resources and time, respectively. Curriculum overload in science, large class sizes and lack of classroom assistants were also among the most frequent responses (Figure 7.1)

Figure 7.1 Issues of concern in primary science identified by teachers



The responses to first three of these issues were sufficiently numerous to analyse in relation to those factors which showed correlations with them, namely: gender, age of teacher, classes taught and whether or not teachers had undertaken professional development.

Teachers' lack of knowledge / expertise / confidence and training

Fewer (23%) young teachers (in their 20s) responded that teachers' lack of science knowledge / expertise / confidence / training was an important issue than teachers in the other age groups. Between 50% and 60% of teachers in their 30s, 40s, 50s, and 60s highlighted it as a major problem. There was no appreciable difference in the responses of female and male teachers, teachers who had or had not received professional development in science or teachers of different classes.

Lack of resources

More male teachers (37%) than female teachers (25%) highlighted lack of resources, and more females (22%) than males (16%) indicated that lack of time was an issue of concern. More younger teachers (35% of 20s and 45% of 30s) than older teachers (28% of 40s and 20% of 50s) said lack of resources was an issue. There was a similar response from teachers of all age groups regarding resources (21-25% identified it as an issue of concern). However, only 21% teachers who had carried out professional development indicated lack of resources as an issue in contrast to 36% of those who had not undertaken such development.

Lack of time

More female teachers (22%) than males (16%) indicated that lack of time for science was an issue of concern. Teachers' age did seem to be a factor: the percentage of teachers highlighting time ranged from 12% of those in their 20s to 26% in the 50 – 59 age group. There was no observable effect of class taught – between 21 and 24% teachers of all age groups said that time was a major issue. There was some evidence that teachers who had undertaken professional development were more positive in relation to time for science than those who had not, with 18% and 22% respectively indicating that lack of time was an issue of concern.

Summary of factors

A summary of the factors which seem more likely to have an influence on the identification of specific issues is shown in Table 7.1a.

Table 7.1a Likely factors underlying specific issues identified by teachers

IDENTIFIED ISSUE	INFLUENCED MOSTLY BY:
Teachers' lack of knowledge / expertise / confidence / training in science teaching	Age
Lack of resources	Gender Age Professional development participation
Lack of time	Gender Professional development participation

Teacher comments

The data above is based on a categorisation of teachers' comments to the question in which they were invited to comment on the issues facing primary teachers in their science teaching. As was stated earlier, many teachers identified more than one issue. The quotes below provide a flavour of the responses to this question and might provide deeper insights into the teachers' thinking on this matter:

- *the science curriculum is too structured and not as much fun as it should be/ time is an issue as is the lack of a set science class room - therefore we have to move equipment around/ cost of resources/lot of teachers paying for materials themselves*
- *the biggest issue is covering the content - there's a lot of it/ continuity is tricky - making sure different years don't overlap/ it's difficult for teachers to have knowledge of every part of the curriculum*
- *teachers have lack of confidence in teaching due to lack of science knowledge/ not enough time to set up and carry out practical/ no assistants to help with practical*
- *don't have facilities & expertise/ curriculum getting too wide/ the biggest problem is the lack of facilities for practical work & the lack of expertise/ also the curriculum is getting too wide*
- *organisation of lessons is vitally important, there needs to be a practical element/ due to restrictions, there is a tendency to become book-bound but there needs to be practical work/if there is a class of 30 pupils, practical work is more difficult and they might need to be split*

- *gathering of resources and facilities to teach the subject accurately/ primary class is not geared towards science teaching/ teachers have no time and inadequate training to teach the subject*
- *the biggest issue is the lack of knowledge of many teachers/ another issue is the lack of overall time because of the time spent on maths and literacy*
- *the biggest problem is fitting it in and also the staff's ability to teach it properly/ the staff aren't confident in teaching it as there's not a set menu - the curriculum isn't clearly defined*
- *not enough resources/ too much diversity in the class (level)/ it is hard to teach students of different levels the same thing/ they have to be broken up into groups which makes it difficult/*
- *no background in science/ time given to science is not enough for the curriculum required to be covered/ layout of classroom is not suitable for science/ no classroom assistants, they would be a help/ science programme is not good – some things are not scientifically correct/ more training given to teachers/ not possible for primary teachers to be expert in all subjects*

Cross-sector perspectives

Conference delegates (see Appendix 5 for details of the conference) were placed in seven cross-sector groups to consider the relative importance of the issues that teachers had identified in the telephone survey. Each group comprised teachers, teacher educators, researchers, CPD providers and policy makers. Groups were asked to place in priority order the three issues they considered to be of highest importance and to identify the three they considered to be of lowest importance.

The results from the groups were collated and seven issues emerged as being highly important as shown in Table 7.2a. Not all groups had felt able to differentiate between their top three issues.

Table 7.2a Rank order of issues identified as being highly important

ISSUE	RANK
Lack of knowledge/expertise/confidence/training of teachers	1
Not enough investigation	2
Concentrating too much on written work over practical	3
Difficult to make classes practical / fun	4
Not enough time	5
Lack of money / funding	5
Lack of resources	5

All groups identified 'lack of knowledge/expertise/confidence' of teachers as being of highest importance. No other issue was unanimously placed in this category, though some groups attached equal importance to two or more issues. 'Integrating ICT' was the only issue identified as being of neither high nor low importance. The issues considered by delegates to be of least importance are shown in Table 7.2b.

Table 7.2b Issues identified as being of lowest importance

ISSUE
Classrooms too small
Not enough staff
Primary not geared towards science
Science imposed on teachers
Overloaded science curriculum

Comparisons between different stakeholder groups

There are some interesting comparisons between priority issues identified by teachers alone and those considered most and less important by the mixed-sector group comprising teachers, teacher educators, researchers, CPD providers and policy makers. Both groups identified the teacher factors (lack of knowledge, expertise, confidence and training in science) to be the most important issue of concern in primary science. The next most important was lack of resources according to teachers (ranked 5 by mixed group) and lack of investigation by the mixed group (ranked 12 by teachers). In a similar vein, teachers highlighted lack of time as their third most important issue, which was only 5th in the mixed group.

In relation to the issues considered less important, two received the lowest ranking in both the teachers and the mixed group. These were: science being imposed on teachers and not enough staff. The differences arose with respect to the issue of classrooms being too small for effective science teaching, which was ranked 4th by teachers but received the lowest rank in the mixed group, and the overloaded science curriculum, 7th most important according to teachers and the lowest ranking by the mixed group. Two issues that were considered more important by the mixed group than the teachers were integrating ICT into science and the need to keep up with research in science teaching (both ranked 15 by teachers).

These observed trends are not surprising: the issues teachers highlighted as more important than the mixed group were those of which they would have much more direct experience, namely: lack of resources, lack of time, small classroom size and teaching an overloaded science curriculum. Those considered more important by the mixed group than by teachers were probably less immediate for the teachers, for example, not enough investigation, integrating ICT into science and the need to keep up with research in science teaching.

8 IMPROVING CHILDREN'S SCIENTIFIC LITERACY

8.1 Background

There is much debate about what constitutes scientific literacy and about the nature of science that should be taught at school (Murphy *et al* 2001). The term 'scientific literacy' has been used variously as a definition, a slogan or as a metaphor (Bybee 1997). As a definition, the term 'scientific literacy' may be used to facilitate discourse, for description and explanation, or to embody a programme of action Scheffler (1960). When used as a slogan 'scientific literacy' serves to unite science educators behind a single statement representing the purpose of science education. As a metaphor, the term 'scientific literacy' refers to being well educated and well informed in science, as opposed to merely understanding scientific vocabulary.

While the term 'scientific literacy' has been used for the past 40 years in the USA it is not so common in the UK. Hurley (1998) stated that scientific literacy is known as 'public understanding of science' in the UK. Scientific literacy can, therefore, be considered as the minimal scientific knowledge and skills required to access whatever scientific information and knowledge is desired In this report the term 'scientific literacy' refers to the skills that primary children need to help them to become active and informed citizens, together with the conceptual knowledge that underpins their development. In addition children should have the knowledge and skills to attain the required targets laid down in national curricula.

The issue of *what* science should be taught has been debated widely over past 15 years. In 1985 the American Association for the Advancement of Science (AAAS) launched a long-term effort to reform science, mathematics and technology education, referred to as Project 2061. It was so named because the project's originators were considering all the science and technology changes that a child entering school in 1985 – the year Halley's comet was in view – would witness before the return of the comet in 2061 (Nelson 1998). This project set out to identify what was most important for the next generation to know and to be able to do in science, mathematics and technology – that is, what would make them scientifically literate. Some of its guiding principles were that:

- Science literacy consists of knowledge of certain important scientific facts, concepts, and theories; the exercise of scientific habits of mind; and an understanding of the nature of science, its connections to mathematics and technology, its impact on individuals, and its role in society.
- For students to have the time needed to acquire essential knowledge and skills of science literacy, the sheer amount of material that today's science curriculum tries to cover must be significantly reduced.
- Effective education for science literacy requires that every student be frequently and actively involved in exploring nature in ways that resemble how scientists themselves go about their work.

The contemporary science curricula in the US were considered to be 'overstuffed and undernourished' (Nelson 1998). A prescriptive set of specific learning goals (benchmarks) from kindergarten to year 12 was recommended in '*Benchmarks for Science Literacy*' (AAAS 1993) which suggested reasonable progress towards the adult literacy goals laid out in a sister report '*Science for All Americans*' (AAAS 1990).

8.2 Findings from the current research

Making science relevant to the lives of children is key to their understanding of scientific concepts. This has been recognised for many years (see the introduction to Section 5 of this report). The findings of the current study reveal that relating science to the lives of the children is the best way to enable them to develop scientific literacy. This section describes the detailed findings regarding ways to improve children's scientific literacy from the perspectives of the teachers from the telephone survey and focus groups in the research and from cross-sector working groups at the stakeholder conference (primary teachers, teacher educators, CPD providers and policy makers).

