Using ICT in Science

Evaluation of a Secondary School Development Project

Final Report

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December 2004

FOREWORD

The contract for the evaluation of the 'Using ICT in Science' Project was awarded in March 2003, and an interim report was produced in February 2004. In this final report we add to the previous report the details of the evaluation of the final phase of the Project and consider the future development of the school as 'a learning school'.

We would like to thank the participants in the schools – both pupils and teachers **-** for allowing us to share the excitements and difficulties they encountered in the course of their developments, and for giving so generously of their time to contribute to the evidence gathering. ICT is at a very early stage in its impact on schools, and no doubt there will be further imaginative initiatives ahead. It is clear that these early pioneering enterprises have set the scene for great changes in the future.

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SECTION 1: THE CONTEXT OF THE SCHOOL AND EVALUATION PROJECTS

This evaluation project is concerned with the effects of the introduction of sets of laptop computers and associated data-projectors and interactive whiteboards into the three science departments of a large secondary school in Scotland, and focuses on three aspects of the school initiative: the impact on the teachers and teaching; the impact on learners and learning; and the implications for the future development of the school as a learning community. The school initiative is set within the national context of the Future Learning and Teaching Programme, the principal aim of which is to encourage schools, education authorities and other bodies with a stake in school education to create a learning and teaching environment for the future which is sensitive to individual needs, will promote attainment and which tackles the barriers to inclusive learning and teaching in the community.

The School Context

The school is a large non-denominational secondary school, (Roll 1100, teaching staff N= 85). Its catchment area includes a small town area with additional elements of rural and city areas; these do not include significant areas of social deprivation. The attainment statistics indicate that the school performs well with respect to the nationally available statistics. The science departments have together a total of 17 staff, some of whom are part time. (1.3)

The School's *ICT in Science* Project Proposals

The school initiative was introduced partly as a result of an HMIE report, in which it was suggested that more use should be made of ICT to enhance teaching and learning, and partly in response to the SEED report *A Science Strategy for Scotland*. The main aims of the school project were to enhance the learning, motivation and independence of pupils in both science and in ICT; and to develop and pilot the use of technology to enhance learning and teaching strategies which maximised the effective use of ICT. (1.4)

The aims of the Evaluation Project

The evaluation project which began in March 2003 and ended in July 2004, had four specific aims:

1. To evaluate the impact of the project on integrating ICT into teaching practice, in selected areas of the science curriculum, including any impact of more flexible deployment of ICT resources.
2. To evaluate the impact of the project on student competence and confidence in science and developing key related transferable skills and dispositions.
3. To evaluate the impact of the project on students' attitudes to science, and investigate any resulting impact on take up of science subjects at key stages in the curriculum.
4. To evaluate the relationship between the project and the school's CPD programme on teacher competence and confidence in using ICT in science and on developing the school learning community. (1.5)

The methodology

The methodology included: interviews with teachers, and with the initiators and developers of the school project, with senior management staff in the school and with pupils (1.6.1 and 1.6.2); classroom observations (1.6.3) and a staff questionnaire (1.6.4.).

SECTION 2: INTRODUCING AND IMPLEMENTING THE CHANGES

Although the project was initially conceived and planned by senior staff (the Project Team Leaders), they put considerable thought into the means by which they would ensure that all the science staff were included in the active implementation of the technology, and the degrees and kind of support needed so that all the science staff (N= 17) could be included. The planners focussed their attention on S1/2 and developed set exercises within the S1/2 curriculum (2.3.1 a).

The hardware initially comprised two class sets of laptops, 4 digital projectors, two interactive whiteboards and a number of accessories such as data loggers and sensors. Over the period of the project additional whiteboards, laptops and peripherals were added (2.3.1 b). Additional funding allocated by SEED in March 2003 was used to purchase 3 fixed interactive whiteboards and the school subsequently sourced funds for an additional 4 mounted boards, with projectors which were taken into use after Easter.

The Project Team Leaders comprising the three Principal Teachers and an AHT initiated departmentally-based staff development to introduce the other science staff to the units they had developed. The initial introduction comprised awareness raising of what the technology (e.g. the interactive whiteboards) could do; tuition on the working of the boards and the laptops; tuition to all staff involved on how to manage the set ICT-based materials with a class (2.3.2). The planning decisions carried through into implementation appear to have resulted in the regular and sustained use of the equipment by the whole staff group in science. This is a significant achievement, and in further sections of this report we examine in greater detail how this was brought about.

The staff development took the form of demonstrations and active modelling of teaching by more experienced members of staff; staff acting as mentors for colleagues; informal visits to each others' classrooms; the frequent and open discussion in the shared staff room of how things could be done and how problems might be resolved (2.4). A few staff had regular and long-standing contacts with colleagues in other schools and shared subject materials and information e.g. on useful websites with them.

The cross-curricular interdepartmental exchanges in the school had not been frequent, mainly comprising demonstrations of a department's activities during inservice days. Additional opportunities were provided at twilight CPD sessions on Active Learning. This almost certainly reflects the subject focussed interests and discourse of most secondary teachers when talking about ICT. What we would judge to be eminently transferable to other departments, however, is the quality of the planning and induction processes which the development team had set in place which had resulted in the full use of the technology in classrooms by all teachers, even if at this early stage the benefits were difficult to quantify in terms of learning (2.4.3).

The factors which were identified as supporting the development were:

- The additional ICT provision of extra interactive whiteboards. This hugely increased the ease of use of the technology for many teachers. This was further enhanced by the purchase of additional interactive whiteboards, allowing easy access in every science room (2.5.1 a).
- The provision of the set material for the S1/2 curriculum as a focus for common action and the associated programme of support from the promoted staff in the early stages. Although ICT was observed in use at all age stages within the school, the commitment of the promoted staff to anticipating and /or being responsive to the needs of their colleagues in introducing the S1/2 activities had clearly contributed significantly to the high level of use of the equipment observed (2.5.1 b and c).
- The enthusiasm and skills shown by the pupils was a highly motivating experience for the staff, making them feel their efforts were worthwhile (2.5.1 d).
- The staff room shared by the three science departments provided the forum for formal and informal meetings and exchanges which allowed information to be exchanged rapidly across quite a large staff group. The provision of set S1/2 activities gave a common curriculum context and focus for professional discussions (2.5.1 e).

The factors which were identified as barriers to the development were:

- The scarcity and lack of immediacy of technological support (2.5.2 a).
- The lack of time to review software and the unavailability of guidance on its uses (2.5.2 b).
- The nature of the existing curriculum with which they had to comply, particularly the extensive content coverage dictated by external exams 2.5.2 c).

The basis of the decision taking by staff *(2.6)*

- The reliability of the equipment and the convenience of using it.
- Their confidence in and level of their ICT skills.

- What they had seen working in another teacher's classroom, or what had been recommended as 'good' by a current or former colleague.
- The degree of enthusiasm which was shown by the pupils.
- Whether the programme or activity matched well to the topics in the given curriculum.

What was clearly discernible was the value of informal staff communication and mutual support in helping the staff of the science departments to undertake a significant step in the journey towards using ICT regularly in their classrooms and to begin thinking about changes in teaching and learning. What was not discernible was an articulated or shared model of learning which could give coherence to the developments and to the experiences of the pupils and which could form a framework for the ongoing monitoring and evaluation of their plans and their outcomes. We return to this in a later round of interviews discussed in Section 5

SECTION 3: THE IMPACT OF THE TECHNOLOGY IN THE CLASSROOMS

How have the ICT resources been integrated into selected areas of the science curriculum and what has been the impact on the teaching practices? What changes have the technologies brought about in the pupils' learning activities?

The methods of data gathering included classroom observation and pupil and teacher interviews (3.2.2).
A wide range of technology was observed in use, for example for presentational purposes, (e.g. PowerPoint); for data management (e.g. Excel); for simulations (e.g. ACTIVESTUDIO); and for tutorial purposes (e.g. SCHOLAR). The extent to which potential learning gains will actually be made using the technology in these ways will, of course, depend on other aspects of the learning context known for some time to be potential limiting factors in understanding science information e.g. the level of difficulty of the information, the compatibility of the information with what pupils already know, the account taken of pupil misconceptions etc. (3.3.1 a).

The teachers had a typical range of different teaching styles which were clearly well established before the installation of the technology, and which they continued to follow regardless of whether the technology was being used in the class. These styles were derived from personal characteristics and preferences and from past experiences and determined that the technology was used in different ways and to different degrees by individual teachers, even within the set pieces which had been prepared by the PTs (3.3.1 b).

How were the pupils and teachers acquiring the necessary ICT skills?

The model of learning which was applied to the pupil acquisition of ICT related skills was that of 'just in time' learning, integrated purposefully into the science activities. This model of learning was also that being applied by the teachers to their own learning as they themselves started to use the technology for their teaching. The pupils, like the teachers, rapidly learned from each other. Teachers expressed frustration and feelings of being professionally undermined when they could not get systems to work. This suggested that having individuals with adequate technical expertise to hand to provide support was an important and valued source of learning for those teachers with limited experience, particularly at the start of the project (3.3.2).

What specific knowledge and skills within science do teachers believe are promoted by their technology use? Are these closely determined by the curriculum e.g. 5-14 or Standard Grade? Are they supplemented by the teachers' additional aims?

The aims of the lessons remained fairly tightly linked to the aims of the existing courses. The most common learning activities of the pupils were directed towards finding, acquiring and presenting science knowledge.
Generic skills: The generic skills identified by the teachers were research skills, independent learning and collaborative learning. ***Research skills*** include the use of a search engine, the ability to refine searches, recognise reliable web sources and the ability to scroll and select from information on a computer screen. These activities belong to the field of information literacy which is the area best known to and understood by librarians. The staff were becoming aware that more structure and guidance should be built into 'researching' activities to assist pupils (3.4.1 a).

Because of their growing confidence and levels of expertise with the technology, the pupils were seen to take ownership of the management of it in the classroom, and this was seen by teachers as a contribution to ***independent learning*** and the enhancement of enthusiasm for science. Independent learning is generally used in schools to mean that pupils are able to find specific information without the teacher having to present it. However, being a competent life-long learner also encapsulates the skill of knowing what kinds of questions are appropriate and important to raise in order to engage meaningfully with information on a subject. This tends not to be part of the model of independent learning applied within a school science curriculum based mainly on content acquisition (3.4.1 b).

Group work in which pupils were working in pairs on given tasks – usually searching for information and occasionally putting together a joint presentation were frequently used and were considered to be promoting collaborative skills. .Our observations suggest that the form and purpose of group tasks to support learning in science could profitably be discussed and developed across the science team with the aim of changing practice in such a way that ensures that an effective, coherent, articulate and informed approach to collaborative learning is developed (3.4.1 c).

Specific science knowledge and skills: The basic structure and content of the curriculum in the certificate years S1 to S6 had not been changed as a consequence of the introduction of ICT so the main content of the curriculum was therefore being presented largely as before, with the structure and progression unchanged. The staff anticipated that the ICT resources would allow the pupils faster access to information, a wider field of information and increased motivation through the quality of information accessed which would enhance conceptual understanding, which, in turn, would form the basis of more effective learning in later school courses (3.4.1 d).

What was the impact of ICT use on the pupils' development of skills and knowledge in science?
There is an aspiration and an expectancy on the part of all involved in the Science Project that the pupils' understanding of science will be improved. However, although there was evidence of increased enthusiasm for science, there is at this early stage in the uses of ICT little objective evidence of the extent to which the pupils have actually acquired more robust knowledge as a consequence of the use of ICT. Software is available to support virtual experiments. Some evidence from the pupil interviews suggested that the pupil responses to virtual experiments were very positive and pupils generally indicated enthusiasm for learning science through using the technology for information finding, data logging and simulations (3.4.2 a). The interview data from the pupils confirmed the teachers' view that the pupils' attention and concentration span was improved through both seeing the teachers' comments coming up on the whiteboard, and seeing information presented in a more accessible form than board diagrams or teachers' verbal explanations could provide (3.4.2 b). Some reservations were expressed by Learning Support about the extent to which the different ICT based forms of either transmission of information, or the forms of it's re-presentation back to the teacher did actually assist the slow learners significantly in their understanding of intrinsically difficult topics. However, teachers did suggest in interviews that with the use of ICT in some lessons, the burden on teacher dominated transmission and directions were reduced and more time could be available for talking and discussing difficulties with pupils (3.4.2 c).

What has been the impact on the teaching and learning activities? (3.5)
Teaching was judged to be enhanced through specific ICT use: e.g. the data projector and interactive whiteboard were observed being used to make illustrative points through good quality photographic images and an appropriate software programme. It was possible too for pupils to access software which was also on the teacher's board, and they could be talked through the software. The use of the technology also allowed a greater variety of teaching activities which actively involved the pupils (3.5.1).

Both teaching and learning were judged to be enhanced through e.g. the use of revision software; through enhanced visual presentations of complex concepts (e.g. chemical bonding); for enhancing data analysis activities through data-logging (3.5.2).

Neither teaching or learning were judged to be enhanced when there was a breakdown in the technology, or when learning activities were unfocussed on science issues, being more dominated by the ICT procedures (3.5.3).

Overall we judged that the main areas of enhancement were in the traditional activities of the teachers to enhance knowledge coverage and uptake by the pupils. Several of the Project Team Leaders indicated their growing awareness of the need to start thinking about different strategies for learning and hence for teaching. They had come to realise that the use of technology did not in itself deliver change in practices; once change in practices were identified and planned through, the technologies were merely the tools to make the changes possible (3.6).

SECTION 4: THE PERSPECTIVES OF THE PUPILS

The pupil interviews

Overall, twenty nine pupils (20 male, 11 female) were interviewed: 20 in May 2003, 16 in May 2004 – seven were interviewed on both occasions. They covered all year groups and a range of abilities. Pupils in S1/2 were interviewed in pairs, the older pupils as individuals (4.2.2).

What have been their experiences with the technology at home*?*

Although all pupils said that they had access to a computer at home, some were reportedly ‘broken’, and had been for sometime, while some pupils had ‘privileged access’ – i.e. access to family computers in addition to their own personal laptops. Factors such as informed support from or competition with siblings and parents, personal preferences for writing by hand, in addition to beliefs regarding the benefits of word processing were all reported as determining the range and frequency of PC use at home (4.3.1 a).
Home computers were regularly used for homework, particularly using the Internet and word processing, including ‘cut and paste’. Most pupils indicated a clear understanding of plagiarism (4.3.1 b). The school web page provides a very useful resource which could enhance partnerships between the home and the school but its use was still at an early stage and few pupils reported using it (4.3.1 c).

Where did pupils acquire their ICT skills?

Pupils had mainly acquired their ICT skills in the home or primary school, and in IT classes, computing or business studies in the secondary school (4.3.2).
When asked about experiences of using ICT as a learning tool in the school subjects, Modern Languages, Geography and English were mentioned. The interactivity of the programmes was the key factor in generating enthusiasm and approval (4.4).

What have been the benefits and disadvantages to their learning in science lessons?

Pupils reported more control and independence, the aiding of comprehension and recall of information, and increased understanding prompted by animated or three dimensional representations. Clearly the technology had contributed to assisting teachers and pupils to bring variation to what had been hitherto a predominantly talk and text dominated situation. However, as one sixth year pupil observed, having a whiteboard did not necessarily mean a teacher would teach better. The disadvantages identified were associated with the early difficulties with the technology (4.5 a).

Was the technology used to support pupils with learning difficulties?

The classroom observations and pupil interviews indicated that all the pupils were reporting benefiting in some degree from the way in which information – either in the form of knowledge or instructions – became more engaging and accessible through the use of the computers. However, the subject materials and the programmes and sites used were not in any way differentiated and all pupils read or interacted with the same level of material. No activities or programmes were seen in the observations or reported by pupils which were specifically designed to be helpful to slow learners or those with particular learning difficulties. The allocation of additional time to the Learning Support staff for consultations could support the improvement of this situation in the future, and ultimately lead to a more coherent approach to learning within and across the different subject areas (4.5 c).

Did the laptops have a beneficial effect on pupils' attitudes and motivation?
Overall, pupils from across year groups indicated that they benefited from the use of lap tops in science subjects. With a few exceptions, most pupils were positive and enthusiastic (4.5 d).

Did the technology detract from practical engagement in science?
Information in the first round of interviews had suggested that there might be a trend away from interest in real hands-on science in favour of the clean and certain world of the simulations. However, specific questioning of pupils in the second round indicated there was still an enthusiasm for hand-on experiments. Most pupils appeared to favour the sometimes *'smelly'* and *'messy'* practical experiments undertaken in class. Older pupils (i.e. those in S6) were found to appreciate the way in which use of lap top programmes in conjunction with hands on experiments could facilitate and ease their understanding of science (4.5 e).

SECTION 5: TEACHERS AS LEARNERS AND THE LEARNING SCHOOL

Achievement of the Aims of the School Project

Had the aims of the school project been achieved?
It seemed to us there was much evidence that the technology had been very successfully introduced into the science classrooms of the school, from S1 through to S6, and was in regular use (5.3.1).
What factors had been the key to the successful initial adoption of ICT?
Two general strengths had contributed to this success: the initial thought and planning given to the introduction of all staff to the technology; and the initial processes of regular demonstrations, modelling sharing and practising. A Project Team Leader gave the following pointers to other school staff considering a similar initiative:

1. plan in detail for the integration of ICT into the lessons, not used as an add on;
2. involve all staff not just the enthusiastic;
3. ensure continuity of coverage across the curriculum and the year;
4. embed and integrate into pupil activities for active learning;
5. start with staff development and invest a lot of time in it;
6. after school staff sessions are important;
7. share experience and expertise in different areas across the team;
8. develop sharing and trust. Trust is easier with respect to the use of technologies – less so in areas related to teaching and learning. People are wary of saving 'I can't do this style of teaching or support learning like this'. (5.3.2)

Had the project promoted the development of new ways of learning and teaching?
There was rather less evidence that the project had succeeded in the aspiration set out in the original project proposals that the use of the technology would usher in '*new ways of learning and teaching in science subjects'* as indicated in the original Project proposals (5.3.3).

Had the Project had an effect on attainment in science?
We could not find nor was it possible for us to generate data within this project which could link any changes in attainment or in the uptake of science to the use of the ICT. The project was in far too early a stage and other factors within the school were more likely to be influencing any variation from previous years (5.3.4).

What factors were likely to influence the future developments?
Staff identified the following as influencing their further developments: the fading of the initial novelty factor; the need for materials to be more fully integrated into the curriculum rather than slotting into an already existing curriculum; the extent to which staff were feeling overall 'innovation overload'; their identification of a need for a more structured approach particularly in the tasks given to pupils (5.4).

What models of learning would be appropriate for future consideration?
It is increasingly recognised that the improved learning and the transformation of teaching are not guaranteed merely by the presence of the technology. In our view there had been no opportunity or context for science staff to overview the aims and objectives of the range of different initiatives which had

already been introduced into the school (CASE, VAK, Critical Skills etc.) to see the common threads and to capitalise on the commonalities in order to optimise their understanding, save duplication and - most importantly of all - to give a coherent experience of education within the school to the pupils (5.5).

At the end of the first phase of the project (Dec. 2003) we generated some models of enhanced teaching and learning based on the activities with we had seen in our classroom observations and structured in the form of Critical Skills principles (Appendix 1) which we hoped might offer a context for the staff to discuss aspects of ICT and learning as well as teaching (5.5.1). At this stage we were advised that although individual teachers would continue to develop their skills and different ways of using the ICT in their own style and for their own specific purposes, there was unlikely to be further significant developments in the thinking and discussions of the whole staff group in relation to the overall aims of the project during the management reorganisation period (5.5.2).

The Impact of the School's CPD Programme

What has been the impact of the school's CPD programme on teacher competence and confidence in using ICT in science and in developing the school learning community?

A questionnaire was devised in consultation with the ICT co-ordinator, and was circulated to all the school staff in the Spring of 2004. 24 teachers (28% of the teaching complement) responded, representing 16 departments including Guidance and Support for Learning (5.6.1). The responses from the staff sample indicated that their basic computer-using skills were well consolidated. The access to ICT in their classrooms varied widely but the figures appeared to indicate that the level of regular use in classrooms was low. The obstacle most frequently identified to further use was access, either to the equipment per se or to the classroom beforehand to set up in preparation for the next lesson (5.6.2 a).

What were the staff experiences of Staff development?

No staff member had undertaken Masterclass training but most had completed their NOF training. Only a minority indicated that they found it a positive and useful experience (5.6.2 b)

What forms of CPD did they value?

The form of staff development most frequently engaged with (96%) - and in this questionnaire the most highly rated in terms of usefulness - was informal discussions with immediate subject colleagues, and for a minority, (25%), meetings with subject colleagues from other schools. For 88% of the staff, 'exploring through trial and error in my own classroom' received the next highest rating of usefulness. While experienced by a majority, (75%), whole school in-service with outside input was rated as the least useful of all the forms of staff development listed, with external award bearing courses and subject-oriented professional journals also rated on the 'not useful' side of the scale (5.6.2 c).

What are the key characteristics of staff learning?

The model of teacher learning which emerges from a variety of studies indicates that the development of teachers' knowledge and use of ICT is an individual and subject centred model. The planning and leadership associated with the early phase of the project (Section 2) allied with the challenge presented by the novelty of the ICT use allowed a small but powerful learning community to develop within the science department. For developments to move forward in a unified way however, strong curriculum or management leadership would be required (5.7.2).

The Developing School

How can the school develop further as a learning community?

The model of planning, inclusion, support, practice and modeling adopted by the Science Project Team worked well in creating a productive 'learning community' of teachers who successfully engaged with ICT and began its regular use in classrooms. However, it is not certain that all staff would wish to change in any radical way, and subsequently individualistic developments were being adopted by most of the science teachers now they were familiar with the technology. The literature on school development suggests that at this stage the school needs to work together on developing a unifying statement about the features of its philosophy and practices in learning and teaching. The Critical Skills Coaching Kit offers a model of key *ideas for developing coherent classroom approaches (5.7.3). The school was identified as being at level 3 on the Mooij and Sweets (2002) model of school development with respect to ICT implementation (5.7.4)*

Why should secondary schools seek to develop innovative pedagogy ?

Arguments are advanced for the adoption of the innovative pedagogies which the powers of ICT enable. The development of appropriate innovative pedagogies must involve teachers in the two way process of bridging theory and practice. This project demonstrated just how challenging and professionally stimulating such pedagogy-led technological innovation can be when the ownership of development is put in the hands of a team of teachers committed to curriculum development as a vehicle for their own professional development.

SECTION 1: THE CONTEXT OF THE SCHOOL AND EVALUATION PROJECTS

1.1 Summary Overview of Section 1

This evaluation project is concerned with the effects of the introduction of sets of laptop computers and associated data-projectors and interactive whiteboards into the three science departments of a large secondary school in Scotland, and focuses on three aspects of the school initiative: the impact on the teachers and teaching; the impact on learners and learning; and the implications for the future development of the school as a learning community. The school initiative is set within the national context of the Future Learning and Teaching Programme, the principal aim of which is to encourage schools, education authorities and other bodies with a stake in school education to create a learning and teaching environment for the future which is sensitive to individual needs, will promote attainment and which tackles the barriers to inclusive learning and teaching in the community.

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1.2 The National Context

The aim of the Future Learning & Teaching Programme is to encourage schools, education authorities and other bodies with a stake in school education to create a learning and teaching environment for the future which is sensitive to individual needs, will promote attainment and which tackles the barriers to inclusive learning and teaching in the community. One of the means to these ends is the provision of modern technology to assist in the development of effective learning and teaching contexts.

Many difficulties have been identified world wide in the development of confidence and competence on the part of subject teachers in the use of ICT. A key challenge for school managers is how to support the development by staff of the skills and enthusiasms both to allow benefit from the advantages and efficiencies which the uses of technology bring to a range of current professional activities and to promote its uses by pupils for similar enhancements in their lives as learners.

Since in the future, learning to use current and emerging technology will be a continuing process for teachers rather than a one-off qualification, the concept of 'a professional learning community' is appropriate. This involves the creation of a context in which professionals can comfortably engage with change, and which offers opportunities for them to develop their professional repertoires and practices through mutual engagement and enquiry. Additionally, the emerging model of effective practitioners (Standard for Chartered Teachers) requires the proactivity of good teachers to be extended beyond their own classrooms to other colleagues. Indeed, the concept of the school as a 'learning community' encompasses productive learning interactions between teachers, school managers, pupils and parents (Scardamalia and Bereiter (1999).

1.3 The School's Characteristics

The High school is a non-denominational six-year comprehensive secondary school with a roll of around 1100 and a teaching staff complement of 85 teachers, some of whom are part time. The catchment area includes the small town in which it is located, nearby rural areas of the Authority, and part of an urban suburb. These catchment areas do not include significant areas of social deprivation. The school buildings are modern and are being continuously improved, for example the Library, science areas, Support for Learning, Design Technology have all had recent extensions or refurbishments.

The school statistics indicate that the school performs well in relation to the nationally available statistics. In 2003 their statistics for unauthorised absences, standing at 0.63% for S1 and 0.82% at S2 are below their Authority and the national averages.

Student attainment in National Qualifications has been consistently above the national average for Scotland and also above the average for schools in the same authority. Although in some years the attainment details have fluctuated, over the period 1997 - 2002 the above statement holds true. Detailed statistics on the attainment records are presented in Appendix 6.

The science departments comprise 17 staff of whom four are part time. At the time of the project there were three principal teachers for the three subjects: chemistry, biology and physics. The three subject staff groups share a small common staff base which serves as a store for equipment and resources, a work area and a social area for lunch and coffee breaks.

