The impact of ICT in schools – a landscape review

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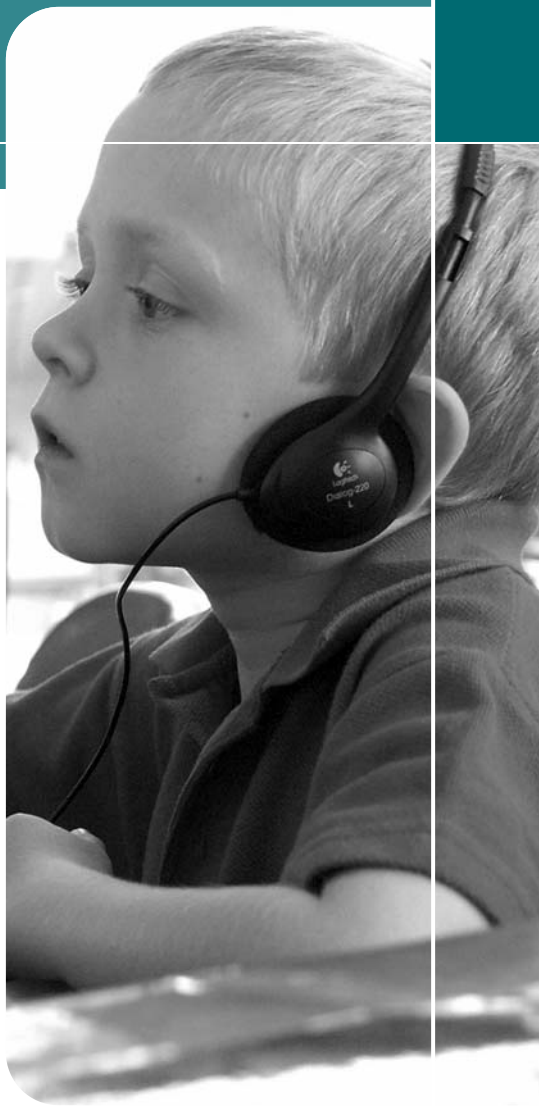
Executive Summary



Introduction

The impact of ICT in schools report was commissioned by Becta on behalf of the Department for Education and Skills (DfES) to analyse the impact of ICT on the schools sector across the United Kingdom. Over 350 published literature sources were consulted, ranging from policy documents, professional journals, research reports, reviews and digests to commercial publications. These have been listed in the bibliography although not all are referred to explicitly within the body of the report. This summary sets out the key messages from the literature, focusing firstly on the infrastructure to support the use of ICT, secondly on the impact on learning and teaching and, thirdly, on the extent to which ICT supports communication and links within and across schools and into the wider community. It concludes by drawing out several issues for further exploration and research.

Setting the context: ICT provision and access

In recent years there have been numerous surveys designed to give information on the extent to which schools are developing the capacity to integrate ICT into learning, teaching and management processes. The evidence gathered has shown a steady increase in the number of computers and other technologies over time, with most schools achieving the baseline targets for computer-to-pupil ratios. This finding, to a degree, masks considerable variation within and across schools with regard to regular access to reliable technologies and broadband connectivity. Evidence of the impact on learning and teaching indicates that, where the use of ICT is most effective in enhancing the learning experience, teachers have been able to integrate a number of technologies such as laptops, interactive whiteboards and the internet. Such combinations of hardware, software and connectivity allow them to develop innovative approaches to learning and teaching.

A critical factor in the effective use of ICT is the existence of a school-level e-strategy that addresses future development and sustainability and includes some means of monitoring progress against identified milestones. While innovations often begin within a key stage or subject department, they require a whole-school commitment if they are to become embedded in the daily experience of pupils, providing continuity and coherence across the years. While champions can, and often do, lead the way, new developments need leadership and strategic planning to ensure sustained changes in practice.

Teachers' confidence and skills levels have improved significantly in recent years, in part due

to the provision of more relevant and appropriate staff development opportunities. The newer programmes, such as Hands on Support (DfES, 2004) and Masterclass (Granville et al., 2005), are more flexible and targeted than before and there is a wider range of ways of learning about the new technologies and their implementation, including through the use of ICT itself. As a result, teachers – and school leaders – are able to identify the kind of training they want and need as well as how they can acquire it. Trainee teachers and the teacher educators have differing needs and these are beginning to be addressed.

Teachers' skills in working with ICT have developed significantly over the years and they are using ICT to support a range of planning and administrative activities at both class level (in planning and preparation and report writing, for example) and school level (in attendance and assessment records, and timetables amongst others). There is some evidence that, as teachers have acquired and developed ICT skills and confidence in using the technologies, they have experienced a reduction in some aspects of their workload.

Impact on learning and teaching in the classroom

The considerable investment that has gone into introducing ICT into schools – hardware, software, networking and staff development – will be deemed worthwhile if there is evidence that it has made a commensurate impact on the performance levels and progress of pupils. In drawing conclusions from the available literature, it is necessary to acknowledge the extent and nature of the evidence available.

While large-scale surveys such as those undertaken as part of the evaluation of Curriculum Online (see for example Kitchen et al., 2006), the Impact of ICT in Scottish Schools (Condie et al., 2005) or by BESA (BESA, 2006) provide quantitative data on access, provision, attitudes and preferences using samples that can be defended statistically, much of the evidence of impact on attainment and a range of intermediate outcomes such as motivation and engagement is derived from small-scale case studies which are often snapshots of impact early in the life of the implementation of a new technology. The number of different technologies available and the rate at which they are developing provide considerable scope for researchers although this has tended to result in a fragmented and unsystematic evidence base from which to evaluate the impact of ICT more generally.

Impact on attainment, motivation and engagement with learning

At present the evidence on attainment is somewhat inconsistent, although it does appear that, in some contexts, with some pupils, in some disciplines, attainment has been enhanced. There is a need for more systematically gathered evidence although it is already apparent that, where ICT has been successfully embedded in the classroom experience, a positive impact on attainment is more likely.

The body of evidence on the impact of ICT on intermediate outcomes, such as motivation, engagement with and independence in learning, is greater and more persuasive. The benefits identified in the literature include increased collaboration, greater engagement and persistence, more on-task behaviour and better conceptual understanding. Understanding of the extent to which ICT can support creativity, including critical thinking skills and problem-solving abilities, is developing, although some of the evidence appears contradictory. In the studies encountered, positive findings were associated with a range of technologies, particularly those with strong visual elements such as digital video, drama-oriented software and multimedia

presentations. Much of the evidence is drawn from small-scale case studies and there is a paucity of large-scale, methodologically rigorous research from which generalisations may be drawn.

In general, impact is most clearly observed where tasks have clear educational aims, are designed to maximise the potential of the ICT in use and are perceived as purposeful by pupils.

Impact within specific subject areas

Some areas of the curriculum have been the focus of considerable ICT development. Apart from initiatives to support literacy and numeracy, evidence of positive impact has been reported in mathematics, modern foreign languages, science, history, geography, physical education and the creative arts. Much of the evidence is the result of small-scale studies, however, and further research is needed to determine the extent to which the successes recorded can be replicated elsewhere, and their persistence over time.

There has been considerable development in the provision of online resources for teaching across subject areas, from a range of sources, commercial and public. More specifically, learning of modern foreign languages has benefited greatly from the increased availability of online resources as well as technologies such as digital video and photography, while animations and simulations have enabled pupils to grasp more complex concepts in mathematics and the sciences. These have been particularly effective in supporting understanding of abstract or microscopic concepts and processes in science.

Digital video and photography have also been proven to improve performance in physical education, sport and the dramatic arts where performances can be recorded, watched time and again, and improvements of skills targeted.

Impact of specific technologies on learning and teaching

The range of technologies available for use in the classroom has increased rapidly as the infrastructure in schools has developed. Interactive whiteboards (IWBs) have been the focus of a considerable number of studies, large and small, in no small part due to government endorsement and support for them. They are relatively common in schools compared with other technologies and the reports from studies of their impact draw similar conclusions. The outcomes are almost universally positive, particularly where they are used in conjunction with other technologies and there are clear pedagogical reasons for their use. Display and presentational software, including animations and simulations, combined with IWBs, help pupils to develop an understanding of abstract concepts through concrete examples and graphical images of, for example, microscopic processes.

Mobile technologies are growing in availability and, given their attractiveness to pupils, are gradually being introduced to support various educational initiatives, usually with a focus on communication. They have been shown to be effective in supporting learning for disaffected and 'hard to reach' pupils, where attending school is problematic for personal or family/cultural reasons.

Laptops, which teachers have found particularly useful for management and administration, have been less enthusiastically received by pupils, who prefer the smaller technologies such as PDAs and multi-function mobile phones. Mobile technologies are being developed for use with hard-to-reach learners and in projects aimed at improving access to ICT for those pupils without a computer in the home. Educational software developers are beginning to capitalise on pupils' enthusiasm for games and gaming, potentially benefiting the development of a range of skills

including decision making, information processing and team working.

Whole-school approaches to implementing ICT-supported education have often been more successful in primaries than in secondary schools; this appears to be a function of their size and the greater commonality of approach used. This is an area that would benefit from focused study, to determine what factors are critical in realising the aims of a whole school e-strategy.

Technologies with a visual dimension – digital video, photography, video conferencing – engage pupils and provide a stimulus for collaborative working and discussion and, where the pupils are in control of the technology, give them a sense of ownership and control of the learning process. Such technologies appear to be especially effective when used with groups of pupils with special or additional needs.

Learning platforms and virtual learning environments, are often used as repositories or communication technologies, although there is evidence that they are, for many schools, becoming central to a whole range of activities, linking various technologies and applications. They can make a significant contribution towards personalising the learning and teaching experience, for both pupils and teachers. They have been shown to support discussion and collaborative activity as well as multi- and cross-disciplinary work.

Impact on specific groups of pupils

The needs of specific groups of pupils, such as those with special needs, the disaffected and the children of Travellers, are being addressed through various initiatives involving a range of technologies. Compared to the school population as a whole, the numbers in each group are relatively small and, as a result, much of the evidence of the impact of ICT use comes from small-scale studies. The very nature of the problems faced by the pupils involved means that the initiatives tend to be relatively intensive in terms of individual support. As a result, while the evidence may point to gains for the pupils involved, issues of scale and sustainability arise.

There is a growing body of evidence on the positive impact that ICT can have on the learning of pupils with special educational needs, whether through adaptive or assistive technologies specially designed to support pupils with specific disabilities or through the use of mainstream technologies such as digital video and photography.

Personalisation of the learning experience

While there is evidence that the new technologies are increasingly becoming integrated into the learning experiences of pupils and that learning is being enhanced by the new technologies, growth has been limited by the need to provide fast connectivity and a virtual learning environment (VLE) or learning platform. The little systematic evidence that exists indicates that good resources can have an impact on motivation and attainment. Once established, e-learning can offer flexible, personalised learning and bridge the gap between home and school learning. There is a concern, however, that there is not yet a good understanding of how teachers can support pupils and make the most of e-learning packages.

A persistent theme in the literature is the extent to which ICT can make the learning experience more personalised, more targeted at the needs of the individual learner. Combinations of technology and applications give greater choice in relation to what, when and where to study, selecting according to interests, learning styles and preferences and need. Such systems can give the pupil more autonomy and independence with regard to learning and a range of sources of

information to draw on. This can be unsettling for some teachers and may well change the dynamics of the pupil–teacher relationship. There is little in the literature on the potential impact on relationships in the classroom as schools develop e-capability and use ICT to support the learning process more widely.