Teacher perspectives

Telephone survey

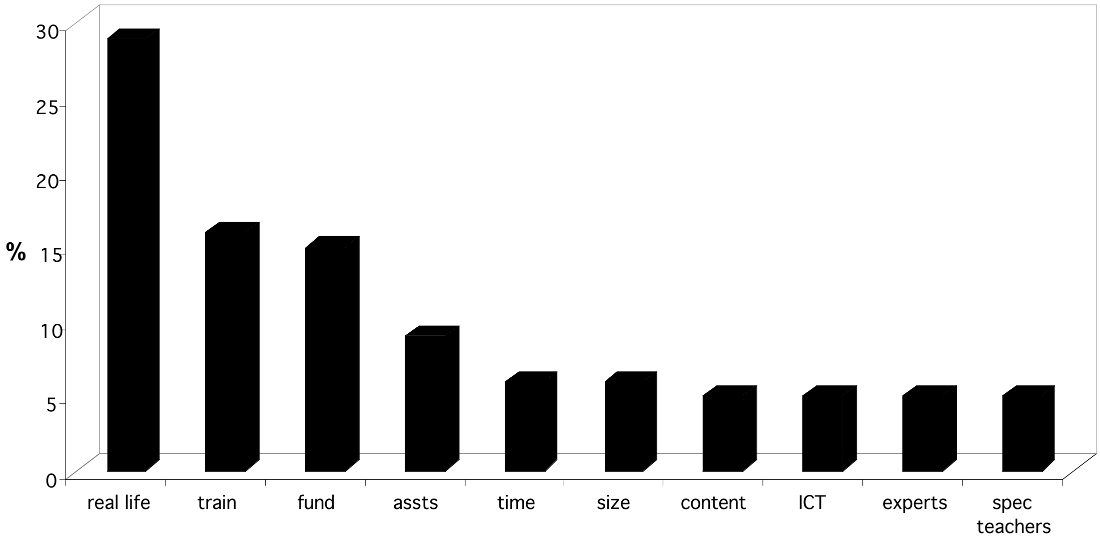
Teachers in the telephone survey identified the following ways that primary science may be improved so that children are best supported to develop the sorts of skills that will help them to become active and informed citizens (Table 8.1)

Table 8.1 Teachers' identified ways to improve children's scientific literacy

IMPROVEMENT	RANK
Make science more applied to real life	1
More training for teachers	2
More funding / resources	3
More teaching assistants	4
Smaller class sizes	5
More time for science	5
Incorporate ICT	7
Less content in science curriculum	7
More experts visiting school	7
Specialised science teachers	7
More work with sec schools	11
More industry links	11
Encourage children to question	11
Better textbooks	14
Same weighting as Eng/maths	14
More flexibility for teachers	14
No improvements	14
Improve classrooms	18
Dedicated science room	18
More field trips	18
More links with HEIs	18
Improve investigative skills	18

Of these issues, making science more applied to real life occurred in nearly a third of all the responses (see Figure 8.1) The next most frequent responses highlighted lack of resources and time, respectively. More training for teachers and more funding were the next most frequently recorded responses. Other factors that a substantial proportion of teachers suggested were: more teaching assistants, smaller class sizes, more time for science, incorporate ICT, less content in the science curriculum, more experts visiting schools and the use of specialised science teachers (Figure 8.1).

Figure 8.1 Ways to improve children's scientific literacy



The data above are gleaned from teachers' responses to the open question about how primary science may be improved so that children are best supported to develop the sorts of skills that will help them to become active and informed citizens. Below are some examples of the verbal responses of some of the teachers to this question.

- *keep relating to things happening in real life/science museums & exhibitions, science days for the older children, excitement interest keep relating it to things that are happening in real life/For the older children, trips to science museums and exhibitions/science days are run for children where they are able to try things they would*
- *there shouldn't be as much in the curriculum/ they should keep it more practical and relate it more to the kids, for example they should have more about nature*
- *we are trying to set up an industry link, to ensure you've got the support of expertise in your community/would like to see us going out more into the community/industry/if children see real purpose to what they're doing relate it to real life they will learn it more successfully/ensuring there's always a practical element, children learn by doing*
- *relate more to real life situations/ more stress on practical side/ more open ended investigations it should be related more to real-life situations/ there should be more stress on the practical side & more open-ended investigations*
- *allow children to explore the environment from a young age to get in touch in world around them, gain respect for the world and assist their growth*
- *less focus on reaching SATs targets more topic investigation in areas where the children's interests lead them we don't have time to do it because the curriculum is too rigid there is no leeway*
- *science classes should have an assistant, should be a 1:15 ratio/ more money for science resources/ should be someone in maybe 10 schools who could be called upon to help support and develop schools/ secondary school teachers seem to have a negative attitude to primary school teachers/ need more cross phase work*

- *teachers should be encouraged to teach science as it's not the most popular subject amongst teachers*
- *work has to be more investigative/ teachers should be trained better for science teaching/ more practical work as opposed to learning info from a book*
- *need more specialist teachers as primary school teachers are not knowledgeable enough to teach it and therefore lack confidence/ also more funding it replace disposable equipment that is needed each time a practical is carried out*
- *confident teachers - in service/ provision of resources/ clear focus of what is wanted out of teaching of science/ less emphasis on knowledge & more on sills & understanding they need confident teachers/ better provision of resources/ they need a clear focus of what is wanted out of teaching science/ less emphasis on knowledge & more on skills and understanding*
- *I think there needs to be a revision of the National Curriculum /I think there needs to be a priority of formative testing rather than summative testing, I think teacher subject knowledge needs improving and I think there should be more visiting professionals in schools to regenerate. I think science is one the subjects which all children enjoy and it should be give more prominence.*
- *all teachers should have sufficient subject knowledge and should be able to link into other curriculum areas /more resources All teachers should have sufficient training and subject knowledge and should be able to link science into other curriculum areas/ more resources*
- *better if there were more resources readily available. Would be valuable if it was cheaper to take children out to demonstrate things so that they could learn from experience. They use school grounds a lot to demonstrate things such as habitat, but having access to more specialised equipment to demonstrate sound for instance, would be very useful but currently too expensive*
- *training implications, teachers coming out of college haven't got the skills, knowledge gaps, its about providing better training to teachers, too much emphases on literacy and numeracy when we should be moving towards a more integrated approach to teaching*

Focus groups

Focus group teachers felt that making science relevant to children's lives was most effective when they were being taught 'in context' such as outside, or when they were on trips and visits. They also talked about the difficulty children had relating the science they learned in school to their everyday lives. One teacher told the story of her own son coming home from school and rushing to the cutlery drawer in the kitchen, taking out a fork, banging it on the side of the table and holding it upright on the table to demonstrate the sound of the tuning fork they had seen in school that day. He was distraught when it 'did not work'. His mother opined that it was the first time he had come home with any desire to tell her about anything that had happened in school. She also commented on the difficulty she had in trying to explain… The following extracts develop some of these points:

> ***Key Stage 1 Female 1*** *(group 6) …With the younger ones you are all the time trying to put science in a real life context …ideally in an ideal world with*

science put in a real life context you want to take the children out of school and put them in a real life context like taking them to a water treatment factory, things like that ... and that costs an awful lot of money. It costs a fortune to organise those kinds of trips but that is not covered in budgets.

Deputy Head Female 1*: They [the children] are not going to automatically make the connection [between classroom science and the real world].*

Key Stage 2 Female 1 *(group 6): When we used to do any writing up of experiments I used to always put a bit at the end about the relevance to everyday life to try and get them in the habit of thinking.*

Key Stage 2 Female 1 *(group 5): In life, you look up a book or you ask someone or you look up on the Internet and I think - do children of 10 need to know about anthers and stamens and filaments? It is not relevant to them.*

Key Stage 2 Female 2*: No, it is more important that they go out into the countryside and realise the names of some of the flowers, which they don't know. Mine don't know the name of a primrose. It's sad, isn't it?*

Cross Sector Perspectives

Discussions about improving children's scientific literacy took place during one of the major workshops at the stakeholder conference. The objective of this workshop was to assess the potential factors which could improve children's scientific literacy and the feasibility of such improvements. There were two groups each of schoolteachers, HEI teachers and researchers and CPD providers and one group of policy makers (see Appendix 5 for details of this workshop).

Table 8.2 below lists the overall results for each sector. This gives an overview of the decisions made by the different sectors, but it does not take account of the discussions nor of the diversity of opinion which was an inevitable part of such an exercise.

Table 8.2 Factors which may improve children's scientific literacy

	Potential	Feasibility
Encourage pupils to question/investigate	Teachers (1) CPD (1) Policy makers (1) HEIs (1)	Teachers (1) CPD (1) Policy makers (1) HEIs (1)
Make science more applied to real life	Teachers (2) CPD (2) Policy makers (2) HEI (2)	Teachers (2) CPD (2) Policy makers (2) HEIs (2)
More work with secondary schools	Policy makers (3)	Policy makers (3)
More training for teachers	CPD (3)	Teachers (3)
More time for science	Teachers (3) HEI (3)	
Reduction of content in science curriculum		CPD (3)
Incorporation of ICT		Teachers (3)
More flexibility for teachers		HEIs (3)
Better textbooks		
More field trips		
More funding/resources		
More links with HEIs		
Smaller class sizes		
Dedicated science room		
Improved classrooms		
More experts visiting schools		
More industry links		
More teaching assistants		
Same weighting as English/maths		
Specialised science teachers		

At a glance two main areas (encourage pupils to question/investigate and make science more applied to real life) stand out as the main factors which have potential for improving children's scientific literacy. Both can feasibly be implemented. It is interesting to note that they both relate directly to the pupil experience. All groups had indicated these issues as crucial to the improving of science in the primary group. The third and fourth factors could both be considered as means towards enhancing the pupils' experience.

The differences between the sectors are noteworthy. The 'policy makers' group, which largely consisted of inspectors, highlighted the importance of primary schools working together with secondary schools. The inspectors would have had the most experience of observing science being taught at these levels. Unsurprisingly, the CPD providers selected more training for teachers as one of the most important factors leading to the improvement of children's scientific literacy and the teachers thought this was highly feasible. Both teachers and HEIs indicated that more time for science was very important – this could be due to the fact that both of these groups could be considered 'at the chalk face' and perhaps felt that much of their time for 'deep' teaching had become eroded. In regard to additional feasible improvements, the CPD providers chose reduction of content in science curriculum, teachers included the incorporation of ICT, and the HEIs suggested more flexibility for teachers.

Comparisons between stakeholder groups

Table 8.3 shows the ranks given to different developments as ways to improve children's scientific literacy by survey teachers and the various workshop groups.

Table 8.3 Ways to improve children's scientific literacy

IMPROVEMENT	RANK				
	Teacher survey	Teacher workgroups	CPD	Policy makers	HEI
Make science more applied to real life	1	2	2	2	2
More training for teachers	2	3	3		
More funding / resources	3				
More teaching assistants	4				
More time for science	5	3			3
Incorporate ICT	7	3			
Less content in science curriculum	7		3		
More work with secondary schools	11			3	
Encourage children to question / investigate	11	1	1	1	1
More flexibility for teachers	14				3

Teachers in the survey mentioned making science more applied to real life most frequently in response to the question about ways that primary science may be improved so that children are best supported to develop the sorts of skills that will help them to become active and informed citizens. There was remarkable consistency between the different sector groups in placing this second in terms of both its feasibility and its potential for providing such improvement.