1.4 The School's *ICT in Science* Project Proposals

The school had been inspected by HMIE in May 2000. The Inspectors' report was generally very positive. With respect to ICT in the school, however, they had indicated the following:

> *Overall there was a need to develop pupils' ICT skills more systematically across subjects. The provision of ICT resources was increasing significantly. This potential should be harnessed by ensuring that more regular and effective use is made of ICT to enhance learning and teaching, and to improve attainment within all departments.*

And with particular respect to S1/S2 science:

> *There was a need for the course to include more use of computers and varied materials to match the range of pupils' abilities.*

The school's proposals for the project, *ICT in Science*, was developed primarily by an Assistant (now Depute) Headteacher in collaboration with the three Principal Teachers in the science subjects (the Project Team Leaders), and was partly a response to the HMIE report and the SEED report '*A Science Strategy for Scotland'*, (SEED 2001) and partly as part of their ongoing concern, shared by many schools, to find a means for inducting more teachers into the regular classroom use of computers.

The basic aims set out in the *ICT in Science* project proposal document were, for pupils:

- enhancement of the learning of pupils in S1-S6 in biology, chemistry, physics and science;
- increased pupil responsibility for learning;
- improved ICT skills (including research and information handling).

And for teachers:

- piloting the use of 'next generation' ICT in science;
- developing learning and teaching strategies which will maximise effective use of ICT

However, the aspiration set out in the HMI report *Use of ICT in Learning and Teaching, 2001* was also highlighted:

> *Skills in using ICT provide the potential for access to lifelong learning opportunities that can empower all learners to develop their own unique intellectual capacity and operate as effective members of a digital society.*

And from the Scottish Executive (2001) document: *A Science Strategy for Scotland* the proposals quoted:

> *We need to help teachers deliver a vibrant curriculum via a range of high quality learning experiences that promote effective lifelong learning of science, especially the capacity to respond effectively to new scientific developments and issues.*

It was thus intended that ultimately links should be made between the school's ICT initiative and the other developments currently being undertaken or promoted in the school to develop the pupils' more general skills in learning: CASE; (Adey and Shayer 1994) the Thinking Skills Initiatives; Visual, Auditory and Kinaesthetic learning styles (VAK); the Critical Skills Programme (Mobilia, 1999 (see Appendix 4) inservice on which had been attended by some staff; and engagement with the Creativity in Education agenda. These different initiatives, according to the school's proposals, were expected to contribute to a '*joined-up approach to constructivist, challenge-led learning'*

The main technology focus of the school project was the use of mobile sets of mobile LAN laptops, together with associated data projectors and interactive whiteboards. This provided access to an extensive bank of general purpose packages and specialist science tutorial software (e.g. SCHOLAR), available locally and through the world wide web. The specific project objectives centred on the more active engagement of pupils in the learning process; their engagement with a greater degree of responsibility and motivation than previously; and better differentiation through flexibility in content and/or outcomes in the learning tasks. The changes in relationship between learner, teacher and subject matter was intended to build on the foundations laid by the CASE initiative in particular which is well established in the science department with S1 pupils.

1.5 The Aims of the Evaluation Project

The overall aim of the evaluation project was to assess the successes of the processes and procedures of the early stages of the introduction of the technology through data collection designed to illuminate the key professional features and concerns for the benefit of SEED and others in the educational services. There were three focal points of interest: within the classrooms, the impact on the teachers and teaching; and the impact on learners and learning; and beyond the science department, the implications for the future planning of whole school development.

1.5.1 Specific Aims

1. **To evaluate the impact of the project on integrating ICT into teaching practice, in selected areas of the science curriculum, including any impact of more flexible deployment of ICT resources.**

2. **To evaluate the impact of the project on student competence and confidence in science and developing key related transferable skills and dispositions.**

3. **To evaluate the impact of the project on students' attitudes to science, and investigate any resulting impact on take up of science subjects at key stages in the curriculum.**

4. **To evaluate the relationship between the project and the school's CPD programme on teacher competence and confidence in using ICT in science and on developing the school learning community.**

The first and fourth aims are associated with the changes in the teaching activities of the staff, the learning contexts which they create for the pupils and the CPD processes which enable and support these changes. The second and third aims relate to the changes in the pupils' experiences attainment and attitudes in science and their engagement with learning.

The evaluation project began in March 2003 and finished in July 2004.

1.6 Methodology

1.6.1 Interviews with school staff

Interviews were undertaken in March/April 2003 and in May/June 2004. In the initial set of interviews 10 full time teachers (including one learning support) were interviewed face to face from the total science staff group of 17. Those interviewed included the three Principal Teachers (of physics, biology and chemistry) and the AHT (physics) who had overall responsibility for the project (the Project Team Leaders). The interviews were recorded with the permission of the staff, transcribed and coded using an Nvivo package. The key codes were linked to aspects of the detailed research questions set out in the evaluation proposals.

The second set of interviews was undertaken in 2004 and comprised two different sets. The first set comprised semi structured interviews, undertaken to explore the thinking behind the development of the classroom materials, and the ways in which they had been used by different teachers. These interviews involved eight teachers, 5 of whom had developed ICT materials for use in S1/2, three of whom had engaged with the materials as users only. Additionally, semi-structured interviews were undertaken with five members of the school staff who had key roles in the science and in other school ICT related developments: the Headteacher; the PTs in Geography and in Learning Support; the PT in physics and the Deputy Headteacher who were both key figures in the *ICT in Science* project. The aim of these interviews was to gather information on their reflections on the science project, and the perceived implications beyond in the wider development of the school as a 'Learning Community'.

1.6.2 Interviews with pupils

a) The Pupil Sample

Pupils were talked to informally in classes when the observations were taking place. Additionally, a total of 20 pupils participated in formal interviews and were interviewed in May 2003 and in May 2004. In order to access a range of pupils' experiences of ICT, a cross section of pupils were included. As a result, pupils from S1 through to S6 took part, in addition to those taking Standard Grades, Intermediate Level courses, Higher Level and Advanced Higher courses. This meant that pupils with a range of abilities participated.

b) Interviewing Pupils

Different methods were employed for younger and older pupils. For example, older pupils (S5 & S6) were invited to take part in individual, one-to-one interviews, while younger pupils (S1 to S4) were interviewed in pairs. Given that that interviewers were unknown to pupils, paired interviews were regarded as an appropriate method for younger pupils who might be less inclined to talk openly in a one to one situation with an unknown adult (see Garbarino 1992). Paired interviews were found to work especially well in terms of encouraging younger pupils to speak out, and share their views in the company of a friend or classmate. A prompt sheet was developed in order to elicit more extended responses. This worked particularly well with younger pupils.

The semi-structured interview schedule addressed a range of topics with regard to the introduction ICT in the science subjects with pupils being initially asked about their access to a PC and favoured use in the home environment. This was considered important since it provided a source of baseline information about pupils' familiarity with ICT, as well as pre-existing ICT skills that could be readily transferred to classroom activities.

c) Ethics and consent

In keeping with 'best practice' with regard to ethical research with children and young people (see Alderson, 1995) the research project was fully explained to pupils. This was undertaken in both verbal and written forms. All pupils were asked to sign consent slips and were given written information about the research project. The young people were also asked to grant permission for interviews to be tape-recorded and the confidential boundaries of the interview were explained.

Data derived from the pupil interviews is presented primarily in Section 4.

1.6.3 Classroom Observations

The main method of data gathering with respect to practices in the classrooms was by direct observation. In devising our observation schedule, we initially undertook unstructured observations in a number of classrooms, and ascertained from the teachers what their specific aims were with respect to the lessons and to the technology. We also took account of the aims and research questions set out in our contract, and in the school's original planning document, particularly with respect to their aspiration to promote independence in pupils' learning. We also agreed with the staff group a programme of observations which allowed not only the observation of classes from S1to S5, but also lessons in which no technology might be being used. This latter strategy allowed us to reflect on the extent to which the use of ICT had affected (or not) the normal styles of teaching and learning, and to see what effects might be particularly related to ICT use.

The schedule was subsequently devised and refined by three research team members who undertook the formal observations. In the final formal data gathering 26 lessons were observed.

The data from the classroom observations is presented primarily in section 3

1.6.4 The Staff Questionnaire

In the autumn of 2003 a questionnaire was constructed in consultation with the Deputy Headteacher. The aim was to gather information in the range of ICT uses and skills of the teachers, and on their perceived usefulness of different kinds of staff development in ICT. The data are presented primarily in section 5.

SECTION 2: INTRODUCING AND IMPLEMENTING THE CHANGES

2.1 Summary Overview of Section 2

Although the project was initially conceived and planned by senior staff (the Project Team Leaders), they put considerable thought into the means by which they would ensure that all the science staff were included in the active implementation of the technology, and the degrees and kind of support needed so that all the science staff (N= 17) could be included. The planners focussed their attention on S1/2 and developed set exercises within the S1/2 curriculum (2.3.1 a).

The hardware initially comprised two class sets of laptops, 4 digital projectors, two interactive whiteboards and a number of accessories such as data loggers and sensors. Over the period of the project additional whiteboards, laptops and peripherals were added (2.3.1 b). Additional funding allocated by SEED in March 2003 was used to purchase 3 fixed interactive whiteboards and the school subsequently sourced funds for an additional 4 mounted boards, with projectors which were taken into use after Easter.

The Project Team Leaders comprising the three Principal Teachers and an AHT initiated departmentally-based staff development to introduce the other science staff to the units they had developed. The initial introduction comprised awareness raising of what the technology (e.g. the interactive whiteboards) could do; tuition on the working of the boards and the laptops; tuition to all staff involved on how to manage the set ICT-based materials with a class (2.3.2). The planning decisions carried through into implementation appear to have resulted in the regular and sustained use of the equipment by the whole staff group in science. This is a significant achievement, and in further sections of this report we examine in greater detail how this was brought about.

The staff development took the form of demonstrations and active modelling of teaching by more experienced members of staff; staff acting as mentors for colleagues; informal visits to each others' classrooms; the frequent and open discussion in the shared staff room of how things could be done and how problems might be resolved (2.4**.** A few staff had regular and long-standing contacts with colleagues in other schools and shared subject materials and information e.g. on useful websites with them.

The cross-curricular interdepartmental exchanges in the school had not been frequent, mainly comprising demonstrations of a department's activities during inservice days. This almost certainly reflects the subject focussed interests and discourse of most secondary teachers when talking about ICT. What we would judge to be eminently transferable to other departments, however, is the quality of the planning and induction processes which the development team had set in place which had resulted in the full use of the technology in classrooms by all teachers, even if at this early stage the benefits were difficult to quantify in terms of learning (2.4.3).

The factors which were identified as supporting the development were:

- The additional ICT provision of extra interactive whiteboards. This hugely increased the ease of use of the technology for many teachers. This was further enhanced by the purchase of additional interactive whiteboards, allowing easy access in every science room (2.5.1 a).
- The provision of the set material for the S1/2 curriculum as a focus for common action and the associated programme of support from the promoted staff in the early stages. Although ICT was observed in use at all age stages within the school, the commitment of the promoted staff to anticipating and /or being responsive to the needs of their colleagues in introducing the S1/2 activities had clearly contributed significantly to the high level of use of the equipment observed (2.5.1 b and c).
- The enthusiasm and skills shown by the pupils was a highly motivating experience for the staff, making them feel their efforts were worthwhile (2.5.1 d).
- The staff room shared by the three science departments provided the forum for formal and informal meetings and exchanges which allowed information to be exchanged rapidly across quite

a large staff group. The provision of set S1/2 activities gave a common curriculum context and focus for professional discussions (2.5.1 e).

The factors which were identified as barriers to the development were:

- The scarcity and lack of immediacy of technological support (2.5.2 a).
- The lack of time to review software and the unavailability of guidance on its uses (2.5.2 b).
- The nature of the existing curriculum with which they had to comply, particularly the extensive content coverage dictated by external exams 2.5.2 c).

The basis of the decision taking by staff *(2.6)*

- The reliability of the equipment and the convenience of using it.
- Their confidence in and level of their ICT skills.
- What they had seen working in another teacher's classroom, or what had been recommended as 'good' by a current or former colleague.
- The degree of enthusiasm which was shown by the pupils.
- Whether the programme or activity matched well to the topics in the given curriculum.

What was clearly discernible was the value of informal staff communication and mutual support in helping the staff of the science departments to undertake a significant step in the journey towards using ICT regularly in their classrooms and to begin thinking about changes in teaching and learning. What was not discernible was an articulated or shared model of learning which could give coherence to the developments and to the experiences of the pupils and which could form a framework for the ongoing monitoring and evaluation of their plans and their outcomes. We return to this in a later round of interviews discussed in Section 5

2.2 Research Questions and Methodology

Before the evaluation project had begun, the Project Team Leaders had clearly begun to lay foundations for a community of developing practice through their enthusiastic leadership in the exploitation of the new technology for reaching teaching and learning goals. In our visits and data collection we explored and documented aspects of the development and activities of this group within science and the potential for extension of the ethos and style of their learning and engagement with innovation to their colleagues beyond the science department. In this section we examine the departmental planning and management of the initial staff development. In Section 5 we consider data gathered beyond the science departments and the implications for further staff development in the school.

The data in this section is primarily derived from teacher interviews undertaken in March/April 2003. In total 10 full time teachers (including one learning support) were interviewed face to face from the total science staff group of 17. (see para. 1.6.1 for further details)

The research questions addressed were:
Who initiated the project and what were the key features of the initial plan?
How was the project introduced to the other staff?
How did the staff group manage their own learning? What models of CPD did they value?
What were the added opportunities and advantages if any, afforded by the provision of additional mobile whiteboards?
What factors supported and inhibited the innovations?

2.3 Initiation and Planning of the Project

An important feature of any development is the conception and introduction, as this is the stage when ownership of the project and the ideas begins to be established. In this section we explore how the science staff, who would likely bear a significant proportion of the work associated with the initiative, were introduced into the planning process, the benefits and difficulties they anticipated, and the support they were offered or sought in order to take the changes forward. Of particular interest is the ways in which CPD strategies were designed to develop confidence and skills in the use of ICT by all science staff.

2.3.1 Who initiated the project and what were the key features of the initial plan?

a) The initial planning decisions

The initiation of the school's ICT project had been prompted by the HMIE report indicated in Section 1.4 in which the development of ways to integrate ICT into the learning and teaching had been recommended. The AHT who was a former Principal Teacher of Guidance (teacher of Physics/Science) and who had just been given responsibility for ICT development in the school was aware that the classrooms were too small to accommodate many desktop computers, and believed that the most appropriate philosophy of ICT use was to bring the ICT to the place of learning rather than to have separate suites of ICT and bring the learners to the technology. He was aware of the potential of a wireless network to allow this to be realised, and was encouraged by the Rector to form a team with the three Principal Teachers of science to develop a proposal for consideration by SEED. These four staff formed the Project Team Leaders. The resultant document, '*ICT in Science'* the aims of which are outlined in Section 1.4, formed the basis of the funding. This allowed them to purchase hardware, software and staff training opportunities, although all were aware from the outset that the wide range of aspirations set out in the document were markers for the future rather than closely linked to the immediate short term initiative of introducing the laptops into the science classrooms.

In the initial considerations, one PT had felt that in view of the wide range of ICT skills and aptitudes among the staff, it might be best to pilot the technology with a small number of proficient staff. However, on reflection the group decided to proceed as follows:

- to include all the science staff as far as possible (N=17);
- to focus the project on the S1/2 curriculum where there was a fall off in motivation with some pupils;
- to insert into the existing S1/2 curriculum materials some basic ICT-based activities e.g. looking at databases; CD ROM material and resources; internet searches; presentation of data;
- to use some of the funding to release staff to undertake this development work;
- to have an internal programme of CPD for colleagues to introduce the hardware and the ICT classroom activities to show how these could work.

These decisions carried through into implementation appear to have resulted in the regular and sustained use of the equipment by the whole staff group in science. This is a significant achievement, and in further sections of this report we examine in greater detail how this was brought about.

b) The hardware

The evaluation project began in April 2003. At that time the science departments had already purchased 24 laptops housed in two mobile recharging cabinets (an additional 7 laptops were added soon afterwards in June; 4 digital projectors (mobile, on trolleys); two interactive whiteboards; with associated peripherals such as 2 wireless printers, and 6 data loggers with several types of sensors. These latter were also mobilised through the use of trolleys. All the equipment could be accessed by individual teachers through the booking system set up by the PTs in order to track the frequency and distribution of the use of the hardware.

The additional funding allocated by SEED in March 2003 was used to purchase 3 fixed interactive whiteboards. In addition, the school subsequently sourced funds for an additional 4 mounted whiteboards, with projectors which were taken into use after Easter.

The hardware therefore finally consisted of 7 fixed position whiteboards, and two mobile ones, each of which were located between two classrooms, thereby cutting down some of the inconvenience of moving them into a number of different classrooms. The usefulness of the additional hardware is discussed in Section 2.5.1 a).

2.3.2 How was the project introduced to the other staff?

We had a series of meetings and we also had a number of bulletins. We had a trial meeting where we had a final view of how the school would actually evolve. It was very much a reassurance that we would proceed in a way this year so that the inserts which we created would be fully supported and proficient staff plus myself would provide all the materials and software. That seemed to be accepted quite readily. All the staff saw this was a wonderful opportunity. Very few schools would have a chance to have such a large amount of hardware.

Although the project was initially conceived and planned by senior staff, they put considerable thought into the means by which they would ensure that all the science staff were included in the active implementation of the technology, and the degrees and kind of support needed. Thus, although not all of the teachers we interviewed had seen, or remembered seeing the initial school project proposals *'ICT in Science'*, all were using the laptops and/or the interactive whiteboards in their classrooms. As with many projects involving ICT, the initial stages had been characterised by some technical difficulties with the hardware, and in the early stages the PTs had had to contend with a level of frustration generated by this in themselves as well as within the staff (see Section 2.5.2 a). However, by the end of the spring of 2003 these problems had been overcome as well as they could be by the staff, and the technology was in regular use.

However, in the view of the AHT, the most important part of the early stages of the implementation had been ensuring that all the staff were positively disposed towards the initiative and felt adequately supported:

> *A lot of teachers were lacking in confidence at the beginning of the year, but because they have had that support are happy to try things out themselves. It is something which I knew from the start we would have to do, and I've been vindicated. We'd had to make sure that everybody was on board because otherwise you end up having an awful lot of expensive hardware not doing very much.*

The planning covered a series of stages in the induction of the staff:

a) Awareness raising: for example, before the equipment had arrived a demonstration of an interactive whiteboard was organised to let staff see what could be done.

b) The use and management of the computers: a session was run on how to use them, and the working of a booking system which allowed everyone to book sets and know they would be available. At this stage the computers were not yet networked, but they could be used as 'standalones' by teachers who wished to get started. Practice in getting pupils to log on and off helped to boost confidence in the use of the LTs with a class.

c) Through all these sessions it was emphasised that the focus should be on the learning of science on the part of the pupils rather than on the learning of ICT skills. Teachers who had the skills to allow use of the technology beyond the set S1/2 topics were encouraged to use the technology to the full and to circulate new knowledge and skills to their colleagues. The key features of this collegiate model of learning are explored below.

2.4 Staff Development Strategies

How did the staff group manage their own learning? What models of CPD did they value?

Since the use of class sets of laptops and interactive whiteboards are in the early stages of development in schools in Scotland, a focus of interest within the evaluation was the mechanisms by which the staff group developed their skills in applying the technology. There were two quite distinct areas of learning: the initial gaining of familiarity and confidence in the use of ICT generally, and its use in pedagogical settings.

2.4.1 Learning about ICT

The interviews with the teachers indicated that with respect to their learning about the uses of the technology:

a) There had been a wide range in the levels of basic ICT skills of the staff at the beginning of the project. Some staff had used computers throughout the period of their slow introduction into schools over a decade or more, while staff relatively new to teaching indicated they had experienced a high level of use of modern computers in university subjects or ITE training. However, not all the staff were skilled beyond basic word processing, and a few had minimal competency even on keyboard skills. Most who indicated they had used home computers for professional work cited the production of worksheets or assessment as the main areas of activity.

b) Although many of the staff were working through the NOF training, there was a fairly negative evaluation from the participants of its efficacy, several expressing the view that they were doggedly working through exercises just for the sake of handing in work (see Section 5.6.2 b). However one or two teachers who had minimal skills indicated that at least it had forced them to be more involved with programmes such as Excel. It seemed that all the staff now had the basic competence to go forward into more sophisticated training in the pedagogical uses of the technology although no staff had undertaken a programme of training to assist in this during the time of the evaluation.

2.4.2 Developing the pedagogical uses of ICT

None of the staff had any experience within the Masterclass programme (see Appendix 7), therefore the main vehicle for staff development in the pedagogical uses was primarily within the department and in the support which had been planned by the PTs. The aspects of the support which were identified as being particularly valuable were as follows:

a) Developing staff through example and modelling

The initial staff development sessions had as their focus those materials that all the teachers dealing with S1/2 classes would be using, including some of the PTs. This enabled both advanced and less skilled ICT users a common focus for their interactions and discussions on the classroom management of the ICT. One teacher described how the PT running one session had set it up so that staff had to ‘be the class’ and had acted out the role of teacher as a model of how it might be done:

> *Well we had set aside time basically after school where us members of staff would basically be the class. We were actually having a look at the software and primarily looking at how the person was taking us as a lesson - how she went around the class and how she managed to keep everybody on task, because obviously there was a huge range in the ICT abilities. There was myself sitting there quite happily getting on with it, which was giving me more chance to observe everybody else and observe how she was actually going about making sure everybody was on task, so we did it in that sense. But then obviously the first time you take it into the classrooms it’s a relative new experience but I did it with a good class - I felt confident about using it with them.*

b) Availability and responsiveness of experienced staff

The promoted staff (AHT and the three PTs) made themselves readily available to offer support:

> *We have had a staff CPD programme for the year and everybody knows that if you call upon help, whatever that help might be, team teaching, demonstrations outside the school, whatever, we respond, and because of that staff have been more prepared to give it a go.*

c) Open staff relationships

The relationships between sub groups of staff members made it easy for colleagues to visit each other’s classrooms in an informal way when certain equipment was being used, in order that illustrations of the technology in use could be seen and advice sought:

I have to say the informal staff development has been incredible. People have been quite free to go in and out of each other's rooms in a way that has been more than expected. And obviously I would hope that that would continue, and that informal helping of each other, recommending software - 'have you tried this?'- that that would continue.

d) A shared location and focus for discussion

The science staff meets in a staff base shared between the three science subjects, so there is a daily, permanent forum for informal talk and exchange of views and information. Additionally, the common activities written into the S1/2 course meant everyone had areas of common teaching concerns with colleagues.

e) Input from science colleagues outside the school

Some of the existing networks of subject teachers were being used to seek out information, though it was suggested that this was not very productive, since, as one teacher indicated, most schools are not equipped in the way that they now are, and they feel they are in the vanguard. Another relatively recently qualified teacher was still in contact with individual friends now teaching in schools who had been to university with her, and they regularly exchanged information about 'good' software and useful subject specific sites:

The ones I try and keep contact with are the ones that I went to university with and we do exchange an awful lot of things like websites or even worksheets that they have made up. And I have found it very helpful for courses like the one which we've just started teaching this year and I know my friend up in Orkney taught it last year, so I phone her up and ask if she used any ICT or any websites that she's gone on to.

A probationer reported regular meetings with her peer group colleagues at formal Authority probationer meetings, and here too information about useful sites for specific topic areas was informally exchanged. The once per term meetings of some local subject Principal Teacher groups were sometimes attended, but were not seen by all the subject PTs as a particularly useful focus for discussions on ICT uses. More casual contacts between meetings and personal contacts, usually with former colleagues in previous schools, were suggested as being most valued. A proposed e-mail network was reported to have failed because of the low level of ready access which many of its potential members had to computers. Few of the teachers interviewed said they read the School Science Review.

f) Exchanges with colleagues within the school

Although laptops and other ICT are being used in other departments in the school, the only exchanges reported to us were when whole school events allowed demonstrations of the interactive whiteboards etc. to be set up. Although the AHT was in a position of overview, there seemed little knowledge at class teacher level of what might be happening in other departments.

2.4.3 Sharing expertise across the school

The CPD activities associated with ICT which the teachers indicated were valuable to them almost all related to the demonstration, and 'hands-on' use of specific technology e.g. the interactive whiteboards, in the context of subject specific software. When asked about 'good' ICT use, teachers always indicated specific science topic related sites or programmes. This suggests that events which had been organised within the school for interdepartmental exchanges were likely to have limited success with respect to transferability of expertise, except in the general sense that other departments had expressed 'envy' about the level of hardware which the sciences now had at their disposal and they were keen to acquire more technology in their departments. Whereas primary teachers have a common language in curricular terms for discussions with colleagues in their school, secondary teachers' typical use of subject based discourse cuts them off from colleagues in other areas. However, as the AHT indicated, the leaders of the science team were now interested *'in moving away from hardware, software, and content, and more to pedagogy.'* Such a move would certainly assist interdepartmental discussions. We look at the wider school picture and ways around the subject barriers in Section 5.

What we would judge to be eminently transferable to other departments, however, is the quality of the planning and induction processes which the development team had set in place which had resulted in the full use of the technology in classrooms by all teachers, even if at this early stage the benefits were difficult to quantify in terms of learning.

2.5 Factors which Supported or Inhibited the Innovations

2.5.1 What were the factors which supported the innovations?

a) ***The additional ICT provision***

What were the added opportunities and advantages if any, afforded by the provision of additional mobile whiteboards?

Prior to the introduction of the technology into the science departments, the booking of time in ICT suites or in the Library in which to take whole classes had been a frustrating and unproductive experience for both teachers and pupils and incompatible with the 'use when appropriate' model of ICT integration into lessons. The original idea of mobile interactive whiteboards which allowed teachers to access the technology whenever they planned to use ICT in a lesson had originally had its attractions. However, in practice, the relatively small size of the classrooms and the narrow corridors, allied with the fact of the fixed science benches, made it difficult for the portable interactive whiteboards to be readily set up and flexibly used.