Impact on communication between schools and with the wider community

Almost all schools are networked internally and linked to the internet, increasingly by broadband. Much of the literature is concerned with how schools were using these. Improved communication within schools has led to centralised attendance, assessment and recording systems, while links with the external world can support communication with parents and others within the local community as well as contact with schools and agencies in other countries.

Impact on administration, management and workload

Intranets are being used by schools, primary and secondary, to support a range of administrative activities including attendance monitoring, assessment records, reporting to parents, financial management and the sharing of information amongst staff. In addition, some are used as repositories for learning resources. Increasingly, albeit slowly, schools are extending their use of ICT through the introduction of learning platforms in order to meet various learning and teaching and communication objectives.

Better management systems usually mean more data-gathering procedures. There is evidence that schools are becoming better at identifying the data to be gathered and in using it strategically, for self-evaluation and monitoring purposes.

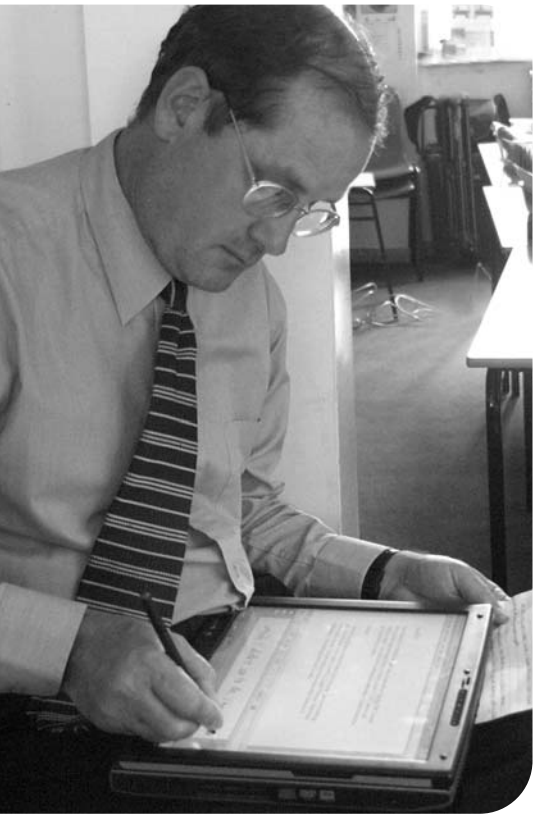
Impact on communication with parents and the wider community

Improving communication with parents is considered to be important in reducing the home–school divide in that parental attitudes to schools and their support for the work of the school are viewed as critical factors in ensuring that pupils gain as much as they can from the learning opportunities provided. While much is written about the potential for using ICT to bridge the gap between in- and out-of-school learning and to gain parental support, improved home–school links are as yet unrealised in many instances. This is an aspect that has developed relatively slowly, although there is evidence of the benefits to be gained if it can be realised, and studies are under way of alternative technologies, such as using PDAs to compensate for lack of access to a computer out of school. Other obstacles identified include limitations on the networks and connectivity as well as a lack of interoperability across systems.

As schools grow in e-confidence, ICT becomes embedded in the everyday practices of the school, drawing on a range of technologies to support learning, teaching and attainment.

Most schools are linked to the wider community and beyond through the internet, providing a rich source of resources for teachers and learning opportunities for pupils. Schools are developing links with schools in other countries through video conferencing, and with other services and agencies such as libraries and the careers services.

However, as ICT becomes an everyday experience for pupils in classrooms, schools also have to consider how they ensure that all pupils have similar learning opportunities and the 'digital divide' does not develop into a system-wide disadvantage for those who have limited or no access to ICT out of the school. Pupils, teachers and parents seem to benefit from good home–school links using ICT and the newer, cheaper, mobile technologies might go some way to providing a solution.



Summary

The development of ICT in schools is progressing unevenly across and within schools and technologies. Some seem to be content with achieving the government's targets in terms of numbers of computers and connectivity, while others are being highly innovative, attempting to capitalise on the benefits that ICT has been shown to bring.

As schools grow in e-confidence, ICT becomes embedded in the everyday practices of the school, drawing on a range of technologies to support learning, teaching and attainment. The literature is very positive about some aspects of ICT use, rarely negative, but mainly incomplete or inconsistent. Further studies, particularly with a longitudinal element, should shed light on the processes that schools go through in becoming e-confident and e-capable, the impact on relationships within the school, between home and school and across networks, and on pedagogical practice. Using ICT effectively in schools is about more than changing resources; it is about changing practices and culture.

Introduction

1.1 Background to the study

This study was commissioned by the British Educational Communications and Technology Agency (Becta) on behalf of the Department for Education and Skills (DfES) to analyse the impact of information and communications technology (ICT) on the schools sector across the United Kingdom. It draws on a range of publicly available literature, including research findings, policy statements and grey literature, seeking out evidence of where the introduction of ICT has made a difference to the day-to-day experiences of teachers and pupils, in the classroom and more widely, with a focus on the compulsory school sector.

The primary aim is to build a 'big picture' landscape of the impact of ICT in the school sector, with reference to a range of educationally related outcomes extending beyond, but also including, Key Stage attainment. Thus impact, in the context of this study, focuses on the ways in which the use of ICT has changed the learning and teaching experiences of pupils, practitioners and institutions.

1.2 Approach to the analysis of the literature

Within this study, the focus is on evidence of the impact of ICT on the school sector since 2000. Government-funded support for ICT through, for example, the National Grid for Learning (DfEE, 1997), the Superhighways initiatives (DfEE, DENI, Scottish Office, Welsh Office, 1997) and, subsequently, the ICT in Schools initiative, really only began in earnest in the mid 1990s. However, while there were evaluations of and research into ICT in education prior to this period, it is only within the last five to six years that this has become a substantial body of evidence, at both national and local levels, on the subsequent implementation and impact of these initiatives. Increasingly, research into and evaluation of the use of ICT in education has generated evidence not only of the effectiveness of different technologies, but also of the conditions for successful implementation of new approaches to learning and teaching through ICT, and ways in which it might support schools in improving the experiences of pupils and, in turn, attainment. The growing volume of evidence is a reflection of the ubiquity of the new technologies in recent years, in schools and in society in general, as well as a reflection of the rapidity with which new technologies appear and old ones are superseded.

The search for evidence was based, initially, on the four key objectives that the DfES Harnessing Technology strategy (DfES, 2005) aims to achieve. These are:

1. to transform learning and teaching, improving outcomes and sharing ideas;
2. to engage 'hard to reach' learners through the provision of special needs support, motivating learning experiences and increased choice;
3. to build an open accessible system with more information and services online, improving personalised support and choice; and,
4. to achieve greater efficiency and effectiveness through the use of online resources and improved systems and procedures.

The literature listed in the bibliography came from a range of sources. Initially, the team drew on materials gathered and produced as a result of funded research and evaluation exercises that they had undertaken (for example, Stark et al., 2002; Livingston and Condie, 2003; Condie et al., 2005), supplemented by material generated through electronic searches of the literature and additional materials from the Becta database of research findings.

Searches were limited to UK and European studies where one or more areas of the UK were involved. Initial searches used broad search terms such as ICT/technology + education, which became more focused and specific as they developed, for example technology + teaching + physics or technology + special educational needs. Abstracts and executive summaries were gathered and reviewed by at least two members of the team for relevance and the full papers and reports sought where it seemed warranted and relevant. In addition, newsletters, case study reports and web-based literature were gathered.

Approximately 350 documents were identified as having some relevance to the study, although only 200 have found their way into this report. Grey literature, particularly government policy documents, was included, as were national survey reports and peer-reviewed journal articles. A full bibliographic list of the documents consulted is included as Annex 1, following the list of references to materials used in the report.

1.3 Reflections on the literature

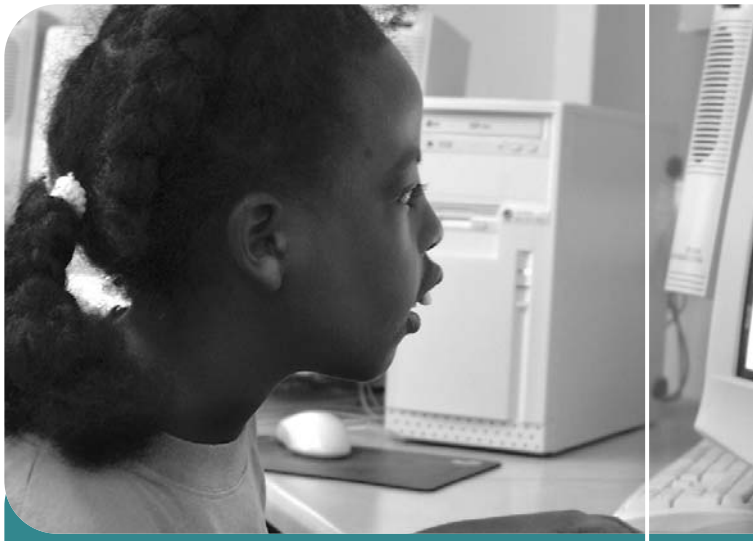
In the course of this study, we read and considered almost every piece of literature gathered, whatever the source. The documents that we consulted ranged from policy documents, professional journals, research reports, reviews and digests to commercial publications – much taken from the internet. We did not exclude any research reports on the basis of criteria related to methodology or theoretical robustness, but rather focused on relevance to the central theme of the study. (See Furlong and Oancea (2005) for a discussion of these concepts in relation to educational research.) The issues raised by Cox et al. (2003a) in reviewing the literature on the relationship between ICT and attainment also apply here. The nature of the research is important and findings are influenced by whether the use of ICT is studied in natural settings, looking at how teachers use their existing ICT resources, or whether the focus is on a new initiative or intervention designed to change practice. Intervention studies can potentially cause greater disruption to existing practice, affecting the settings in which ICT is used and teachers' pedagogical practices as well as challenging teachers' attitudes, beliefs and existing practices. These can, in turn, affect the research findings and influence the implications that follow. This has been borne in mind in compiling this report.

The range of literature gathered was extensive,

from large-scale national surveys to case studies of single classes or schools. The former provided broad generalisations from quantitative measures, while the latter illuminated the issues through the more immediate experiences of pupils and teachers working to implement the new technologies. Taken together, the 'hard' data from the larger, quantitative studies (often based on national samples of pupils and practitioners and using standardised tests or similar) and the 'softer', qualitative evidence from small-scale research and evaluation reports (including the growing number of practitioner case studies from the ICT Test Bed Project), provide an overview of what has been learned about the impact of the new technologies on schools, pupils and teachers across the United Kingdom. As a result, reports on small-scale studies (with limited generalisability) and commercial documents (potentially biased), have been used judiciously and primarily as illustrations of specific strategies within limited contexts.