The differences between survey teachers and those attending the conference were interesting. There was a strong difference in the ranking of 'encourage children to question / investigate. Survey teachers mentioned this although it was 11th in rank, whereas those at the conference selected this as the most likely to lead to improvement in terms of potential and feasibility. The latter groups could have been strongly influenced by the discussions the previous day during the mixed sector workshops (see section 7.2) and by the content of the keynote talks (see appendix 5).

Of the other factors prioritised as important for improving scientific literacy, survey teachers indicated more funding and resources and more teaching assistants. These teachers' responses appeared to relate very much to the practical 'here and now' ways to improve primary science. The teachers who attended the conference had more opportunity to reflect on science teaching, and their other main priorities were more time for science and more incorporation of ICT into science teaching. Both of these factors were also ranked fairly highly by the survey teachers.

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Appendix 1 Telephone questionnaire instrument

QUEEN'S UNIVERSITY, BELFAST
ST MARY'S UNIVERSITY COLLEGE, BELFAST

Science Questionnaire for Primary Teachers

Thank you for agreeing to take part in this UK-wide survey and we hope that it will be an interesting experience for you.

The aim of the work is to explore issues for primary teachers in their teaching of **science**. We are seeking to identify the main strengths and weaknesses and ways in which we can improve the experience of primary science for both teachers and children.

There are **ten** questions. Most have sub-sections and require mostly one-word answers. Two questions will give you the opportunity to give your views on the major issues for primary teachers in science and how the experience of primary science can be improved for teachers and children.

All your responses will be treated in the strictest confidence and all responses are entirely anonymous.

Science Questionnaire for Primary Teachers

1. Background Information – the teacher

1. **Your Gender:**

Male ☐ Female ☐

2. **Your age range:**

20s ☐ 30s ☐ 40s ☐ 50s ☐ 60s ☐

3. **About how many years have you been teaching?**

<5 ☐ 5-10 ☐ 11-20 ☐ >20 ☐

4. Which age group do you mostly teach?

4-6 ☐ 7-9 ☐ 10-11 ☐ It varies ☐

5. What is your highest qualification level in <u>science</u>?

GCSE ☐ (SCE standard) **A'level** ☐ (SCE higher) **Degree** ☐ **Other** Please specify:

6. Which of the following describes your position in school?

Head ☐ **VP** ☐ **(or deputy head)** **Science Coordinator** ☐ **Other** Please specify:

7. As a teacher, have you carried out any professional development or research / project work in <u>science education</u>?

Yes ☐ **No** ☐

If yes, please give details:

2. Background Information – school factors

1. Do you perceive your school as urban or rural?

Urban   Suburban   Rural

2. Approximately how many children are in your school?

< 50   50-200   200-500   500-750   750+

3. Do you have a classroom assistant when you are teaching science?

Most of the time   Some of the time   Never

4. **Would you say your resources for teaching practical science are:**

Good   OK   Poor

5. About how much time do you have for teaching science per week?

_ h /less   _-1h   1-2 h   >2h

6. Which subject(s), if any, do you feel your school rate as more important than science?

7. Which types of formative assessment in science would be commonly carried out in your school, if any?

- **using checklists to record observations of children**

  Yes   No

- **evaluating children's pictures, graphs etc which show their scientific reasoning**

  Yes   No

- **providing feedback with advice for improvement**

  Yes   No

8. What, if any, other types of assessment are used?

9. Do you know of any extra funding which your school has obtained for science?

Details:

3. What do you think are the main issues facing primary teachers in their science teaching?

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4. Teaching Across the Curriculum

How would you rate your confidence from 1-5 in teaching each of the following subjects from **1 = very low to 5 = very high**?

	Number (1-5)		**Number (1-5)**
English	☐	History	☐
Mathematics	☐	Geography	☐
Science	☐	ICT	☐

5. Developing children's science skills

How would you rate your confidence (1-5) in developing the following, from **1 = very low to 5 = very high?**

	Number (1-5 or n/a))		**Number (1-5 or n/a)**
Their recording of data	☐	Their observation skills	☐
Their ability to recognise, design, and carry out a fair test	☐	Their ability to interpret findings	☐
Their ability to address how science might affect their lives?	☐		

6. Your own science teaching skills

How would you rate your confidence (1-5) in the following, from **1 = very low to 5 = very high**?

	Number (1-5)		**Number (1-5)**
Deciding the science skills to be developed in an activity	☐	Explaining scientific ideas to children	☐
Using ICT for preparing science lessons	☐	Using ICT with children for science teaching and learning	☐
Organising & delivering practical work	☐	Assessing practical work	☐
Using questioning as a tool in science teaching	☐	Ensuring that *all* the children are engaged in science learning	☐

7. Developing children's science knowledge

How would you rate your confidence (1-5) in developing children's understanding of the following areas from **1 = very low to 5 = very high (please state if you <u>do not teach</u> the topic)**?

	Number (1-5)	**n / a**
LIVING THINGS		
1. Basic life processes, e.g. circulation, respiration, digestion	☐	☐
2. Life cycle of a flowering plant (pollen, stamen, stigma, fertilisation, seed dispersal)	☐	☐
MATERIALS		
3. Distinctive properties of solids, liquids and gases	☐	☐
4. The water cycle	☐	☐
5. Permanent / temporary change	☐	☐
ENERGY AND FORCES		
6. Friction	☐	☐
7. Renewable & non-renewable energy sources	☐	☐

8. Investigating series and parallel circuits ☐ ☐
9. Insulators and conductors ☐ ☐
10. How sounds are produced ☐ ☐
11. How sound travels through a variety of materials ☐ ☐
12. The reflection of light from mirrors and other shiny surfaces ☐ ☐
13. How we see things ☐ ☐

8. Different approaches to science teaching

Please score the following 1-3 depending on how often you use them in your science teaching, where **1 = never, 2 = occasionally & 3 = often**

	1 – 3		1 -3
Role play		**Drama**	
Teaching science from stories		Developing thinking skills in science	
Encouraging pupils to try out their own ideas in investigations		Using history to teach science (eg transport, the work of scientists)	
Teacher demonstration		Group work	
Relating science to real life		Taking pupils on field trips and/or visits to industry	
Discussion		Integrating science with other curricular areas	

9. Your attitudes to primary science teaching

How would you rate your agreement (1-5) with the following statements, from 1 = strongly disagree to 5 = strongly agree?

	1 - 5		1 - 5
1. Children love learning science		2. There are not enough good books for teaching science	
3. My class is too large to do science practicals		4. Girls are less interested than boys in science	
5. I am enthusiastic about teaching science		6. I like to watch TV programmes about science	
7. I am anxious to improve my science teaching		8. I enjoy children's questions about science even when I don't know the answer	
9. I'm often impressed by my pupils' science ability		10. My classroom is unsuitable for science teaching	
11. I try hard to get girls more involved in science		12. The science curriculum is too difficult	
13. There is not enough good software for science teaching		14. Standardised science tests are a bad idea in primary schools	
15. I don't have enough time for science practical work in class		16. I'd love more help with science teaching	

10. Current challenges and future opportunities

How can primary science be improved so that children are best supported to develop the sorts of skills that will help them to become active and informed citizens?

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Thank you very much for taking part in this important research

Appendix 2 Characteristics of teacher sample

Gender, Age, Position in School and Classes Taught

The total number of teachers in the sample was 300 (100 from England; 50 each of Scotland, Wales and Northern Ireland. One third of the teachers were men (male 33.3%; female 66.7%). This disproportionately high percentage of male teacher

s (the UK average is less than 15% in primary schools) could be explained by the fact that almost half of the sample (49%) was made up of school heads and a further 15% were vice-principals. The seniority of the sample is also reflected in the age profile. The age groups represented in the sample were as follows:

20s	8.7%
30s	21.7%
40s	30.7%
50s	37%
60s	1.3%

More than half of the teachers (53%) had been teaching for more than twenty years, whilst relatively few (7%) had been teaching for less than five years. Approximately one third (31.3%) of the total sample indicated that they acted as the school *science coordinator*.

The proportions teaching younger (4-6 and 7-9 year old) and older groups (10-11 year old) were similar, at 34% and 31% respectively; the rest responded that they taught various classes.

Location and school size

In relation to the location of the school, 27% respondent perceived they were from urban areas, 25% suburban and almost half (47.3%) from rural areas. Only 10% of the schools had fewer than 50 pupils, and about half (52%) had between 50 and 200 pupils. More than a third (36%) of the schools were quite large, having between 200 and 500 children, whist only a small proportion (3%) had more than 500 pupils.

Resources, time and relative importance of science teaching

Most teachers responded that their resources for teaching practical science were good (44%) or OK (47%). There was a sizeable minority, however, who described their resources as poor (9%). Nearly a third of teachers (30%) had a classroom assistant with them most of the time when they were teaching science, 34% had a classroom assistant in some of the time when teaching science, and 36% never had a classroom assistant during science lessons.

In relation to the time spent teaching science, 9% spent between half an hour and one hour per week. Most spent between one and two hours per week on science (59%), whilst 27% teachers said they taught science for more than two hours per week.

When asked whether they felt that their school rated specific subjects as more important than science, 79% responded English and 74% mathematics. It was interesting to note, however, that 13% teachers responded that they did not perceive their school rated any subjects as more important than science.

Professional development, research and project work in primary science

About half of the sample (51%) indicated that they had carried out professional development, research and/or project work in primary science. This work ranged from short in-service courses, conferences, school development work in science, primary-secondary transition projects in science, a one-year advanced certificate course in primary science, open university course in primary science, work for consortium based research for two years investigating different primary schools methods of teaching, cluster work to organise science teaching in schools, research into the opportunity that children are given to ask questions, part of a professional network that researched how children can be taught measuring in science in a better way part of AstraZeneca (Science Teaching Trust) primary science projects, project work on the art of science, environmental issues and linking science and ICT and action research projects.

Appendix 3 E-mail questionnaire instrument

SCIENCE IN PRIMARY SCHOOLS – HEI Survey

Background Information:

1. Name of your organisation: (*type here*)
2. Name of your department: *(type here)*

Details of Primary Science Initiatives:

We are interested in learning about your/your department's experience of carrying out small- and large-scale initiatives in primary schools over the last 5 years. If you have completed several initiatives in this time, please feel free either to complete a set of questions for each initiative or to complete the questions for one initiative only and then provide a brief description of any others at the end of the questionnaire (question 11).