The problems with the interactive whiteboards are - I can't actually fit it in between my bench and the blackboard and so whenever I use the Whiteboard, I have to move the two cupboards in front of my bench, move the Whiteboard in there and then I have to connect up a digital projector with one of the plug sockets on the front 2 benches which means that the front 2 benches cannot then be used by pupils using the laptops as there isn't enough space. It takes a while to get it set up because …(...)…I have to get the Whiteboard from through there and because its very narrow actually getting it right through, you know the wee corridor and back round here, so it's potentially 10/15 minutes.

Because of the high level of room use, there was seldom free time between classes for the equipment to be set up before the beginning of the period.

The hardware made available through the project overall is detailed in section 2.3.1 b). The additional 3 fixed interactive whiteboards eliminated the hassle described above for all the teachers using the labs in question, and allowed the convenience of using the equipment to be extended to more staff. This had an immediate effect of allowing decisions to be made on the basis of the usefulness of the technology for the particular lesson, rather than whether time, energy and space allowed. And it not only increased the use of the equipment, but for these extra classrooms, it could be now planned into the lesson quite differently. When the boards were wheeled into the front of the class, taking up a considerable amount of room, the equipment tended to be used by the teacher during the introduction to the lesson, in a formal way, then put aside. Or the teacher would decide that the 15 minute use for which it was required did not merit the effort and disruption for the additional 15 minutes required to set it up.

The additional fixed boards allowed this very useful technology to be available throughout the lesson, and to be used flexibly as the lesson proceeded, for example for either the teacher or for pupils to project at any time any material or information they wished to draw to the attention of the rest of the class. In other words, the use was both more integrated into and more responsive to the flow of the interactions between the teacher, pupils and the subject in hand.

Factors which have been identified in other development projects as being central to effective use include sufficient access to the technology in the individual teacher's classroom (Levy, 2002). Teachers in one primary school pilot who initially considered it important for the boards to be mobile so that all staff in the school could participate in their use, concluded that the ease of setting up was critical, and the daily requirement for re-location and dealing with the leads was a significant barrier to regular use. In that study and in subsequent evaluations of interactive whiteboard use, the permanent installation of the interactive boards in each classroom has been identified as essential for regular use and benefits to be established (Smith, 2003).

b) The provision of set materials by the PTs and observation of colleagues

As indicated earlier, the PTs had generated some common material for all teachers to use within their standard S1/S2 course units. This allowed all the teachers to get started in using the technology, with a clear guide as to how it could be done. The fact that the same equipment was being used in the same units meant that the teachers had a common focus for their discussion of tips and difficulties, problems and successes. As indicated from the interviews, this was a very supportive aspect of the project, particularly for those teachers whose initial confidence and level of ICT skills were low.

> *As soon as another teacher was using it in the classroom and you knew, you would just kind of go in and see how they were going to use it for the particular block of whatever you were going to do. I had a try of it before I attempted to take it into the classroom. So it was good that there was a chance to be able to do all of this, and someone always around to help you. We are all at different levels as well.*

c) The commitment and teamwork of the promoted staff

It was clear to the evaluators that the three Principal Teachers and the AHT were committed to the success of the project. They had been proactive in driving the initial planning, and installations and had been responsive to the expressed concerns or needs of the staff in developing the support strategies for staff development. The logbooks they had set up to monitor equipment use gave them an easy overview of events, and they reported how they had actively sustained staff morale (and their own) through the inevitable initial teething problems of the technology.

> *Anyone who is embarking on a similar project I would say make sure that it's well supported, piloted, and tried out before it goes out to staff so when staff get it, its only little problems that are occurring. So there's a big job I think for the principal teachers here in particular not to be negative about this and sell it to the staff as a positive thing.*

> (What was the biggest barrier to getting it all going?)
> *Getting the network up and running to start with. We had one set of laptops up and networked and one that wasn't, the network kept going down. The initial problems were all technical, the majority of it has been technical, and it still happens. It is the case there are fewer problems than there were before, but that only because everything is getting going well now, which is great because it means you can get on with the lesson you planned.*

This has proved to be a critical phase for projects such as this, when new demands are made, new skills are needed, and staff morale and commitment is vulnerable when the technology fails leaving them with lessons planned which they cannot present, and with a class waiting expectantly. (See also para 2.5.2 a) below).

d) The positive reactions of the pupils

> *… the use of computers is something that has street cred and therefore youngsters come at it with an enthusiasm that one strives to cash in on, to maximise their learning.*

When the laptops were used, the teachers felt the pupils were more motivated, more engaged than previously. Getting such immediate and positive feedback from S1/2 pupils in particular made the staff feel their efforts with the ICT were worthwhile.

e) The forum and context for professional meetings and discussions

As indicated above, the common staff room for the three departments provided the forum for formal and informal meetings and exchanges which allowed information to be exchanged rapidly across quite a large staff group. The common focus on the set S1/2 activities gave a common curriculum context and focus for professional discussions:

> *And because we were all doing it at the same time, I think we all kept each other going because somebody would try something and would say 'oh that has worked really well' so you would think 'oh I'll do that as well'. And that is the way we have been working with quite a lot of the extra stuff we have been doing lately. I think that has really been a bonus as well. You've always got people who will help you if you are stuck. You do have that back up which has been tremendous.*

In other reports on the introduction of ICT (e.g. Simpson and Payne 2004) we have commented on one of the key differences between primary and secondary school contexts in providing a congenial forum for learning through professional exchanges about ICT use. Normally, within primary schools, the staff discussions are facilitated by the fact that all staff sit together in the primary staff room, there is a common curriculum in the form of the 5-14 guidelines, and common features of learners to be taken into account – all teachers have pupils at common levels to deal with. These conditions are seldom present in secondary developments, particularly where staff with particular ICT interests and/or advanced skills are recruited as the initial volunteers into projects. In deciding to include all staff, regardless of their initial ICT skills and to concentrate on S1/2 in the first instance, the planners of the ICT Project had created similar conditions conducive to collaborative learning.

2.5.2 What were the factors which inhibited the innovations?

a) The scarcity of technological support

In the early stages there were difficulties with the technology, particularly with respect to the necessary linkages through the Authorities IT system which is on one network and is not designed to take account of the specific uses within the educational services. It was indicated to us that although the level of support from the Authority had been good in the circumstances, any further developments of ICT within the school would meet with difficulties associated with the management of the systems:

> *I think the key problem we have is - and it is a point I have made over and over again to the Authority - if you have an ICT problem, a technical problem, the teacher needs it looking at straight away. The engineer may be in on the Tuesday, your problem is on Wednesday, you wait a week before he comes back. That is not good enough if you have got a class of kids and you are wanting to deliver a highly intensive ICT type course. I would like the type of arrangement where I have an engineer/network manager on site when I need him or her. Not a day a week. It is really not on, in the long term I don't think it is going to be feasible.*

As with many schools, their salvation has been an 'excellent school technician who has turned his hand to ICT and is basically self taught' The IT support from the Authority is recognised to be under severe pressure, but the servicing of the school system is at its limit given the present staff and the increasing amount of hardware.

b) Lack of time and guidance for development

In the national surveys relating to ICT use, teachers rate the lack of time to review software as being one of the greatest barriers to developments, and the staff in this project clearly concurred with that. Most of the science teachers interviewed in this evaluation felt they needed time to review software, and to adapt it for their particular purposes; one regretted the absence of outside expertise to assist them in this task, commenting that, as they were in the vanguard, there were few other school staff they could turn to for advice.

c) *The existing curriculum and assessment round which they have to work*

We have a curriculum which is content driven, assessment arrangements that are clearly predicated on recall of knowledge, a culture within the education profession - although for good reasons - which sees content as the most important priority. It requires a development of attitudes, a shift in the culture of schools to actually move from content to process and actually convince staff that by doing that you will get the same amount of content covered if not more.

For most of the staff, covering all the content which was set out in the course was the most important consideration when planning lessons, and those lessons which involved ICT were no different. However, in the view of one member of staff, this was driven by the exam system. Every time the external exams contained some questions directly related to a specific area of a subject, the teachers felt compelled to add it as another set of knowledge to be covered by their materials, otherwise their pupils might be disadvantaged in their certificate exams.

I am a firm believer that until we tackle assessment, how we assess pupil performance, we'll never get away from this tension. To me we have all sort of structural, restructuring of systems in schools and colleges but one thing has never changed in 100 years is how we assess kids. Until we actually move away from this paper and pencil exercise we are never going to overcome this. That was the frustration at the 20/20 science conference. To me it is a glaring omission from the whole subject of how to deliver a science education in 20 years time. If you are assessing it in the same way that you have done in the last 100 years nothing can change I find it immensely frustrating that this doesn't even get picked up by many people.

2.6 The Basis of the Decision Taking by Staff

What are the bases for decision taking on the part of staff with respect to the practices they have chosen to introduce?

The bases of the decision taking which were identified through the formal interviews and informal discussion with teachers indicated that the following could all be factors determining the decisions taken by an individual member of staff:

- the reliability of the equipment and the convenience of using it;
- their confidence in and level of their ICT skills;
- what they had seen working in another teachers' classroom, or what had been recommended as 'good' by a current or former colleague;
- the degree of enthusiasm which was shown by the pupils;
- whether the programme or activity matched well to the topics in the given curriculum.

What was clearly discernible was the value of informal staff communication and mutual support in helping the staff of the science departments to undertake a significant step in the journey towards using ICT regularly in their classrooms and to begin thinking about changes in teaching and learning. What was not discernible was an articulated or shared model of learning which could give coherence to the developments and to the experiences of the pupils and which could form a framework for the ongoing monitoring and evaluation of their plans and their outcomes. We return to this in a later round of interviews discussed in Section 5

SECTION 3: THE IMPACT OF THE TECHNOLOGY IN THE CLASSROOMS

3.1 Summary Overview of Section 3

How have the ICT resources been integrated into selected areas of the science curriculum and what has been the impact on the teaching practices? What changes have the technologies brought about in the pupils' learning activities?

The methods of data gathering included classroom observation and pupil and teacher interviews (3.2.2).
A wide range of technology was observed in use, for example for presentational purposes, (e.g. PowerPoint); for data management (e.g. Excel); for simulations (e.g. ACTIVESTUDIO); and for tutorial purposes (e.g. SCHOLAR). The extent to which potential learning gains will actually be made using the technology in these ways will, of course, depend on other aspects of the learning context known for some time to be potential limiting factors in understanding science information e.g. the level of difficulty of the information, the compatibility of the information with what pupils already know, the account taken of pupil misconceptions etc. (3.3.1 a).

The teachers had a typical range of different teaching styles which were clearly well established before the installation of the technology, and which they continued to follow regardless of whether the technology was being used in the class. These styles were derived from personal characteristics and preferences and from past experiences and determined that the technology was used in different ways and to different degrees by individual teachers, even within the set pieces which had been prepared by the PTs (3.3.1 b).

How were the pupils and teachers acquiring the necessary ICT skills?

The model of learning which was applied to the pupil acquisition of ICT related skills was that of 'just in time' learning, integrated purposefully into the science activities. This model of learning was also that being applied by the teachers to their own learning as they themselves started to use the technology for their teaching. The pupils, like the teachers, rapidly learned from each other. Teachers expressed frustration and feelings of being professionally undermined when they could not get systems to work. This suggested that having individuals with adequate technical expertise to hand to provide support was an important and valued source of learning for those teachers with limited experience, particularly at the start of the project (3.3.2).

What specific knowledge and skills within science do teachers believe are promoted by their technology use? Are these closely determined by the curriculum e.g. 5-14 or Standard Grade? Are they supplemented by the teachers' additional aims?

The aims of the lessons remained fairly tightly linked to the aims of the existing courses. The most common learning activities of the pupils were directed towards finding, acquiring and presenting science knowledge.
Generic skills: The generic skills identified by the teachers were research skills, independent learning and collaborative learning. ***Research skills*** include the use of a search engine, the ability to refine searches, recognise reliable web sources and the ability to scroll and select from information on a computer screen. These activities belong to the field of information literacy which is the area best known to and understood by librarians. The staff were becoming aware that more structure and guidance should be built into 'researching' activities to assist pupils (3.4.1 a).
Because of their growing confidence and levels of expertise with the technology, the pupils were seen to take ownership of the management of it in the classroom, and this was seen by teachers as a contribution to ***independent learning*** and the enhancement of enthusiasm for science. Independent learning is generally used in schools to mean that pupils are able to find specific information without the teacher having to present it. However, being a competent life-long learner also encapsulates the skill of knowing what kinds of questions are appropriate and important to raise in order to engage meaningfully with information on a subject. This tends not to be part of the model of independent learning applied within a school science curriculum based mainly on content acquisition (3.4.1 b).

Group work in which pupils were working in pairs on given tasks – usually searching for information and occasionally putting together a joint presentation were frequently used and were considered to be promoting collaborative skills. .Our observations suggest that the form and purpose of group tasks to support learning in science could profitably be discussed and developed across the science team with the aim of changing practice in such a way that ensures that an effective, coherent, articulate and informed approach to collaborative learning is developed (3.4.1 c).

Specific science knowledge and skills: The basic structure and content of the curriculum in the certificate years S1 to S6 had not been changed as a consequence of the introduction of ICT so the main content of the curriculum was therefore being presented largely as before, with the structure and progression unchanged. The staff anticipated that the ICT resources would allow the pupils faster access to information, a wider field of information and increased motivation through the quality of information accessed which would enhance conceptual understanding, which, in turn, would form the basis of more effective learning in later school courses (3.4.1 d).

What was the impact of ICT use on the pupils' development of skills and knowledge in science?
There is an aspiration and an expectancy on the part of all involved in the Science Project that the pupils' understanding of science will be improved. However, although there was evidence of increased enthusiasm for science, there is at this early stage in the uses of ICT little objective evidence of the extent to which the pupils have actually acquired more robust knowledge as a consequence of the use of ICT. Software is available to support virtual experiments. Some evidence from the pupil interviews suggested that the pupil responses to virtual experiments were very positive and pupils generally indicated enthusiasm for learning science through using the technology for information finding, data logging and simulations (3.4.2 a). The interview data from the pupils confirmed the teachers' view that the pupils' attention and concentration span was improved through both seeing the teachers' comments coming up on the whiteboard, and seeing information presented in a more accessible form than board diagrams or teachers' verbal explanations could provide (3.4.2 b). Some reservations were expressed by Learning Support about the extent to which the different ICT based forms of either transmission of information, or the forms of it's re-presentation back to the teacher did actually assist the slow learners significantly in their understanding of intrinsically difficult topics. However, teachers did suggest in interviews that with the use of ICT in some lessons, the burden on teacher dominated transmission and directions were reduced and more time could be available for talking and discussing difficulties with pupils (3.4.2 c).

What has been the impact on the teaching and learning activities? (3.5)
Teaching was judged to be enhanced through specific ICT use: e.g. the data projector and interactive whiteboard were observed being used to make illustrative points through good quality photographic images and an appropriate software programme. It was possible too for pupils to access software which was also on the teacher's board, and they could be talked through the software. The use of the technology also allowed a greater variety of teaching activities which actively involved the pupils (3.5.1).

Both teaching and learning were judged to be enhanced through e.g. the use of revision software; through enhanced visual presentations of complex concepts (e.g. chemical bonding); for enhancing data analysis activities through data-logging (3.5.2).

Neither teaching or learning were judged to be enhanced when there was a breakdown in the technology, or when learning activities were unfocussed on science issues, being more dominated by the ICT procedures (3.5.3).

Overall we judged that the main areas of enhancement were in the traditional activities of the teachers to enhance knowledge coverage and uptake by the pupils. Several of the Project Team Leaders indicated their growing awareness of the need to start thinking about different strategies for learning and hence for teaching. They had come to realise that the use of technology did not in itself deliver change in practices; once change in practices were identified and planned through, the technologies were merely the tools to make the changes possible (3.6).

3.2 Research Questions and Methodology

3.2.1 ICT can be used very effectively to improve many current aspects of teaching and learning – e.g. transmission of knowledge, practising of vocabulary; it can be used to extend and enhance current practice - e.g. the use of interactive whiteboards and simulations or dynamic models to illustrate difficult and complex concepts. It can also be used to transform aspects of learning contexts e.g. to allow collation or aggregation of data from remote sources; to enable online interaction with peers/experts in other locations; to support asynchronous learning etc. In this section we explore the ways in which the technology was being used or considered across the spectrum of improvement/innovation and the thinking and planning processes which determined the teachers' actions and progress.

It is also possible to characterise the learning tasks with which pupils engage in within classrooms as supporting different aspects of learning – again along a spectrum from acquisition of given knowledge and skills and practice in use, through to independent creative thinking. It was the stated aspiration of the school project that the ICT should enhance the possibilities for pupils' independent learning. Both the impact on teaching and the impact on learning were taken into consideration when the data gathering observation sessions were planned.

The research questions addressed were:

How have the ICT resources been integrated into selected areas of the science curriculum and what has been the impact on the teaching practices? What changes have the technologies brought about in the pupils' learning activities?

3.2.2 Methodology

The main method of data gathering with respect to practices in the classrooms was by direct observation. The observation schedule was devised after initial exploratory visits to the classrooms and subsequently refined by the three research team members who undertook the observations. In the final formal data gathering 26 lessons were observed (see 1.6.3 for full details).
Additional information from the teachers' and pupils' interviews has been used to supplement the observational data.

3.3 Introducing Technology into Teaching and Learning

3.3.1 How have ICT resources been integrated into the science curriculum?

a) The range of uses

The Project Team Leaders had written into their materials ways in which ICT could be used with specific areas of the curriculum for S1/S2, e.g. Solids, Liquids and Gases, variation in living things. However, in the observational data gathering, a range of uses of the technology outwith these set areas was also observed as teachers extended their activities in accordance with their level of skills and engagement with the resources available in their subject area, and used the technology beyond the S1/2 years. For example, the data projectors and interactive whiteboards were used to support an extended range of teaching activities such as the use of:

- overlaying teacher annotations on existing high quality graphics (for example with the interactive whiteboard);
- multimedia elements within teacher presentations (for example with PowerPoint);
- simulations to graphically demonstrate processes (for example with ACTIVSTUDIO on carbon bonding);
- quiz software to support whole class interaction and discussion of ideas and concepts (for example to support revision of a topic using a locally developed question bank for a Standard Grade unit).

- tutorial materials to provide a teacher-led ‘guided tour’ of new content areas (for example with SCHOLAR materials on the energy relationships)

Other uses of ICT supplemented or extended empirical investigations which were observed included:

- interactive modelling of solutions using local class data (for example with Excel);
- data-logging software to support analysis of real data in the classroom (for example while examining the insulating properties of different materials);
- data handling to focus on the analysis of information rather than its collection or manipulation (for example with Excel using data on light and distance);
- hyperlinks to bring ‘current, real-world data’ from commercial or industrial www sites to support presentations (for example using Powerpoint or ACTIVSTUDIO based study units on lasers).

Where the objectives of the course also involve the development of theoretical understanding through data interpretation, computer based systems for data capture and display can give access to an accurate data set in an easily interpretable form, in real time where appropriate, or speeded up to fit the timescale of the set periods for science lessons. This was reported to us as being used, but was not actually observed.

Uses such as these noted above do appear to have the potential to enhance the development of understanding of the pupils of complex scientific concepts. Incorporated into the lessons as an additional means of representing or rehearsing information, such uses have been shown to enhance learning for some pupils (BECTA 2003). The extent to which the potential learning gains will actually be made, will of course depend on other aspects of the learning context known for some time to be potential limiting factors in understanding science information e.g. the level of difficulty of the information, the compatibility of the information with what pupils already know, the account taken of pupil misconceptions etc. (Osborne et al., 1983; Driver and Scanlon, 1988; Simpson, 1990; Monk and Osborne, 2000)

b) The influence of idiosyncratic teaching styles

One of the main influences on the way technology is used by teachers is their typical personal repertoires of teaching, or teaching style, consequently, a package which we saw used by different teachers was used in very different ways even when ostensibly they were following the same guidelines. The teachers had a typical range of different teaching styles which were clearly well established before the installation of the technology, and which they continued to follow regardless of whether the technology was being used in the class. One teacher, for example, reported having used the individual pupil laptops a lot, and seldom felt the need to use the whiteboard; another reported having used the interactive whiteboard regularly, but felt the case for using the laptops was much less.

Some teachers expressed words of caution on the use of their locally produced common resources. Although the local ownership of the materials was identified as a major strength by the project developers and all the teachers interviewed acknowledged the value of being provided with common materials, some insisted that their own experience suggested better approaches, exemplification and teaching orders. As a consequence they stressed the importance of being able to adapt common materials to support better their own lesson planning. Their judgement of what was better than the set piece was based on their own experience of what had worked for them in the past:

> *It’s difficult to use other people’s materials. I have my own way of presenting ideas. It’s good to think about other ways of doing things but I think I have it right sometimes. I have a lot of experience.*

Thus different teaching styles derived from personal characteristics and preferences and from past experiences determined that the technology was used in different ways and to different degrees by individual teachers, even within the set pieces which had been prepared by the PTs. As a consequence, although almost all the episodes we observed of technology use had changed the activities of the teachers and learners, it was almost certainly the style and predilections of the teacher in the way the specific technology was deployed as much as the use of the technology per se which determined whether the optimal degree of learning enhancement was being achieved.

The initial set materials in the S1/2 courses had served a valuable 'scaffolding' function in supporting novice users of the technology to get started with their classes, but teachers clearly preferred materials which were also flexible enough to allow them to diversify in their use. This is perfectly reasonable, provided there is a common framework or articulation of what constitutes 'quality' in the use of ICT in different ways, and some evaluation of the outcomes in relation to the framework or the specific learning intended. We were not aware at any stage of such a framework, and return to this in Section 5.5.

3.3.2 How were the pupils and teachers acquiring the necessary ICT skills?

In order to engage effectively with the technology, both pupils and teachers, had to experience learning in two different areas: firstly, acquiring or extending their skills in the use of ICT, and secondly, using the application of these skills to further their teaching and learning in science.

The model of learning which was applied to the pupil acquisition of ICT related skills was that of 'just in time' learning, integrated purposefully into the science activities:

> *I see absolutely no purpose what so ever in being taught a Microsoft office package or whatever, in isolation. Because if you do that you'll forget everything. I have got evidence to prove that. I have now a class of first years who are pretty proficient at PowerPoint, many have never seen it before, starting to do presentations. Even pupils who are not significant achievers are now very confident with Word and PowerPoint. Now to me, you learn what you need from the package to do the job. 'Just in time learning'. To me that is the most effective learning in ICT.*

This model of learning was also that being applied by the teachers to their own learning as they themselves started to use the technology for their teaching. The acquisition of skills within the context of a purposeful activity in teaching or learning a school subject is in contrast to the approach typically offered to pupils within Computing Departments, where the acquisition of the skill is disassociated from content matter, and is polished by engagement in practice tasks – this model was the one with which the teachers were somewhat unhappy within the NOF training. (See Section 5 6.2) (NOF training refers to training opportunities for teachers funded through New Opportunities funding by the central UK government. It takes different forms according to the different providers, but in this Authority, teachers proficient in basic ICT skills act as tutors to colleagues in their school through demonstrations and set exercises).

Any teaching of ICT to pupils which was mentioned to us was described in a contextualised form – for example, some pupils were taught how to apply tabs when they were using databases. As can also be seen from the pupils' responses (Section 4), the high level of demands on the pupils' ICT skills is not seen by the pupils as a significant factor in this project. The pupils are generally up to speed in the skill levels required; for pupils with less secure skills the teachers reported an increase in their confidence in using ICT, and as is typically found in most pupil populations, the skills of some pupils exceeded those of the teachers. The pupils' skills were also recognised by the teachers to be increasingly developed as they came through from primary schools and used computers at home. As Scottish ICT survey data has also shown, there tends to be no simple or typical age related gradient in skills and experience from S1 to S4 (Condie et al. 2002). As one teacher in the school observed:

> *Their skills have increased so much, to the extent that they can do that now. With the 4th years I can now open an excel spreadsheet and select the data, whereas 3 years ago if I did that with a higher class I would have had to say 'this is what a spreadsheet is'. So ICT skills are becoming more a part of their lives, so again we can use them more. We are not having to teach the ICT skills and looking three years ahead again, I would hope that that is more the case.*

An additional feature of the type of learning was the extent to which the pupils (like their teachers) rapidly learned from each other. However, as the data from the Project Leaders indicated, these new resources, and the subsequent extension of their uses by the individual teachers which we observed in classrooms, were developed without any reference to the 5-14 ICT guidelines, any school ICT policy, or knowledge of the ICT requirements on pupils or ICT skills developed, used or required in other subjects. If the school is to support a range of departments introducing ICT, different initiatives based on ICT, and generally move significantly towards learning through ICT, a number of aspects of ICT need to be dealt with at whole school level.

For example, although no pupil indicated in the interviews that they had no access at home, it was clear that, either because computers were 'broken' or not readily accessed by the youngster, (see section 4) there was indeed a 'digital divide' which could seriously disadvantage some pupils. The lack of overall awareness of the teachers of the guidelines and of what was going on elsewhere in the school (e.g. in the Computing Department, or ICT courses) could lead at the very least to unnecessary duplication or omissions in their teaching, and at worst to a lack of overall coherence in the expectancies put on and the experiences of the pupils. This fragmentation of activities on the part of the staff and different departments was evident elsewhere (see section 5).

The instrumental and 'just in time' nature of the ICT learning preferred by many teachers extended to their familiarity with network infrastructures and procedures. Several inexperienced users made reference to the importance of their having confidence that systems work routinely and that they would be able to get round problems as they arose in classroom use. As they acknowledged that this confidence could only develop over time and with experience in the classroom, they placed special importance in having technical support and help at hand in their first attempts to use the technologies. They expressed frustration and feelings of being professionally undermined when they could not get systems to work. This suggested that having individuals with adequate technical expertise to hand to provide support was an important and valued source of learning for those teachers with limited experience at the start of the project (see Section2.5.2 a).