The evidence uncovered was patchy in terms of technologies and strategies for their use in schools. Some aspects have been well researched, such as interactive whiteboards, while others have come to the attention of researchers more recently, such as online resources and learning platforms. In addition, what appeared initially to be several different studies into a specific technology often turned out to be multiple outputs from the same study, and this was compounded by the number of reviews and summaries of the literature compiled by different bodies and presented in different formats. As a result, making a clear judgement on the weight of evidence for any one innovation or initiative is not straightforward. In addition, some documents have not appeared in this report as they duplicated or summarised findings from other sources.

Section 2 of this report considers the context in which learning and teaching happens and those factors which influence the extent to which ICT can have an impact in schools, including school policies, levels of ICT provision, management and organisational orientation towards the use of ICT and the confidence and competence of staff in using ICT to support learning and teaching. Section 3 focuses on the impact on learning, teaching and attainment as a result of the use of ICT within the classroom and across the curriculum. In addition, it looks at the impact of its use with specific groups of learners. Section 4 looks at the literature on the impact on classroom practice, on schools where ICT-based systems for administration and communication have been developed and implemented and on how ICT is beginning to link schools with parents and the wider community. The final section, 5, draws conclusions from the analysis of the literature and outlines some of the implications for policy, practice and further research.



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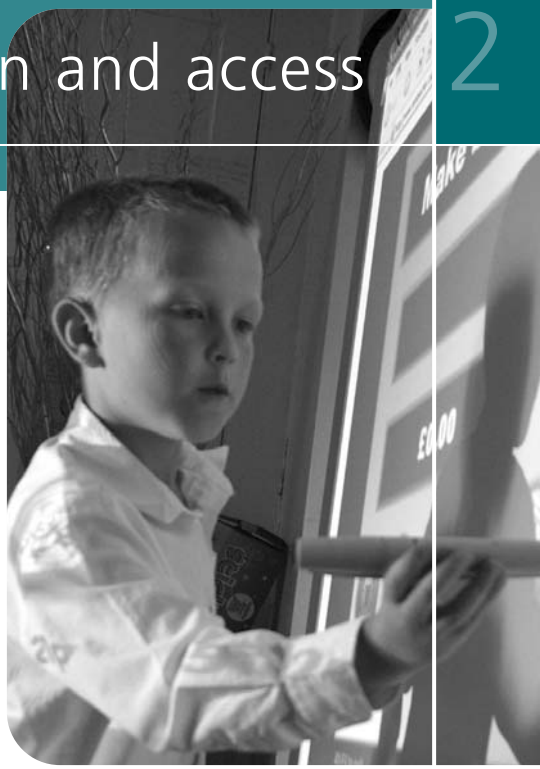
Setting the context: ICT provision and access 2



The extent to which schools are in a position to implement and take advantage of ICT in learning and teaching depends on development across a number of dimensions relating to infrastructure including: school policy; resources; teacher confidence and capability; connectivity; security; and management of the system. Each of these has, to a greater or lesser extent, an influence on the ways in which ICT becomes part of the learning and teaching process and has an impact upon the experiences of pupils, teachers and schools. This section describes the context in which the use of ICT in learning and teaching is developing.

2.1 Policies, management and leadership within schools

In 2005, Ofsted observed that, in England, few schools had a strategic plan that saw ICT as a tool for raising standards (Ofsted, 2005). More generally, planning lacked coherence and there was little evidence of rigorous evaluation of the use of ICT at institutional level. In Scotland, one of the key drawbacks to the development of ICT was the finding that few schools had systematic approaches, that is, a policy and strategy for developing information literacy (HMIE, 2005). BESA (2005) reported that the best opportunities for exploiting the potential of ICT were in schools where technology was an integral part of institutional planning strategies which included procedures for maintaining and enhancing the ICT capability and infrastructure of the institution on a regular basis, in other words a comprehensive e-strategy. It was estimated that, by the end of 2005, 50 per cent of primary and 67 per cent of secondary schools in the United Kingdom would have e-learning strategies in place (BESA, 2005).

A strategic plan, preferably one that is developed in the context of a whole-school policy, is important in that it identifies priorities, sets targets and timetables and gives a framework against which to monitor and evaluate progress.

In the 2004 Scottish survey of the impact of ICT, a significant number of schools reported that little progress was being made because ICT was no longer on the development plan (Condie et al., 2005). One interpretation is that schools felt that once they had achieved certain, primarily quantitative, targets, the rest would almost inevitably fall into place. The evidence is that there is a lot more to integrating ICT into the educational experience of pupils than achieving a set ratio of computers to pupils and networking them – that is just the start. On the other hand, having a policy is no guarantee of being able to procure further resources; strategic planning for ICT involves financial planning.

Leadership and management are significant factors in the extent to which policy becomes practice and developments in ICT become embedded into the life of the school and experiences of staff and pupils. Much of the literature encountered in this study focused on the experience, attitudes and beliefs of those with formal, structural responsibilities within schools; there was less evidence of the influence that 'informal' leaders or 'champions' can have on a school or local authority.

Ofsted (2004a) noted that leadership in primary schools was improving, as was forward planning

with regard to ICT use and the clarity of vision of how the new technologies might be used. The Ofsted report concluded that good leadership was a critical factor in the development of ICT maturity and recommended that courses on strategic leadership in ICT should be made available to middle management and those working to support schools in implementing new ways of working with ICT. In particular, they recommended that all those working with schools should be aware of the impact of ICT on teaching and learning in their area of expertise.

In Scotland, the Masterclass initiative was launched in 2002. Its key aim was 'to inspire educational professionals to champion ICT use in teaching and learning and become part of a community facilitating dissemination of good practice in use of ICT across Scotland' (Granville et al., 2005, p.1). It was evaluated in 2005 and it was concluded that the specific focus on school leaders had made a positive impact on participants, which in turn influenced ICT development in schools (Granville et al., 2005). (See http://www.ltscotland.org.uk/onlinecommunities/aboutmasterclass.asp for further detail.)

Some form of committee or working group, with the remit to oversee developments and monitor the implementation of the strategic plan, can provide support to those attempting to implement the new technologies, particularly the ICT co-ordinators. In Scotland, 25 per cent of primary schools and 89 per cent of secondaries reported that they had a group or committee of this kind (Condie et al., 2005). This may, in part, be a function of the size of the institution: the more complex organisation of the secondary school may require a more formal system of implementation and monitoring. It would be interesting to explore the extent to which these differences in structure impede developments or whether informal structures in primary schools are sufficiently developed to support sustained development; there is little in the literature on this.

One benefit of formal structures for schools, and for researchers, is that they make visible the decision-making process and its outcomes. In Scotland, for example, ICT co-ordinators reported that, whereas the agenda in such decision-making bodies had previously tended to focus on the acquisition of ICT resources, there had been a shift towards how ICT might be used to support learning and teaching. Similarly, their own remits had been modified in line with changing priorities and included: 'prioritising school needs, allocating resources, identifying future needs' and 'staff development, promoting use of ICT, monitoring the use of ICT' (Condie et al., 2005, p.36). Formal structures also provide a framework for monitoring and evaluating progress against institutional milestones.

While the existence of an ICT working group or committee would seem to be a critical feature, there is some evidence to indicate that the appearance of 'champions' within a school can make a significant difference to the likelihood of any initiative becoming embedded within practice. In several instances in the literature, the introduction of new technologies was down to the drive of one or more enthusiasts within a school or department, 'champions' who introduced new approaches to teaching and learning and influenced their colleagues by example. However, the evidence also indicates that where this is the sole driver of change, whatever the initiative, it is unlikely that new practices will become embedded in the practice of the institution/authority or sustained long term (Condie et al., 2004; Condie et al., 2005).

The 2004 report on the ICT Test Bed project (Somekh et al., 2004) and other initiatives such as those in some Kent schools (Ellis, 2003), suggest that while champions can have some effect, this tends to be on only the one or two aspects in which the individual is particularly interested – a personal hobby-horse or specialist area. Somekh et al. (2004) noted that where institutions adopted a

whole-institution strategy, strong mutual support mechanisms developed, enabling the growth of technological maturity and increased staff and pupil confidence and competence.

Fullan (2005) argues that where initiatives are sustained, and where they become embedded in institutional practice and culture, management and leadership are critical factors. In particular, where responsibility and leadership are distributed throughout an organisation, it is more likely that sustained change will be achieved. This would imply that, while an enthusiastic teacher or headteacher might make some impact, unless there is a commitment throughout the institution, with accountability for progress at key points, it is unlikely to be sustained or become part of the culture.

The provision of staff development, either directly or indirectly, is a significant responsibility for leaders and managers. Ofsted (2004b), in one portrait of the successful implementation of ICT, noted that senior management led by example and shared a vision of how school staff could develop their ICT skills collegially and create resources across subject areas. There was clear recognition that they had to understand and work with the internet generation, Prensky's 'digital natives' (2001). As part of national policy development, initiatives to improve teachers' confidence and competence in working with ICT have been implemented alongside those intended to improve the infrastructure within and between schools and the wider community.

2.2 Access to ICT

The first ICT initiatives (Superhighways, 1995–97; National Grid for Learning, 1998–2000; and, in England, ICT in Schools, 2000–present) were concerned with ensuring that schools had access to sufficient hardware, through specified computer-to-pupil target ratios, and were networked, both within the school and to the outside world through the internet. Subsequently, there have been various related developments such as wireless technology; broadband connectivity; teaching aids such as interactive whiteboards (IWBs); presentation software; and online programs (for example SCHOLAR – http://scholar.hw.ac.uk/index.html).

Developments have been monitored through surveys of ICT provision within and across the regions of the United Kingdom (UK). While some of the information available relates to the UK as a whole, other data is restricted to, for example, English schools. This section provides an overview of the position towards the end of 2005, although the picture is incomplete for some parts of the UK.

The main findings indicate that, in 2005:

- most schools in England had achieved or exceeded the national targets for computers to pupils, with reported figures of 1:6.1 in primary schools (compared to 1:8.8 in 2002 and 1:8 in 2003) and 1:3.7 in secondary schools (compared to 1:5.9 in 2002 and 1:5 in 2003) (Becta, 2005a).
- the smallest primary schools (<200 pupils) tended to have better computer-to-pupil ratios than did the largest primaries (>300 pupils), at 1:4.7 and 1:7.9 respectively, although this was not in evidence in the secondary sector (Becta, 2005a).
- 51 per cent of primary schools and 86 per cent of secondary schools had all their computers linked to the school network, as compared to the 2002 figures of 32 and 64 per cent respectively (Becta, 2005a).
- most English primary schools (63 per cent) were connected at 2 Mbps or less and 18 per cent were connected through broadband at 8 Mbps or above, with the remainder somewhere in between. English secondary schools tended to have faster connections, with 43 per cent connected at 2 Mbps or less and 44 per cent connected at 8 Mbps or above (Becta, 2006a).

- in England, 41 per cent of primary schools and 71per cent of secondary schools made use of wireless technology (Becta, 2006a).
- 71 per cent of primary schools and 91 per cent of secondary schools in England had a school website, with 26 per cent of schools using the website to provide pupils with access to learning resources (Becta, 2006a).

Surveys also provide information on the availability of other technologies. For example, by autumn 2005, approximately 93 per cent of primary schools, 96 per cent of secondary schools and 85 per cent of special schools had at least one IWB (Becta, 2006a).