1. Name of project: *(type here)*
2. Brief description of project: *(type here)*
3. Contact name for project: *(type here)*
4. Reference to any associated publication(s) of the project: *(type here)*
5. How was your project funded? *(type here)*
6. Please give brief details of your project, for example:
   - What was the rationale for carrying out this piece of work? *(type here)*
   - What was the geographical scope for the project? Local / Regional / UK-wide (*Please delete as appropriate)*
   - How many schools did you work with? *(type here)*
   - Was the project aimed primarily at supporting teachers, children or both? *(type here)*
7. What were the outcomes of the project (e.g. new models for classroom practice in primary science, cross-curricular work, creative contexts for science teaching etc)? *(type here)*
8. a) What do you feel has been the impact of your work in participating schools (e.g. increased interest in science/skills development by students, improved confidence of teachers etc.)? *(type here)*

   b) Have you any evidence to support this? *(type here)*
9. Please also describe any challenges faced during the project *(type here)*
10. Would you describe the impact of the project as: *(Delete all but one)*
    - Short-term
    - Medium-term
    - Long-term

    Please provide details for why you have selected this option
11. Please add any other details about this or other projects you have undertaken in primary schools which you feel may help to inform our research. (*type here)*

Thank you for taking part in this survey: your response is much appreciated.

Appendix 4 Focus group discussion summaries

There were seven focus groups. The overall composition was as follows:

- 34% foundation/KS1 teachers
- 58% KS2 teachers
- 8% heads/deputy heads
- 88% female; 12% male teachers

Group 1

This focus group dealt with a wide range of topics, including resources (their range, funding and organisation), levels of teacher confidence, the effects of the transfer test on classroom teaching, the growing role of the private tutor, ideas for practical science and recording of practicals, the teaching of SEN pupils, the role of gender in science teaching, the range of ICT resources, thinking skills, and the value of trips to museums and educational centres.

The discussion differed from the others in that at the end there was a discreet time when the group was asked to specify general recommendations about the teaching of science.

The group identified the following key issues:

- the level of funding for science is inadequate, especially compared to other subjects
- the resources available to buy are now very good, but there is simply not enough
- money to buy enough equipment/texts for the schools
- the transfer test has reduced the amount of practical work done beforehand. This in turn has reduced the pupils' enthusiasm for the subject
- recording of science practical work seems to be a problem, since it often is done through written work which the pupils do not enjoy as much
- for some teachers there are problems teaching SEN pupils, although for others it is a positive experience
- the role of gender is seen differently by some teachers: some perceive girls as being more passive and needing more encouragement in the practical work
- the resources for ICT are a problem
- the group seemed very positive about the value of external visiting speakers to the schools, and of trips to museums etc
- the teachers seemed to agree that thinking skills are naturally developed through effective science teaching

The group made a number of main recommendations:

- more practical work in science
- less interference by private tutors
- photos and/or scrapbooks to record practical work
- better ICT resources at an appropriate level
- more time out to plan/train for science
- better advice form ELB advisors
- more ideas for trips/visiting speakers

Group 2

Unlike the other groups the discussion seemed very defensive and not very forthcoming on many issues. This could have been due to because of the presence of more than one teacher from one single school, including that school principal.

The focus group dealt with the following topics: resources (their funding, storage, and accessibility), the transfer from KS2 to KS3, the balance between practical and theoretical work, assessment (both in terms of SATs and classroom formative/ summative assessment, the curriculum, the differences between KS1 and KS2, teacher confidence, teaching methods, thinking skills, the relevance of science, the teaching of SEN pupils, gender differences and additional suggestions for improving science teaching.

From the discussion a number of issues and suggestions were raised:

- the teachers were stoically making do with limited resources
- they did not seem to be making maximum use of advisory support, either through distance or lack of awareness of their resources.
- unlike many of the other focus groups the transfer from KS2 to KS3 seemed very well organised and supported by materials produced by the secondary schools: bridging units can work
- the teachers did not seem to have a problem with the balance between practical and written work, unlike most other groups
- in terms of assessment the group admitted that there is more written recording and assessment in KS2, but seem very defensive about the content required for the SATs
- there appeared to be no problems in the transition from KS1 to KS2
- teachers admitted that they were more confident on certain topics than others, but the principal made the point that having specialists undermines the existing good work that classroom teachers are doing. Such teachers must realise that they are not expected to know everything
- there was little interest in the teaching of science through history
- the teachers used a variety of teaching methods, including effective group work, and stories and had little problem teaching the concept of a fair test. They did, however, acknowledge that differentiation required more effort and training/resources.
- the group was aware of the thinking skills which could be developed through science, although they admitted that the term itself is just a buzz word of the moment
- the group used a variety of methods to try to help those children with special needs, especially those learning English as another language
- there was no marked difference in attitude towards science or in results in assessment observed between boys and girls.
- individuals suggested an after school science club and science trips, but realised that resources and funding would be a problem

Group 3

The discussion centred on the topics of resources (their funding, organisation and storage), the place of science within the Scottish curriculum, the role of assessment and its differing forms, the transition from primary to secondary school, the importance of thinking skills, the value of specialist PIP training, inclusion (and in particular teaching of SEN pupils and the role of gender) and teaching methodologies.

The group differed from many of the other focus groups in several ways:

- support for the curriculum, which, the teachers claimed, allowed enough flexibility so as not to be constricting.
- the training received through the PIP scheme which is particular to Scotland but which appears to have been a major success in motivating these teachers to be more innovative in their classroom teaching and assessment.
- their views on the role of gender: it seems that the boys are more confident in approaching practical work than the girls, who need more encouragement to remain on task.
- the level of resources which appeared generally to the teachers' satisfaction.
- there appeared to be little problem in the transition from KS2 to KS3, unlike in the other groups where there were frequent reports of inconsistencies between schools.

The group made a number of suggestions for how science teaching could be improved but more often expressed their support of existing features in their experience. Among these were the following:

- support for the sponsorship of science resources in schools through either the AstraZeneca project or Tesco vouchers
- support for the flexibility inherent in the Scottish curriculum
- support for the expansion of alternative formative forms of assessment which are less pen-and-paper focused and which create greater enjoyment for both teachers and pupils.
- support for standardised units of science to ease the transfer from primary to secondary school
- support for using science to enhance thinking skills
- support for making science relevant to the children's own everyday experiences
- continued inclusion of SEN pupils for whom science can be a very enjoyable subject, especially when it is made practical and hands-on.
- the suggestion that girls should be encouraged to participate as fully as boys in practical science classes.

Group 4

The discussion was varied and dealt with a very wide range of topics relating to the teaching of science in primary schools. In particular the topics discussed were resources (their storage, funding), the curriculum and forthcoming changes, the balance between practical and written work, levels of teacher confidence, the progression from KS1 to KS2, teaching methodologies for science, the effect of the transfer test, the skills promoted through effective science teaching, (formative) assessment, and the progression in science from KS2 to KS3.

In the discussion the following key issues emerged:

- lack of equality in resourcing across schools
- fear of less science in the future in primary schools
- teachers recognised the value of practical work which pupils enjoy greatly, but which can be squeezed out for various reasons: lack of teacher confidence, too much content in KS2 science compared to KS1, lack of time and resources
- awareness of the failings of the transfer tests but also of the importance they have given to the teaching of science
- the group were not particularly in favour of formative assessment methods

The following main suggestions were made to improve practice:

- equal amounts of equipment across schools
- a greater awareness of the range of (thinking) skills which are available through science, but which are often not fully exploited.
- promote greater pupil involvement in science
- help pupils apply their knowledge in other contexts
- create a maximum of opportunities for practical science
- help develop skills rather than simply filling with facts
- the group was aware that there remains work to be done in easing the transfer from primary to secondary science in terms of reducing repetition and teaching in-depth knowledge/concepts which had only been superficially taught for the transfer tests.

Group 5

The group seemed more positive than many others about the amount of science resources in their schools, although realised that the storage and organisation of the resources was often far from ideal.

The group realised that the children enjoy the practical aspects of science but often found it harder to record their results in a written form. There was a useful discussion of other options for recording data, for instance through wall displays of photographs. The group also seemed opposed to the amount of factual detail which needed to be learnt which often worked against the amount of practical work and also against the pupils' enjoyment of science.

The teachers realised that there is a problem to be addressed in terms of the progression from KS2 to KS3, where pupils are now being taught more science in primary schools and often have to repeat topics in secondary school.

The group seem generally opposed to the pressure from SATs and the resulting imbalance of practical and theoretical work, and yet they did acknowledge that SATs have raised the profile of science and helped to standardise the content taught in schools. They seemed to be well served by the nearby university in terms of having access to real science and real scientists. The teachers valued the involvement of external organisations and trips to exhibitions.

The teachers also valued science as a subject for SEN pupils, who seemed to have considerable success in practical work, despite their other difficulties.

There was no consensus with regard to gender, with most teachers seeming to perceive no major differences between boys and girls' attitudes.

History is taught as a discrete subject and not linked to science teaching.

Group 6

The discussion centred on a number of major topics from which it appeared that the participants shared a desire to deliver science programmes that were: well-resourced and supported, skilfully delivered enabling maximum pupil participation, relevant to the needs of the children in their lives beyond school, part of a unified progression extending from primary to secondary school, and part of a curriculum and assessment system which allows enough flexibility to teach the children skills rather than simply transmitting factual information.

There appeared to be a lack of confidence on the part of the participants in their own scientific knowledge and an acknowledgment of the need for clear and supportive teaching materials to facilitate the delivery of the curriculum. The group were however very positive about the potential of science within the curriculum, although acknowledging that often it is the pupils' enjoyment which seems to suffer by imposing too much written work and assessment on the practical work. The group make a number of recommendations:

- there should be a renewed emphasis on practical science
- their science teaching should be more closely related to the real world, perhaps through involvement in external groups/organisations/companies.
- more supportive resources for teaching science
- more teaching of skills rather than content alone
- greater continuity and a more logical progression from primary to secondary science

Group 7

This group discussed several issues. In regard to resources for science, they commented on how these varied between £100 and £1000. Consumables were an issue especially those concerned with electricity.

The group considered science was not a priority; rather it is in the shadow of literacy, numeracy and ICT. One said a 'science hour' would be needed to bring it back to high status but there was disagreement among the group as to the success of a 'science hour'.

They generally agreed that history as it appears in national curriculum isn't a good vehicle for teaching science, though it makes a good background for some aspects of science. Maths skills tended not to be transferred.

They thought that ICT doesn't have enough examples of software to develop science skills. There was little evidence of teachers using the Net for research. The group thought that science and ICT would have registered as the areas the teachers in the telephone survey would have been least confident with in conjunction with Maths. Generally this group expressed confidence in all areas of science teaching. Observation could mean many different things to different teachers. Fair testing (or unfair testing) was recognised readily in Key Stage 1. There was not much evidence of science being related to children's own lives either by children or teachers.

They discussed that boys and girls participated equally – there was no marked gender bias in roles taken or interest shown. The least 'academically' able were willing to make suggestions and share ideas more so than children who would be labelled as 'able' as they are afraid of 'getting it wrong'. There was no indication of children considering jobs in science as careers, or relating it to real life situations except when the learning environment is real, as in a visit.

Appendix 5 Conference report

Primary science in the UK: current challenges and future opportunities

The project team held a conference in St Mary's University College and Queen's University Belfast on 23rd and 24th September 2004. This report details the activities and presents the findings from the workshop and plenary sessions.