3.3.3 ***What changes had the technologies brought about in the pupils' learning activities?***

Given the variety of ICT-based packages being used, and the adequate level of competence of most pupils in the use of these packages, what were the common forms of application to enhance learning in science?

We observed the pupils actively engaging with a variety of packages in the context of learning science, for example:

- general purpose packages **-** e.g. Word or Excel;
- presentation packages – e.g. PowerPoint;
- interactive tutorial packages – either intranet-based (e.g. from the ACTIVSTUDIO suite) or internet-based (e.g. SCHOLAR);
- data-logging packages;
- interactive quiz packages;
- internet search engines;
- data analysis and graphical presentation packages
- document stores and collections.

The main difference in the learning activities which were taking place in the context of ICT use, in comparison with lessons in which ICT was not used, was that rather than accessing information directly from the teacher, from texts or from engaging with practical work, they accessed the content from novel ICT based sources, for example:

1. from general science information web sites, which had been found by pupil initiated searches;

2. from teacher selected web sites that frequently had a tutorial format, leading them through interactions which could be individual or whole class;
3. from teacher-produced learning materials e.g. created using the PowerPoint package;
4. from highly structured tutorials e.g. on ‘the carbon cycle’ hosted by SCHOLAR;
5. from packages which supported the logging and easy manipulation or presentation of locally captured experimental data.

The products of their search for or their electronic encounter with the given pre-specified knowledge was frequently not presented in written reports as hitherto, but in ICT formats, primarily PowerPoint. When these activities replaced the worksheet activities, teachers expressed concern that they might not have the information to hand for later revision. Where the information search was structured, as with the functions of the body within S2, pupils built up their own notes, often in a Word file, which they could later access as revision material. The focus of this search was not a PowerPoint presentation but a summary of notes which might eventually be worked into a presentation. However, with acids and alkalis, although each pair of pupils had a different topic to research, the focus of the activity was the building up of a PowerPoint presentation. As a result, there was evidence that for some learners the challenges presented by the PowerPoint design competed with a focused engagement with the content of their research. In other lessons, pupils were instructed to record the results of information searches in their jotters, but were expected to use the information discovered in PowerPoint presentations for class use. Individual pupils had no access to the group presentations beyond the time of the presentation to the class. As a result, paired ‘research’ and presentation tasks offered students an experience of only a limited area of the curriculum – their chosen or allocated topic. Listening to the unrefined presentations from their peers is unlikely to have extended and enriched their learning in those other areas. Although the active use of the school website as a resource for pupil learning should assist with this difficulty, it was not being used in this way at the time of our observations and interviews.

3.4 The Enhancement of Pupil Learning within Science

3.4.1 The aims of the teaching in the science curriculum

What specific knowledge and skills within science do teachers believe are promoted by their technology use? Are these closely determined by the curriculum e.g. 5-14 or Standard Grade? Are they supplemented by the teachers’ additional aims?

There are two different features to be considered here, the generic knowledge and skills and those specific to science. Firstly the generic skills: these included research skills, independent learning and collaborative learning.

a) Research skills

The evidence suggests that teachers believe in particular that the ICT resource enhances and refines student ‘research skills’. The teachers valued pupil research activities as giving them valuable experience in seeking, reading, selecting and deciphering information from a number of sources. Now whilst these research skills might also be identified as featuring in other subject areas, history and modern studies for example, they formed a key element in the shared vision of science in the group of teachers interviewed:

> *Research is an important skill for science. I believe you need to be able to do this in science. This skill is more important that simply having factual knowledge about the subject.*

The skills associated with such a task include the use of a search engine, the ability to refine searches, recognise reliable web sources and the ability to scroll and select from information on a computer screen. These activities belong to the field of information literacy which is the area best known to and understood by librarians. That the teachers (in this school and more generally) are not familiar with the characteristics of these information literacy skills which are central to and developed within librarian services was clear both from our interviews and from national survey research carried out recently in schools (see Williams et al. 2003). Attendance at a presentation by Alan November had alerted one of the Team Leaders to the need for guidelines for both pupils and staff and she intended to enlist the aid of the school librarian in devising these.

Staff were thus beginning to see that helping students to adapt to and make the most of this new internet landscape was an important additional key skill in science, and a valuable element in the progression of pupils' development as effective independent learners through their school careers. The S1 and S2 research and presentation activities therefore potentially articulated well with the demands to be made of pupils when faced with supported self study which characterises learning in years 5 and 6.

Teachers generally have increasingly appreciated that the web offers such a vast amount of information that they need to offer students more guidance on just what to look for in their research time. Other research in this field, for example Chaplin (2003), suggests that a clearer structure, perhaps in the form of a research and writing frame, benefits students by helping them to focus their minds, make more efficient use of their time and indeed help them shape their presentations more effectively. The evidence suggests that staff in the science department have arrived at this conclusion and will be reviewing their practice when next using ICT for extended 'research' tasks.

There is however evidence that teachers recognise the need to maintain a balance between learning through 'research' and learning in a whole class teacher led situation.

> *The software gives a better build-up and background but the teacher's explaining skills are needed as an intervention for learners. Then the software can be returned to. I do this with the whole class and sometimes with individuals. There are lots of times when you want to take the whole class together. So there is the danger of death by a thousand PowerPoints but there is still much to be gained by the collaborative nature of ICT project work.'*

b) Independent learning

> *(benefits to learning?) I think the enthusiasm that the children show for science. I think I can guide them towards the science more easily by using the ICT, and they love being involved with it and I love giving them the ownership of getting the laptops out, the ownership of setting up the whiteboard for them, setting up the projector. I like giving the ownership of the class to them and I think the ICT helps me with that, it's no longer me, just me, there's a bit of machinery around that's helping me and they like that machinery and they take charge of it and I think it gives them an ownership of their learning much more easily than I could do without the ICT. Enthusiasm, motivation - yeah that's the biggest for me.*

The model of teaching and learning in the Critical Skills programme is based on a considerable amount of thoughtful preplanning with respect to the learning processes, expert support and intended outcomes associated with any activity in order to allow learners to exercise their valued freedom and experience of ownership in a context which is likely to be effective.

The pupils certainly exhibited confidence in the setting up of the technology, and were observed setting up laptops and power supplies, logging onto user areas, and packing away the items safely. The process of handling the hardware, setting up and plugging in was the first stage in a sequence of independent learning tasks characterised by the way the lesson unfolded. When they had the opportunity to move about in the classroom and take charge of the laptops the pupils had potentially embarked on the first stage of an independent learning journey. In this sense, it is impossible to divorce the responsibility for setting up the hardware and accessing the learning resources with the responsibility for continuing with one's own learning task. However, there were occasions when the process of setting up the equipment etc was done by pupils only to be stopped and attention refocused on the teacher who then embarked on a whole class lesson in which the ICT resources were used sparingly. In such cases the momentum for independent learning was not capitalised upon.

There was a danger, noted by one teacher, that the pupils' skills and enthusiasm for the technology would drive the teachers to use it even when it was not necessarily the best way of dealing with the learning. But in order to decide this, teachers had to think carefully about the learning intended:

> *One of the skills for teachers to acquire is when to decide it is not appropriate. In many cases it is not. When is whole class teaching using a whiteboard appropriate, and when is it appropriate to make the classroom more fun? Let's be honest! And to try and move on from this notion that a teacher's job is to shovel loads of facts into young people's heads. And I see ICT being one of many means by which that can take place. Yes, I suspect, particularly in senior school we'll be much more individual self-study, IT support. The learning experience could be much richer all through the school using ICT but I certainly don't see this as threatening teachers. I see it as very much … hopefully I see it as one of a number of tools.*

Independent learning, is generally used in schools to mean that pupils are able to find specific information without the teacher having to present it. However, being a competent life-long learner also encapsulates the skill of knowing what kinds of questions are appropriate and important to raise in order to engage meaningfully with information on a subject. Pupils learning how to ask different kinds of profitable questions tends not to be part of the model of independent learning applied within a school science based mainly on content acquisition.

c) Collaborative learning

The term 'learning to work collaboratively' as a valued outcome of the uses of the technology was frequently mentioned by the teachers. It appeared to us that this usually meant that pupils were working in pairs on given tasks – usually searching for information and occasionally putting together a joint presentation.

The use of group work as it is practised in primary classrooms has the purpose of allowing different groups of children to work at different levels on the curriculum. A primary teacher may have four or five activities at different levels in e.g. in writing, reading or mathematics going on in her class. The use of group work in secondary schools for this purpose is almost unknown – most classes work on exactly the same materials at the same time and differentiation is built into the extent to which the teacher offers support, or the level of work deemed acceptable from pupils with different skill levels. Group work may also be used as a means of giving people practice in working in teams, a skill valued by employers, given the changing nature of many workplaces. This aspect of learning is carefully and thoughtfully built into the Critical Skills programme, since learning how to work in a team does not happen simply by doing it.

> ***Collaborative learning:*** *a collaborative learning community is a deliberately constructed classroom culture within which teachers and students support one another in pursuit of clearly articulated goals.* (see Appendix 4)

As the coaching kit shows (EBD 1999), in order to manage group work for this purpose, a well informed teacher needs to know how to set up tasks to allow profitable collaboration to take place, how to support and monitor the activities and how to de-brief pupils so that they all learn from their experiences. The materials make a distinction between pupils working together, working in a group, working as a group, and working collaboratively. The last of these is the context within which learning as conceived within the field of social constructivism takes place. Group work in science which is aimed at this important form of learning is planned in such a way that particular forms of pupil discussion are deliberately prompted by the interventions of the teacher.

Our observations suggest that the form and purpose of group tasks to support learning in science could profitably be discussed and developed across the science team with the aim of changing practice in such a way that ensures that an effective, coherent, articulate and informed approach to collaborative learning is developed (see Section 5).

d) Knowledge and skills specific to science and the 5-14 and Standard Grade curriculum
The basic structure and content of the curriculum in the certificate years S1 to S4 had not been changed for any year group as a consequence of the introduction of ICT. For example, the set ICT-based activities in the S1/2 curriculum had been inserted into the already existing curriculum. The intention was that not only would the generic skills noted above be developed, but that learning of the science skills and information specific to these courses would be improved. The main content of the curriculum was therefore being presented largely as before, and the structure and progression were unchanged.

> *Hopefully they have a better understanding of some of these difficult concepts that are difficult to visualise and that will translate into better learning later. If you can get an understanding of the concepts in the lower school then that should follow through. And obviously there are transferable skills in terms of researching skills. In terms of their understanding of science, I would hope that they would be able to visualise things more.*

Thus the range of ICT uses were introduced without radical changes to curriculum or content. On several occasions staff made reference to the ICT resource as allowing children faster access to information, a wider field of information and a increased motivation through the quality of information accessed. The hope was that this would enhance conceptual understanding which would form the basis of more effective learning in later school courses.

The nature of ICT materials and the web sources of information allows the linear curriculum to be challenged, as learning does not happen in a linear fashion unless subject to constraint and distortion. An approach based on more loosely constructed areas of knowledge can offer pupils a far richer and more stimulating learning landscape. The 5-14 curriculum allows for rather more scope in this respect than the Standard Grade. The flexibility introduced when pupils had access to rich and extended set of e-resources was exploited occasionally to allow pupils to take charge of the direction as well as the pace of their learning. For example, small groups in an S1 class were allowed to choose individual themes for investigation from a pre-established set within a topic description according to their interests. However, as one teacher indicated, the flexibility which the use of ICT potentially allows sits uneasily within the rigid framework of the subject oriented Standard Grade:

> *The ICT doesn't always offer the sort of learning which the Standard Grade courses expects – it allows a little too much breadth – a breadth that Standard Grade doesn't reflect.*

The linear and knowledge dominated curricula of the secondary school can be served, and perhaps learning within it improved, by using ICT, but the technology offers the possibility of a richer and more appropriate learning experience in science when the curriculum is differently conceived (see for example, Miller, R. and Osborne, 1998; Osborne, 2000; Nuffield, 2003).

3.4.2 What was the impact of ICT use on the pupils' development of skills and knowledge in science?

a) the impact on understanding in science
There is an aspiration and an expectancy on the part of all involved in the Science Project that the pupils' understanding of science will be improved. However, although there was evidence of increased enthusiasm for science, there is at this early stage in the uses of ICT little objective evidence of the extent to which the pupils have actually acquired more robust knowledge as a consequence of the use of ICT. The results of one early exercise in testing which had been done by the teachers themselves in one of the specific areas in which ICT had been used (solids, liquids and gases) had not proved reassuring:

> *I was quite disappointed because I did spend a lot of time doing this project with solids, liquids, gasses, using the ICT, you could just tell the kids were enjoying the program. When it came to the actual test, it is probably the test we have had for the last ten years and needs up-dating, maybe to be more relevant on the ICT, but tests tend to be used for years and years unfortunately … but em,*
> Interviewer: There wasn't a huge difference in the test results?
> *Well, compared with other results, no, I must say, no. As far as the programs are concerned, in S1 and S2 the kids obviously do enjoy getting the laptops out, using the laptops. I think if they are*

interested then they are gaining something, rather than from textbooks. So I think it seems to be beneficial.

Thus, although the technology appeared to be engendering more enthusiasm and interest on the part of the pupils, the question remained: were the pupils learning better? The Project Team Leaders were clearly aware of this challenge still being potentially unmet, and were struggling to think of a way forward. The key, they thought, was related to the structure of the tasks offered as learning experiences and their sound basis on a science education rationale.

But on a formal level I think we really have to say 'how are we … what are the sort of tactics and techniques we use for interacting with the pupils and how are we ensuring that they are actually learning and not just being amused by it?' I found sometimes when they are researching information, I found that some of the kids are very good at finding information but not very good at analysing it. And how do we structure things, how do we ask the right questions to help them to do that? To help them to actually engage with it. When it works well it is great. (Project Team Leader)

It is wrong to assume that finding information and working at it independently will result in a deeper understanding of science - that the research activity *per se* will result in a clearer understanding in science. Newton and Rogers (2003) suggest that learners derive benefit only when ICT activities are chosen for which there is a clear science education rationale:

Uncritical use of ICT carries the risk of offering pupils a poor experience which wastes their time, misleads their thinking and distracts them from the purposes of science..

Our classroom observations suggested that extended ICT research tasks offered students some opportunities for collaborative work in pairs via the exploration of sources of information and the planning of presentations. Whilst these activities allowed the development of ICT skills there is no evidence to suggest that such activities resulted in an enriched understanding of concepts in science.

A second area where teachers hoped to identify learning gains is that of handling variables and recognising relationships. Using dataloggers linked to laptops students can record data faster and use the analysing facilities within the software to interrogate the data and make sense of it. These analytical skills build upon the foundation laid down by the thinking skills training of the CASE programme:

The cognitive acceleration approach is full of good ideas and helps focus on methods and good science. The data loggers help children to think differently as scientists. They come to understand that science is not just experiments on the bench that go right or wrong but that they can say something about a situation with variables - input and output-and what ones they are looking at to make a fair test.

However, some teachers when interviewed indicated they were not involved in the CASE initiative and could not comment on links between their uses of ICT and the skills promoted in CASE.

The second change in learning activity lies in the use of virtual experiments in science. Software is available to support Standard Grade courses in particular. This software includes demonstrations of key experiments. Some evidence from the pupil interviews suggested that the pupil responses to these virtual experiments are very positive. The experience is seen as a cleaner way to do science - real science being far more messy, smelly and unreliable. The researchers saw very little bench practical work in their series of observations. In one class the observer listened to a discussion on simulated experiments by pupils, in which they clearly were of the view that they enjoyed these more because they always went right. They seemed to be turned off by the typical school science practicals which occasionally didn't work. In the virtual world, experiments were clean, didn't smell and always worked. This was clearly seen by this group as the best kind of 'science'. However, one very articulate sixth year pupil in interview clearly saw value in the uncertainty of real science.

Pupils generally indicated enthusiasm for learning science through using the technology for information finding, data logging and simulations. Potentially science is no longer dominated by the smelly, messy, labwork with broken equipment and unconvincing results. But this is a new type of science experience, one which is clean, modern and engaging. In a sense this environment is one in which an education in science can be redefined; new and different skills can be practised and a new set of attitudes generated towards science lessons. In a sense this is potentially the start of a move from real science to virtual science. McFarlane et al. (2002) distinguish between the use of ICT as a tool within the investigative process, and the use of ICT as a substitute for the laboratory based element of the investigation. She argues that computer –based simulations may provide better support for the development of theoretical understanding than practical work. However, she also emphasises that the choice of task need to be carefully matched to the learning objectives to ascertain when the use of a good computer-based simulation would be most likely to support the intended learning. In order to engage fully with the development of appropriate ICT based materials, teachers need to begin talking about the nature of science and the kind of learning which will be involved:

> *Simulations. I have accept wholeheartedly that science should be real, it should be messy but sometimes the nightmares of science can actually get in the way of the principles whereas a simulated experiment, where you know that you are not going to have to deal with extraneous problems, you can get to the actual physics, so it is extremely useful.*

b) The impact on motivation and interest

As indicated above, the main activities which were described in the interviews and which were seen in the observations were primarily concerned with the acquisition of knowledge and the presentation of that knowledge. And the immediate response of all the teachers when asked to comment on the benefits to learning was to indicate that the pupils' motivation was greatly increased and their enthusiasm for science especially in S1 and 2 was markedly better in comparison with previous years.

> Interviewer: So, how would you envisage persuading SEED or others that this has all been worthwhile? What is the best value you see coming out of the ICT science project? What makes you say 'I am convinced this is worthwhile'? What would it be?
>
> *Teacher: The motivational aspect. The enthusiasm.*

> *There are a lot of people who detest science, just don't like the subject and yet are happiest whenever I give them a science project which uses the laptops and they can actually work and find things out for themselves. To me that's the most satisfying thing, the fact that if the pupils enjoy it or pupils get more from it than what I could possibly teach them just on the blackboard then that's what it's all for at the end of the day.*

The interview data from the pupils (section 4) confirmed the view that their attention and concentration span was improved through both seeing the teachers' comments coming up on the whiteboard, and seeing information presented in a more accessible form than board diagrams or teachers' verbal explanations could provide.

c) The impact on the slower learners

The teachers also considered that there was a positive impact by the ICT on those children who had been put at a disadvantage by the teachers' typical approaches:

> *I'm noticing a bigger difference on a motivation scale because less able kids get nothing but negative feedback if you like a lot of the time. They can't take part in class discussion because they don't really know the answers but there's an insularity about the laptops. It's just them that know when they are wrong. One of the comments that went out in the newsletter to parents - I collected a load of comments from the class about what they thought was good about the laptops and one of them was - you can be wrong without anybody knowing and they just self assess and get them right and I think they feel on the same level as everyone else because they are sitting at a laptop just like everyone else. In a traditional system the ones who are doing well seem to be, you know, the ones who are favoured somehow. In a traditional lesson you do try hard to include everyone but inevitably the keen*

enthusiastic more intelligent ones will tend to take over more of the talking time in the class. I think also the thinking skills, some of the traditionally less able, one pupil in my first year class who excels in thinking skills had a really high mark in CASE and has a good mind for problems but doesn't do well in traditional remembering and stuff.

This was true also of PowerPoint presentations and the use of other packages:

That definitely, you could see youngsters who are not the most able, were enthusiastic and worked hard at it and derived a great deal of pleasure and confidence from it. There was one pupil in particular who is very shy about speaking out in class and where she would have been teased for that, she liked the Whiteboard and went on to the next slide, to the next slide and I think it took her forward that day.

From observation I would certainly say the less able pupils in the class do get into IT. Whereas if you shoved a textbook in front of them I think they would be struggling. I think quantifying this is very difficult. I suppose it is one thing, we haven't sat down and talked about 'is it benefiting everybody or is it only benefiting a certain group of people?' It is just from observation, as I say, even the less able kids on the whole do get into IT. Most of the programs we have used have been very good.

In the interviews with Learning Support staff reservations were expressed on the extent to which the different forms of either transmission of information, or the forms of it's re- presentation back to the teacher did actually assist the slow learners significantly in their understanding of intrinsically difficult topics (see sect 4). A science teacher confirmed that there may be difficulties masked by the slick PowerPoint slides:

'They are very keen on using ICT. The alternative energy worked well. Some can understand it and write it up well. Some copy it straight out and if you ask a question you see that they have not understood it at all. The poor ones just copy it out.'

Teachers did confirm in interviews however, that with the use of ICT in some lessons, the burden on teacher dominated transmission and directions were reduced and more time could be available for talking and discussing difficulties with pupils.

3.5 Enhanced Teaching and Learning Contexts

What has been the impact on the teaching and learning activities?

Although most teachers expressed a conviction that the use of the technology aids the learning of some complex concepts more effectively than conventional resources, and that the enhanced motivation and engagement with the activities prompted by the pupil laptop use implies for them that learning will be better, the teachers and the research team did not find a way of generating secure evidence that this is in fact the case. In addition to the complication of the very different teaching styles deployed by different teachers when using the same technology, there was the added difficulty which has also beset research on variables such as class size: if the ICT based teaching strategies and classroom activities fail to take account of some of the key factors necessary for generating improved learning, is it likely that the independent variable (the introduction of ICT) would make a difference?

For example, we saw 'Crocodile Clips' selected for use in a classroom to offer different levels of demand on pupils, and to offer self-pacing of the learning. One teacher was enthusiastic about the programme and what it offered. However, use of the programme per se does not guarantee improvement in learning. As another teacher observed:

It is when things are less formally structured and even there are quizzes and things on it that does get them engaged a bit more but they can float through things very easily. With Crocodile Clips in physics, I find that they sometimes just skim through the information without really doing all the things to it that they are meant to do. I think that is where we need to say 'how do we actually change our teaching methods, how do we actually make sure that we are actually using it to enhance their learning'. There is no doubt that it is a good babysitter. They will be happy using *the computers. They enjoy using them. But is it doing the science better? We have got to make sure that that happens.*

As we have already indicated the idea that effective use of the technology perhaps needed a different approach to teaching than that currently used in school science was beginning to be discussed by the Project Team Leaders. This requires further professional learning beyond mere competence with the technology. Differences in the interactions of the teacher with the pupils, or in the way the lesson was structured through the use of the ICT packages was perhaps the key determinant of enhancement of learning, rather than the mere use of the technology itself. We return to this in the final section when considering models of good practice and how to increase the probability of that enhancement happening.

Following our observational sessions in classrooms, we tried to classify the episodes observed with respect to the enhancement of the teaching and learning by the use of the technology.

3.5.1 In what context was teaching enhanced?

Some examples of ICT use appeared to complement and enhance the activities of the teacher, particularly when science knowledge was being introduced or reinforced. For example, the data projector and interactive whiteboard were observed being used by a teacher to make illustrative points through good quality photographic images and an appropriate software programme. In other classrooms the use of PowerPoint by the teacher to prepare and amend diagrams before the lesson resulted in clear and efficient presentations with no time being wasted in writing or drawing on the board, and the filling out of the worksheets could be done as whole class activity, leaving the pupils with good notes for later review and revision. The teachers commented on the degree of flexibility this afforded when amending diagrams for different groups or classes. It was possible too for pupils to access software which was also on the teacher's board, and the teacher could talk them through the software. The use of the technology also allowed a greater variety of teaching activities which actively involved the pupils – e.g. getting pupils to drag the answers to set questions into the answer boxes. Pupils were allocated different aspects of a topic to find information on – e.g. different elements in the periodic table or different body systems, with the aim of presenting their findings, usually on PowerPoint slides, to the class.

In these instances, the learning may well have been improved by the pupil engagement generated by the novelty of the use of the technology, but the lesson content and style was basically the same as might have been presented using paper resources, and the planned outcomes of the lesson overall did not appear to change in any additional way by the use of the technology, for example, to enhance understanding of the nature of science, or promote independent learning. However, it did allow teachers to introduce more variety into their presentations of information and into the activities of the pupils, all of which appeared to have a positive motivational effects and were highly commended by the pupils (see section 4).

3.5.2 In what context was both teaching and learning enhanced?

The use of the technology to streamline or improve the teachers' presentations does not guarantee the enhancement of the learning of the pupils. However, we did observe its uses in ways in which we judged the learning to be aided.

a) Focus on Revision

For example, the laptops were observed being used by a group of Higher pupils who were doing some final revision for the next day's NAB assessment using SCHOLAR. NAB is the National Assessment Bank which offers end of unit assessments which provide stepping stones within Higher Still courses. The pupils were extremely focussed on their revision, working individually at their own pace, in areas of the material where they judged their own need for revision was greatest, and they received no formal input from the teacher other than general management and technical input as appropriate. The use of the laptops allowed the pupils to target their own areas of learning thus making the most efficient use of the available revision time provided no more than their rehearsal of material was what was required. The episode thus allowed more pupil controlled revision to take place, the learning mainly comprising practice on content to be covered for an exam.

Active models and multimedia presentations in tutorial packages (such as SCHOLAR) were augmented to good effect by additional teacher commentaries. The teacher used the online material as a structured visual resource with the whole class, but added a commentary in which different interpretations were offered and possible explanations tested. The lesson took the form of a ‘conducted tour’ of the content, led by the teacher’s ‘out loud thinking’ but with a strong emphasis on building understanding and testing knowledge. The online resource allowed the teacher to ‘model’ and make visible his thinking about the science content and so communicate his enthusiasm for the subject matter.

b) Dealing with difficult concepts

When dealing with some difficult or complex concepts, the use of the technology allowed the teachers to offer presentations which enhanced the visual representation of the material, for example the use of simulations of changing population characteristics, allowed pupils to interact and manipulate the variables. Diagrams and animations in specific topic areas, e.g. solids, liquids and gases; the breathing system; the electric motor; were regarded by the teachers as a significant improvement on what they had presented previously, through teacher drawn or other static two dimensional sketches in texts. The use of complex diagrams or animations rather than text based materials and teacher exposition linked well with the VAK (Visual/Auditory/Kinaesthetic) inservice which the teachers had experienced, which had suggested a need for variety in the medium of presentations. The pupils’ observations on the benefits they identified from the use of ICT supported this view (see section 4).