A further factor influencing ICT use is the way in which computers are deployed within the school and there has been considerable debate on whether they should be classroom-based, in labs or suites, or both. Prior and Hall (2004) noted that 77 per cent of primary, 98 per cent of secondary and 69 per cent of special schools in England reported at least one ICT suite while, in Scotland, 83 per cent of primary teachers used a shared computer base or suite with their pupils, as did 69 per cent of secondary teachers (Condie et al., 2005). Passey et al. (2004) supported the use of suites, particularly when combined with IWBs, stating that they enhanced pupil engagement by creating environments that encouraged positive attitudes towards learning and behaviour. This was particularly apparent with disaffected pupils, who would pay attention to the whiteboard although they would rarely look at a book. The evidence indicated that computer suites can be cost effective, they can provide opportunities for developing ICT skills and knowledge and they can help to embed ICT as a regular part of the curriculum when timetabled for each class. A number of pupils can work at a computer at the same time and the teacher can demonstrate applications to the whole class. In addition, they can be accessed by other community groups out of school hours.

However, there was some concern expressed by Scottish teachers that computer suites tended to result in learning about ICT rather than through ICT (Condie et al., 2005). When computers were readily available in the classroom, they tended to be used throughout the day and for a variety of purposes, becoming a relatively routine part of day-to-day activities. Computers in the classroom are particularly useful in personalising learning, whether as a consequence of special needs, individual interests or individualised learning programmes or activities (Becta, 2001). In their report on the roll-out of the NGfL programme in ten Pathfinder local education authorities, Somekh et al. (2002) noted that, in primary schools, specialist computer suites led to a move away from using ICT to support the whole curriculum; lessons in computer suites tended to focus on the acquisition of ICT skills and understanding.

The debate on whether to base computers in the classroom, in suites, or both, has effectively been overtaken by the development of wireless technologies and by a growing recognition of the need to provide as wide a range of ICT provision as possible. Becta, in summarising the outcomes of the NGfL Pathfinders programme, comments that while computer suites remain popular with schools, more flexible arrangements using wireless technology and classroom-based clusters are required to support learning within subject areas, across the curriculum [http://partners.becta.org.uk/index.php?section=rh&rid=11222; see also HMIE, 2005].

2.3 Teachers' confidence and competence

There is a need to consider, separately, the contributions that in-service or continuing professional development (CPD) and pre-service education make in preparing confident and competent teachers. This section considers the readiness of new and experienced teachers to embrace the new technologies and to use them

more generally. It focuses briefly on the attitudes of teachers to ICT, their needs and the kinds of the training provided as part of the drive to embed ICT in schools. The impact of ICT on developing classroom practice, where teachers have sufficient skills and confidence to begin to integrate various technologies into learning and teaching, is considered in Section 4.

National in-service programmes have been targeted primarily at experienced practitioners who are coming to terms with new technologies and new ways of working. In contrast, those who are entering pre-service training directly from schools are more likely to be familiar with the new technologies and less likely to be reluctant users of ICT as a teaching resource. As a result, the implications for pre- and in-service training are likely to be somewhat different.

2.3.1 Pre-service or initial teacher education

The majority of teachers in classrooms today trained before ICT became a significant development in education. As a result, in-service programmes have been developed to provide the requisite skills and understanding. Alongside this, teacher training institutions have developed programmes designed to provide student teachers with the necessary competence and confidence to at least begin to use ICT within their practice.

Most students entering pre-service or initial teacher training programmes today will have had considerable exposure to ICT in their own education, as well as for recreational and personal use. However, an assumption that they will already have acquired a basic level of ICT knowledge and experience could disadvantage further those who, for whatever reason, have not had the same opportunities to develop their skills (Simpson et al., 1999). While many trainee teachers may feel comfortable with the hardware and software they have used and observed in their classrooms as pupils, or in their home contexts, they may still lack the confidence to make best use of new resources. If core ICT skills and exposure to the new technologies are not available as a structured part of pre-service training, there is a risk that new teachers will continue to apply 'safe' technology, namely that which their own teachers have used, and resist the opportunity to be innovative about the choice of ICT resources for their own use.

Trainee teachers need to have the opportunity to investigate the use of ICT as a pedagogical tool, to experience the benefits of ICT in teaching for themselves, and to explore potential applications in the context of their own teaching practice (Graham and Thornley, 2000). However, this necessitates teacher educators being competent and confident with ICT resources and the associated pedagogy themselves (Yildirim, 2000). Teacher educators will need to be much more than expert users of ICT; they will need to be 'specialist educators who can make students secure in the range of pedagogical uses soon to be required of beginning teachers' (Simpson et al., 1999).

If core ICT skills and exposure to the new technologies are not available as a structured part of pre-service training, there is a risk that new teachers will continue to apply 'safe' technology... and resist the opportunity to be innovative about the choice of ICT resources for their own use.

Recent research suggests that student teachers' understanding of the pedagogy of teaching with ICT develops in stages which correlate closely to their developing understanding of the pedagogy of their subject, and that this level of sophisticated thinking generally matures late in their training (Taylor, 2004). The research also suggests that there is no clear relationship between the level of ICT skills of student teachers and the level of sophistication in their thinking about the use of ICT in teaching and learning. The conclusion from this is that whilst basic ICT skills and exposure to ICT in teaching (such as through observations) should be part of the early stages of teacher education, teaching of ICT pedagogy should be initiated later in the training process, when the students' understanding of and ability to reflect on effective pedagogy are more developed.

This is not to overlook the fact that one objective of pre-service training should be to develop the confidence of student and new teachers to be innovative and creative in their application of ICT to teaching (Sime and Priestley, 2005). There is a risk that teachers without confidence in both their knowledge of ICT and of the associated pedagogies will become bound by the resources available, rather than developing their own materials and approaches. However, there is also a risk that new teachers with very enthusiastic designs for applying ICT to their teaching can be disappointed and restricted by the resources that are actually available to them in schools (Sime and Priestley, 2005).

There is a need for more research into whether the use of ICT resources by teacher educators as part of pre-service programmes has a significant effect on new teachers' use of ICT in their first jobs (Galanouli and McNair, 2001) or whether observations of ICT use in teaching, combined with pedagogical discussions, have more impact. In order to investigate the ways in which e-learning can support the teacher training process, the Teacher Training Agency (now the Training and Development Agency for Schools, TDA) provided grants for a series of case studies into the use of ICT by trainee teachers. Seventeen small-scale projects are described in the report of progress on the research (TTA, 2005). The technologies investigated included virtual learning and managed learning environments, video conferencing and tablet PCs. The amount of detail provided is limited and some of the summaries are of 'work in progress' rather than outcomes, therefore it would not be appropriate to summarise impact across the studies. However, a number of positive outcomes have been reported for several of the individual projects which tend to be very much in line with other findings from the literature (see Section 3.3). The majority of the negative findings were concerned with practical issues such as learning how to use the technologies, the time and cost demands of starting up the project, and the impact of the new technologies on the culture of the school.

Student teachers are concerned about issues other than having the skills to cope with ICT in the classroom and have expressed disquiet about the impact of ICT on the pupil–teacher relationship, where there is a reduction in the perception of the teacher as expert and, in turn, on his or her status (Mee, 2005). Some experienced teachers have expressed similar concerns (Condie et al., 2005), particularly in relation to pupils being more confident and skilled in ICT than they felt themselves to be.

Finally, the importance of ICT in supporting teachers' administrative functions should also be addressed in pre-service training. Teachers are increasingly expected to apply ICT as at least part of the solution to increasingly demanding workloads, and administrative ICT techniques should form part of pre-service education, not just because administration is part of placement experience, but because once in service, teachers have little time for training in support of

administrative tasks (PricewaterhouseCoopers, 2001).

More research on the transition from student teacher to classroom practitioner is required – more specifically, evidence on the longer term impact on practice of their pre-service experience, the subsequent demands of the first few years within the school and the context in which they find themselves working. Contextual factors would include: level and type of provision; staff development and support, in school and in the local authority; and the availability of resources.

2.3.2 In-service training

The initiatives to introduce ICT into schools in the 1990s were accompanied by national programmes of staff development which aimed to develop confidence and competence in the workforce. These programmes were resourced through New Opportunities Funding (NOF) and often involved attendance at a series of staff development sessions which focused primarily on developing technical competence and understanding rather than on pedagogical principles. Beastall (2006) describes the NOF programmes as 'largely unsuccessful' and evidence from other studies supports this (Conlon, 2004; McCarney, 2004: Condie et al., 2005; Stark et al., 2002; Ofsted, 2004c).

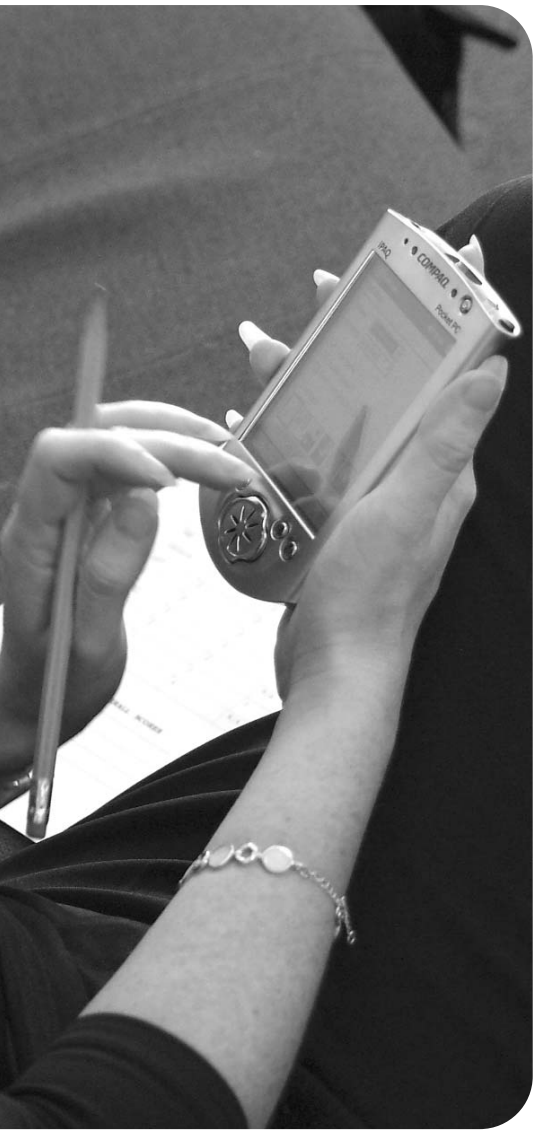
More recent initiatives, such as Hands on Support (HOS) in England (DfES, 2004) and Masterclass in Scotland (Granville et al., 2005), focus more on developing an understanding of the pedagogical value of ICT. Masterclass also addressed the issue of distributed leadership, providing staff development to three key groups: school/classroom-based staff, including ICT co-ordinators, school librarians and those with a staff development remit; centrally-based staff, including local authority staff and Her Majesty's Inspectorate (Education); and senior management in schools, that is, headteachers and deputy heads. Similarly, the National College for School Leadership (SLICT) Programme provides support for school managers and leaders (see http://www.ncsl.org.uk/programmes/slict/index.cfm).