Background

The conference was the third strand of the project and had the following aims:

1. To provide a clear, evidence-based analysis of current issues facing primary science in the UK with particular reference to the specific areas outlined in the tender documentation
2. To explore primary teachers' attitudes to science and ways in which they support primary students to develop scientific literacy
3. To evaluate the impact of the types of science initiatives already taking place in UK primary schools
4. To identify a niche within which the Wellcome Trust cold usefully take forward its work in this area

The conference had four inter-connected functions. Firstly, it was a forum for dissemination of interim findings of the project, based on data obtained from the telephone survey and from the focus group interviews which had been conducted in England, Northern Ireland, Scotland and Wales. Secondly, it provided an opportunity to contextualise these findings, and the project in general, within the current state of the wider debate surrounding primary science teaching in the UK. Thirdly, it was an integral part of the methodology of the project and, as such, aimed to collect views from the various groups of participants represented. Finally the conference presented an opportunity for the various groups of delegates to learn from each other's experience.

The delegates represented the four jurisdictions within the UK and represented different interest groups who were either involved directly or indirectly with the primary science teaching community: teachers, policy makers, teacher educators, researchers, CPD providers, local authority groups, special interest groups and inspectors.

The conference was organised in such a way as to provide opportunities for input, discussion and both formal and informal exchanges of ideas (see conference programme overleaf).

UK Primary Science: current challenges and future opportunities

St Mary's University College / Queen's University Belfast
23rd/24th September 2004

Programme – Day 1

Thursday 23rd September
Arrival and registration
Lunch
Welcome: The Very Reverend Professor Martin O'Callaghan
Keynote: Bob Ponchaud
Overview of findings from a UK-wide survey of primary teachers (Colette Murphy)
Coffee
Plenary
Close of session
Reception at Queen's University
Dinner at the Wellington Park Hotel

Programme – Day 2

Friday 24th September			
Keynote: Hugh Lawlor			
Coffee			
Report and discussion of day 1, chaired by Colette Murphy and Jim Beggs			
12	128/	131/	135/136
Po Wo	CPD Worl	Teac Worl	HEI / rese Workshop
Lunch			
Report of day 2 discussions; plenary and evaluation			
Close of Conference			

Keynote address – Bob Ponchaud

The first keynote address set the scene for the conference. Starting with an anecdote about his own primary science experience, Bob Ponchaud asked the question: *Are we still lighting fires for children in the teaching of science*? The speaker presented science as an important and indeed successful part of the primary curriculum across the UK, whether as a discrete subject, as is the case in England and Wales or taught in a more integrated way as in Northern Ireland and Scotland. There is a general recognition that much of the success in attainment in science, specifically at Level 4 is due to an increase in teachers' subject knowledge, as evidenced by the ability of those emerging from ITE courses to teach science effectively. It was suggested that literacy and numeracy are being addressed through science. Despite these gains, the speaker maintained that we were not giving teachers a clear view of the way forward, since *prescription and guidance from the centre are not the same as clarity of purpose*. The prescriptive nature of the National Curriculum and the imposed assessment tasks can militate against teachers' creativity and their willingness *to step outside the box*. It was recognised, however, that the assessment regime is not as prescriptive in parts of the UK (Wales and Scotland). The negative aspect of accountability can result in *what can be measured* becoming *what is valued*. Science is particularly vulnerable to this kind of interference, since it can become distorted and reduced to a body of knowledge.

A lack of creativity within science teaching can also be the result of lack of resources. Whilst it was accepted that primary teachers can be very inventive and frequently have to improvise, there are limits, and lack of resources can impact negatively on pedagogy. *We need a realistic review of what hardware and software are needed to allow primary science to move forward*.

Some teachers have commented that science is receiving less prominence in the primary curriculum, largely because of the introduction of compulsory literacy and numeracy programmes, but also because of a low priority given by school management. The question was raised: *How can we get science 'off the back burner'?* It was suggested that policy makers and senior managers in schools need to raise the profile of science at national level.

Training of co-ordinators for science is another major issue requiring attention; most science co-ordinators in post will have received little, if any, training in taking the lead in science. By establishing a training programme for science co-ordinators, the status of the subject would be raised within schools. Training should not simply focus on knowledge and understanding, important though these be; it is necessary also to raise pedagogical knowledge and understanding. Teachers need to focus on the bigger picture in order to widen the horizon of the pupils and to prepare them for further study of the subject at secondary level and beyond. The potential of the vast amount of material available needs to be harnessed and channelled for maximum effect; there could be a role in this for the National Network of Science Learning Centres and other organisations in helping teachers get best use from available resources.

In turning to the trends and future opportunities, the following were highlighted:

The need to move to assessment for learning, as opposed to the assessment of content. There should be greater use of talk in science to encourage more scientific enquiry. There should be a balance between subject and topic structure, improved provision of continuing professional developed and changes in scientific enquiry. As a vision for the future, the speaker presented his own:

- Science that lights fires as well as fills the pots
- Teachers have regained the confidence to be creative, their subject knowledge is broad and gives them access to the 'big picture'
- Classrooms are where talking science and scientific enquiry engages children
- Deep understanding in the children is fostered and real life issues are addressed
- Assessment is an integral part of learning and not a means of grading performance.

This talk raised a number of issues which stimulated discussion and which provided a springboard for the discussions which were to take place in the workshop sessions.

Workshop 1- Issues of concern in primary science

The objective of this workshop was to give delegates an opportunity to respond to statements which had been highlighted in the telephone survey (see section 7.1). Delegates were placed in seven cross-interest groups to consider the relative importance of the issues of concern in science identified by primary teachers, to place in priority order the three they considered to be of highest importance, and to identify the three they considered to be of lowest importance. A scribe in each group recorded and, later, reported on the discussion surrounding the decisions.

The results from the seven groups were collated and eight issues emerged as being highly important. The three highest placed issues from each group were scored 3>1 and the issues were placed in rank order as shown in Table 1.

ISSUE	RANK
Lack of knowledge/expertise/confidence/training of teachers	1
Not enough investigation	2
Concentrating too much on written work over practical	3
Difficult to make classes practical fun	4
Not enough time	=5
Lack of money/funding	=5
Lack of resources	=5

All groups identified 'lack of knowledge/expertise/confidence/training' of teachers as being of highest importance. No other issue was unanimously placed in this category, though some groups attached equal importance to two or more issues. 'Integrating ICT' was the only issue identified as being of neither high nor low importance. Not all groups had felt able to differentiate between their top three issues. The issues considered by delegates to be of little importance were also grouped. Those in the lowest category of importance were: classrooms too small, not enough staff, primary not geared towards science, science imposed on teachers and overloaded science curriculum.

Feedback on workshop discussions

Each group gave a short verbal report on their discussions. There were comments on the workshop task relating to the difficulty of discussing some of the issues in isolation. Most groups initially grouped the issues into two sets: more important and less important. The majority of groups then went on to discuss particular issues in more detail.

All groups talked about the lack of knowledge / expertise / confidence to teach science. One made the point that there is a difficulty when one member of staff attends science professional development, in that it is difficult to transfer the learning to the rest of the staff. All groups commented that more training is needed to improve teachers' confidence and knowledge in science. It was suggested that specialist trainers should go into schools and work with teachers. There was general agreement that teachers' perceptions of what they should teach in science did not always match what the children should learn. Many teachers provide children with too much detail which can end up being confusing. Two groups made the point that professional development training in science for teaching assistants could provide a significant improvement in the facilitation of practical science learning and teaching. The role of the regional Science Learning Centres was considered to be pivotal in addressing the training needs of primary teachers.

Some groups discussed regional differences. There were comments that science might be becoming lost in Scotland and Northern Ireland, where it is, or will be, part of a broad area of teaching (environmental studies and 'The World Around Us' respectively). There also seemed to be significant regional differences in the allocation of resources for science teaching in primary schools, although no details of this were provided. There appeared to be regional differences also in provision and training in relation to ICT.

All groups discussed resources, although there was a range of opinion as to how far lack of resources was an important issue in primary science. Some groups considered current levels of resources were adequate. Others pointed out that whilst resources *per se* might not be a major issue, there were problems with their storage and retrieval in primary schools.

ICT was a popular subject of discussion. Many groups talked about ICT in general, since it was an issue which spanned all subject areas. Others cautioned that ICT was being used in some cases to replace hands-on activities in science.

Two other issues were discussed widely. Firstly, children's engagement in science and the difficulties many teachers experienced in trying to make science 'fun', especially for the older children, due to the requirement to concentrate on the learning of a large amount of content for national tests. Secondly, the usefulness of keeping up with research; one group commented on the value of the conference in this regard and many groups talked about the recent focus on the development of children's thinking skills and the role of science to promote thinking skills.

Other issues focused upon were related to the lack of time for effective science teaching. They included: too much writing in science, the overloaded science curriculum, not enough time for investigations, not enough time to integrate science effectively with other curricular areas. One group argued that there was an urgent requirement for developers to take a holistic view of the primary curriculum so that there could be much better links between 'subjects'.

Keynote address – Hugh Lawlor

The second speaker developed a number of strands which had been raised either in the first plenary talk or had emerged in the workshop session. The title of the talk 'Science education – looking ahead' took the debate further. Hugh Lawlor focused on science education within the curriculum in general, comparing and contrasting the primary experience with findings from secondary science experience. He discussed some of the challenges facing science education, in particular concentrating on Key stages 1-4 or equivalent and he suggested some possible changes which might be made to science education to provide a reorientation of the subject.

The question was posed as to how relevant the content of science education was, particularly to contemporary science. In terms of pedagogy, there tended to be a focus on didactic teaching with a restriction to one answer. Anecdotal evidence of children's views of science as 'boring' raised the searching question: *How can science be boring*? It was suggested that it is not creative enough and that that what is taught can be too difficult. The problem of low up-take of science at Key Stage 4 was raised. The topic of over-assessment was reiterated and the growing shortage of science teacher highlighted as a problem which could jeopardise science teaching, and ultimately the future of science as a discipline.

At primary school level, there appeared to be a steady increase in the results produced in SATs. What remained a problem was the time pressure on the curriculum and the science content which has remained largely unchanged. Primary-secondary transfer remained a problem as did the content within the secondary curriculum. A question was also raised about the relevance of the content, of the curriculum and also of the appropriateness of the science taught for the full-ability range of pupils in secondary schools.

The speaker called for a focus on scientific literacy, with science explanations and ideas about science. At KS1 and 2 it was recommended that there should be few radical changes but more of a focus on ethical issues. There is also little evidence of integrating science with other subjects [in England]. At KS 3 the introduction of 21st Century science should result in the teaching of more contemporary themes, such as genetics and forensics, more focus on scientific literacy and greater attention to the range of learning styles in children. At KS4 core science would equate to scientific literacy. A science programme might consist of a core plus a range of pathways which may be the traditional subjects or double are, or contemporary science which could be extensions of the 21st century science project or applied/vocational projects such as vocational GCSEs, GNVQ or applied science double award.