For example, in a lesson on different forms of chemical bonding the teacher and pupils used a model projected on to the interactive whiteboard to explore the construction of different molecules. While this activity could have been supported on a blackboard or with a physical model, the interactive whiteboard, along with the use of colour and movement, and the opportunity to annotate the completed model, appeared to contribute to the effectiveness and impact of the presentation.

One example of technology used to good effect was seen in an S4 lesson about genetics and inheritance. Good use was made of interactive software relating to fruit fly genetics. The teacher directed the learning, using a PowerPoint and interactive whiteboard to summarise key learning outcomes but at the same time punctuated the lesson with challenges presented on the laptops via a standard grade genetics package. This appeared to us to be an example of a well-crafted lesson, planned in advance to offer different kinds of learning challenge and support with the best use of ICT built into the lesson plan.

c) sharpening the focus of data analysis

When dealing with data and the analysis of data to support experimentation we observed a number of situations where the use of data logging and manipulation software delivered benefits for teaching and learning. These learning benefits combined aspects of learning about science and the development of more generic learning skills.

These packages helped sharpen the focus of activity on analysis. Teachers using these packages expressed an enthusiasm for the features of these packages which allowed pupils to concentrate on the *analysis* of the data rather than their reproduction or the more mechanical aspects of data handling. Thus they hoped that these packages would help pupils to see experiments as opportunities to explore the relationship between variables and to search for pattern and meaning in data. They saw the software as a means of allowing pupils to re-run experiments in search of consistency. Additionally, they saw that using such software would allow findings to be replicated and represented more quickly. As a result they saw that pupils could spend more time on the critical examination of the data and so develop their capacities for arriving at judgements based on evidence - in science settings and more generally.

For example, in a lesson on different forms of insulation the teacher and the pupils used a set of temperature probes linked to data logging and presentation software to explore the insulating properties of different materials. While this experiment could have been carried out without the use of such software, its use allowed the pupils to take much more direct control over the experiment and to concentrate their thought and analysis on the results rather than the mechanics of their production.

However, our observations suggested that the use of such software was not yet a matter of routine and that teachers' practice involving its use is still evolving. The teachers have found that the apparatus is complicated to set up and adjust initially. As a consequence it is necessary to set up the software and apparatus in a room especially so that it could be used repeatedly with classes. Experience with the software appears to show that the pupils need to be supported if they are to see the purpose of the experiment and are to be able to analyse the findings and arrive at sound judgements about what the data reveal. This observation, therefore, provided another illustration of the general point that the use of ICT tools *can* provide an enhanced context for learning, but *only* where use is allied to good and confident teaching closely targeted to the articulated learning outcomes.

3.5.3 In what context was neither teaching nor learning enhanced?

a) Breakdown in technology

When no enhancement was judged to have occurred, the problem frequently lay with the technology. For example in one case the network was so slow that the planned lesson ground to a halt and the exercise was eventually abandoned. This highlights the need for the technology to be checked for the robustness of its working before teachers are expected to use it. If the technology is unreliable for any reason, teachers are forced into double preparation:

And it is likely you have booked the computers for this period, you can't get them any other time and the system is down so what do you do? So all this planning that you have put in, that is the end of it. So there always has to be a plan B I think, with this. And I think we are now getting to the stage where sometimes we don't have a plan B because we are getting so used to just being able to book them out - you come in and everything doesn't necessarily go swimmingly well but, you have planned for that and most of the time it works. Then when it doesn't it just all falls down around you and I think you have to be more ready for when that sort of things happen.

b) Unfocussed activities

On some occasions, however, the technology was working effectively, but the use to which it was put did not in any way harness its power to the advantage of the teacher or the learners. An example of this was when pupils were left to use the resources made available through the use of their laptops to find and copy material as notes for some unidentified future use. They were observed searching for material in a very haphazard manner rather than having a structured input from the teacher to aid guide their work. It was clear that the students were barely engaging with the task or valuing its purpose. The teacher merely ensured there was an acceptable level of quiet and was engaged on some other pressing administrative task.

The creation of PowerPoint slides by pupils, where there was no explicit or shared view of the learning or subject related purpose was also classified in this category. The pupils were purposefully engaged in the task, but the criteria for success tended to be given in terms of the number of slides, the text and the use of diagrams etc. rather than in terms of the advancement of understanding of content or other aspects of science. This activity may have enhanced the skills of some pupils in creating PowerPoint slides, but the advantage with respect to the learning of science was not clear.

There were a number of instances when it seemed to the research team that there was a need to be alert to the distortion of the pupils' concept of the nature of science. The blanket cutting and pasting of paragraphs, some of which were not intelligible to the young learners, perhaps represented both a wasted opportunity for learning for 50 minutes, and left the learners believing that successful learning in science was about assembling factual data in a colourful way. One teacher raised this possibility with the observation:

> *....and they couldn't pronounce some of the words 'and the polype..pe..peptides have' and I said 'well, what are they?' I said 'well that's really good you did a great presentation and that's really very advanced for what we need to do but what we could do for next time is go away and search and use the laptop to find out what this polypeptide is and come back and tell us next time.' I feel it's taken them way onto things that perhaps we don't need to be on at that particular time but maybe*

> *that's the old grumpy traditional teacher in me being too narrow minded in exam focus. I should be more relaxed about it.*

Both of these illustrations point towards the need for teachers to consider reviewing the ways in which they structure their lessons and guidance for the pupils and as we have already indicated, this was becoming clear to the teachers themselves from their experiences.

> *As far as researching topics, presenting their findings, you have to be very careful that it doesn't just become a general 'lets run up through Google and see what we can find'. It has to be kept reasonably tight so that the benefits outweigh any time wasting.*

We recognise that our observations have occurred at an early stage in the potential development of a new pedagogy relating to the enrichment of learning in science via ICT aspired to in the Project proposal. We would judge that the main enhancement for the pupils to date has been in those more traditional learning activities, in particular the acquisition of information in covering the expectations of a knowledge laden curriculum. There is no doubt that the new ICT resource has a beneficial effect in motivating learners to engage with science. However we observed repeatedly that the use of technology per se, no matter how interesting or visual the images presented, did not automatically create a context which ensured enhanced understanding in science. It is encouraging that there appeared to be a growing awareness of this critical issue among several teachers within the Project Team Leaders.

3.6 How far have classroom developments progressed?

Until the end of 2003 the achievements of the project can be seen in terms of a trajectory towards the discussion and advancement of changes in their approach to learning and teaching. In the initial stage, technical issues and problems tended to dominate. Team discussions initially centred on removing barriers to learning created by technology that did often did not work reliably or consistently. The staff and their Team Leaders found themselves in technical problem solving mode for much of the time in their classrooms and they had little time to experiment with or reflect on opportunities for enhancement of learning. Once the initial technical problems were largely solved and pushed into the background, the teachers could concentrate on experimenting with different forms of the technology in their classrooms.

As their technical competence increased and their confidence in a range of classroom uses grew, they began to diversify their uses in accordance with their personal plans and teaching styles. However, as we have indicated, these were fairy well confined to the enhancement of traditional teaching strategies particularly designed to promote knowledge coverage and uptake by the pupils. It was clear that the project had served as a valuable setting in which the team could potentially discuss and develop shared ideas about learning and how it might be enhanced by the use of ICT. These discussions appeared to become more common as the project progressed, but were still largely confined to two of the Project Team Leaders.

The identification of quite ambitious learning benefits had been a feature of the early project planning, but reflection on the progress of the project in practice led to a review of how this might be achieved. For example, while the project proposal was couched in terms that suggested that the use of ICT would of itself deliver more independent learning, in practice two of the Team Leaders came to the realisation that such benefits required the technologies to be harnessed to serve appropriate teaching and learning approaches and classroom techniques. These approaches and techniques had to be discovered, invented and shared in practice. The use of technology did not in itself deliver change in practices; once change in practices were identified and planned through, the technologies were merely the tools to make the changes possible.

In the next section we review in greater detail aspects of their progress in the late stages of the Project period, and consider the kind of learning models which might prove useful for further developments in their context.

SECTION 4 THE PERSPECTIVES OF THE PUPILS

4.1 Summary Overview of Section 4

The pupil interviews

Overall, twenty nine pupils (20 male, 11 female) were interviewed: 20 in May 2003, 16 in May 2004 – seven were interviewed on both occasions. They covered all year groups and a range of abilities. Pupils in S1/2 were interviewed in pairs, the older pupils as individuals (4.2.2).

What have been their experiences with the technology at home*?*

Although all pupils said that they had access to a computer at home, some were reportedly 'broken', and had been for sometime, while some pupils had 'privileged access' – i.e. access to family computers in addition to their own personal laptops. Factors such as informed support from or competition with siblings and parents, personal preferences for writing by hand, in addition to beliefs regarding the benefits of word processing were all reported as determining the range and frequency of PC use at home (4.3.1 a).

Home computers were regularly used for homework, particularly using the Internet and word processing, including 'cut and paste'. Most pupils indicated a clear understanding of plagiarism (4.3.1 b). The school web page provides a very useful resource which could enhance partnerships between the home and the school but its use was still at an early stage and few pupils reported using it (4.3.1 c).

Where did pupils acquire their ICT skills?

Pupils had mainly acquired their ICT skills in the home or primary school, and in IT classes, computing or business studies in the secondary school (4.3.2).

When asked about experiences of using ICT as a learning tool in the school subjects, Modern Languages, Geography and English were mentioned. The interactivity of the programmes was the key factor in generating enthusiasm and approval (4.4).

What have been the benefits and disadvantages to their learning in science lessons?

Pupils reported more control and independence, the aiding of comprehension and recall of information, and increased understanding prompted by animated or three dimensional representations. Clearly the technology had contributed to assisting teachers and pupils to bring variation to what had been hitherto a predominantly talk and text dominated situation. However, as one sixth year pupil observed, having a whiteboard did not necessarily mean a teacher would teach better. The disadvantages identified were associated with the early difficulties with the technology (4.5 a).

Was the technology used to support pupils with learning difficulties?

The classroom observations and pupil interviews indicated that all the pupils were reporting benefiting in some degree from the way in which information – either in the form of knowledge or instructions – became more engaging and accessible through the use of the computers. However, the subject materials and the programmes and sites used were not in any way differentiated and all pupils read or interacted with the same level of material. No activities or programmes were seen in the observations or reported by pupils which were specifically designed to be helpful to slow learners or those with particular learning difficulties. The allocation of additional time to the Learning Support staff for consultations could support the improvement of this situation in the future, and ultimately lead to a more coherent approach to learning within and across the different subject areas (4.5 c).

Did the laptops have a beneficial effect on pupils' attitudes and motivation?

Overall, pupils from across year groups indicated that they benefited from the use of lap tops in science subjects. With a few exceptions, most pupils were positive and enthusiastic (4.5 d).

Did the technology detract from practical engagement in science?

Information in the first round of interviews had suggested that there might be a trend away from interest in real hands-on science in favour of the clean and certain world of the simulations. However, specific questioning of pupils in the second round indicated there was still an enthusiasm for hand-on experiments. Most pupils appeared to favour the sometimes *'smelly'* and *'messy'* practical experiments undertaken in class. Older pupils (i.e. those in S6) were found to appreciate the way in which use of lap top programmes in conjunction with hands on experiments could facilitate and ease their understanding of science (4.5 e).

4.2 Research Questions and Methodology

4.2.1 Research Questions

The broad aim of the interviews with pupils was to elicit the opinions and views of the pupils on their experiences and the impact of the use of the technology on their learning experiences.

The specific research questions addressed the following aspects of the project:

The experiences of pupils with the technology to date – both at home and in school (including use of the school website).
The benefits to their learning in science lessons.
The use of the technology to support pupils with learning difficulties.
The interaction between hands-on and virtual science.

4.2.2 Methods

a) The Pupil Sample

Pupils were interviewed at two points during the evaluation: at an early stage in May 2003 and then a year later in May 2004. Twenty pupils took part in the first round of pupil interviews in May 2003, and sixteen pupils in May 2004. With regard to the second round of pupil interviews the original intention had been to include, as far as possible, the same pupils who had been interviewed in the first round of interviewing during May 2003. Unfortunately, due to periods of internal examinations for third year pupils and external examinations for S4 and S5 pupils this proved an impractical plan. Moreover, sixth year students who had previously taken part had since left the school. In total, thirty one individual pupils took part in interviews, seven of whom were interviewed twice over the two rounds of interviews.

In order to access a range of pupils' experiences of ICT, a cross section of pupils across the ages and stages were included in the sample. Pupils from S1 through to S6 took part, and included some taking Standard Grades, others taking Intermediate Level courses, Higher Level or Advanced Higher courses. In addition a few pupils identified as having specific learning difficulties also took part. The sample thus included pupils with a wide range of abilities, with a male: female distribution of (20 : 11)

b) The processes of interviewing the pupils

Slightly different methods were employed for younger and older pupils. The older pupils (S3, S4, S5, & S6) were invited to take part in individual, one-to-one interviews, while the younger pupils (S1 and S2) were interviewed in pairs. Given that that the researchers were unknown to pupils, paired interviews were regarded as a more suitable method for younger pupils who might be less inclined to talk openly in a one to one situation with an unknown adult (see Garbarino 1992). Paired interviews were found to work especially well in terms of encouraging younger pupils to speak out, and to share their views in the company of a friend or classmate. A prompt sheet was developed in order to elicit more extended responses from younger pupils specifically in terms of their views on the advantages and disadvantages of the use ICT in their science classes. In addition, a checklist covering word-processing and other tools (e.g. use of spell and grammar check), as well as internet searching activities was used in the second round of pupil interviews, to structure the information gathering on the extent of pupils' ICT use and skills.

While there was some overlap between the two interview schedules, the second round of pupil interviews provided the opportunity to explore their experiences more fully at a time when the technology had had more time to 'bed in' since at the onset of the evaluation, the young people's experience of ICT use in science was fairly limited and the innovation less integrated into the science curriculum. Consequently, pupils in the second round were able to provide more considered explanations than previously.

c) *Ethics and consent*

In keeping with 'best practice' with regard to ethical research with children and young people (see Alderson, 1995) the research was fully explained to the pupils. They were informed in appropriate language about the rationale for the research and how the information would be used to help other schools introduce ICT into learning and classroom activities. This information was relayed to pupils in both verbal and written forms. All pupils were asked to sign consent slips and were given information to take away about the research project. They were also asked for their permission to tape-record the interviews and the confidential nature of participating in interviews was explained fully at the beginning of each interview.

4.3 The Pupils' Experiences of Computer Use

4.3.1 Access to and use of a computer at home

What have been the experiences of pupils with the technology at home?

a) Personal access to a computer

Home uses were explored in terms of how and when computers were used, and particularly in relation both to set homework tasks and to extension of activities beyond the immediate tasks set e.g. seeking out additional relevant websites.

Most pupils stated that they had access to a PC at home. At one end of the spectrum pupils described what could be termed 'privileged access' to a PC at home. For example two pupils indicated that they enjoyed multiple access to what they called a 'family PC' with printing facilities and access to the internet, in addition to having their own personal laptop. According to these pupils, their parents purchased a laptop specifically in order for them to do schoolwork:

> *We've got a family computer. I've got like – me and my big brothers we've got one in a separate room for us to play games on and stuff which doesn't take up the memory of the other one. And me and my big brother have got a computer with no internet access, just for school work.'* (Female Pupil S1)

By comparison, and at the other end of the spectrum, a few pupils said that they had PC at home but they were 'broken' or had crashed. Significantly, one pupil who participated in the both sets of pupil interviews stated in May 2003 that his PC was 'broken' and intimated this again during the subsequent interviews conducted in May 2004. This raises the possibility that not only do some pupils not have access to a PC at home, but that for others, the access maybe severely limited or restricted. It is also relevant that pupils who do not have a working PC at home may be prohibited from openly disclosing this in an interview or other educational setting where materially advantageous circumstances are described by other pupils. Such a 'digital divide' (see Valentine et al 2002) requires to be acknowledged when evaluating the impact of ICT on pupils' competence and learning. Other research findings have demonstrated that differences in pupils' home access tend to heighten inequities (Deaney et al 2003).

Overall, the majority of pupils said they had access to a working PC in their home and evidenced a variety of family circumstances and attitudinal characteristics which appeared to impact on their use at home. Factors such as competition with siblings and parents, personal preferences for writing by hand, in addition to beliefs regarding the benefits of word processing were all reported as determining the range and frequency of PC use at home. This suggests that patterns of home use are a complex issue and are mediated by a number of different attitudes and social factors.

b) Using ICT at home for school work

To what extent did pupils use computers at home for school work?

In order to elicit information regarding pupils' word processing and ICT skills a check list of activities was used in interviews with the young people. This allowed discussion of a number of activities including the use of spell check and cutting and pasting. In undertaking home assignments, a range of word processing tools and searching for information on the internet appeared to be used as a matter of course by most pupils:

> *I use it (PC) for homework and things – writing English essays and it can correct all my spelling.* (Male Pupil S2)

Some variations in responses were found in relation to the cut and paste facility and this function did not appear to be utilised fully by all pupils. One sixth year pupil for example, provided a critical view of the spell check function and its value. This pupil said that she disliked American spelling and was also sceptical with re-wording suggestions provided by the auto grammar check. As a consequence, she said she rarely, if ever used this facility.

When asked about accessing and using information from the internet, many pupils said that they regularly undertook this activity, gathering information for school projects (i.e. on specific topics such as kangaroos, football and gangsters) and other homework assignments. Some pupils also indicated that they used the 'cut and paste' function to gather information from internet sources which they then saved for later reference in a Word document. In the context of discussion about searching for information from internet, some pupils communicated an awareness of plagiarism. They made statements such as: *'you don't use the same words'* as the text gathered from web based sources, and emphasised that: *'you must put it into your own words'*. Clearly the message regarding copying information appears to have been taken on board by a number of pupils. One pupil observed they would be penalised if they used verbatim extracts; if *'found out'* and discovered by teachers, pupils indicated that the consequences were serious, and that no marks would be given for work copied from internet sources.

c) Virtual Links: the home and the school

What uses were made of school website?

The school web page provides a potentially very useful resource which could enhance partnerships between the home and the school. During the period of the evaluation the site, which had been developed by staff and pupils in the High School, became active and pupils were asked about their use of this in the second round of pupil interviews. They were shown a visual image of the main web page of school site in order to gain an immediate and spontaneous response from pupils. All pupils indicated that they were aware of the site but they appeared to have made limited use of it at the time of interviewing. However, some pupils did say that they found the web site useful for accessing information especially for notification of school events and dates of school holidays.

Pupils reported that some subjects (e.g. geography) teachers had demonstrated the subject link web page in class and pupils' were shown how to access useful links. Other pupils also said they were aware of subject related links but few younger pupils reported that they had accessed these resources independently at home. Nevertheless, younger pupils did anticipate that the site would be a very a useful resource as they progressed up the school and embarked on the exam syllabus.

In the initial stages of the evaluation there were some indications that there were expectations of potential benefits of the flexibility offered by the ICT interface between the home and the school. At that time only a few instances of how pupils exploited this flexible interface were brought to our attention. For example the following sixth year pupil explained how work undertaken at school could be completed at home and then e-mailed to his teacher:

> *It's good to do it on the computer straight away. And I finished it off at home and was able to e-mail it to my teacher.* (Male pupil S6)

Similarly, during the second round of pupil interviews only a couple of young people mentioned the use of this type of link between the home and the school, suggesting that any developments were still in the early stages.

4.3.2 The Pupils' Acquisition of ICT Skills
Where did pupils acquire their ICT skills?

a) The home and family

Many pupils said that they learned their skills at home with a proficient and supportive parent or sibling. Mothers, brothers and fathers were all mentioned as skilled and available people who would troubleshoot when young people found themselves in difficulty at home. The specialist knowledge and expertise of family members was often highlighted and appreciated by pupils:

> *Both my dad and step dad work in IT so I've been around computers for ages.* (Male Pupil S2)

Alternative sources of knowledge proved significant for other pupils. The primary school was identified as an important source of competence and confidence by a few pupils, especially those in S1 and S2 who had transferred from primary school relatively recently. It was also the case that the primary school context was important from the point of view of a few pupils who indicated that they had limited access to a PC or little previous experience. For example one S3 pupil reported that a particularly ICT aware and competent primary teacher had developed and raised her skills in this area. Finally, a few pupils maintained that they were self-taught and had learnt through experience and by *'messing around'* on computers.

b) Within the secondary school context

A few pupils raised the issue of using in science ICT skills transferred from other subjects. They clearly appreciated being able to put their skills to purposeful uses with science.

> Interviewer (JB): *So do you think there's any advantage of using the laptops in science?*
> Pupil 1: *Yeah.*
> Pupil 2: *Yeah, because like you can use CDs which makes the work much more enjoyable because they've got wee games and stuff.*
> Pupil 1: *And they've got videos and things on there.*
> *Pupil 2: 'Cos we get IT in schools as well and we can use all the skills from that in science rather than not doing anything with them.* (Male Pupils, S2)

Pupils identified specific subjects where they had formally learned various ICT skills within school, for example some pupils mentioned Information Technology courses in first year, as a helpful source of building skills and confidence in ICT. Other useful subjects mentioned included Modern Languages, Geography and English where pupils said that they had benefited from the use of ICT in their course work. One pupil illustrated that subject choice had a significant impact on developing skills:

> *There was business studies in second year and that's where I learnt to touch type. And then there was computing. It depends on what you take as well cos' if you don't take computing you're bound not to be as good as others that have taken computing* (Male Pupil S4)

4.4 Using ICT in Secondary School Subjects

a) What uses have they experienced in other, or earlier school subject contexts?

In particular, pupils identified language learning (i.e. French and German) as a subject where they had also experienced and appreciated the use of whiteboards in class. These were described as being used to good effect particularly in the teaching of German. Pupils who raised this issue referred to the use of smart boards and the way in which it could model pronunciation and aid spelling:

> *There are loads up there* (Language Department). *I think there are about five or something* (Interactive whiteboard). *They are really good, especially in German. Cause you need the spelling for it. But you can see it up on the board and that is good.* (Pupil 11 Interviews 2004)

Another subject area highlighted regularly by pupils was geography. A specific programme for a geography topic on volcanoes was mentioned and clearly pupils were impressed with, and enthusiastic regarding this particular programme.

b) What have been their specific experiences within their science classes?

As we have indicated in section 3, the technology was used in a range of different ways within the science classrooms. Just as the teachers used the technology in traditional practices, so the pupils used the technology for the old routines of drill and practice, although the technology made the processes more engaging. For example they mentioned the use of specific programmes which took the form of individualised revision using lap top programmes and quizzes, in addition to group revision activities undertaken by the whole class. The interactive nature of the activities were more attractive than the traditional reading and writing tasks:

> *I think in first year we did solids, liquids and gases. And it was a programme we had for that. I prefer like a programme with more like interactive, answer questions and fill in stuff. And that was like that.* (Male pupil S2)

A few pupils became animated and were extremely positive when they described a voting system described as being like: *'the TV programme 'Who wants to be a Millionaire'.* In this context, all pupils cast their vote for 'right' and 'wrong' responses. While the individual pupil was aware of their own performance (i.e. whether their own answer was correct) this information remained private and was not relayed to the class as a whole. Yet the teacher and this S3 class were able to see the extent to which the class group had successfully grasped a topic area.

4.5 ICT and Learning in Science

a) What have been the benefits to their learning in science lessons?

During the second round of interviews all pupils were asked whether they had particular examples where they thought that the use of ICT (i.e. the whiteboards or use of the lap tops and programmes) had in some way assisted their learning about science. In response to this question pupils raised issues directly linked to the learning of science, as well as more standard examples which could apply to ICT and learning more generally. Pupil accounts of their learning experiences tended to differ between groups of pupils (younger/older, academic/non academic).

One learning benefit described by pupils related to self-control and efficacy. One pupil described her sense of autonomy and independence when engaged in researching and preparing a power point presentation with another pupil:

> *Oh I enjoyed just looking up all the stuff and like just, like managing it all yourself and doing what you wanted to. That was good.*
> (Female pupil S2)

Some pupils thought that using the laptops aided their comprehension and recall of information. A pupil explains her perspective:

> *Like if you were sitting with a text book in front of you, I don't usually remember it. Whereas if I'm on a package I'll remember: 'Oh! That was on the laptop'.* (Female pupil S4)

When explaining the advantages of ICT pupils often made comparisons with book learning, teacher talk and the use of lap top programmes. As the following illustrates, laptops can make concentration and uptake of information easier for pupils than teacher talk:

> *When the teacher is talking about something the mind drifts off whereas the laptops right in front of you can just …… I can't think of the word.* [Focus? Concentrate?] *Yeah – that's it.* (Male pupil S3)

Some pupils who intimated that they commonly encountered difficulties in understanding instructions given by teachers indicated the use of technology helped them over this difficulty. For example the following pupil explained how the use of whiteboards in his science class had been beneficial:

> *It can be hard to understand what the teacher is saying. It's good to understand how it is on the whiteboard cos' you can see it. But it's hard to listen and like take down things. The smart board*

> *is working quite well cos' like you can see what they are saying at that moment.* (Male pupil S2)

In the interviews, visual learning of topics was frequently mentioned, as were software programmes with accompanying games and quizzes. These new vehicles for learning were positively commented on by pupils. A particular issue raised was the three-dimensional representations of science concepts. Visual explanations of this nature were thought to bring specific advantages. According to some pupils their learning was greatly enhanced and consolidated by such 3D imagery. In the following example a pupil talks about acceleration:

> You actually get to see it and the process of it working rather than just trying to imagine in your head. Cos, I've not done physics before and it's a bit confusing when you hear all these fancy words. *(Female pupil S6)*

Clearly the technology had contributed to assisting teachers and pupils to bring variation to what had been hitherto a predominantly talk and text dominated situation. This variation as a means to support different learning styles had been recommended in the VAK (Visual, Auditory, Kinaesthetic) in-service programme which had recently been run in the school. And the pupils indicated the benefits. However, while this can improve communication and uptake of information, some S6 pupils tended to be more circumspect and critical. Their views were especially informative since they were in an ideal position to reflect on the use of more traditional teaching methods and the use of ICT in the curriculum:

> *I think ICT can be seriously overdone. I think a teacher standing in front of the class simply because they have a whiteboard doesn't mean they are going to teach better - whatever the colour of the board. And having notes in front of you can be a million times more useful than having a computer screen.* (Female pupil S6)

More effective communication of information does not necessarily improve learning. We shall return to this in section 5.

b) What did pupils see as the disadvantages of the laptop use?