The main impact of in-service training has been increased confidence and willingness to embrace new technologies and approaches (Ofsted, 2004b; Condie et al., 2005). However, there is a cautionary note from Ofsted (2005) in their report, *Embedding ICT in schools*, where they observe that while staff competence and confidence has improved, this is more in using the applications themselves than in using them effectively in learning and teaching. There remains a tendency to stick to safe, tried and tested approaches to classroom practice. More optimistically, there is evidence that this increased confidence has led some teachers to try new approaches and activities and discover for themselves the impact on pupils and the teaching and learning process. Further exploration of the factors that lead to innovation and experimentation by teachers could identify ways in which this becomes more widespread.

There is also evidence that training must be perceived as purposeful by teachers and, ideally, tied closely to the introduction of new technologies and/or software, such as IWBs. Research on teachers' training needs (see for example Condie et al., 2005) reported that teachers were looking for staff development beyond managing the technology and, increasingly, for guidance and advice in embedding ICT in everyday practice, particularly in relation to specific subject areas. In addition, they wanted training only in those technologies to which they had access in school. They preferred the 'hot' information and advice that peers and colleagues could provide, rather than 'cold' information from manuals and workbooks – and training that addressed their specific needs, rather than the 'one size fits all' approach of the NOF programme. The personalisation of learning was also an issue for trainee teachers, according to Barton and Haydn (2004). Course materials and

web-based resources designed to support student teachers' development in ICT were largely disregarded, often due to a lack of time to read through what were often perceived as very detailed documents. The focus for the trainee teacher was more on the short-term agenda and on gaining the skills and understanding to support practice during placement. In this, the attitudes of the department to ICT use, 'modelling' of practice by teachers and being 'talked through' applications by practitioner colleagues and other support staff was perceived as more helpful.

The newer programmes, including HOS and Masterclass, seem to have taken this on board. The evaluation of Masterclass (Granville et al., 2005) tells of a number of positive effects, including changes in the ways in which ICT was used in the classroom, an increase in new hardware in schools and greatly improved skills amongst participants. It provides evidence of more networking and sharing of resources amongst practitioners through the online facilities available as an integral part of the programme, although not all participants took advantage of this.



2.4 Summary of key points

- The majority of schools have achieved the baseline targets for computer-to-pupil ratios, although this is more the case in the secondary than in the primary sector.
- While there are schools, and departments within schools, that are making significant progress in using ICT to support learning and teaching (using for example, websites and IWBs), many schools still do not have the hardware or sufficient broadband connectivity to allow them to develop more innovative approaches and/or use the newer technologies.
- Significant numbers of UK schools lack an e-strategy that addresses future development and sustainability; neither do they have a system for monitoring and evaluating performance and progress.
- There have been significant changes in the nature of staff development for teachers in recent years. New programmes such as Masterclass and Hands on Support are more flexible and targeted at individual needs and people in key roles in schools, and online resources are becoming more numerous and reliable.
- Leaders also need staff development. Most progress has been observed where leaders demonstrated commitment and supported staff in achieving the strategic aims of the school. This involves both understanding of the potential of the technologies available and of how they can become integrated into the day-to-day life of the school.

Impact on teaching, learning and attainment 3

The study, in reviewing the impact of ICT on learning and teaching, sought evidence of its impact on attainment and on intermediate outcomes such as motivation and behaviour. In searching the literature on the impact of ICT in schools, these are the themes that generated the greatest number of publications, perhaps reflecting wider, political concerns over raising standards of learning and teaching in schools and, in turn, attainment. Some of the literature looked at the impact of ICT in general, whilst other documents focused on specific technologies and teaching strategies.

3.1 Use of ICT in teaching and learning

In our own experience, as teachers in the primary and secondary school sectors and as teacher educators, early ICT use in schools (pre-2000) can be broadly depicted as supporting drill or practice in previously taught skills or concepts, as assistive technologies for pupils with special needs and/or as a treat or reward when work was completed satisfactorily. There was little collaborative work and pupils tended to work individually on the class computer in the corner of the room. Given the novelty value of computers in the 80s and early 90s, and limited access out of school, access to a computer was perceived as motivating in itself and used to promote pupil engagement in the learning process and ease classroom management in a relatively crude manner.

By contrast, current use can be broadly described as characterised by collaborative, investigative and problem-solving activities designed to develop increasingly independent learners who are confident users of ICT, exploring and finding out for themselves, with greater peer interaction compared to non-ICT lessons (Hennessy et al., 2005). This is reflected in growing emphasis on e-learning defined by the DfES (2003) as those approaches that exploit 'interactive technologies and communication systems to improve the learning experience' (DfES, 2003, p.7). Similarly, the JISC policy statement describes e-learning as 'learning facilitated and supported through the use of some or all of the various technologies', including computers, desk- and laptop, mobile and wireless tools, electronic communication tools, learning platforms and IWBs (JISC, 2004, p.10).

Thus effective e-learning initiatives bring together benefits derived from a range of technologies and other related initiatives such as laptops for teachers, data projectors, interactive whiteboards, computer suites or clusters and online resources, although broadband connectivity is crucial (Passey, 2005). The nature of the learning experience may have changed, but of greater interest is the extent to which the use of ICT has influenced a range of learner outcomes and what aspects of the ICT-augmented experience appear to have made a difference.

3.2 Impact of ICT use in teaching and learning

This section describes and analyses the evidence for changes in the nature of the learning experiences of pupils due to the use of ICT, and the impact that this has had on a number of

learner outcomes. Impact on learning at individual, school or national level can be discerned through measuring changes in performance levels on standardised tests, such as Key Stage tests and GCSE results, while softer measures of improved learning include pupils', teachers' and parents' perceptions of performance and progress. Other benefits have been identified including motivation and engagement, independent learning and autonomy and key or core skills such as collaborative learning and communication, all of which can contribute to improved knowledge, understanding and skills. This can, in turn, have an impact upon attainment.

3.2.1 Impact on learning and attainment

There are few studies that attempt to discern a direct, causal relationship between ICT use and attainment, although many identify improved attainment as one of a number of outcomes of increased ICT use. Unfortunately, it is not always clear how attainment is defined or measured in some of the research reports. In some, 'attainment' refers to performance on standardised tests while in others, the definition is broader and impact relates to observed improvements in pupils' understanding within specific subject areas, that is, domain-specific cognitive development. In discussing the relationship between ICT use and attainment, more weight has been given to those studies that used standardised tests or similar reference points, while those drawing conclusions on the basis of the arguably 'softer' evidence of teachers', parents' or pupils' perceptions of improvement in performance have been used to elaborate upon or supplement the findings.

In an extensive review of the literature on ICT and attainment, Cox et al. (2003a) found evidence of positive effects on pupil attainment in almost all National Curriculum subjects. This was most marked in the core subjects of English, mathematics and science, where there has been greater investment in the development of subject-specific ICT resources to support learning and teaching. These are also the areas where the evidence of change in attainment levels was more robust, often drawing on national testing results. The evidence of the effects of ICT in other subject areas was considered by the authors to be inconsistent, patchy and somewhat limited in the range of technologies investigated.

More specifically, ICT was found to support language development in general, particularly at the early stages, whereas it tended to have positive effects in science and mathematics on specific concepts and, in learning modern foreign languages, on the acquisition of sub-skills such as word recognition and vocabulary building. Cox et al. (2003a) concluded that teachers' pedagogies had a large effect on pupils' attainment, with aspects such as the technologies selected, the ways in which they were deployed and the extent to which the teacher planned and prepared for the lesson, being significant. Most of the research that they encountered on the use of ICT hardware and software was limited to a small range of resources, many of which were used by individual teachers working in relative isolation. They concluded that the frequency and range of ICT use influenced the effect on attainment and that, when used effectively, there was evidence of a positive influence on attainment. The most effective use was where ICT use was directly linked to curriculum objectives and specific concepts and skills, becoming an integral part of the learning experience. In a similar vein, Passey et al. (2004) concluded that, where ICT was clearly embedded in classroom activity, there was a positive impact on pupil attainment at GCSE level.

Similar findings are reported in other large-scale studies and summaries of evidence of impact, including those from Ofsted and Her Majesty's Inspectorate of Education (HMIE). Pittard et al. (2003) noted that evidence from large-scale studies, most notably ImpaCT2 (Harrison et al., 2002), showed that the use of ICT can motivate pupils and result

in a positive effect on attainment amongst those pupils who make relatively high use of ICT in their subject learning. Strand 1 of the ImpaCT2 investigation focused specifically on pupil learning and attainment and found positive associations between ICT use and achievement on some Key Stage (KS) tests, although the strength of the associations observed varied with stage and subject area. Statistically significant positive associations were found between ICT use and higher levels of attainment in: National Tests in English (KS2); National Tests in science (KS3); GCSE science (KS4); and GCSE design and technology (KS4). Positive associations were also found between ICT use and National Test results in mathematics (KS2) and in relation to GCSE outcomes in GCSE modern foreign languages and geography (both KS4), although these did not reach statistical significance.

However, it was also noted that no association between superior performance and low levels of ICT use was observed. Factors such as the expertise of the teaching staff, access to subject-specific resources at each Key Stage and the quality of the materials were identified as influential. The findings from ImpaCT2 form a significant part of the evidence in many of the literature reviews encountered in the course of this analysis.

Other documents report on findings from studies of specific groups of pupils and/or technologies. For example, Ofsted (2004a) reported a steady increase in pupils' levels of attainment in ICT (as a subject within the curriculum) in primary schools and, more specifically, found that emailing raised the attainment levels of reluctant learners. In a study of the use of ICT with deaf pupils, the RNID concluded that the attainment levels of deaf pupils could be improved where ICT was used effectively, as too was motivation (RNID, 2004).

The Ofsted review of the use of ICT in secondary physical education identified a positive relationship between the use of ICT and attainment in coursework at Key Stage 4. The use of video analysis improved pupils' movements and their skills of observation and analysis. It also increased motivation to learn, improved evaluation skills and led to more consistent and accurate performance (Ofsted, 2004d). The corresponding review of the use of ICT in business education also showed a link with achievement. The quality of coursework and portfolios was of a high standard and clearly presented. In addition, ICT had been used effectively for data analysis, research (using the internet) and the understanding of concepts such as stock control, break-even analysis and cash flow (Ofsted, 2004e). Parrott (2003), in discussing the factors influencing the development of ICT literacy in pupils, noted that while ICT had made only a small improvement in the GCSE results of those pupils who were regularly exposed to its use, this was likely to increase as the new technologies became an integral part of the learning experience of pupils in schools.

Where ICT has become a regular part of the classroom experience, there is evidence of positive impact on learning and pupil performance. Various studies have found evidence that the visual nature of some technologies, particularly animations, simulations and moving imagery, engaged learners and enhanced conceptual understanding (see, for example, the findings of Passey et al., 2004; Livingston and Condie, 2003; and HMIE, 2005). Similarly, the use of software that enabled pupils to view their designs in 3D was found to enhance the quality of pupils' work (Ofsted, 2005).

Overall, the evidence on the impact on attainment of learning through ICT remains inconsistent, however. Many of the reports of a positive impact are based on case study research, much of it drawing on the perceptions of teachers and others. One study that did find contradictory evidence was the EPPI review of the literature on the effectiveness of ICT in literacy learning (ages 5–16 years). The authors concluded that there was little substantive evidence that it had a positive

effect on literacy outcomes, although they did acknowledge that some of the studies they encountered had been excluded on methodological grounds (Torgerson and Zhu, 2004). Their analysis did uphold the conclusion by others that ICT increased motivation and the development of ICT skills. The last of these was also reported by Ofsted (2004a), in addition to the finding that ICT reinforced learning in numeracy and literacy. They reported that ICT was particularly effective for pupils with special needs in that it enabled them to overcome barriers to learning which, in turn, led to improvements in achievement. More generally, it helped them to participate, to present their work more attractively and improved self-esteem and confidence (Ofsted, 2004a).