In addition to these curricular changes, the speaker proposed some more general changes:

- More presentations to large groups and small group/individual follow up (to account for lack of science teachers available in schools);
- New laboratory designs for vocational programmes;
- Greater use of ICT and e-learning;
- Greater need for CPD to deliver the changes – HEIs and new Regional Learning Centres in England and the National Centre from 2005;
- Continuing pressure to reduce assessment demands in science.

Workshop 2 – improving children's scientific literacy

The objective of this workshop was to assess the potential factors which could improve children's scientific literacy and the feasibility of such improvements. In contrast to the first workshop, groups were organised according to the specialism of the delegates. There were two groups each of school teachers, HEI teachers and researchers and CPD providers and one group of policy makers.

Participants were asked to rank order of improvements identified by teachers in the telephone survey (see section 8.1)

Some groups were surprised to find that teachers had not listed *assessment* as one of these factors. One explanation for the absence of assessment as a significant factor may be that assessment practices are not standardised across the four jurisdictions. In Wales, for example, SAT tests are being abolished and in Scotland within the 5-14 guidelines, national assessment is not mandatory at primary age.

Groups were required to establish the areas which, from their own professional perspective, would have the potential to improve children's scientific literacy and then to establish the three top areas. Following this, they were then to focus on the same aspects but this time from the point of view of feasibility.

Table 2 below lists the overall results for each sector. This gives an overview of the decisions made by the different sectors, but it does not take account of the discussions nor of the diversity of opinion which was an inevitable part of such an exercise.

Table 2 Factors which may improve children's scientific literacy

	Potential	Feasibility
encourage pupils to question/investigate	Teachers (1) CPD (1) Policy makers (1) HEIs (1)	Teachers (1) CPD (1) Policy makers (1) HEIs (1)
make science more applied to real life	Teachers (2) CPD (2) Policy makers (2) HEI (2)	Teachers (2) CPD (2) Policy makers (2) HEIs (2)
more work with secondary schools	Policy makers (3)	Policy makers (3)
more training for teachers	CPD (3)	Teachers (3)
more time for science	Teachers (3) HEI (3)	
reduction of content in science curriculum		CPD (3)
incorporation of ICT		Teachers (3)
more flexibility for teachers		HEIs (3)
better textbooks		
more field trips		
more funding/resources		
more links with HEIs		
smaller class sizes		
dedicated science room		
improved classrooms		
more experts visiting schools		
more industry links		
more teaching assistants		
same weighting as English/maths		
specialised science teachers		

At a glance two main areas (encourage pupils to question/investigate and make science more applied to real life) stand out as the main factors which have potential for improving children's scientific literacy. These can feasibly be implemented. It is interesting to note that they both relate directly to the pupil experience. All groups had indicated these issues as crucial to the improving of science in the primary group.

The third and fourth factors could both be considered as means towards enhancing the pupils' experience.

The differences between the sectors are noteworthy. The 'policy makers' group, which consisted of a large proportion of inspectors, highlighted the importance of primary schools working together with secondary schools. They would have had most experiences of observing science being taught at these levels. The CPD providers selected more training for teachers as one of the most important factors leading to the improvement of children's scientific literacy and the teachers thought this was highly feasible. Both teachers and HEIs indicated that more time for science was very important. In regard to additional feasible improvements, the CPD providers chose reduction of content in science curriculum, teachers included the incorporation of ICT, and the HEIs suggested more flexibility for teachers.

Feedback on workshop discussions

In the feedback session on the second workshop, some general points were raised in addition to the discussion of the feasibility and priority areas. One group raised the differences between the jurisdictions; it was felt that in Wales there was much more flexibility due to the lack of prescription which resulted in teachers taking more risks with the topics. In England, it was felt that the priority area for science had moved to post-14, and that government took the view that science in primary is now satisfactory but secondary is in disarray. In Scotland there was a major focus on science but it was felt that this was restricted to some local authority areas or situated within specific projects. Another difference which seemed to affect England more than the other areas was the use of teaching assistants in schools. The pros and cons involving teaching assistants in science teaching were debated.

There was discussion on assessment. Whilst assessment had not been highlighted by the teachers in the telephone survey as a way to improve primary science, there was strong feelings in some groups that assessment practices were crucial. It was pointed out by more than one group that the assessment dictates pedagogy and that in some parts of the UK, assessment militates against innovation within science teaching. It was recognised, however, that it is up to teachers to strike a balance between their own pedagogy and ensuring that what and how they teach matches the assessment requirements.

There was also some discussion about content and the balance of topics of science and the need to contextualise this within the curriculum. It was agreed that how the subject was taught was in many ways more important that the content. This led to a discussion on the training for teachers; it was considered unrealistic to train all primary teachers as science teachers because of its specialist nature. Some groups pointed to the need for science to be integrated with other subjects and for more links between science and other subjects to be identified.

Some groups stated that science is no longer treated as a priority within schools and that it has been superseded by other initiatives such as literacy, numeracy and ICT. It was suggested that there should be a Science strategy, although this suggestion did not receive unanimous approval.

It was concluded that great strides had been made in science teaching in primary schools but that much remains to be done.

Conference evaluation

An important element in the conference was obtaining feedback from the teachers on the value of the content of the conference but also in giving the research team some indication of the participants' views on the direction the research should be taking both in the shorter and in the longer term. Evaluation forms were completed by 58 delegates; they were asked to respond to the following key questions:

- In what way(s) was the conference useful to you?
- Where do we go from here?

Delegates were free to make as few or as many observations as they wished. The responses were collated, analysed and grouped where common issues, ideas and suggestions were identified. The numbers of responses received are shown in brackets.

Responses to: '*In what way(s) was the conference useful to you*?'

The highest number of responses (87) related to the opportunity which the conference had provided to meet people and share ideas. These were divided as follows

- The opportunity to see the UK wide perspective across all regions, differences and some common issues (29)
- Hearing views across different sectors – teachers, trainers and policy makers (22)
- Meeting people (13), sharing ideas (12), networking (6) and the opportunity to talk to teachers (5), were the remainder of responses in this group.

Personal perspectives and impressions

Though varied, these responses provide the greatest evidence of how participation in the conference and focus groups had affected delegates personally as well as professionally. Individual comments indicated that delegates felt challenged and informed (2). The conference was described as being stimulating, influential and inspiring; a 'very special opportunity'. Four responses identified the conference as an opportunity for teachers to be welcomed, heard and to have their opinions valued. Delegates commented that it had provided the opportunity to reflect on the support which primary teachers need, whilst challenging personal ideas (2) confirming their own perceptions (5) and hearing affirmation through the consensus of opinion between delegates, keynote speakers and project findings to date (2).

Future developments

Responses in this section were both general and specific; there was no overarching consensus. Six responses indicated that the conference had provided a focus on feasible ways forward, highlighting areas for development, key issues to be addressed and where improvements could be made. Two delegates observed that the conference had shown how change might come in a variety of ways and one that there was the opportunity to think about the development of primary science in a wider context. Individual colleagues identified

- Informing colleagues (BBC Learning)
- Supporting the direction in which ASE is moving
- Intention to feed back questions in own area to instigate discussions.

Current issues

Seven responses indicated that the conference had provided a good, overall picture of primary science education and teaching and the opportunity to keep up with current issues and research. Delegates appreciated the discussion of relevant issues and practice. One delegate commented favourably 'getting up-to-date information from the survey'.

Research

A total of seven responses specifically included mention of this and other research. These were:

- Exchanging ideas about research interests (2)
- Hearing the results of the telephone questionnaire and focus groups (2)
- Being involved in (*this)* research (2)
- Reflection on research methods (1)

Others' perspectives

Opportunities to hear and challenge the perspectives of others were identified in the following six responses:

- Opportunity to meet and discuss primary science with an enthusiastic and knowledgeable group
- Hearing overall perspectives from teachers to 'experts'
- Hearing policy makers' concerns
- Reflection on science from primary to post-19
- Identifying common problems
- Having the opportunity to lobby policy makers

The profile of primary science

Though only three delegates specifically referred to this, responses in this category reflected the opinion 'wonderful – raising of science profile in the UK' of one delegate. One delegate specifically identified raising the profile of primary science in Northern Ireland; one commented that it was good to see science 'receiving focus again'.

Miscellaneous comments

- Awareness of The Wellcome Trust's funding of, and interest in, primary science.
- Visiting Belfast
- Finding workshops informative
- Having some KS3 focus – also seen as a criticism by one delegate
- Keynote speakers were entertaining and stimulating
- Workshop sessions were good

Responses to '*Where do we go from here*?'

Again, the range of responses was wide. One suggestion was that we should identify what primary science is for, before trying any more new initiatives. Two delegates gave the response that any ways forward should be consistent with general principles of good practice, and not be restricted to those with particular relevance to primary science. The remaining responses, queries and suggestions have been grouped by content.

Suggestions specifically identifying The Wellcome Trust

It was recognised that funding from the Trust had resulted in a wide range of delegates, especially teachers, being able to attend, and this had resulted in a good mix of perspectives and ideas. It was suggested that representation at a similar event should be both increased and widened, for example by inclusion of non-science organisations working within science education and representation of the industry sector. Two delegates specifically mentioned regional and cross-interest conferences. Delegates were interested to know how Wellcome would use the conference to inform its work, specific suggestions were:

- Support for similar conferences (*can we have more? Where is the next one? More conferences like this.*)
- Encourage the Wellcome Trust to continue to support primary science and influence policy makers
- Establish Wellcome grants to develop approaches to address the issues identified as main priorities
- Encourage Wellcome Trust to fund research into science related to pupils' lives (similar to their post-16 work), to trial these then establish CPD systems for their dissemination.
- Establish a small consultative group, funded by the Wellcome Trust, to sketch out strategy and development. (see also below)
- Circulate a full pack of any curriculum/training materials developed as a result of this conference to all primary schools

Dissemination of Conference findings

Eleven delegates identified this in general terms. Specific suggestions were

- Dissemination to policy makers and funding providers at all levels
- Dissemination to schools
- Delegates being able to access findings
- Delegates being kept informed of future developments arising as a result of this conference.
- Establish e-mail contact groups to enable delegates to keep in touch
- Facilitate discussion
- Implement the identified changes
- Publicise 'publicly' – including to government/assemblies

'SETPOINTS' were identified as a good forum for dissemination. There was also a suggestion that the conference data should be presented in terms of the inter-relationships between factors, which had emerged in the workshop discussions: 'mapping the hierarchy' rather than representing as a prioritised list.