In the initial round of interviews the pupils did report a downside. Similar to the experiences of teachers, the negative drawbacks identified were largely confined to technical hitches and associated problems. In the following a pupil represents a fairly typical view where the uncertainty in securing a reliable network connection and loosing information was considered a set back:

> *You see, we do a lot of work on the computer and sometimes you can't go on it because the networks down and you've lost a lot of your files.* (Male Pupil S2)

Some pupils raised the issue of technical hitches (e.g. problems getting logged onto the Internet) and broken equipment when asked about disadvantages of using ICT in the classroom. By the time the second set of interviews were undertaken these technical hitches had largely been overcome.

c) Was the technology used to support pupils with learning difficulties?

The classroom observations and pupil interviews indicated that all the pupils were reporting benefiting in some degree from the way in which information – either in the form of knowledge or instructions – became more engaging and accessible through the use of the computers. However, in the science classes, the subject materials and the programmes and sites used were not in any way differentiated. All pupils read or interacted with the same level of material. No activities or programmes were seen in the observations or reported by pupils which were specifically designed to be helpful to slow learners or those with particular learning difficulties.

The principal teacher of Learning Support confirmed that some of the subject information given in the programmes was at a level beyond the understanding of some pupils, although their work could result in a neat and impressive presentation. In his view, the more interactive the programme, the more the subject was potentially made accessible and he had seen the use of some materials which he considered extremely supportive of learning. With the allocation next session of more time for consultation between Learning Support and the subject teachers, he was anticipating it would be possible for discussions about the learning involved in different science units to be discussed at an earlier stage in their development and indeed saw these discussions as being so important that all subject teachers should be involved so that a more coherent approach to learning within and across the different subject areas could be established.

d) Did the laptops have a beneficial effect on pupils' attitudes and motivation?

As in most studies of technology use in schools, the majority of pupils reported increased motivation and interest when ICT was introduced to the science classroom activities. Many pupils interviewed at both points in the evaluation did refer, in general, to the 'fun' and enjoyable aspects of the use of ICT.

> *When you see the teacher bring out the laptops you know it's going to be a good lesson* (Female Pupil, S5 Interviews 2003)

Interestingly, even when pupils talked about their direct experience of using the laptops in the classroom they appeared to become more animated and interested. This observation would seem to further support pupils' verbal accounts of increased enthusiasm!

e) Virtual versus 'hands on' experiments

Did the technology detract from practical engagement in science?

Information in the first round of interviews had suggested that their might be a trend away from interest in real hands-on science in favour of the clean and certain world of the simulations. However, specific questioning of pupils in the second round indicated there was still an enthusiasm for hand-on experiments.

Most pupils appeared to favour the sometimes *'smelly'* and *'messy'* practical experiments undertaken in class. While the benefits of the 'virtual experiment' were acknowledged, including the obvious advantage of being able to observe a dangerous or complex experiment that might not otherwise be available, pupils expressed a clear preference for 'hands on', practical experiments. The independent and active learning afforded by practical experiments was said to be one of the benefits of the 'hands on' experiments:

> *If you learn it yourself you know what you've done wrong, or not done wrong. But if you've done it on the computer, it's all there for you.*(Male pupil S4)

While the experiments carried out on laptops were observed to always go according to plan and run smoothly, the success of 'hands on experiments' were observed to be more precarious and uncertain. Important implications can be drawn from these differences, not only with regard to the strengths and limitations of ICT, but also for teaching and learning about the nature of science. Comparisons in both in terms of the 'tidy' and predictable outcome of the virtual experiment, in contrast to the business of actually 'doing' a practical experiment, appears to provide a unique opportunity for science learning. This kind of learning situation could be harnessed and exploited by teachers, in order to explore and the foundations of scientific knowledge.

In the following example a sixth year pupil described his experience of a positive use of ICT in science. This is a significant example since he aptly illustrates how a laptop used in conjunction with a live experiment can enhance learning in science:

> *A lot of them are controlled by the laptops* (experiments*). Sixth years get to use some of the electronic equipment that's been bought in and they run it off a real time system. So if we were doing an experiment, for example I was doing a PH measurement and I was using a titrator, I'd do it physically. However the computer will be graphing it for me instead while it's going away.* (Male pupil S6)

An interesting characteristic of this example is the image of 'seamless and joined-up integration' of ICT which parallels science teachers' views about what constitutes successful integration of ICT in the teaching of science. In this context this particular pupil said that use of ICT was *'more accurate'* than manually graphing the experiment yet this worked in unison with conducting a conventional experiment. Importantly, in this instance ICT complimented and enhanced the learning of science, interacting fruitfully with established methods of learning.

SECTION 5: TEACHERS AS LEARNERS AND THE LEARNING SCHOOL

> *How do we move from the current position – which I would describe as ICT enriching a traditional approach to learning and teaching – how do we move to a shift that allows people to be more self directive and independent? This is the huge task ahead. We are dealing with a culture that has been embedded for a long, long time. We are slowing moving away from this but have a long way to go yet.*
> Project Team Leader

5.1 Summary Overview of Section 5

Achievement of the Aims of the School Project

Had the aims of the school project been achieved?

It seemed to us there was much evidence that the technology had been very successfully introduced into the science classrooms of the school, from S1 through to S6, and was in regular use (5.3.1).

What factors had been the key to the successful initial adoption of ICT?

Two general strengths had contributed to this success: the initial thought and planning given to the introduction of all staff to the technology; and the initial processes of regular demonstrations, modelling sharing and practising. A Project Team Leader gave the following pointers to other school staff considering a similar initiative:

1. plan in detail for the integration of ICT into the lessons, not used as an add on;
2. involve all staff not just the enthusiastic;
3. ensure continuity of coverage across the curriculum and the year;
4. embed and integrate into pupil activities for active learning;
5. start with staff development and invest a lot of time in it;
6. after school staff sessions are important;
7. share experience and expertise in different areas across the team;
8. develop sharing and trust.

He/she felt that the development of trust was easier to establish with respect to the use of technologies than in areas related to teaching and learning. People who would be happy to indicate they were unable to use some aspect of the technology would be more wary of saying 'I can't do this style of teaching or support learning like this'. (5.3.2)

Had the project promoted the development of new ways of learning and teaching?

There was rather less evidence that the project had succeeded in the aspiration set out in the original project proposals that the use of the technology would usher in '*new ways of learning and teaching in science subjects'* as indicated in the original Project proposals (5.3.3).

Had the Project had an effect on attainment in science?

We could not find nor was it possible for us to generate data within this project which could link any changes in attainment or in the uptake of science to the use of the ICT. The project was in far too early a stage and other factors within the school were more likely to be influencing any variation from previous years (5.3.4).

What factors were likely to influence the future developments?

Staff identified the following as influencing their further developments: the fading of the initial novelty factor; the need for materials to be more fully integrated into the curriculum rather than slotting into an already existing curriculum; the extent to which staff were feeling overall 'innovation overload'; their identification of a need for a more structured approach particularly in the tasks given to pupils (5.4).

What models of learning would be appropriate for future consideration?

It is increasingly recognised that the improved learning and the transformation of teaching are not guaranteed merely by the presence of the technology. In our view there had been no opportunity or context for science staff to overview the aims and objectives of the range of different initiatives which had already been introduced into the school (CASE, VAK, Critical Skills etc.) to see the common threads and to capitalise on the commonalities in order to optimise their understanding, save duplication and - most importantly of all - to give a coherent experience of education within the school to the pupils (5.5).

At the end of the first phase of the project (Dec. 2003) we generated some models of enhanced teaching and learning based on the activities with we had seen in our classroom observations and structured in the form of Critical Skills principles (Appendix 1) which we hoped might offer a context for the staff to discuss aspects of ICT and learning as well as teaching (5.5.1). At this stage we were advised that although individual teachers would continue to develop their skills and different ways of using the ICT in their own style and for their own specific purposes, there was unlikely to be further significant developments in the thinking and discussions of the whole staff group in relation to the overall aims of the project during the management reorganisation period (5.5.2).

The Impact of the School's CPD Programme

What has been the impact of the school's CPD programme on teacher competence and confidence in using ICT in science and in developing the school learning community?

A questionnaire was devised in consultation with the ICT co-ordinator, and was circulated to all the school staff in the Spring of 2004. 24 teachers (28% of the teaching complement) responded, representing 16 departments including Guidance and Support for Learning (5.6.1). The responses from the staff sample indicated that their basic computer-using skills were well consolidated. The access to ICT in their classrooms varied widely but the figures appeared to indicate that the level of regular use in classrooms was low. The obstacle most frequently identified to further use was access, either to the equipment per se or to the classroom beforehand to set up in preparation for the next lesson (5.6.2 a).

What were the staff experiences of Staff development?

No staff member had undertaken Masterclass training but most had completed their NOF training. Only a minority indicated that they found it a positive and useful experience (5.6.2 b)

What forms of CPD did they value?

The form of staff development most frequently engaged with (96%) - and in this questionnaire the most highly rated in terms of usefulness - was informal discussions with immediate subject colleagues, and for a minority, (25%), meetings with subject colleagues from other schools. For 88% of the staff, 'exploring through trial and error in my own classroom' received the next highest rating of usefulness. While experienced by a majority, (75%), whole school in-service with outside input was rated as the least useful of all the forms of staff development listed, with external award bearing courses and subject-oriented professional journals also rated on the 'not useful' side of the scale (5.6.2 c).

What are the key characteristics of staff learning?

The model of teacher learning which emerges from a variety of studies indicates that the development of teachers' knowledge and use of ICT is an individual and subject centred model. The planning and leadership associated with the early phase of the project (Section 2) allied with the challenge presented by the novelty of the ICT use allowed a small but powerful learning community to develop within the science department. For developments to move forward in a unified way however, strong curriculum or management leadership would be required (5.7.2).

The Developing School

How can the school develop further as a learning community?

The model of planning, inclusion, support, practice and modeling adopted by the Science Project Team worked well in creating a productive 'learning community' of teachers who successfully engaged with ICT and began its regular use in classrooms. However, it is not certain that all staff would wish to change in any radical way, and subsequently individualistic developments were being adopted by most of the science teachers now they were familiar with the technology. The literature on school development suggests that at this stage the school needs to work together on developing a unifying statement about the features of its philosophy and practices in learning and teaching. The Critical Skills Coaching Kit offers a model of key ideas for developing coherent classroom approaches (5.7.3). The school was identified as being at level 3 on the Mooij and Sweets (2002) model of school development with respect to ICT implementation (5.7.4)

Why should secondary schools seek to develop innovative pedagogy ?
Arguments are advanced for the adoption of the innovative pedagogies which the powers of ICT enable. The development of appropriate innovative pedagogies must involve teachers in the two way process of bridging theory and practice. This project demonstrated just how challenging and professionally stimulating such pedagogy-led technological innovation can be when the ownership of development is put in the hands of a team of teachers committed to curriculum development as a vehicle for their own professional development.

5.2 Research Questions and Methodology

In this section we reflect on the processes of the continuing implementation, the contexts in which the teachers have successfully learned how to use ICT and ways in which the momentum of development could be taken forward both in the science department and in the wider context of the emergence of 'the Learning School'.
Had the aims of the school project been achieved?
What has been the impact of the school's CPD programme on teacher competence and confidence in using ICT in science and in developing the school learning community?
How can the school develop further a learning community?

The methodology included meetings with the school Project Team Leaders, interviews with members of the Team who had contributed to the development of the ICT curriculum materials, with key school management staff, and Learning Support staff.
A questionnaire on their ICT use and staff development experiences was sent out to all school staff.

5.3 Achievement of the Aims of the School Project

5.3.1 Had the aims of the school project been achieved?

It seemed to us there was much evidence that the technology had been very successfully introduced into the science classrooms of the school, from S1 through to S6, and was in regular use. The staff had weathered the early technical problems, and there had been careful and thoughtful planning in the initial stages which had ensured that all the teachers in the science staff group were included in the initiative, had seen good practice modelled, were fully supported in their learning and had consequently increased in their confident, regular use of the technology. Clearly, the first stage of the introduction of ICT into the science courses had been successfully implemented.

5.3.2 What factors had been the key to the successful initial adoption of ICT?

We identified the following as strengths which had contributed to success:

a) the thought and planning which had been given to introducing the technology to the staff, the support of the promoted staff throughout the early phase and the common forum and focus for subsequent staff discussions and learning. We consider that this, rather than a focus on what technology was used and how should be one key message to other schools or colleagues planning similar ventures with staff new to the uses of ICT.

b) interacting with this was the type, scale and management of the technology. The fact that they achieved and sustained regular use of the equipment was because of the setting in which they could all use it regularly, demonstrating, sharing and practising on a regular basis, thus allowing snags and difficulties to be overcome through maturing practice. This is in contrast to the professional development which takes place outside and fails because of the complete change of setting and requirements for use when it is applied in a classroom.

One of the school Project Team Leaders identified the following factors as being central to their success and presented them as advice to others:

- plan in detail for the integration of ICT into the lessons, not used as an add on;

- involve all staff not just the enthusiastic;
- ensure continuity of coverage across the curriculum and the year;
- embed and integrate into pupil activities for active learning;
- start with staff development and invest a lot of time in it;
- after school staff sessions are important;
- share experience and expertise in different areas across the team;
- develop sharing and trust.

He/she felt that the development of trust was easier to establish with respect to the use of technologies than in areas related to teaching and learning. People who would be happy to indicate they were unable to use some aspect of the technology would be wary of saying 'I can't do this style of teaching or support learning like this'.

5.3.3 Had the project promoted the development of new ways of learning and teaching?

There was rather less evidence that the project had succeeded in the aspiration set out in the original project proposals that the use of the technology would usher in '*new ways of learning and teaching in science subjects'* as indicated in the original Project proposals. It seemed from our observations of the lessons in which ICT was used and those in which it was not used, that despite the introduction of technology, these science lessons were very similar. They were also similar to those of other schools and classrooms, whether or not ICT was used, and they largely comprised typical school science learning activities, in which pupils engaged with learning traditional school science information.

The teaching was mainly a mixture of teacher presentation of predetermined content, exposition, demonstration and pupil interaction; the teachers showed a wide range of teaching styles, with different teachers using different strategies for moving the lessons forward through the set material and securing the interest, motivation and diligence of the pupils on the given tasks, and using different degrees of latitude for pupils to follow independent activities with respect to the content and any interaction with it. When ICT was added, the teachers clearly used the technology differently from each other – even when the ICT related activity was prescribed within the curricular material – depending on their professional skills or preferences with respect to technology, teaching styles and classroom management strategies. Nevertheless the most common pupil activities took the form of seeking out factual information (often designated 'researching'), copying it into personal resources (e.g. notes in jotters); or (less frequently) using apparatus to investigate some given phenomenon; subsequent writing up of reports or summary key points (using PowerPoint) for presentation to others (teacher or peers or both). Visual presentations and animations were effective in aiding pupils to understand factual information previously presented in texts.

Almost all studies which investigate the introduction and use of ICT in schools indicate that the major feature of the outcomes has been the use of ICT to apply the traditional functions and practices of the schools – particularly knowledge transmission and acquisition. Significant innovations in pedagogy simply do not take place.

> *Even given the wide ranging and rapid changes around them, most teachers continue to discharge their role in a conventional manner: as sources and transmitters of knowledge to students in a classroom. ....The expertise of the teacher continues to be defined as a mixture of the mastery of knowledge and classroom management; it is not defined as understanding how students learn and enabling them to do so.* (Lewis 1999; pg.147)

In studies within Scotland, practices already existing in the teachers' repertoires continued to predominate regardless of the use of the technology Condie et al. 2002; Simpson and Payne, 2002. Nevertheless it could be argued that, innovation in pedagogy apart, if research begins to indicate that pupils experience improved motivation and attainment, even by means applying ICT within traditional teaching and learning routines, this will have been a positive finding, although arguably perhaps not one necessarily commensurate with the expenditure.

5.3.4 Had the Project had an effect on attainment in science?

We could not find nor was it possible for us to generate data within this project which could link any changes in attainment or in the uptake of science to the use of the ICT. The project was in far too early a stage and other factors within the school were more likely to be influencing any variation from previous years. However, other research has indicated that more positive motivation resulted when ICT use was focused on both teaching and learning, than when ICT was used to support teaching alone (Passey et al. 2004).

In our evaluation, as in Passey's study, teachers widely reported on positive motivational impacts arising when pupils could make improvements to the quality of their work in terms of researching (i.e. finding information), writing, editing, appearance and presentation. Passey highlights the possibility that where this is seen as a focus of interest by the teacher, then internal cognitive aspects of the learning process (aspects such as reasoning, comparing, analysis, evaluating, and conceptualising) may be given less attention overall and may not be as appropriately supported by the ICT.

In talking of benefits, the teachers indicated where they felt understanding of science was advanced: for example, that 3-D animated models were assisting comprehension; that the ability to use data logging helped focus on the processes of analysis; and that collaborative group work was enhanced. While some members of the team who developed materials for the project were aware of the learning approaches and activities suggested by the Critical Skills programme, they were not yet embedding such activities into the structured materials provided for colleagues to use in classrooms. Nor were the rationale, purposes and activities design principles of such approaches shared widely with other colleagues. Thus the translation from theory to practice with respect to the application of the Critical Skills approach was at a very early stage.

5.4 Planning Future Developments in Science

What factors were likely to influence the future developments?

By the end of 2003 the core Project Team of teachers were beginning to articulate the key factors which were signalling the need for further thought if the project was to move forward to begin to fulfil the original aspirations.

a) *The fading of the novelty factor*

Again, what we are finding now, I suppose we are just getting past the honeymoon period. At first it was a real novelty. What I find now is the tricky thing is keeping them on what they need to be on.

The Project Team Leaders were beginning to articulate that more secure strategies needed to be put in place to exploit the power of the technology once the novelty of using it wears off. It was acknowledged that the pupils' ICT skills were increasing year on year, that soon pupils straight from primary would be familiar with techniques that the teachers were currently having to teach to 3^{rd} and 4^{th} years. Although one teacher expressed the view that the interpolation of more sophisticated technological demands on the pupils – such as digital photography of experiments, or using animations in presentations was a way forward, others considered that a clearer link between the technology, however sophisticated, and improvements in learning had yet to be established.

b) *The need for materials more integrated into the curriculum*

The present ICT activities, especially for S1/2 had been interpolated into an existing curriculum and set of topic booklets. It was possible in the next phase to start any new developments afresh with ICT more fully integrated from the outset. But it was recognised that a prerequisite for this planning to be effective was the writers and developers being much clearer what the use of ICT could achieve in terms of added value to the learning:

They are cutting all sorts of stuff down off the web and they don't have a clue what it's about and it all looks great. Somebody comes in to the room and all the laptops are out and they are doing PowerPoint presentations and letters twirling in from the side and sound effects. I can *just imagine the Prime Minister coming in and going 'this is education, this is the way we want it to be!' and the kids don't have a scoobie what they are actually talking about. So there are lots of issues about the use of IT and the learning. A teacher still has a tremendous input into structuring it so that they will learn what they require to learn and it's a balance between guiding them to the correct information and allowing them to search for the correct information because inevitably when they search they come up with inappropriate material that is not taking them in the direction you want them to go.* (Project Team Leader)

This aspect was also raised by the staff in Learning Support, who noted that the materials were not differentiated in any way, and some of the material was far too difficult for some learners to understand. As one teacher confirmed:
Some can understand and write it up well. Some copy it straight out and if you ask a question you see they have not understood it at all. The poor ones just copy it out. But they can go at their own speed. (Teacher)

When asked about the merits of ICT and the enthusiasm of the pupils a Learning Support teacher commented:

It wasn't so much the ICT programme as what they could produce ***from*** *it. So they could, you know, write all this fancy stuff, put it on a poster or something. Yes, to be fair, they'd be learning something about that particular element, but some of the stuff they choose to write down, they couldn't possibly be understanding.*

It appeared to the evaluators that in future development, the focus should move from ICT being an aid primarily for didactic teaching and the transmission of subject content, towards more on the use of ICT to support and extend learning, directed towards helping pupils build understanding, with associated attention given to new roles for the teacher as learning designer and facilitator of learning. The Critical Skills Coaching Kits give guidance to teachers who plan to make this journey.

c) Taking account of the changing role of the teacher

The quote above on the role of the teacher in structuring tasks for learning highlights the key issue of the changing requirements. With the knowledge bases of the Internet freely available to pupils, it is becoming clear to many teachers that their role is no longer one of being the repository and the transmitter of information:

And you find a lot of science that you don't know. The number of things that they will come up with and you say 'I didn't know that!' It is then beginning to take that and say 'how does that fit into this' or 'how did you …'. I think that is where, in lots of ways it is taxing us more in terms of not getting hung up on the computer but 'lets look at the information, what can we do with it, what does that tell us, what have we found out and how do we actually use that information?' (Project Team Leader)

My vision would be that it has got to change the way we teach. At the moment I would say that we've got value added from the ICT. I think we have seen some changes, when they come on board I think that will increase the pace of change. But my ultimate vision is that ICT will change teaching. The traditional didactic approach will, over time, start to be less significant than it has been in the past. (Project Team Leader)

d) Innovation overload

Despite the view expressed above that the science project was potentially just in the early stages of a longer term development, there was a reluctance on the part of the promoted staff to 'push' staff any harder into further change:

I think it is a tricky thing, in the department and in the school. There is so much good material and so many good systems that it is difficult to try and integrate these things without making people feel overloaded. (Project Team Leader)

There were indeed a number of worthwhile initiatives which had been introduced to the school, (CASE, VAK, Critical Skills, etc.) however these were generally regarded as separate initiatives. This perceived separateness made teachers feel that they were beginning to suffer from innovation overload. Any common features of the initiatives, particularly those associated with learning models, did not appear to have been extracted by the teachers to give them a sense of a coherent overview, consequently there was a tendency for individuals to pick isolated elements from each system they encountered if they considered them attractive – e.g. one teacher described how she had picked up the 'jellybabies' tip from colleagues who had attended the Critical Skills staff development. One teacher reported that pupils too were not seeing any cohesion between their experiences:

> *It's more a case of some pupils like it and others don't, so when you tell a class you've got CASE on Wednesday it's a case of some are saying 'yeah its great!' and others going 'why do we have to do this?'*

The problem identified by the teacher was the difficulty that pupils had in grasping that for the CASE lessons, it was not the product, but the process which was important, therefore if they had not finished a piece of work, it did not matter, they just had to stop it wherever they had got to, and start something new along with the others. This is in sharp contrast to most of the rest of their experiences in the curriculum, in which the product in the form of acquisition of skills, knowledge and understanding in the curricular areas is the most important aspect. However, it is the stated aim in both science and CASE that the development of critical thinking is a central purpose of the activities.

e) *Identifying the need for 'structure'*

The teaching episodes in secondary schools typically centre round the delivery or coverage of specific content or activities, through the application of well honed teaching skills and teacher developed support material, worksheets and notes. While there is a clear structure in the content which is derived from the set curriculum, and there is a clear structure in the teaching, derived from an amalgam of standard teaching practices for the subject and personal teaching skills and style, there is no common agreed framework to guide the teachers in their planning when their focus changes, and becomes effective independent pupil learning through the use of the technology which potentially puts all the basic knowledge needed by pupils - and much more - immediately at their fingertips.

Indeed what was common to many of the class sessions that we observed was a lack of clear structure linking teacher input, topics, pupil activities, specific learning, and the demonstration or other confirmation of that learning. Although this seemed to the observers to be true in most lessons, the presence of the technology appeared to highlight this lack of structure, and this was raised and commented on by a number of the promoted staff and one teacher who had been particularly active in the development of the materials for the project:

> *But on a formal level I think we really have to say 'how are we … what are the sort of tactics and techniques we use for interacting with the pupils and how are we ensuring that they are actually learning and not just being amused by it?' I found sometimes when they are researching information, I found that some of the kids are very good at finding information but not very good at analysing it. And how do we structure things, how do we ask the right questions to help them to do that? To help them to actually engage with it. When it works well it is great.* (Project Team member)
>
> *Also making sure the projects that I give them are a lot more structured so you can't actually go off on a tangent as that's the problem with the ICT – is because there is so much information available to them they have a tendency just to go mad and just randomly pick websites which have got nothing in them so I think the Critical Skills taught me to actually focus more, making sure that they had a framework of work which focuses the task also the fact that they know they are on a time limit. At the start it was actually difficult for them to do.* . (Project Team member)

As the last quote implies, control over the learning had previously been maintained because of the limited access pupils had to sources of information and the narrowness of the tasks they were able to perform. An information finding task using the vast information sources of the internet must be differently structured. Clearly, merely trying to add the technology to lessons to streamline typical current teaching practices will not suffice either to exploit the full powers of the technology or to promote the kind of future independence in learning and engagement with science that are aspired to. There appear to be two major barriers to the teachers moving forward in their development of their vision of teaching and learning, both of which were identified by teachers:

- the current fixed curriculum and the form of the examinations. These were considered to drive the teaching towards didactic coverage of specific information to ensure pupils performed well in the external exams.
- the lack of an overall framework for considering how best to think about learning or to structure materials for supporting learners who had the new technology at their disposal.