Valentine et al. (2005) found that parents and pupils believed that ICT improved motivation and confidence, made schoolwork more enjoyable and improved achievement. They reported a statistically small improvement in attainment in mathematics and English linked to the home use of ICT for educational purposes at particular key stages, and concluded that home use brings advantages in terms of new sources of information, enhanced presentation and raised self-esteem which, in turn, affect attainment.

> All of the secondary school teachers involved felt that ICT had a positive impact on pupil interest in and attitudes to schoolwork – pupils took greater pride in their work and it was more likely that tasks were completed and on time.

There were some indications of gender-related differences in home use, where girls tended to use ICT for educationally-oriented activities while boys tended to play more games. In relation to game-playing, there was some statistically significant evidence that the extensive use of ICT for leisure purposes was linked to lower progress towards attainment targets, that is, the more time spent playing computer games (or other leisure pursuits), the less was available for study.

In summary, the evidence seems to point to an impact on attainment where ICT is an integral part of the day-to-day learning experiences of pupils, although the weight of evidence is insufficient to draw firm conclusions. (Evidence of impact within specific subject areas is considered in more detail in section 3.2, and of particular technologies in section 3.3.3.) Some of the evidence from small-scale, primarily qualitative studies, is less robust, but even where attainment is clearly defined and standardised tests are used, isolating the impact of the ICT use on attainment is problematic. Schools and classrooms are involved in any number of initiatives designed to improve performance and attainment, making it difficult to identify the impact of individual projects or interventions. The evidence on the impact on some of the intermediate outcomes such as motivation and engagement, as opposed to the end-point outcome of attainment, is somewhat more persuasive.

3.2.2 Learning styles and the impact of ICT

The concepts of 'learning styles' and 'learning preferences' feature in a small, but growing, proportion of the literature on the benefits of ICT in schools. Where they do, the potential of ICT to present learning experiences in a range of formats is seen as one way of meeting the different learning styles of pupils.

Theoretically, learning styles are generally considered to have a physiological basis and to be

fairly fixed for the individual – 'characteristic cognitive, affective and physiological behaviours that serve as relatively stable indicators of how learners perceive, interact with and respond to the learning environment' (Keefe, 1979, p.4). There is a significant body of literature that investigates and explores the identification and classification of learning styles and how they might influence the learning process (see, for example, Riding and Rayner, 1998; Kolb, 1984; Coffield et al., 2004).

There are also many instruments designed to identify individual learning styles, including the Index of Learning Styles (Felder and Silverman, 1988; Felder and Soloman, 1999). However, Felder and Soloman (1999) note that, while the profile of an individual's learning style can provide a pointer to the probability of a tendency towards one or another kind of learning experience or instructional style, it should not be used as an assessment of whether or not a learner is suitable or otherwise for a particular subject or discipline. In addition, they argue that labelling learners in this way may be damaging, if not misleading. Adding further complexity, Riding and Rayner (1998) differentiate between learning styles and learning strategies, where the concept of learning strategies refers to the approaches that learners develop in order to deal with different learning tasks, so that they can make effective use of their preferred cognitive style.

Where learning styles are discussed in the literature on the use of ICT in the classroom, rarely is the term defined or portrayed as problematic. Quite apart from the underpinning complexities identified above, there are other concerns around the practicalities of identifying individual pupils' cognitive styles and providing for them within the classroom. These concerns should be borne in mind when reference is made to learning styles in the following discussion. One conclusion we have reached is that the issue of learning styles and the role of ICT in learning and teaching requires focused investigation using robust, empirical methods.

3.2.3 Impact of ICT use on motivation and engagement

One of the most frequently cited findings is that of increased motivation and improved engagement exhibited by pupils when ICT is used in learning and teaching, both overall and in relation to specific technologies such as digital video (see, for example: Pittard et al., 2003; Passey, 2005; Passey et al., 2004; Becta, 2003a).

The most significant research study to date on the motivational effect of ICT on pupils (Passey et al., 2004) aimed to identify and, where possible, quantify impact and to relate it to aspects such as learning outcomes, behaviour, school attendance, truancy, anti-social behaviour and uses of digital content. This study drew on a range of theoretical stances, problematising the concept of motivation and identifying a number of different dimensions. It defined eight measures that could be used to identify and quantify these – learning goals, academic efficacy, identified regulation, intrinsic motivation, performance approach goal, performance avoidance goal, external regulation and amotivation. Each of these is based on, usually implicit, reasons pupils might have for engaging with tasks in the context of school. For the first four, high levels of measurement produce a positive learning profile while for the last four, low levels are desirable. The measures formed the basis of pupil questionnaires and motivational profiles were constructed from the responses.

The study found that, when working with ICT, pupils' learning was characterised by high levels of motivation towards achieving personal learning goals – a desirable outcome – but also high levels of motivation towards gaining positive feedback on individual competence (performance approach goals) – which was less desirable. This latter characteristic was evidenced in the pupils' concerns that they might get things wrong in front of others, particularly the teacher.

Overall, however, the forms of motivation associated with ICT use were concerned with learning rather than mere task completion and, when using ICT, pupils perceived their classrooms to be very focused on the process of learning. Passey et al. concluded that using ICT helped to draw pupils into more positive modes of motivation and could offer a means by which pupils could envisage success. All of the secondary school teachers involved felt that ICT had a positive impact on pupil interest in and attitudes to schoolwork – pupils took greater pride in their work and it was more likely that tasks were completed and on time.

Analysis by gender indicated that both boys and girls were motivated by the use of ICT, although there appeared to be a greater positive effect on boys than girls. One possible explanation, put forward by the authors, is based on the traditionally held view that boys tend to work in 'burst' patterns of activity while girls are more persistent in their approach. ICT, they argue, enables boys to shift from working in 'burst' patterns towards more persistent patterns of working.

Other benefits included reportedly better pupil behaviour in most cases where ICT was used, access to better resources, particularly the internet, for research and independent study, and improved quality of work in terms of writing, appearance and presentation. Writing and publishing software supported many aspects of writing and the appearance and presentation of work was enhanced by the availability of presentational software, often linked to use of interactive whiteboards whose presentational features, annotation effects and possibilities for direct interaction were extremely motivating (Passey et al., 2004). Investigations into the effect of the use of specific technologies on motivation and attainment have increased significantly in recent years (see Section 3.3).

In a small-scale qualitative study, Sime and Priestley (2005) also found that, where ICT was used, students engaged more deeply and for longer periods with activities, and took greater pride in the work they produced. Other studies have found evidence that the visual nature of some technologies, particularly animations, simulations and moving imagery, engaged learners and enhanced conceptual understanding (Passey et al., 2004; Livingston and Condie, 2003; HMIE, 2005).

There is also evidence that the tasks given to pupils have to be perceived by them as purposeful; the mere presence of a computer is not enough in itself to sustain motivation (Passey et al., 2004; Condie et al., 2005; Burden and Keuchel, 2004). The new technologies tend to have little novelty value for pupils whose out-of-school experiences of ICT hardware often far exceed those in school in terms of speed, quality of graphics and sound and innovation (Condie et al., 2005). Passey et al. (2004) reported that ICT use had to be coupled with appropriate learning tasks and that teaching should provide a core of focused pointers (such as where to find appropriate sources and how to select relevant information). Where ICT use was focused on both teaching and learning, the potential for raising motivational levels was greatest.

While increased motivation is important, Davies et al. (2005), in reviewing the research evidence on the impact of ICT in the 14 to 19 age range, found that motivational variables do not in themselves lead directly to improvement in achievement; rather, the effects of increased motivation are mediated by other variables that are linked to the development of learner autonomy and higher-order cognitive skills. The development of metacognitive skills and self-regulation, it is argued, leads to increasingly effective learning strategies amongst pupils, greater engagement with learning activities and, in turn, attainment. While Davies et al. focus on the 14 to 19 age group and therefore deal with issues of self-concept around the time of adolescence and their impact on learning and attainment, the

implications are relevant more widely. Digital technologies, of themselves, are unlikely to make an impact on attainment unless they are embedded within 'powerful learning environments' (p.11). However, they note that research into the characteristics of such environments is, as yet, at a very early stage of development.

3.2.4 Developing creativity

One facet of digital technology potential, as yet exploited to only a limited extent, is that of creativity. Creativity can be broadly defined as the generation of new ideas or concepts, or new associations between existing concepts. Loveless (2002), in her wide-ranging literature review of creativity, new technologies and learning, identified ICT as a set of tools that could be selected and deployed as and when appropriate in the creative process. In addition, it is argued, the characteristics of ICT can make a distinctive contribution to creative processes. Her research indicated that learners and teachers could use ICT to support imaginative expression, autonomy and collaboration, fashioning and making, pursuing purpose, being original and judging value. ICT could offer opportunities to be creative in authentic contexts in ways which were not formerly possible or accessible. Indeed, creativity could be promoted and extended with the use of new technologies where there was the understanding of, and opportunities for, the variety of creative processes in which learners could engage.

Loveless noted that digital technologies were being used creatively in education with a range of authentic, relevant and challenging activities established in the areas of:

- developing ideas (supporting imaginative conjecture, exploration and representation of ideas) and in making connections (supporting, challenging, informing and developing ideas by making connections with information, people, projects and resources).
- creating and making (engaging in making meanings through fashioning processes of capture, manipulation and transformation of media).
- collaboration (working with others in immediate and dynamic ways to collaborate on outcomes and construct shared knowledge).
- communication and evaluation (publishing and communicating outcomes for evaluation and critique from a range of audiences).

These activities involved, variously, the use of control technology, programming (with LOGO or with digital toys), engaging with simulations and adventure games, creating hypertext stories, using CAD/CAM software, web-based exploration and testing tools, constructing avatars to meet in virtual worlds and composition for art, drama or music.

In research with secondary pupils studying art, Long (2001) noted the development of a growing awareness of the potential of multi-modality in the pupils' work. Loveless (2002) noted that the internet not only offers collaborative opportunities – linking with real artists, writers and musicians or simply other like-minded individuals – it also offered a presentation and publication outlet for pupils' creative work.

Creativity is now regarded as central to children's abilities to work imaginatively and with a purpose, to judge the value of contributions and to fashion responses to problems posed across the curriculum (Facer and Williamson, 2004). On the basis of a series of small-scale research and development projects, Facer and Williamson concluded that a collaborative approach was important in stimulating developments in creative learning and suggested that digital technologies should be designed to support creative collaboration in the classroom. This could help children more easily externalise, share and refine ideas, explore different representations of ideas through

different media and take advantage of multiple opportunities to adapt and revise their work.

They argued that those digital technologies that stimulate non-linear working should be developed further and that a culture that values and supports creativity and collaboration should be fostered. Activities involving animation, digital video, online puppetry, web-page design and drama-oriented software offer possibilities for exploitation to create personalised, creative learning materials such as digital narratives, multimedia presentations and 3D landscapes or architectures. A significant issue for schools is the extent to which the ethos and culture of the classroom can support and encourage creativity as opposed to the acquisition of existing skills, knowledge and understanding.