Research and future projects

Several delegates mentioned their appreciation of being involved in research and would welcome the opportunity for further involvement. One delegate asked how the report would locate this research within other relevant literature e.g. the work of the Assessment Reform Group.

It was suggested that

- We should find out '*what actually happens in classrooms'* rather than make assumptions based on the data collected so far.
- A small research seminar be established to interrogate the assumptions made during/ as a result of the conference

One delegate suggested that a working group be established from those attending the conference to identify first steps, which could lead to a pilot project being undertaken in the different regions. There was also a request for the opportunity to discuss ideas for specific projects e.g. using video to support children's self assessment of scientific enquiry.

Teachers, training and support

One response, 'teachers are the greatest resource' reflects the 20 delegates who specifically identified 'teachers' in their suggestions. This group of ideas includes initial teacher education, CPD and other forms of professional support. The question, 'what is the best type of training?' was asked by one delegate; five stated the need to 'boost teachers' confidence'. Specific suggestions and questions were:

- Identify the issues underlying teachers' concerns
- Disseminate good practice
- Develop strategic options and co-ordinated partnerships for training
- How can training needs be communicated?
- Develop a strategic and co-ordinated plan addressing both ITE and CPD in terms of pedagogy, confidence and relevance
- Use the expertise and enthusiasm of teacher delegates (to the conference) to develop cross-curricular investigative activities to support less confident colleagues.
- Practical training for teachers, including training in investigative science. Is there consequently an increased need for advisory teachers?
- Re-establish the role of advisers, as opposed to inspectors.
- Training and support through CPD
- Develop the Science Learning Centres to support teachers effectively and creatively
- Keep (or establish?) the development of science teaching and learning as a priority for policy makers

The nature of science to be taught/learned

The relevance of science to children's lives had emerged as an issue at various points during the conference. Specific responses were:

- Ensure science is relevant/appropriate/contemporary/enjoyed
- How to link science to real life and ethical issues?
- Develop a curriculum which will motivate and enthuse

Status of science/integration/SATs

The effect of the National Literacy Strategy and daily mathematics lesson on the status of science as a core subject in the National Curriculum for England and Wales had been raised during discussions. The need to 'assess what we value' rather than 'value what we assess' (keynote address – Bob Ponchaud) reflected the concern that the science being taught was influenced by what could be assessed. Regional differences are also reflected in the following comments:

- Do not let science become lost in an integrated curriculum
- Use the information from this research to boost the status of science; it has become low priority
- Don't allow SATs (England) and Transfer Tests (NI) to dictate teaching – this is damaging
- How can we make assessment less constraining?

Funding and influencing policy makers

Six delegates identified funding in this section of responses. A further eleven responses made specific reference to policy makers as follows:

- Publicise the findings of this research to government
- Influence change and the way forward at government level
- Inform central government and devolved assemblies about the challenges facing science
- At local levels, use findings with policy makers and school Senior Management Teams

Miscellaneous suggestions

- Partnership initiatives
- More cross-sector networking and sharing of practice

Conclusion

The conference was regarded as a success by the research team and, as can be seen from the constructive responses in workshops and evaluations, by the participants. Several important suggestions were made as to how the research agenda could be taken forward and how policy could be influenced by research such as this and by the involvement of the Wellcome Trust. These are referred to in chapter 4.

Appendix 6 ANOVA table showing a significant effect (at p < 0.05) of teachers' professional development in science on aspects of their confidence

		Sum of Squares	df	Mean Square	F	Sig.
Qd1. How would you rate your confidence in teaching History	Between Groups	3.133	1	3.133	4.854	.028
	Within Groups	187.179	290	.645		
	Total	190.312	291			
Qd1. How would you rate your confidence in teaching Geography	Between Groups	2.968	1	2.968	4.250	.040
	Within Groups	202.522	290	.698		
	Total	205.490	291			
Qd1. How would you rate your confidence in teaching Science	Between Groups	5.786	1	5.786	8.945	.003
	Within Groups	187.584	290	.647		
	Total	193.370	291			
Qe1. How would you rate your confidence in developing ... Their observation skills	Between Groups	8.137	1	8.137	13.857	.000
	Within Groups	170.285	290	.587		
	Total	178.421	291			
Qe1. How would you rate your confidence in developing ... Their ability to recognise, design, and carry out a fair test	Between Groups	7.430	1	7.430	10.066	.002
	Within Groups	214.060	290	.738		
	Total	221.490	291			
Qe1. How would you rate your confidence in developing ... Their ability to interpret findings	Between Groups	3.728	1	3.728	6.129	.014
	Within Groups	176.382	290	.608		
	Total	180.110	291			
Qe1. How would you rate your confidence in developing ... Their ability to address how science might affect their lives	Between Groups	7.882	1	7.882	11.690	.001
	Within Groups	195.552	290	.674		
	Total	203.435	291			
Qf1. How would you rate your confidence in ... Deciding the science skills to be developed in an activity	Between Groups	7.813	1	7.813	11.697	.001
	Within Groups	193.694	290	.668		
	Total	201.507	291			
Qf1. How would you rate your confidence in ... Explaining scientific ideas to children	Between Groups	4.461	1	4.461	6.420	.012
	Within Groups	201.485	290	.695		
	Total	205.945	291			
Qf1. How would you rate your confidence in ... Organising & delivering practical work	Between Groups	5.730	1	5.730	9.072	.003
	Within Groups	183.184	290	.632		
	Total	188.914	291			
Qf1. How would you rate your confidence in ... Assessing practical work	Between Groups	7.200	1	7.200	10.438	.001
	Within Groups	200.043	290	.690		
	Total	207.243	291			
Qf1. How would you rate your confidence in ... Using questioning as a tool in science teaching	Between Groups	2.803	1	2.803	5.101	.025
	Within Groups	159.361	290	.550		
	Total	162.164	291			
Qf1. How would you rate your confidence in ... Ensuring that all the children are engaged in	Between Groups	2.265	1	2.265	4.028	.046

science learning						
	Within Groups	163.064	290	.562		
	Total	165.329	291			
Qg. How would you rate your confidence in developing children's understanding of ... Basic life processes, e.g. circulation, respiration, digestion	Between Groups	3.199	1	3.199	4.900	.028
	Within Groups	189.305	290	.653		
	Total	192.503	291			
Qg. How would you rate your confidence in developing children's understanding of ... Life cycle of a flowering plant (pollen, stamen, stigma, fertilisation, seed dispersal)	Between Groups	3.834	1	3.834	6.335	.012
	Within Groups	175.509	290	.605		
	Total	179.342	291			
Qg. How would you rate your confidence in developing children's understanding of ... The water cycle	Between Groups	2.931	1	2.931	4.345	.038
	Within Groups	195.576	290	.674		
	Total	198.507	291			
Qg. How would you rate your confidence in developing children's understanding of ... Friction	Between Groups	9.048	1	9.048	9.415	.002
	Within Groups	278.715	290	.961		
	Total	287.764	291			
Qg. How would you rate your confidence in developing children's understanding of ... Renewable & non-renewable energy sources	Between Groups	5.140	1	5.140	5.153	.024
	Within Groups	289.281	290	.998		
	Total	294.421	291			
Qg. How would you rate your confidence in developing children's understanding of ... Insulators and conductors	Between Groups	4.388	1	4.388	4.408	.037
	Within Groups	288.691	290	.995		
	Total	293.079	291			

Appendix 7 ANOVA table showing a significant effect (at p < 0.05) of school size on aspects of their confidence

		Sum of Squares	df	Mean Square	F	Sig.
Qd1. How would you rate your confidence in teaching Science	Between Groups	10.75	2	5.37	8.50	0.000
	Within Groups	182.62	289	0.63		
	Total	193.37	291			
Qe1. How would you rate your confidence in developing …Their recording of data	Between Groups	5.51	2	2.75	4.87	0.008
	Within Groups	163.41	289	0.57		
	Total	168.92	291			
Qe1. How would you rate your confidence in developing …Their ability to recognise, design, and carry out a fair test	Between Groups	10.02	2	5.01	6.85	0.001
	Within Groups	211.47	289	0.73		
	Total	221.49	291			
Qf1. How would you rate your confidence in ... Deciding the science skills to be developed in an activity	Between Groups	6.22	2	3.11	4.60	0.011
	Within Groups	195.29	289	0.68		
	Total	201.51	291			
Qf1. How would you rate your confidence in ... Explaining scientific ideas to children	Between Groups	8.48	2	4.24	6.21	0.002
	Within Groups	197.47	289	0.68		
	Total	205.95	291			
Qf1. How would you rate your confidence in ... Organising & delivering practical work	Between Groups	7.56	2	3.78	6.02	0.003
	Within Groups	181.36	289	0.63		
	Total	188.91	291			
Qf1. How would you rate your confidence in ... Using questioning as a tool in science teaching	Between Groups	4.59	2	2.29	4.21	0.016
	Within Groups	157.58	289	0.55		
	Total	162.16	291			
Qf1. How would you rate your confidence in ... Ensuring that all the children are engaged in science learning	Between Groups	7.02	2	3.51	6.41	0.002
	Within Groups	158.31	289	0.55		
	Total	165.33	291			
Qg. How would you rate your confidence in developing children's understanding of ... Basic life processes	Between Groups	5.98	2	2.99	4.64	0.010
	Within Groups	186.52	289	0.65		
	Total	192.50	291			
Qg. How would you rate your confidence in developing children's understanding of ... Life cycle of a flowering plant	Between Groups	3.62	2	1.81	2.98	0.053
	Within Groups	175.72	289	0.61		
	Total	179.34	291			
Qg. How would you rate your confidence in developing children's understanding of ... The water cycle	Between Groups	6.04	2	3.02	4.54	0.011
	Within Groups	192.47	289	0.67		
	Total	198.51	291			
Qg. How would you rate your confidence in developing children's understanding of ... Friction	Between Groups	9.25	2	4.62	4.80	0.009
	Within Groups	278.51	289	0.96		
	Total	287.76	291			

Qg. How would you rate your confidence in developing children's understanding of ... How sound travels through a variety of materials	Between Groups	5.63	2	2.82	3.25	0.040
	Within Groups	250.40	289	0.87		
	Total	256.03	291			
Qg. How would you rate your confidence in developing children's understanding of ... The reflection of light from mirrors and other shiny surfaces	Between Groups	6.98	2	3.49	3.98	0.020
	Within Groups	253.44	289	0.88		
	Total	260.42	291			
How we see things	Between Groups	6.52	2	3.26	3.55	0.030
	Within Groups	265.46	289	0.92		
	Total	271.99	291			