Teachers and researchers can do little about the first of these in this project, however, seeking frameworks for the development of structured learning was what some in the core team of teachers were beginning to do*:*

I think we have to work more on the structure of what we are doing with them. I don't think everybody agrees with me on this, but especially if we are doing research work, I think we need to work more on structuring their research work using the computers. With that intermediate 1 class I was talking about … I have used a few writing frames where I was trying to find out information about x-rays so instead of just saying 'go and see what you can find out' I had some questions on a piece of paper so they were actually having to write down information still on the piece of paper … so it was focusing them and they were getting a structure to what they were doing. I think we really need to do the same with the 1st years when they start doing it.

Providing 'writing frames', which comprise headings and questions around which pupils can structure their work is a first step in trying to offer a supportive structure for learning. However, having a clear view of the nature of the learning which is intended, and the conditions which are known to support this learning is a more robust and generalisable approach.

5.5 Introducing Models of Enhanced Teaching and Learning

What models of learning would be appropriate for future consideration?

It is increasingly recognised that the improved learning and the transformation of teaching are not guaranteed merely by the presence of the technology. In the BECTA (2004) review *ICT and Pedagogy,* the conclusions on the positive effects of ICT use in science are scarce, but optimistic. The reviewers note the lack of longitudinal evaluations in which the ICT is planned into a new curriculum and the processes and the outcomes researched, and conclude overall for the secondary subjects, that it is the way in which the ICT is used that makes improvement in attainment possible:

There is a strong relationship between the ways in which ICT has been used and pupils' attainment. This suggests that the crucial component in the appropriate selection and use within education is the teacher and his or her pedagogical approaches. (pg 3 Executive Summary).

In our view there had been no opportunity or context for science staff to overview the aims and objectives of the range of different initiatives which had already been introduced into the school (CASE, VAK, Critical Skills etc.) to see the common threads and to capitalise on the commonalities in order to optimise their understanding, save duplication and - most importantly of all - to give a coherent experience of education within the school to the pupils.

At the end of the first phase of the project (Dec. 2003) we generated some models of enhanced teaching and learning based on the activities with we had seen in our classroom observations (Appendix 1) which we hoped might offer a context for the staff to discuss aspects of ICT and learning as well as teaching. These were based on some of the learning and teaching principles within the Critical Skills framework, but which we integrated into activities which the teachers had already engaged with in ICT and which we felt could potentially be introduced into their typical classroom presentations. An account of the Critical Skills approach to teaching and learning is presented in Appendix 4, and a gloss on the way in which the activities which we suggested as extensions to the teachers' activities incorporated the key principles of critical skills framework is in Appendix 5.

5.5.1 Models of effective teaching and learning derived from their practice

Could their current practices be extended to support independent pupil learning?

The literature offers many different models of learning which aspire to be of help to school staff in their discussions about learning, but these are seldom valued by teachers who have not engaged with the processes of their generation or adaptation for their context. Although in our view the core of the Critical Skills scheme offers exactly the kind of support, models and theory based information which we feel might assist them, only two teachers in the science department had attended the course, and only at the very early stages. In our initial proposals for the evaluation we suggested it might be appropriate to introduce accessible information on possible models with a view to the teachers using these as a basis for their discussions and the creation of their own models to inform their practice.

However, on reflection, the research team decided that, rather than import outside models of learning from research or other sources, information from the teachers' own classrooms might be the most effective basis for introducing ideas and prompting staff dialogue about how they might achieve their aims with respect to the promotion of independent learning. Accordingly, the research team identified seven distinct uses of the technology which had been observed and set out activities associated with each of these, for the enhancement of both teaching and independent learning. In the seven contexts described some aspects of 'good practice' had already been demonstrated by the teachers, others we derived from teacher education/professional development sources and other literature. (The details of these seven contexts are presented in Appendix 1):

- question and answer activities supported by the interactive whiteboard and ActivStudio resources.
- teacher-led individual note-taking in jotters as a whole class supported by use of SCHOLAR materials
- teacher use of PowerPoint as an 'organiser' to support a variety of different learning activities throughout the lesson
- Demonstration of a data handling package supporting graphical representation of class generated information
- Individual pupil knowledge construction through note-taking supported by the use of a SCHOLAR package accessed online via laptops
- Small group investigations and project work to create PowerPoint presentations
- Pupils searched the www for information to support revision for NAB testing

These activities had been observed with different teachers, most with more than one teacher, and all were within the capabilities of the teachers involved with respect to ICT skills. Some of the observed episodes had shown evidence of 'value added' features with respect to the teaching and learning, others had not.

These were presented as a possible contribution to their staff discussions and developments at a meeting with the Project Team in December 2003. One Team Leader expressed the view that these would form a good basis for prompting discussions at staff development events in the future as she felt the staff had '*to become more analytical than we currently are'*. However most of the points raised at the feedback meeting related to subject specific concerns.

At the beginning of 2004 the Project Team's key reflections were centred on the following:

- the satisfaction they felt in having come a considerable way in the previous 14 months;
- the problems of lack of time and of the need for on-going technical support and resources remained (e.g. for the replacement of expensive projector bulbs);
- the difficulties they had in accessing on-line resources suitable for the Scottish curriculum, and the problems of copyright.

5.5.2 Teachers' perceptions of ways forward.

What did the teachers envisage as the future developments?

The perception that it was learning and the development of innovative pedagogy to support this which was the key area for future development appeared to be the vision only of the two Project Team Leaders. In the final interviews one Team member was enthusiastic about planning further developments in animations to assist in the understanding of complex science concepts. One of the teachers thought she would develop self assessment:

> *Next year? I think I might get pupils to assess one another. Some peer assessment to give them a more formal assessed feedback. This might help them to see more clearly just what a good presentation looks like for future activities. Looking back I might have given some more guidance at the start. I'll do that next time*. (Teacher)

Another highlighted the need for structure being given to the presentations:

> *Next time I would offer more help on PowerPoint and give very precise points for each slide. Also add a tighter time allocation for staff and students.* (Teacher)

One of the Project Team Leaders had attended an external talk from which she had learned about a whole new area in which she felt there needed to be further development:

> *I found it very useful to be able to, first of all, find out where a website originated from, in terms of it's reliability, and how you can track back to find out who actually owns the rights for the website. And also how you can refine searches so that you can maybe pull out only schools' websites or only university websites for a particular theme. And new search engines where they'll do clustered searches. So these are useful. And also ones where just understanding the principles of search engines so that, you know, and that some words are sponsored and, therefore, that you're not necessarily pulling out the website that's got the most instances of that word, but it's who pays the most money for it. So all these kind of issues we're not really touching on at all, but that is a whole school issue.* (Project Team Leader)

This is indeed a whole school issue, related to the whole school planning for ICT. It is something which other schools have dealt with and have already produced support materials for staff and pupils. However, there appeared to be a danger that since the science teachers now all had confidence and basic competence the subsequent developments in ICT were in danger of being somewhat bitty, idiosyncratic, and un-coordinated, perhaps with individuals re-inventing wheels which have already been well designed and tested in practice elsewhere.

At this stage we were advised that although individual teachers would continue to develop their skills and different ways of using the ICT in their own style and for their own specific purposes, there was unlikely to be further significant developments in the thinking and discussions of the whole staff group in relation to the overall aims of the project.

We therefore turned our attention to the rest of the school staff to consider the extent to which this development and other developments in the school were setting the scene for the 'Learning School'.

5.6 The Impact of the School's CPD Programme.

What has been the impact of the school's CPD programme on teacher competence and confidence in using ICT in science and in developing the school learning community?

5.6.1 Methods

A questionnaire was devised in consultation with the ICT co-ordinator, and was circulated to all the school staff in the Spring of 2004. The aim of the questionnaire was to gain information on the competence and experiences of the wider staff group in relation to the uses of ICT and their valued forms of staff development before considering the extent to which the model of staff development applied within science would be applicable across the school, and the extent to which this would contribute to the development of 'The Learning School'. The tables and detailed findings are presented in Appendix 2.

The sample

24 teachers (28% of the teaching complement) responded, representing 16 departments including Guidance and Support for Learning (table 5.1). They were an experienced staff; the number of years in service was typical of staff groups currently in Scottish schools. Most had been teaching for thirteen years or more (table 5.2).

5.6.2 The key findings from the staff questionnaire

a) What were the competencies of the staff and their uses of ICT?

The responses from the staff sample indicated that their basic computer-using skills were well consolidated (table 5.3). 23 of the 24 respondents had computers at home, with access to the www and to e-mail which was used by almost all (N=22) for personal purposes; and by less than half (N=10) for professional purposes. While 18 indicated they regularly searched the www for curricular materials, only 6 visited the Learning and Teaching Scotland website; only one indicated they visited the Scottish Virtual Teachers' site; and none had visited the BECTA site where there is a great deal of information for teachers on the evaluation and research findings relating to the use of different technologies (laptops; whiteboards etc.). Fourteen described themselves as having 'rather more than average ICT skills'; and five as a 'fairly well informed innovator' (table 5.4). It is possible that the most enthusiastic or frequent users of ICT were over represented in the sample, but the science departments were not over represented.

The access to ICT in their classrooms varied widely (Table 5.5) but the figures appeared to indicate that the level of regular use in classrooms was low. The obstacle most frequently identified to further use was access, either to the equipment per se or to the classroom beforehand to set up in preparation for the next lesson.

Although 22 respondents gave examples of how they used the ICT, it was difficult to code and classify as many answers were not detailed enough to distinguish whether the technology was being used as a traditional teaching tool i.e. to help pupils to acquire information and teachers to transmit it, or whether it was being used in an innovative way to support learning. A number of responses suggested the former predominated, e.g.:

Redrafting on the computer, searching the web for information.

Revision purposes. Introduce new topic. Bit of educational 'fun'.

Use of CD ROMs. Use of search engines. Presentation of work.

A few indicated the use of interactive websites, but these can of course be used for traditional transmission of information; others mentioned 'pupils researching' which again may actually mean the looking up of factual information only.

What were the staff experiences of Staff development? What forms of CPD did they value?

b) The staff experiences of NOF training

We were advised by the ICT coordinator that because of the arrangements made within their Authority for the allocation of Masterclass training, no staff member had received such training, and indeed in our interviews with the science teachers, we had established that almost all were unaware of what the Masterclass programme was. However, there had been a programme of NOF staff development throughout the school and we included questions about this in our questionnaire. The results indeed indicated that most teachers had completed their NOF training, although a only minority indicated that they found it a positive and useful experience (see table 5.6).

Table 5.6 The NOF Training Experiences of the Staff Sample

	Yes	**No**
Have you completed NOF Training?	22	1
Did you find it a positive and useful experience?	10	13

In an open question, we asked the respondents to indicate the ways in which the NOF training had advanced or enhanced their skills:

Six respondents indicated that their confidence had been increased:
Became more confident to try different things.
Confidence in using more of the functions.

Six other respondents indicated their advancement through the acquisition of new specific skills:
Learned how to find subject related sites on the web.
Learned how to use PowerPoint and Excel

Two respondents indicated that they had been tutors, thus giving them the opportunity to enhance their skills through practice:
Worked as a tutor so further enhanced ICT skills

We also asked them to indicate the reasons why their skills had not been advanced as they would have wished. Of the 22 who had completed the NOF training, 13 had indicated they had not found it a '*positive and useful training experience'* and 16 indicated that it had not advanced their skills, and indicated why in an open question.

The comments could be clustered as follows:
3 responses referred to the ***processes of the training***: for example
I felt I had jumped through hoops but had not learned anything.
The exercises were too prescriptive.

8 (50%) responses referred to the ***level of the content:***
I knew the material beforehand.
I did not learn any new skills.
Already in possession of basic ICT skills. Needed more advanced skills e.g. pivotal tables in Excel.

3 responses referred to the ***relevance of the content*** for classroom purposes:
Background material was good but not integrated into 'coursework'
Tasks unrelated to the ICT work I was developing at the time.

c) ***What kind of CPD did staff value?***

Staff Involvement in Critical Skills Programme: two staff in the sample had been involved in this training. Overall, four staff in the school had attended, more uptake was planned.

As had been found in the national staff surveys of 1999 and 2001 (Condie, Simpson et al. 2002), the form of staff development most frequently engaged with (96%) - and in this questionnaire the most highly rated in terms of usefulness - was informal discussions with immediate subject colleagues, and for a minority (25%), meetings with subject colleagues from other schools. For 88% of the staff, 'exploring through trial and error in my own classroom' received the next highest rating of usefulness. While experienced by a majority, (75%), whole school in-service with outside input was rated as the least useful of all the forms of staff development listed, with external award bearing courses and the subject-oriented professional journals also rated on the 'not useful' side of the scale.

Table 5.7 The staff experiences of staff development events

Experiences of ICT related staff development. Respondents rated the experiences they had had on a five point scale from 1 = not very useful to 5 = very useful.	**% who had experienced this**	**Average Rating ***
Fairly to very useful		
Exchanging information informally with immediate subject colleagues	96	4.43
Face to face meetings/phone calls with colleagues in subject networks/groups beyond the school	25	4.40
Exploring through trial and error in my own classroom	88	4.20
Neutral to fairly useful		
Attendance at external conferences (e.g. SETT,TEI)	42	3.90
Informal exchanges with colleagues in other subject departments	80	3.67
Taking external non-award bearing/award bearing courses /programmes	50	3.67
Formal cross department meetings/exchanges	25	3.50
Electronic communications with colleagues in subject networks/groups beyond the school	29	3.50
Neutral to not very useful		
Looking in professional journals (e.g. School Science Review; MOST, SEJ, Connect etc)	42	3.00
Taking external award bearing/award bearing courses /programmes	13	3.00
Whole school in-service with no outside input	75	2.82
Whole school in-service with outside input	75	2.58

5.7 The Key Characteristics of School Staff Learning

5.7.1 What are the key characteristics of staff learning?

These data painted a picture similar to that derived from the National surveys (Condie, Simpson et al., 2002) and case studies of ICT implementation (Simpson and Payne, 2002). The model of teacher learning which emerges from a variety of studies indicates that the development of teachers' knowledge and use of ICT could be described in terms of individualistic constructivist pedagogy.

- It is individualistic and learner centred.
- It is based on a large element of trial and error in a practical context.
- Group dialogue is used as a key vehicle for learning, the most valued discourse being with those who are closest in professional terms – in their own subject area, in their own school.
- The introduction of formal knowledge is largely unplanned, often serendipitous; direct instruction, references to texts or external expertise are not valued.
- There are strong links to 'craft knowledge'. Teachers learn to engage with ICT in a practical a-theoretical manner by using it in their classrooms. Both the technology and its effectiveness are valued to the extent that it supports the present practices of teachers and their pedagogical understanding.

Further research would be required to understand both the reasons for this strong pattern, and the ways in which this might impede aspirations for the development of 'learning schools'.

5.7.2 The science department as a learning community

How was the science learning community developed and sustained?

The planning and leadership associated with the early phase of the project (Section 2) allied with the challenge presented by the novelty of the ICT use allowed a small but powerful learning community to develop within the science department. However, as confidence grew in the management of the technology, each individual teacher was beginning to plan the different ways in which they were going to develop the usage as they preferred. In the face of this and the additional pressures of the session, a co-operative and coherent way forward was being increasingly difficult to sustain, and we were advised that as the new management reorganisation of PTs took place over the 2004-5 session, it was unlikely that any significant whole department developments would take place for the foreseeable future.

It seems to be the case that the model adopted by the science staff could be used in other departments, and indeed appeared to be evident in other departments, e.g. Geography, a much smaller department than science in which only three or four individuals worked together. However, the collective, collaborative interactions required to sustain a community of cooperating teachers may be difficult to sustain in larger departments, and is not very compatible with the autonomous, individual centred model typical within the profession which we describe above. For the science developments to move forward in a unified way, strong curriculum or management leadership would be required.

5.7.3 The Developing School

How can the school develop further as a learning community?

The model of planning, inclusion, support, practice and modelling adopted by the Science Project Team worked well in creating a productive 'learning community' of teachers who successfully engaged with ICT and began its regular use in classrooms. This corresponds to the successful integration of ICT into the traditional school as set out in the framework for ICT implementation (Coutts et al. 2001) see Appendix 3. Pursuing further developments which would extend into the next stage, where the curriculum and learning are extended and enriched could be undertaken by the science staff alone, through developing new pedagogical contexts for the science curriculum of S1/2 where there were the least exam constraints.

However, it is not certain that all staff would wish to change in any radical way, and the individualistic developments described above seemed to some of the science teachers to be a reasonable way of proceeding now they were familiar with the technology. If the future developments are primarily by individuals and are only casually shared, there is a danger that the experiences offered to pupils will become fragmented and less coherent. The whole school strategy for staff development could exacerbate this diversification as there is a policy to encourage a wide range of different initiatives, and many teachers knew little of what was going on in anything other than their own contained subject or sub-group.

It is at the node of pupil experience that the duplication, dislocation and incompatibility of some of the initiatives would become apparent. Learning Support staff confirm the extent to which teachers identify with their subject, and the low rating of whole school in-service indicates that more generic issues are not a priority. The deep connection which should run through and unify all school, departmental and individual initiatives should be a shared understanding of what contexts are effective for promoting learning and how these are set up across the school.

The literature on school development suggests that at this stage the school needs to work together on developing a unifying statement about the features of its philosophy and practices in learning and teaching. The Critical Skills Coaching Kit offers a model of key ideas for developing coherent classroom approaches (see pg 1 Appendix 4).

5.7.4 The Stage of the school ICT development

Mooij and Smeets (2002) identify five levels of secondary school engagement with ICT:

1. incidental and isolated use of ICT by one or more teachers;
2. increasing school awareness of ICT relevance for the school, at all levels;
3. emphasis on ICT coordination and hardware within school;
4. emphasis on didactic innovation and ICT support; and
5. use of ICT-integrated teaching and learning, independent of time and place.

These levels have been derived from actual studies in schools, but with an indication from the authors that level five is derived from theory only, and was not encountered in practice. Levels 1 -3 involve the acquisition of hardware, relatively isolated computer use by teachers, with an increasing inclusion of ICT in classroom practices. We would judge that the High School is at level 3. An awareness of the potential of ICT has been raised; resources have been allocated for hardware and intranet connections have been established; time has been allocated for meetings and staff development; participation in ICT use has been promoted and stimulated; small decision making groups have been initiated; projects on innovative ICT use have been undertaken, with an emphasis on the integration of ICT into the curriculum, a focus on pupil-centred learning and on collaborative learning.

The move to the fourth level, where pedagogical innovation can effectively develop requires the emergence of a common vision on the part of the staff, managers and pupils, of new ways of managing teaching and learning. This is something of which the two Project Team Leaders are aware and can articulate, but cannot advance without a coherent framework, such as that offered by Critical Skills and a whole school involvement beyond the science department.

The Critical Skills Toolkit would seem to be the appropriate basis for the school's activities, since more staff are due to be attending the courses, and a small critical mass of teachers will become familiar with their approach. The advent of ICT has made it much easier for teachers to engage in learner centred pedagogy in ways not normally encountered in secondary schools, although the Critical Skills frameworks for learning and teaching were developed almost without reference to ICT. This is useful in putting the learning and teaching to the forefront, with ICT merely as the tool to achieve the aims of the learning activities. Once the coherent framework for learning has evolved and become adopted, all the different school initiatives can be seen to service it in different ways and discrimination on their contributions and more focussed planning can be established.

5.7.5 Why should secondary schools seek to develop innovative pedagogy ?

> *How do we move on from using ICT as an enhancement to what we already do to a position where children are being prepared as self directed learners to participate in a global economy and world. That's the next step we have to take on the journey.* (Project Team Leader)

The argument for innovative pedagogy rests on several premises:

There now appears to be a ceiling of productivity on the traditional, closed, subject dominated, lock-step taught age groupings of the typical class system in secondary schools. The investment in ICT can make only marginal, but expensive improvements in attainment unless the deployment of new technologies is accompanied by development of appropriate pedagogies.

Schools will face increasing challenges in the face of the increasing dissatisfaction of pupils enduring unimaginative educational experiences which relate in few ways to the knowledge and skills they need and which are valued in this technological age in which they now live, and anticipate soon to be working. As Sanger et al. (1997) noted, the ignorance of adults, especially teachers, who are not immersed in the same computer culture as young people with respect to the scale and scope of their activities involving computers, means that issues of a deeply important educational, social and personal nature are neither recognised nor dealt with within educational settings.

The typical model of pedagogy in the secondary school, of relatively inert knowledge transmission from expert to individual novice, followed by practice and committal to memory in contexts dissimilar from the context in which they need to be recalled and applied has been long discredited, and indeed is rejected by teachers themselves when they are subjected to it in their own professional learning. The educational needs of citizens of the 21st century will be much better served by more modern concepts of learning and teaching (Hughes, 2004; Simpson, 2000) linked to authentic assessment strategies.

The development of appropriate innovative pedagogies must involve teachers in the two way process of bridging theory and practice. This project demonstrated just how challenging and professionally stimulating such pedagogy-led technological innovation can be when the ownership of development is put in the hands of a team of teachers committed to curriculum development as a vehicle for their own professional development.

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APPENDIX 1

Contexts for ICT use in Teaching and Learning in Science

Context 1

Teaching and Learning using group work and pupil PowerPoint presentations

Generated from a composite set of classroom observations

Small group investigations and project work to create PowerPoint presentations

ICT adding value to the teaching.
These episodes worked best then the teacher:

- Planned the investigation around a clear purpose expressed in terms of what was to be learned and with a stated structure to scaffold the processes required.
- Used materials that created a purposeful framework for the investigation within which individuals and groups could exercise a degree of autonomy.
- Presented the investigation as a challenge to be engaged with.
- Allowed the pupils to combine information from sources pre-identified by the teacher and where appropriate found by the pupils.

ICT adding value to pupil independent learning.
Independent Learning could be extended by:

- Establish performance (not technical) criteria for assessment of the final presentations.
- Setting the activity us as a simulation or role play e.g. when pupils were told they were to be interviewed as energy consultants in a competition to commission a new energy source.
- Requiring pupils to peer assess the presentations by agreed criteria.
- Setting the group projects up in a way that allowed the contributions to be integrated into a class presentation.
- Requiring the classes to make their presentations available as PowerPoint slideshows via a www page for parental scrutiny.
- Inviting the groups to prepare ‘advice memos’ with the five most important things to get right on how to go about the project to be used with next year’s classes.

Context 2

Teaching and Learning using teacher PowerPoint presentation

Generated from a composite set of classroom observations

Effective use of PowerPoint as an 'organiser' to support a variety of different learning activities throughout the lesson

ICT adding value to the teaching.

These episodes seemed to work well when the teacher:

- Personally designed and created the PowerPoint resource.
- Used PowerPoint to combine resources e.g., text, pictures, audio-visual and www pages.
- Used the software to prompt class, group and individual activities within the presentation.
- Used the software to create visual impact.
- Felt that the form of the presentation added to classroom professionalism.

ICT adding value to pupil independent learning.

Independent Learning could be extended by:

- Incorporating ‘content’ generated during the lesson into the PowerPoint presentation.
- Providing pupils with a copy of the slides to help them re-visit their experience of the activity-based learning.

Context 3

Teaching and Learning using an interactive whiteboard

Generated from a composite set of classroom observations

Effective teacher-led demonstration with question and answer activities supported by the interactive whiteboard and ActivStudio resources.

ICT adding value to the teaching.
These episodes seemed to work well when the teacher:

- took care to match ICT resources closely to the intended learning outcomes;
- personally created or selected presentations and stored them for future use;
- used the software to *add value* to the presentation by:
  - showing animated models and examples;
  - showing visuals and moving images;
  - using graphics and animations to reinforce concepts;
  - using interactive features;
  - combining 'layers' of commercial information and personal annotations;
  - offered interpretive commentaries;
- used the ICT to enhance a personal, preferred teaching style;
- used the tools ICT tools with confidence,
- involved pupils actively in the presentation and learning;
- stressed personal sense-making and understanding rather than acquiring facts or covering materials;
- had predictable and secure access to the ICT tools;

ICT adding value to pupil independent learning.
Independent Learning could be enhanced by:

- having pupils present or demonstrate understanding using the resources;
- breaking longer presentations up with small group discussions or activities;
- providing pupils with copies of text and diagrams to annotate and extend into personally created notes;
- inviting pupils to record the relationship between their personal learning and the syllabus or learning outcome.

Context 4

Teaching and Learning using www to support revision

Generated from a composite set of classroom observations

Pupils searched the www for information to support revision for NAB testing.

ICT adding value to the teaching.
These episodes seemed to work well when the teacher:

- Directed pupils to useful sites located and evaluated for relevance in advance;
- Helped pupils search for new information *within a site* that extended existing understanding;
- Closely matched new information to the demands of the assessment;
- Helped pupils create a personal record of information found in a format relevant to the assessment task.

ICT adding value to pupil independent learning.
Independent Learning could be extended by:

- Reviewing existing knowledge to identify possible keyword searches as a means of developing understanding.
- Having pupils share their findings in small groups.
- Encouraging pupils to keep electronic notes (journals?) into which they could ‘layer’ new information as it became available.
- Encouraging pupils to compare and contrast different explanations and perspectives.
- Having pupils peer-assess each other’s notes and share constructive judgements about their appropriateness and comprehensiveness.
- Encouraging pupils to self-assess the significance of information recorded for the assessment purpose and test intended.