The role of ICT in assessing creative and critical thinking skills has also been investigated. In a systematic review of the literature, Harlen and Deakin Crick (2003) sought evidence of the impact of ICT in assessing creativity. Studies were included or excluded on the basis of a number of criteria, in that they: were concerned with research on pupils aged 4 to 18 years; involved the formative or summative assessment of creative and/or critical thinking using ICT; and were written in English (although not necessarily UK-based). Only two studies were considered to carry 'high weight', that is, they were of sufficient methodological rigour for the review team to have confidence in the findings. While 103 studies were initially identified, only 12 met all of the inclusion criteria for selection. This in itself is significant, indicating the paucity of systematic, robust research in this area.

The evidence from the 12 studies that did meet the criteria was limited and, in some instances, the methodologies used were sufficiently weak to cause the team to qualify the findings as 'tentative' or recommend that they were treated cautiously. The authors were most confident in identifying computer-based concept mapping, with automated scoring, as useful in the summative assessment of critical and creative thinking about complex relationships and in the use of ICT in storing and recording information on the development of pupils' understanding. ICT could be used to remove some of the burden of assessing and giving feedback to pupils from teachers, allowing them to focus on supporting learning. Such feedback was found to be effective in supporting improvement in subsequent test performance.

More tentatively, they found evidence that the use of ICT could provide information on the processes used in problem solving, that computer-based programs resulted in higher performance levels than on equivalent pencil and paper tests, that the nature of the subject matter could influence the performance of girls more than boys and that students' experience with computers and their attitudes towards them could influence the outcomes of computer-based tests. Much of the 'tentative' evidence was inconclusive or conflicting, resulting in a call for more systematic, focused research on specific aspects of assessment such as the conditions and purposes of testing and experience of the students.

In considering the implications for policy and practice, Harlen and Deakin Crick stressed the importance of recognising that ICT is not a single entity and that its use should be based on a consideration of how it can be integrated into the processes of learning, teaching and assessment. They argued that the way to bring about the effective use of ICT in the classroom is through the professional development of the teachers, but development should involve both knowing how to use ICT (the technical dimension) together with understanding how to use the technologies to bring about the higher-order thinking (the pedagogical dimension) that is the basis of developing and assessing creative and critical thinking. In addition, the teacher's role involves supporting learners' need to reflect explicitly on the learning process (developing metacognition), facilitating self-

regulation and allowing learners to gain greater control over their own learning. Harlen and Deakin Crick viewed the teacher's role as one of mediation when ICT is used to support learning.

While the evidence identified in the review echoes the findings of other studies, the question-marks over the robustness and range of the studies discussed leave some cause for concern.

3.2.5 Summary of key points

- The evidence of the impact of ICT on attainment is, as yet, inconsistent, although there are indications that in some contexts, with some pupils, in some disciplines, attainment has been enhanced. There is not a sufficient body of evidence in any of these areas, however, to draw firm conclusions in terms of explanatory or contributory factors.
- One fairly consistent finding is that the greatest impact is observed where ICT has become embedded or integrated within the everyday classroom experience of pupils.
- At present, the evidence of impact on intermediate outcomes such as motivation and behaviour is more compelling. The use of ICT seems to engage pupils, resulting in more on-task behaviour, greater persistence and deeper understanding. Appropriately deployed, ICT appears to support and encourage greater collaborative activity, inquiry or problem-based learning and independent study.
- One caveat to be added here is that, where the use of ICT did appear to affect attainment or any one of the intermediate outcomes discussed, the evidence was often based on a 'snapshot' study, while the initiative was still quite young and possibly benefiting from the novelty of the intervention. Longitudinal or time series studies where impact is measured at intervals as technologies become more commonplace and embedded into the classroom experience would give greater insight into the factors influencing sustainability and impact in the longer term.
- Where the use of ICT is effective, the tasks/activities must be seen as purposeful by pupils and the ICT dimension should be integrated into the experience in such a way that it genuinely enhances learning (provides added value) if the benefits are to be sustained in the longer term.

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3.3 Impact in specific subject areas

The third Curriculum Online survey (National Centre for Social Research, 2006) indicated that the proportions of primary and secondary teachers who considered ICT to be important in the teaching of specific subjects had risen significantly since the first survey in 2002. In primary schools, the majority of primary teachers considered ICT as important for maths, English and, to a lesser extent, science. In secondary schools, substantial increases were observed in the percentages of teachers who considered ICT to be an important aspect of teaching in maths, science and geography at Key Stage 3 and maths, music and modern languages at Key Stage 4. This section considers some of the ways that ICT has been deployed to support subject teaching.

The literature contains numerous examples of investigations into ICT-based strategies that have been developed with a view to supporting learning and teaching within specific subject areas and disciplines although it should be noted that most of those encountered were of relatively small scale projects. Other sources of evidence include literature reviews and overviews of developments by bodies such as Her Majesty's Inspectorate (Education) and Ofsted. Overall, the evidence indicates that ICT has wide applicability across the curriculum and this section looks more closely at the findings on the impact of ICT in literacy (specifically English), mathematics, modern foreign languages, science, social sciences and the humanities (including geography and history).

Looking across schools, HMIE (2005) found that ICT had allowed pupils to learn in a greater variety of ways which were better matched to individual learning preferences and the nature of the discipline. For example, conceptual understanding in science was developed through 3D animations or simulations and the use of video microscopes, while pupils studying modern languages could see, hear and interact with native speakers through video-conferencing facilities, in addition to traditional learning experiences.

3.3.1 Literacy and English language

Broadly speaking, research into the use of ICT in English is fairly consistent in finding that ICT helps improve writing and reading skills, supports collaboration and develops speaking and listening skills. The ImpaCT2 study (Harrison et al., 2002) found that ICT use promoted greater pupil engagement with the subject, allowing opportunities for reflection and analysis and contributing to the development of higher-order skills associated with communication. In addition, the use of word processing accelerated and enhanced writing development. Writing was particularly enhanced where ICT use was combined with high-quality teacher guidance or was deployed in the context of writing for a real audience (Becta, 2003c), where pupils could exploit the potential afforded to composing, drafting, revising and reorganising their work (Mumtaz and Hammond, 2002).

It was found that the development of multimedia design and presentational software packages allowed students to transform different media outputs into seamless integrated reports and presentations promoting communication, negotiation, decision making and problem solving (Reid et al., 2002). In many cases the use of digital techniques allowed pupils to review film and engage in detailed analysis and discussion that would have not have been possible though any other medium (National Educational Research Forum [NERF], 2005).

The ESRC-funded InterActive Education Project at the University of Bristol has supported a significant number of small-scale studies into the impact of ICT across a range of curriculum subjects [www.interactiveeducation.ac.uk/index.htm]. Teachers and researchers investigating ICT use in

English and literacy used email, internet searches and PowerPoint presentations to develop awareness of audience, purpose, register and genre; made use of Storybook Weaver and PowerPoint software to access, manipulate and annotate images to develop understanding of visual narrative; created texts on a number of themes using different ICT resources; and used classroom computers with the interactive whiteboard to explore the etymology of words and the relationship between language, semantics and spelling (InterActive Education, 2006c). The report on the project indicates that the use of ICT in English language teaching and learning has had a positive impact on pupils' attitudes and attainment, although the evidence for this is limited by the small-scale nature of the studies. The findings themselves focus on the positive aspects of ICT in supporting learning in English, such as the potential to create authentic texts for 'real' purposes and audiences and the increased access to textual material through the internet. Well-designed ICT environments allowed abstract concepts such as imagery to be explored, with improved use of literary features in GCSE writing subsequently.

A particular concern in recent years has been the under-achievement of boys in literacy (Condie et al., 2006). One of the small-scale ICT Test Bed projects focused on the impact of ICT on boys' attitudes to literacy in the early foundation stage (Fisher, 2005). It was found that the use of an IWB made boys more interested in literacy activities, particularly writing. This interest was maintained and in some instances heightened when linked to computers. The boys were motivated to complete work to a higher standard than before the ICT Test Bed Project started and were observed to operate at levels they would have found difficult to achieve with traditional pen and paper methods. More generally, they developed a more positive attitude towards literacy through ICT.

Andrews et al. (2005) undertook a systematic review of the effectiveness of different technologies in the teaching and learning of written composition in English with pupils aged 5 to 16 years. While they initially identified over 2000 papers across the world in the area of written composition, the application of inclusion criteria reduced this to 14 reviews of studies on the topic and a further 53 primary research reports (of which 36 were from the USA, 15 from the UK and one each from Australia and Canada).

Further analysis reduced this to nine studies that focused on the effectiveness of ICT in the teaching and learning of written composition in English for in-depth review. However, these were so heterogeneous in methodology and outcomes that it was not possible to undertake a meta-analysis of the evidence generated across the studies. The authors concluded that they could not identify reliable evidence to satisfy the original aim of determining whether ICT was effective in the teaching and learning of English for 5–16-year-olds.

Their key conclusion was that there was insufficient high-quality research to answer the original research questions about the effectiveness or impact of ICT in relation to literacy/English language learning. They did draw implications for policy, practice and research, however, encouraging policy-makers to think of ICT as a range of technologies that may be variously effective in different areas of the English language curriculum, rather than as a key tool in the development of literacy. Consequently, curricular needs should drive procurement. Similarly, with regard to practice, ICT should be regarded as one of many tools to support learning and teaching, a part of the teacher's repertoire to be drawn upon as appropriate to the task in hand.

As with other EPPI reviews considered (Harlen and Deakin Crick, 2003; Torgerson and Zhu, 2004), the authors made particular reference to the need for more research, in particular for large-scale well designed randomised controlled trials, while acknowledging the need for attention to ethical

issues and the limitations of such methodologies. They suggested that a combined research and development approach is needed, one that is focused on both cutting-edge developments in the new technologies and pedagogical application together, as opposed to research into how technologies are subsequently applied within the classroom.

3.3.2 Mathematics

In mathematics, the key benefits identified from research into ICT use have been increased pupil motivation, a more concentrated focus on strategies and interpretation, faster and more accurate feedback to pupils and greater pupil collaboration and co-operation (Becta, 2003d). ICT use made a major contribution to developing problem-solving skills, practising number skills and exploring patterns and relationships. Software used in conjunction with an IWB can provide a dynamic geometry environment. Some of the mathematics projects supported by the InterActive Project team at Bristol University investigated the impact on learning and attainment in just such an environment. The key findings indicated that, in order to provide the most effective learning experience, the teacher/school had to consider all aspects, taking a holistic view of the learning and teaching process. Aspects such as the pupil–computer interface; the teacher's role in the process, including language and ways in which she/he interacts with pupils; the use of other, non-digital tools such as pencils; and the time given to individual and whole-class activity all require to be addressed explicitly in planning for using ICT in the learning and teaching of mathematics [http://www.interactiveeducation.ac.uk/maths_impact.htm].

One project in the InterActive Education series of studies described how pupils were able to manipulate shapes more easily using ICT, helping them to bridge the gap between concrete and abstract concepts and improving their learning and understanding of the properties of quadrilaterals. The whiteboard helped to make all of the pupils' developing conceptions visible to the whole class (NERF, 2005).