Appendix 8 Overview of UK primary science initiatives

Name of Organisation	Name of Project	Brief Description of Project	Funding Body	Geographical Scope	Project Impact
Bath Spa University College/School of Education	Improving Science Together	Identification of Sc1 skills and assessment for learning in primary, plus the need to develop better KS2/3 continuity and progression	AstraZeneca Science Teaching Trust	20 primary and 4 secondary schools in the local area	• Curriculum packs to support good practice. • Better continuity between Y6 and Y7 programmes in science • Increased confidence of science coordinator.
Bretton Hall, University of Leeds	Partnership Teaching	The project focus was on partnership teaching and the planning of lessons for teaching and assessing specific science process skills.	AstraZeneca Science Teaching Trust	25 schools in the local area	• Improved confidence in teaching science. • Equipment grant provided resources for schools. • Ofsted inspection reports on beneficial impact of project.
Canterbury Christ Church College	Partnership in Primary Science	Pairing of science coordinators and NQTs- To combine NQT enthusiasm and subject knowledge with Science coordinators experience and expertise.	AstraZeneca Science Teaching Trust	38 schools in the local area	• Increased confidence of science coordinators using ICT and subject leadership skills developed. • Resources for school using equipment grant. • Increased confidence of NQT teaching science.
York University Chemical Industry Education Centre/ Chemistry	Children Challenging Industry	Advisory teachers across the North of England deliver classroom based INSET to teachers and children focusing on motivating investigations set within industrial contexts	Company donations, Excellence in Cities, Education Action Zones, Regional Development Agencies, Education Business Partnership and participant schools	175 across the North of England	• Improved perceptions of industry • Improved enjoyment and motivation for science from pupils. • Improved confidence of teachers carry out classroom based investigations. • Improved children's skills in carrying out science investigations.
Institute for Science Education in Scotland	Partnership in Primary Science Project (PIPS)	The aim was to work with teachers to promote informed use of ICT in schools while developing teacher confidence in teaching science.	AstraZeneca Science Teaching Trust	Approx. 40 schools across Scotland (project still ongoing)	• Resources materials created by teachers. • Changes in classroom practice. • Confident primary teachers providing CPD for colleagues.
Institute of Education, University of London/ Maths, Science and Technology (MST) (S)	Mapping Access to food in deprived areas: an educational perspective	Role of schools, particularly primary schools, in developing health in the community.	National Health Service Executive	4 schools in the local area	• Improved confidence of teachers. • Teaching pack for healthy eating.
King's College London	CASE@KS2	Project aims include developing scientific thinking among year 3 pupils, devising and testing CASE-based curriculum materials and training teachers in their classroom use	AstraZeneca Science Teaching Trust	21 schools in Hammersmith & Fulham and Harrow	• Raised children's ability to think for themselves. • Improved children's social interactions.
King's College	ASE-King's	The project aimed to improve	Wellcome	England and	• Impact of QCA and

London/ Department of Education and Professional Studies	Science Investigations in Schools project (AKSIS)	the quality of scientific enquiry in schools by developing innovative teaching strategies. Review the National Curriculum orders for Sc1 in order to identify both positive and negative aspects of the orders and to make recommendations for their revision.	Trust	Wales	design of 1999 Science National Curriculum. • Critique of QCA Schemes of work and writing part of them. • New teaching strategies and materials to support them.
Liverpool John Moores University/ School of Education	Promoting Excellence in Primary Schools	The project aimed to improve teachers confidence in teaching science, developing questioning and discussion, improving pupils attainment and attitude.	AstraZeneca Science Teaching Trust	Approx. 50 schools in the local area	• Improved teacher confidence in science. • Increase in use of questioning and discussion in class. • Improvement in children's KS2 SATs results
Middlesex University/ School of Lifelong Learning and Education	How does teacher engagement with science vary over their first 3 years of teaching?	PhD research, following 10 trainees from PGCE year to first two years as qualified teachers to find out what primary teachers do to engage children with science	University research budget and self funding	25 schools in the local area	• Engagement schedule that could be used to observe teachers teaching science. • Identification of critical moments in lessons and how these might be addressed.
Manchester Metropolitan University / Millgate House Publishing and Consultancy Ltd	Concept Cartoons in Primary Science Education	Professional development for teachers using the concept cartoon material. The training involved considered issues about effective teaching and learning in science as well as the range of uses of concept cartoons.	Initially self funded - then GSK plus support from other science organisations eg ASE, IoP, PPARC	Over 4000 teachers across the UK	• New approach to teaching, learning and engagement in science. • Material to support discussion in science. • Increased motivation and engagement of learners. • Increased engagement of students with special needs.
Northamptonshire Inspection and Advisory Services	Enhanced Advisory Services	The project aimed to support teacher's professional development in science teaching and learning. It was set up to support 21 rural primary schools who have been unable to fully access training due to their location.	AstraZeneca Science Teaching Trust	11 rural schools within the LEA	• Improved teacher confidence in teaching science. • Improved pupil attitude towards science. • Improved resources through equipment grant. • Improved level of attainment in SATs.
Nottingham Trent University/ School of Education	The Evidence Based Teaching (EBT) Project	A group of primary school teachers formed a collaborative group coordinated by a university tutor, to carry out action research. Each teacher developed their own piece of action research to meet their own personal professional development aims.	Nottingham Trent University	5 schools covering the local and regional area	• Improved forms of practice. • Dissemination of work at conferences
Queen's University	Science Students in	Primary teachers and science specialist students co taught	AstraZeneca Science	65 teachers in 18 schools in	• Increased teacher confidence in

Belfast and St Mary's University College	Primary Schools (SSIPS) with Stranmillis University College)	investigative science followed up by INSET and school development in science.	Teaching Trust	Greater Belfast & Bangor	investigative science. • Increased student teacher confidence teaching science. • Increase in children's enjoyment of science. • Extra resources through equipment grants.
Queen's University Belfast and St Mary's University College	Science in the New Curriculum (SiNC)	Primary teachers and student teachers co taught science within the new Northern Ireland primary curriculum. This was supported through INSET and e-conferencing.	AstraZeneca Science Teaching Trust	13 Schools across Northern Ireland	• Increased teacher confidence in science in the new curriculum and the use of ICT. • Increased student teacher confidence teaching science and the use of ICT. • Increase in children's enjoyment of science. • Extra resources through equipment grants.
Sheffield Hallam University/ Centre for Science Education	SETPOINT Activity in South Yorkshire	All SETPOINT work seeks to promote the STEM through the provision of learning opportunities to every child at every key stage	DTI, Regional Development Agency, Industry, HEFCE	Schools in South Yorkshire	• A network of organisations which aim to provide a 'one stop shop' for information about science, engineering technology and mathematics.
Software Production Enterprises Ltd. Open University /Goldsmith's College (UCL) – now Bath Spa University College	SPE Making Sense of Science	It focused on the professional development of the science coordinator through the use of distance learning INSET materials combined with tutor support.	AstraZeneca Science Teaching Trust	30 schools in Southern England	• Improved resources through equipment grant. • Greater awareness of their role as science coordinator and greater confidence in carrying out their role. • Working in partnership with other teachers in the classroom and were recognising positive changes in their own and colleagues' teaching of science and in pupils' learning
St Mary's University College Belfast / Queen's University Belfast	DNA fingerprinting investigations in Primary science	The project involved student teachers carrying out DNA investigations with 11-12 year old primary children.	Science Year	5 schools in the local area	• Enjoyment by children of investigations. • Additional support and resources to schools provided by the university and university colleges.
St Mary's University College Belfast	Bird Recognition in Primary classes	Survey of P3-7 children asking how many of 12 common bird species they can recognise.	Self funded with help from RSPB	40 schools across Northern Ireland	• Increased interest in environmental studies.
Stranmillis University	Hands up for Science	On line survey of sidedness in primary and post-primary	Science Year	Over 4000 children across	• Integration of ICT in science

College /St Mary's University College and Queen's University Belfast		schools undertaken by student teachers in 2002.		Northern Ireland	• Increasing skills in students
Stranmillis University College	Science students working in primary school	Students make weekly visits to primary school to undertake investigative science and technology.	Self funding	3 local primary schools	• Better understanding of investigative approaches to science and technology. • Programme now part of year 3 module in university colleges.
University College Winchester/ School of Education	Teachers and children exploring their world	An action research project to develop a set of cases studies of teaching science/ knowledge of the world in the Foundation Stage.	AstraZeneca Science Teaching Trust	18 school in the regional area	• It is hoped the project will develop case studies that will illustrate new models for classroom practice, cross curricular work, creative contexts for science teaching and CPD for primary and foundation science
University of Bath/Education	Evaluation of AstraZeneca Science Teaching Trust funded primary science projects	Evaluation of projects funded by the Trust. Involves visiting providers (fund holders) and making visits to primary schools participating in projects.	AstraZeneca Science Teaching Trust	UK wide	• Broad improvements in primary science teaching across the UK • Creation of new models of professional development for teachers of primary science.
University of Durham// Redcar and Cleveland LEA	Partnership for Continuing Professional Development	Teachers from clusters of local schools met to produce high quality science teaching resources and curriculum guidance materials.	AstraZeneca Science Teaching Trust	37 schools within LEA	• Curriculum packs to support and reinforce good practice. • Increased confidence and self esteem of teachers. • Development of school action plans for science.
University of Durham/CEM centre	Performance Indicators in Primary Schools (PIPIS)	This is a monitoring project designed to give feedback to schools on how well they are doing.	Local Authorities and Schools	A few thousand schools, UK wide	• Improved provision for science in the last few years of primary school.
University of Exeter/School of Education	AstraZeneca-Exeter Science Science through Telematics (AZEST) Project	To investigate the potential of the Internet to offer curriculum support materials and as a discussion forum for primary science.	AstraZeneca Science Teaching Trust	6 schools in the local area	• Better understanding of Forces and Motion in pupils. • Enhanced understanding of the usefulness of concept mapping as an assessment tool.
University of Leicester/ SCIcentre	Changing Children's Attitudes to Science	Provided in-service training and adopt a 'buddy system' of team teaching to help change children's attitudes to science and enhance children's understanding of science.	AstraZeneca Science Teaching Trust	31 schools within Leicester City LEA and Leicestershire EBP	• Positive impact on children's understanding achievement and enjoyment in science. • Increase in teacher's confidence, expertise and enthusiasm in science.
University of Liverpool/ Education	Effective Practice in Primary Science	Looked at the influence of Nuffield Primary Science on effective primary practice.	Nuffield Curriculum Trust	30 schools across the UK	• Models of effective practice.

University of York/ Educational Studies	North Yorkshire AstraZeneca Science Pedagogy and Progression (NYASPP) Project	New project developed out of STAY York provided 'bridging' units to smooth transition for pupils between primary and secondary school	AstraZeneca Science Teaching Trust	Schools in the local area	• The development and teaching of 'Science Enquiry Progression Tasks' (SEPTs). Each SEPT is a pair of practical tasks - one to be taught in Y5 or Y6 in primary school and the other to be taught at some stage in KS3.

Key: Shaded rows indicate e-mail survey responses