Context 5

Teaching and Learning using data handling package

Generated from a composite set of classroom observations

Demonstration of a data handling package supporting graphical representation of class generated information

ICT adding value to the teaching

These episodes seemed to work well when the teacher:

- Planned the demonstration carefully to match explanations and activities carefully to learning outcomes and purposes.
- Data collection followed activity to identify a clear purpose or problem.
- Pupils were invited to frame the problem to be tackled and the information to be collected.
- Lock-step, whole-class approaches were avoided and small group activities introduced.

ICT adding value to pupil independent learning.

Independent Learning could be extended by:

- Inviting pupils to take a problem-based learning approach to both defining the purpose of the data collection and working out how to use the software.
- Blending data entry and data analysis activities to solve real problems.

Context 6

Teaching and Learning using SCHOLAR resources
Generated from a composite set of classroom observations

Effective teacher-led individual note-taking in jotters as a whole class supported by use of SCHOLAR materials

ICT adding value to the teaching.
These episodes seemed to work well when the teacher:

- Planned to use appropriately sized sections of the materials closely linked to specific learning outcomes.
- Made use of the ‘value-added’ features of the materials such as illustrations and dynamic models.
- Offered a commentary on the content and to provide structure to the note-taking.
- Concentrated on group discussion for sense-making and personal knowledge construction rather than coverage of topics.
- Used and invited quick fire question and answer exchanges to test and build understanding and to bridge established knowledge and new ideas
- Adopted a ‘guide on the side’ role by ‘thinking aloud’ to model science thinking and problem solving for pupils.
- Used the SCHOLAR materials as a personal and class organizer of the information to be taught and learned.

ICT adding value to pupil independent learning.
Independent Learning could be extended by:

- Supporting creation of electronic notes rather than jotter notes by providing pupils with a template or starter resource into which to add their own explanatory and illustrative content.
- Inviting pupils to return to the SCHOLAR resource to consolidate their personal learning.
- Providing opportunities for pairs of pupils to compare their notes and peer assess their appropriateness in discussion.
- Requiring individual pupils to add reflective summaries of key learning points as a homework exercise

Context 7

Teaching and Learning using SCHOLAR resources and laptops

Generated from a composite set of classroom observations

Individual pupil knowledge construction through note-taking supported by the use of a SCHOLAR package accessed online via laptops

ICT adding value to the teaching.
These episodes seemed to work well when the teacher:

- Clearly distinguished between different modes of study with SCHOLAR and established a clear purpose for the note-taking activity.
- Planned to use appropriately sized sections of the materials closely linked to specific learning outcomes.
- Made use of the ‘value-added’ features of the materials such as illustrations and dynamic models.
- Worked with pupils to create and establish a structure for the note-taking and encouraged development of summarizing and synthesizing skills.
- Concentrated on group discussion for sense-making and individual personal knowledge construction rather than coverage of topics.
- Engaged closely with pupils to test their understanding and knowledge construction.
- Adopted a ‘mentoring’ role with small groups by ‘thinking aloud’ to model science thinking and problem solving for pupils.
- Used the time pupils were engaged in self-study with SCHOLAR to connect with individuals and small groups in tutorials or micro-teaching.

ICT adding value to pupil independent learning.
Independent Learning could be extended by:

- Supporting creation of electronic notes rather than jotter notes by providing pupils with a template or starter resource into which to add their own explanatory and illustrative content.
- Providing opportunities for pairs of pupils to compare their notes and peer assess their appropriateness in discussion.
- Providing pupils with alternative teacher explanations or illustrations to be incorporated into the notes taken form SCHOLAR.

1) Requiring individual pupils to add reflective summaries of key learning points as a homework exercises.

APPENDIX 2

The Findings from the Questionnaire

a) The characteristics of the respondents

24 teachers (28% of the teaching complement) responded, representing 16 departments including Guidance and Support for Learning (see table 5.1 below). They were an experienced staff; the number of years in service was typical of staff groups currently in Scottish schools. Most had been teaching for thirteen years or more (see table 5.2).

Table 5.1 The Distribution of Questionnaire Respondents by Department

Subject Department	**No. of respondents**
Modern Languages,	**4**
Support for Learning	**3**
Chemistry	**2**
English	**2**
Business/Economics	**2**
R. M. E.	**1**
Physics	**1**
Biology	**1**
Music	**1**
Mathematics	**1**
Art	**1**
History	**1**
Geography	**1**
Technology	**1**
Physical Education	**1**
Guidance	**1**

Table 5.2 The Teaching Experience of the School Staff Sample

Number of years of teaching experience	**Number of respondents**
6 years or less	4
7-12 years	4
13-20 years	7
Over 20 years	8
Not given	1

b) The general ICT uses of the staff sample.

The data on home computer use is presented in table 5.3, showing that 23 of the 24 respondents had computers at home, with access to the www and to e-mail which was used by almost all (N=22) for personal purposes; and by less than half (N=10) for professional purposes. While 18 indicated they regularly searched the www for curricular materials, only 6 visited the Learning and Teaching Scotland website; only one indicated they visited the Scottish Virtual Teachers' site; and none had visited the BECTA site where there is a great deal of information for teachers on the evaluation and research findings relating to the use of different technologies (laptops; whiteboards etc.). Fourteen described themselves as having 'rather more than average ICT skills'; and five as a 'fairly well informed innovator'. (see table 5.4). It is possible that the most enthusiastic or frequent users of ICT were over represented in the sample, but the science departments were not over represented.

Table 5.3 Teachers' general ICT uses

	Yes	**No**
Do you regularly use a computer at home?	23	1
Do you use it for accessing the WWW?	23	1
Do you use it for personal e-mail?	22	2
Do you use it to mail professional colleagues in other schools?	9	15
Do you have a computer for your sole use in school?	5	19
Do you use a computer regularly to e-mail colleagues within the school?	5	19
Do you use a computer regularly for professional e-mail contacts outside school?	10	14
Do you use a computer regularly for seeking out curriculum material on the www?	18	16
Do you regularly visit the BECTA site?	0	24
Do you regularly visit the Scottish Virtual Teachers' website?	1	23
Do you regularly visit the L&T Scotland website?	6	18

Table 5.4 Self assessment of skills level

Level of Skills	**Number of respondents**
1 Fairly basic beginner	0
2 Skilled enough to 'get stuck in'	4
3 About average	6
4 Rather more than average	9
5 Fairly well informed innovator	5
Mean rating	**3.63**

c) The level of access to ICT

In table 5.5 we present an indication of the extent to which this sample had access to ICT equipment, and the extent to which they used it in their teaching on a regular basis.

Table 5.5 The Level of Access to ICT of the School Sample

Please indicate what ICT equipment you have access to in your classroom, dept. or elsewhere and which of these you use on a fairly regular basis.	**Available in my normal teaching areas**	**Available but difficult toaccess/ organise for regular teaching uses**	**I use this several times a week overall**
One networked computer	9	3	0
Several stand alone and networked computers	10	4	2
PowerPoint facilities	8	9	0
Laptops for pupil use	5	5	0
Own laptop for personal use	3	1	0
Interactive whiteboard	10	5	3
Data- projector	5	4	2
Whole class suite of computers	2	5	5
School website	11	7	1
DVD or video player	10	2	5
Digital camera (still or video)	8	3	2
Other	2	0	0

The figures appeared to suggest that even when ICT was available, the level of regular use was low.

d) Obstacles to the use of ICT

20 responded to an open question on the obstacles to their using ICT in ways that they would like to, but could not yet do with ease or regularity. The obstacle most frequently indicated (N=15) was that of access, either to the equipment per se, or to the classroom beforehand to set up in preparation for the coming lesson:

> *One data projector and interactive whiteboard in corridor. Difficulty accessing room to set up equipment.*
>
> *No network point in my classroom.*
>
> *Scanners, plotters, printers, control interfaces available. Need far more data projectors, staff still have to get twenty pupils around a 12" monitor to demonstrate.*

The second factor, although mentioned rather less frequently, was time:

Time needed to become familiar with how to use whiteboard/powerpoint to its full extent; time needed for immediate follow-up activities after training.

Time to develop how I would use it; time to explore what is available; time to develop my own skills.

e) Typical uses of technology in the classrooms

Although 22 respondents gave examples of how they used the ICT, it was difficult to code and classify as many answers were not detailed enough to distinguish whether the technology was being used as a traditional teaching tool i.e. to help pupils to acquire information and teachers to transmit it, or whether it was being used in an innovative way to support learning. A number of responses suggested the former predominated, e.g.:

Redrafting on the computer, searching the web for information.

Revision purposes. Introduce new topic. Bit of educational 'fun'.

Use of CD ROMs. Use of search engines. Presentation of work.

A few indicated the use of interactive websites, but these can of course be used for traditional transmission of information; others mentioned 'pupils researching' which again may actually mean the looking up of factual information only.

Features	The Traditional School	The Extended School	The Quasi-Cyberschool	The Advanced Cyberschool
Defining Characteristics of ICT use	ICT used to: • deliver the existing curriculum • support existing values, structures and processes	ICT used to: • extend learning opportunities • enhance the curriculum • augment existing values, structures and processes	ICT used to: • transform learning models and curriculum arrangements • redefine existing values, structures and processes	ICT used to: • **transform existing learning models and curriculum arrangements** • reconceptualise existing values, and replace existing structures and processes
Location and Structure	School building; normal classrooms	School/Community building with network access.	Physical buildings with open flexible learning areas and significant virtual learning spaces on intranets and internet	A core network of virtual learning spaces and widely distributed locations in a variety of physical buildings
Timetable/Lesson Units	A traditional framework for synchronous delivery based on age groupings	A traditional framework with some supplementary asynchronous or specialist activities for small groups	A significant element of flexibility and asynchronous activity to support work selected, directed and paced by individuals or groups	Fluid, asynchronous and fully individually directed activity
Curriculum	Centrally determined with ICT use adapted and constrained to fit and support the formal set curriculum	Centrally determined but adapted to a limited extent to accommodate some innovative uses of ICT	School managed in ways which combine central and other agency elements to allow learner or parental choice and customisation.	Negotiated by parents, tutors or individual learner to exploit fully the distributed learning opportunities
Teaching, Learning and Assessment Models	Typically transmission and reproduction model; largely paper based seatwork within subject disciplines. Limited use of ICT	Innovative in limited, contained areas of the curriculum. Innovative strategies to help 'non standard' pupils integrate into norms of school experience.	Wide variety of learning contexts depending on requirements of topics and students. Team/peer learning within flexible groupings.	Students follow a fully individualised problem-based learning approach with assessment by a range of agencies
Locus of Control	Largely teacher-directed activity	Elements of learner directed activity and choice within, or of, set menus.	Students responsible for planning own work and for building a personal portfolio of learning projects and assignments for central assessment.	High level of learner or community autonomy
Teacher Role	Sage-on-the-stage and principal knowledge provider and assessor.	Principal knowledge provider, curriculum planner and mediator between learner and set curriculum.	Learning counsellor/ mentor; planner and co-ordinator of general overall programmes	Co-learner in a community of enquiry; facilitator of individuals' requirements

APPENDIX 4

The theory and practice frameworks of Critical Skills

In the text below, extracts from the *Education by Design Level 1 Coaching Kit* (1997) are in italics.
This development programme which originated as *Education by Design* from teachers in one secondary school in association with staff at Antioch University in New Hampshire, USA is promoted as the Critical Skills Programme in the UK. There have been regular visits from the teacher-tutors to Scotland, and a number of Authorities have funded some staff to start the training programme.

The teachers who developed the *Critical Skills* programme begin the Coaching Kit by setting out their belief statement with respect to their aims in the education of their pupils. This was the overarching framework within which they developed their materials:

We believe that education must be experiential, must nurture interdependence, and must enable all members of each generation to develop the judgement necessary to take responsibility for:

the conduct of their lives,
the shaping of their societies,
and their participation in global issues.

We believe that judgement is the integration of knowledge, skills, and standards of ethical behaviour that guides decisions, commitment and action.

This is reminiscent of some of the objectives set out in the Citizenship Education documents in Scotland, and while it could be lightly passed over as merely another idealistic and aspirational mission statement, the associated theory of learning and teaching and the exemplification of learning tasks (the challenges) make it very clear how the teaching and learning activities are well thought through and consciously *designed* to incorporate and optimise the attainment of these ideals.

The four key ideas

They base their planning of classroom learning contexts on four key ideas:

Experiential learning: *this creates an environment in which students are allowed to interact in real life contexts, to construct individual meaning, and to engage in complex actions that reflect life outside school.*
Collaborative learning: *a collaborative learning community is a deliberately constructed classroom culture within which teachers and students support one another in pursuit of clearly articulated goals.*
Standards driven learning: *or results driven learning engages students in thoughtfully designed experiences that necessitate that they practise and develop the significant and demonstrable characteristics we desire to foster in students in terms of knowledge/understanding and skills/dispositions.*
Problem based learning: *is the use of thoughtfully designed and related challenges as the primary (but not exclusive!) instructional approach. These challenges pose a problem for students to solve as individuals, in small groups, or as a full learning community. They create 'the need to know' – allowing students to develop and apply their knowledge/understanding, demonstrate skills/dispositions, attend to their processes and see the big picture that makes the work worth doing.*

While each idea is powerful in itself, they work best in concert to form a coherent classroom approach. Certainly you can have a collaborative community without it being problem based. And you can address standards without being experiential. The unique combination of the four ideas, however, forms a cohesive whole where the classroom culture develops through shared experiences and problem solving to help each student meet targeted standards. Each element reinforces the other to create a whole that is greater than its individual parts.

Based on these four key ideas, the teacher developers of the Critical Skills approach generated a framework of characteristics for their classrooms:

- *Students frequently work as a team.*
- *Students actively solve meaningful problems.*
- *Students publicly exhibit their learning.*
- *Students reflect on what they are learning and doing.*
- *Students apply quality criteria to their work.*
- *Teachers mediate, coach, and support the learning process.*
- *Targeted learning results guide culture, curriculum, and assessment.*
- *Work is interconnected.*
- *Students take responsibility for and ownership of their learning and for the classroom community.*

The developers were aware of the revolutionary nature of the thinking, planning, and the classroom and pupil management activities which are being asked of teachers who try to adopt this scheme - teachers who have experience only of the typical teaching styles and strategies of western schools – learning as an individual pupil journey; mainly transmission teaching styles; highly structured around a content based on acquiring information which is important to and created around a discipline; teacher as subject expert and class controller; teaching strategies passed on from teacher to teacher within subjects; learning objectives which are relatively inflexible; a linear curriculum; and assessments which are primarily judgemental on the individual.

Applying the theory of 'scaffolding' to the teachers as learners, the Coaching Kit charts the kinds of activities which teachers would expect to be able to engage with competently as they pass from *novice*, through *intermediate* to *advanced* application of the teaching strategies.

They deal in detail with the characteristics of the problems set as learning contexts which are conducive to the effective meeting of the aims of their course – both at micro level – the specific knowledge to be gained, and at macro level – the dispositions which are being developed over a longer term.

They describe the characteristics of the collaborative learning community; the strategies for building and maintaining such a community of learners, and how such collaborative learning is different from individual work, or working in a group or working as a group. This embeds the theory of social constructivism into recognisable and practical classroom activities. Few secondary teachers in Scotland have engaged with thinking about knowledge construction in this way and few have acquired even the basic skills of managing group work in classrooms which are evidenced daily in primary classrooms.

The teaching and learning contexts were developed in full acknowledgement of the general climate of accountability for maintaining and raising standards of attainment in secondary schools. ***Learning standards*** are defined as*: the outcomes, frameworks, or standards – set at the classroom, school, district or state level – that define what it is we want our students to know and understand, to do and be like while they are in school, and when they have completed their schooling. These are the significant and demonstrable characteristics we* *desire to foster in children. EBD divides standards into two categories: knowledge/understanding and critical skills/dispositions.*

The Coaching Kit give examples of the kinds of knowledge and understanding they aim to foster, and of the component skills which comprise critical skills, e.g. problem solving, decision making, critical thinking, creative thinking, communication, organisation, management, leadership, ownership, self-direction, quality character, collaboration, curiosity and community. Listed are the types of questions which teachers might raise while supporting the learning activities to prompt development of these qualities.

Teachers working within the overall framework are given methods which can be used to develop and set their criteria and standards within such novel learning contexts, and exemplification of quality criteria. The process of the creation of problem-based challenges within which the pupils will acquire the knowledge and develop the skills and dispositions is illustrated, and examples of problem based challenges from a range of subjects are given.

The final sections of the Coaching Kit deal with assessment and with strategies for developing and extending the teacher's expertise in planning and effectively managing these complex learning environments.

APPENDIX 5

Context 1 Related to the Framework of Critical Skills

Teaching and Learning using group work and pupil PowerPoint presentations

Generated from a composite set of classroom observations

Small group investigations and project work to create PowerPoint presentations

ICT adding value to the teaching.
These episodes worked best when the teacher:

- Planned the investigation around a clear purpose expressed in terms of what was to be learned and with a stated structure to scaffold the processes required.

This recommendation refers to the processes within the Critical Skills programme in which **the teacher sets out the knowledge and understanding 'learning standards' and identifies the quality criteria for this particular activity.** The specific detail of these criteria will depend on how skilled the teacher is in setting out criteria, and how well the pupils are versed in this type of collaborative group work. In the Critical Skills approach, both teaches and pupils are recognised as initial novices in how to do these things, and different work is expected from novices and experts. The Critical Skills approach to group work represents a move away from the typical individual work of the Scottish secondary classroom to a framework for promoting high quality interdependent work – they type of learning to work in teams which employers say they value. The quality criteria include therefore criteria for good teamwork – either attached globally to the group, or identified as different criteria for different pupils, depending on their particular learning needs.

- Used materials that created a purposeful framework for the investigation within which individuals and groups could exercise a degree of autonomy.
- Presented the investigation as a challenge to be engaged with.
- Allowed the pupils to combine information from sources pre-identified by the teacher and where appropriate found by the pupils.

These three points refer to the characteristic of Critical Skills learning tasks in which ***pupils actively solve meaningful problems,*** and are encouraged to present back different ways of tackling the task, or different solutions to a problem, or different forms of presentations. For example, if, as typically happens in classrooms at present, pupils are asked to 'research' some aspect of a science topic, they may all present back information culled from authoritative sources, but do not necessarily ***use*** the information in any meaningful way, and do not actually demonstrate understanding. Their presentation is relatively uncreative and closed – it re-presents information culled from a variety of sources.
If it appears from the form of the task that **the purpose** is to produce four slides with text and graphics, the pupils will focus on this. If the purpose is to make a persuasive public case for some argument while using slides as part of their communications, the knowledge behind the argument becomes the focus of the group work, and generates a different form of discussion within the group. This in turn generates the need for different kinds of criteria for the assessment (see below).

ICT adding value to pupil independent learning.
Independent Learning could be extended by:

- Establish performance (not technical) criteria for assessment of the final presentations.
- Requiring pupils to peer assess the presentations by agreed criteria.

A characteristic of the Critical Skills classroom is that ***pupils apply quality criteria to their work***. The Coaching Kit describes a number of ways in which criteria may be generated. Some types of criteria must be generated by the teacher and are derived from the 'standards' e.g. from the 5-14 curricular guidelines, or from the Standard Grade learning objectives, e.g. 'cite evidence that our fresh water supply is essential for life'. Some could be agreed with individual pupils to cover particular difficulties which they have to address – e.g. one of the Powerpoint slides must be done by a specific pupil with minimal assistance from his/her group peers. Some could be generated through whole class discussion, e.g. some criteria for true collaborative work rather than the work emerging from the efforts of the best pupil(s) in the group/pair, or referring to strategies for helping individuals in a group to achieve a collective goal. The Coaching Kit gives guidance on how teachers can gradually learn the techniques for effectively managing these activities.

- Setting the activity us as a simulation or role play e.g. when pupils were told they were to be interviewed as energy consultants in a competition to commission a new energy source.

This bullet point refers to *forging links with real world settings and the authenticity of school tasks.* There has been a growing research literature since the 1980s on the readily recognised limitations in the transferability of knowledge and skills acquired in the narrow contexts of school tasks (ref?). Employers observe that school leavers who apparently perform well in the simple set tasks of school cannot demonstrate their skills in the real life settings of the workplace. Giving some purpose to school tasks, through requiring some real-life problem to be solved, or through the role play setting of a real-life context extends, enriches and consolidates the knowledge and skills they are developing.

- Setting the group projects up in a way that allowed the contributions to be integrated into a class presentation.
- Requiring the classes to make their presentations available as PowerPoint slideshows via a www page for parental scrutiny.

These two bullet points relate to one of the characteristics of the Critical Skills classroom – that ***pupils publicly exhibit their learning.*** The aim is to break down barriers between the classroom and the school and the environment in which it operates. The school website would be an ideal forum for this form of display. The prospect of an audience beyond the teacher reinforces the view that the point of the learning is not simply to please the teacher and is an incentive to pupils to do good work in the most appropriate formats for the audience. For different topics, rotating groups of pupils could be given the task of preparing a common presentation from the several individual or group productions – and justifying why the particular collation of materials was chosen.

- Inviting the groups to prepare 'advice memos' with the five most important things to get right on how to go about the project to be used with next year's classes.

One of the characteristics of the Critical Skills classroom is that ***the pupils (and teachers) reflect on what they are learning and doing***, and have a commitment to the wider community of learners in the class and school. This bullet point sets a context for a reflective feedback session from which both pupils and teachers may benefit. Pupils' voices are heard, they are being asked to give thought to their experiences and discuss how these may be improved, -critical reflection on their own behaviour may well figure in this! The outcomes of such a session may hugely assist the novice teacher in particular to think about how to improve or enhance the activities he/she is offering the pupils. The whole staff discussion of what the feedback from pupils has been is valuable evaluative evidence for the teachers developing their challenge tasks further. Techniques for stimulating simple and more complex reflection, and individual and group reflection are suggested in the Coaching Kit.

Recommendations

These recommendations have been generated from a variety of sources and with several considerations in mind:
The research literature on teaching and learning over the past two decades;
the aspiration of SEED to devolve decision taking to the schools;
the aspiration of the leaders of the profession for teachers to be empowered, informed workforce.

- The future developments of the school are linked to a framework of ideas about teaching and learning which gives some coherence to both the development activities of the teachers and the experiences of the pupils.
- The Critical Skills framework offers a wide ranging set of principles which could form the initial focus for the school and departmental developments.
- Across the school, a critical mass of teachers who are familiar with the Critical Skills material take responsibility for taking forward the ideas for coherent developments which emerge from the staff discussions.
- The method of staff development which was so successful in the science department for the induction and inclusion of the staff should be considered as the model of preference for many of the developments. (see sect 2.4)
- Each department might be encouraged to develop its own subject ‘mission statement’ with respect to the contribution of the subject experiences to the life and education of the child, both within the school and beyond.

APPENDIX 6

Student Attainment at the High School

Student attainment in National Qualifications has been consistently above the national average for Scotland and also above the average for the schools in the same Authority. Although some years the attainment details have fluctuated, over the period 1997 - 2002 the above statement holds true. The examples below, taken from 2002 statistics, serve to illustrate the success at the High School compared with the national picture.

Attainment at S4.

The percentage of the S4 pupils who secured five or more awards at level 3 or better reached 99% in 2002 (nationally 91%). This represents a clear message of success for virtually all pupils at this level. A similar picture can be drawn for S4 student success in qualifications at level 4 and level 5 with 46% (national 33%) of pupils securing the top grades, 1 and 2, in five or more subjects in 2002. Students in S4 in the school have a track record of higher than average exam success across all levels of attainment.

Attainment at S5.

There is a culture of progression into fifth and sixth form, with around 80% (nationally 64%) of all pupils staying on beyond S4. With such a large cohort remaining on, the results at S5 are consistently above the national achievement figures. Success at level 6 in National Qualifications is such that in 2002 57% (nationally 39%) of pupils on the original S4 roll secured at least one pass wjile 13% (nationally 9%) managed to secure five or more passes at this level.

Attainment at S6.

Students continue to secure success at level 6 when they progress to year 6 with 39% (nationally 30%) of the original S4 roll securing at least three awards at this level. It is only when considering level 7 success that the historic school picture starts to compare less favourably with the national picture. However compared to a national figure of about 12% of the original S4 roll securing one or more passes at level 7, the school figures have shown a trend in a positive direction moving from 10% in 2000 to 15% in 2002.

Reference above to levels of national Qualifications broadly translates to:

Level 3	Standard Grades 5 and 6
Level 4	Standard Grades 3 and 4
Level 5	Standard Grades 1 and 2
Level 6	Higher Grades A - C
Level 7	Advanced

APPENDIX 7

Masterclass

January 2004 http://www.ltscotland.org.uk/news/press.asp?newsid=375

This unique and innovative programme is aimed at establishing a shared vision across Scottish education authorities of the role of ICT in the future, and developing the capability within each authority to take this vision forward. The aims of the Masterclass programme are to:

- establish a shared vision of the potential and challenges of ICT in learning at all levels
- influence, guide and support pedagogical change using ICT across Scotland
- provide inspiration and encourage effective leadership in the embedded use of ICT in learning, teaching and management
- develop and share expectations of good management of ICT at all levels
- contribute to the ongoing development of a toolkit to support the effective use of ICT at all levels
- create a community that is able to implement and sustain the vision
- facilitate the dissemination of good practice in the use of ICT across Scotland.

The Masterclass programme is managed by Learning and Teaching Scotland on behalf of the Scottish Executive. The participants have been nominated by education authorities and institutions and identified as key staff who have a role in the development of ICT locally and at a national level. They include:

- 350 classroom teachers
- 140 senior managers in schools
- 140 local authority officers
- 22 librarians
- 27 lecturers in teacher education institutions.

A four-day residential training course has been developed and an online community established. Participants are expected to be active in the Masterclass community both during and after the training. Learning and Teaching Scotland is taking forward further development of the Masterclass community in a second phase including 'Masterclass - Leadership for Learning' - a programme developed for headteachers modelled on the successful SLICT programme in England.