Cox et al. (2003a) also found that animations and simulations enhanced understanding in mathematics and science and that ICT could create a range of diagrams and other graphical representations of concepts and processes not possible with traditional forms of resources. (See Cox et al. (2003a) for detail of the impact of ICT in specific areas of mathematics such as programming, graphs and algebra.)

Becta (2003d) reported that spreadsheets used with an IWB fostered enhanced understanding of sequences and powerful modelling software helped pupils explore 'what if...?' scenarios and immediately see the consequences of their decisions and discern successful decisions. Immediate feedback encouraged students to conjecture and keep exploring. ICT-based tasks encouraged collaboration while the use of multimedia software motivated pupils, leading to improved performance.

Research also found that the dynamic and symbolic nature of computer environments supported pupils in generalising and making links between their intuitive notions of mathematics and the more formal aspects of mathematical knowledge (Interactive Education, 2006a).

Cox et al. (2003a) noted that many benefits had been identified regarding the use of LOGO in the late 1990s. These included the development of problem-solving skills, transferable skills, higher-order levels of mathematical thinking and the learning of geometric concepts as well as enhanced social interaction through group tasks. Unfortunately, the use of LOGO appears to have diminished as other forms of ICT have been adopted. Concern was also expressed that ICT was used less in mathematics than in many subject areas. This was also noted in ImpaCT2 (Harrison et al., 2002), where 67 per cent of pupils at KS3 never or hardly ever used ICT in mathematics, although at KS4 the figure was over 80 per cent.

3.3.3 Modern foreign languages

The literature indicates that ICT offers many advantages in the area of modern foreign languages (MFL) and teachers in schools are experimenting with a range of resources and using word processing, blogging, authoring software, video conferencing, email, interactive video, multimedia resources, presentations software, spreadsheets, interactive whiteboards and databases. Many writing activities on the computer have been found to encourage pupils to use new language skills, supporting them with colour, images, sound and video (CILT, 2005).

Taylor et al. (2005) argue that ICT use implies a new literacy or a fifth skill in language use. They found that students using ICT for writing in a foreign language were more willing to write and produced longer texts and that computer use led to increased fluency and quality in their writing. ICT appeared to motivate kinaesthetic learners in particular, while drop-down menus within electronic writing frames and PowerPoint presentations encouraged students to produce structured and fluent writing. Similarly, the InterActive Project found that the use of tailored writing frames enhanced language learning (Taylor et al., 2005). They encouraged engagement, resulting in writing at greater length and in more complex ways, and provided scaffolding that helped pupils structure their writing (both in the short and longer term).

The advantages for MFL go beyond the computer and the classroom, however. This is one area where a wide range of ICT-based activities, including games, have been developed and where a range of technologies, including mobile phones and video conferencing, can be integrated into the curriculum (Facer and Owen, 2005; HMIE, 2005; Condie et al., 2004: Condie et al., 2005). Digital resources give access to a vast range of information and learning opportunities and pupils can work at their own pace as digital resources can be slowed down and viewed time after time, to suit the needs of the learner (Passey et al., 2004).

Video conferencing was found to be highly motivating for students and generated powerful learning effects (Becta, 2004b). This was one of the conclusions of the DfES Video Conferencing in the Classroom project which involved 28 schools, including special schools and learning centres, across a range of age groups and a wide geographical area. Teachers involved in the video-conferencing evaluation were convinced that use had a positive impact on achievement. Other cultures could be accessed, enabling cultural identity to be formed. Synchronous face-to-face interaction with native speakers was a great benefit and pupils using this developed greater confidence and competence than would have been expected.

Facer and Owen (2005) found that benefits to foreign language learning include using the internet and video conferencing to communicate with native speakers through links with schools in other countries and accessing foreign language

Synchronous face-to-face interaction with native speakers was a great benefit and pupils using this developed greater confidence and competence than would have been expected.

entertainment and information. The real-life situation was motivating and encouraged learners to practise language in context, aiding the acquisition and development of reading, writing, listening and speaking skills. Pupils could work at their own pace and practise in environments free from embarrassment.

The Digital Video in the MFL Classroom Project (CILT, 2005) supported a range of different mini-projects which aimed to develop video resources for language learning in French, German, Spanish and Japanese. Similar benefits were identified across projects, including: a greater focus on pronunciation; increased opportunities for memorisation; increased pupil motivation; improved class dynamics; the development of collaborative skills; a better understanding of film language and audience; and an increase in the status of MFL in the school. In one project, Year 8 pupils developed a French and a German teaching resource for their peers with scripts on the theme of 'Fortune-telling' using the future tense of the verb 'to be' as the grammar focus of the resource. They explored the impact of different types of camera shot and the power of communicating through the visual image. Their linguistic skills were greatly enhanced as a result of designing the video for a specific target audience. Another Year 8 group, more varied in their ability levels, created resources on the topic of ordering food and drink in a café or restaurant. The project was aimed at improving motivation and classroom dynamics through group work and greater collaboration was observed.

One specific example involved the use of digital video to record pupils wearing different clothing and describing this clothing in French before playing it back to the class through the IWB (CILT, 2005).

In summarising the research findings on the use of ICT in the modern foreign language classroom, Becta (2004g) reported that video conferencing, email and discussion forums all gave access to authentic materials and learning opportunities through communication with schools abroad. As well as developing language skills, they facilitated the development of cultural awareness in pupils. Other technologies also provided advantages, with word processing allowing pupils to plan, draft and edit work and digital video offering opportunities for feedback on language performance through teacher or peer evaluation.

More generally, ICT increased motivation, enthusiasm and confidence and there was some indication of a positive association with attainment (Harrison et al., 2002). It also provided a greater range of learning experiences with collaboration, interaction and communication in the target language as well as supporting differentiated activities for pupils (Becta, 2004f).

The Scottish Schools Digital Network (SSDN), due to be online to all 800,000 teachers and pupils in 2007, currently supports a pilot project, the Modern Foreign Language Environment (MFLE). A collaboration between Learning and Teaching Scotland and the Scottish Centre for Information on Language Teaching and Research (Scottish CILT), it will comprise a website, resource bank and discussion forum [http://www.ltscotland.org.uk/mfle/index.asp]. The discussion forum for MFL has already attracted many teachers who contribute to the news blog area and subscribe to the podcast facility – some even involving pupils in the creation of blogs and podcasts. To date no evaluation or research has been carried out on the impact of the MFLE, though this would be important in providing an evidence base upon which others can draw in setting up similar resources or for further research.

3.3.4 Science

ICT has many applications in science – data-logging tools and digital video for data capture, spreadsheets for data handling, simulation and modelling, creation of virtual environments and

the provision of resources through the internet or on CD-ROM or DVD (Becta, 2003e). As well as making science more interesting, authentic and relevant for pupils, ICT use has been found to allow more time for post-experiment analysis and to foster discussion, communication and collaboration.

Simulations have been shown to help students gain a greater depth of understanding of scientific principles and relationships (InterActive Education, 2006b; Cox et al., 2003a) and permit experiments to be shown that would pose practical difficulties in a school environment. McFarlane and Sakellariou (2002) found that difficult-to-grasp concepts could be considered more readily and that ICT could take over many of the mechanical aspects of practical investigations, allowing pupils to concentrate on interpreting and analysing data. They also noted that data-logging tools, which record and store measurements electronically, can help improve the quality and quantity of results in investigations. In exploring the weather, for example, they could be used to record measurements outside the classroom as well as overnight or periodic data. Combined with analytical software, relationships can be discerned more readily due to the accuracy of the data. Students can also access authentic data on the internet and use its facilities to collaborate with professional scientists.

The use of simulation software offers opportunities to investigate problem or difficult areas which are impossible to create in classrooms – or are often too dangerous (Cox et al., 2003). Simulations and animations allowed pupils to see events that would otherwise be invisible because they happened too quickly, too slowly or were not readily observable. Examples included the flap of a humming bird's wing, the life cycle of a redwood tree, the pulsing of a human heart and a bee collecting pollen on its legs. Similarly, dangerous materials or expensive apparatus could be simulated, such as the processes inside a nuclear reactor or a mass spectrometer, or the dissection of small animals.

Although simulations can eliminate experimental error and provide visual stimuli that help understanding, Trindade et al. (2002) warn that accurate or 'sanitised' data may lead to pupil misconceptions, portraying measurement as uncontentious.

Cox et al. (2003a) showed that the use of ICT and animations in science could be used to challenge pupils' thinking and conceptual understanding (or misconceptions) through providing experiences which resulted in cognitive dissonance or conflict. This provided a focus for discussion and reflection on their understanding. In addition, they found that experience with computer microworlds resulted in improvement in thinking skills and strategic planning as well as the use of more complex scientific language. Papert (2002) defined a microworld as a computer-based interactive learning environment where the pre-requisites are built into the system and where learners can become the active, constructing architects of their own learning. Essentially, they are explorative (usually closed) learning environments with rules of their own – a virtual library, a virtual museum, an invented landscape – within which students can explore concepts and relationships [http://www.iaete.org/soapbox/microworlds.cfm].

Learning platforms, school networks and the internet increasingly provide access to science-based learning materials outside school hours (Lewis, 2003). Specifically developed for secondary chemistry teaching, the approaches developed by Lewis involved using ICT to support associated independent work out of school such as electronic records of homework. In addition, in order to alleviate some of the practical difficulties of laboratory work, details of the next practical to be tackled, reminders on how to use the apparatus and a risk assessment were all presented during the lesson and were available subsequently through web links. Feedback obtained indicated that the ICT presentations were most effective when interwoven with the natural flow of the

lesson rather than trying to deliver the content entirely through what could be a packed display of information.

The use of simulations in science teaching was investigated within the Science Subjects Design strand of the InterActive Education Project (2006b) [http://www.interactiveeducation.ac.uk/science_designs.htm]. For example, when used in the study of the effect of temperature on digestive enzymes, the use of simulations was found to promote differentiation and cross-disciplinary teaching. It also supported real-time graphing of results, allowing pupils to gain greater understanding of the process, in line with McFarlane and Sakellariou's conclusions (McFarlane and Sakellariou, 2002).

In addition to providing opportunities for learning scientific concepts and principles, simulations also allowed pupils to consider decision-making and discuss the societal implications of scientific endeavour (Cox et al., 2003). For example, an apparently simple situation such as a research biologist working in the rainforest can be explored from a range of perspectives – a politician making decisions about environmental issues or a scientist considering the ethics of an experiment – revealing how context influences decision-making and makes seemingly simple situations more complex.

The use of learning objects in science learning and teaching is developing such that they can be incorporated into learning situations, often with the aim of personalising the learning experience (Cox et al., 2003). (Learning objects are small digital units of educational information that can be customised, used flexibly and re-used, and that enhance the content of a learning activity.)

The positive impact of e-learning on attainment was one of the key findings in the evaluation of SCHOLAR, an online programme designed to support pupils working towards national examinations in the sciences and mathematics.

The evaluation included an analysis of performance intended to shed light on the impact of the programme on attainment (Livingston and Condie, 2003). Working with the Scottish Qualifications Authority, the evaluation team analysed pupils' grades on the Higher and Advanced Higher examinations (typically taken at age 17/18), comparing those who had participated in SCHOLAR with those who had not. The analysis showed that pupils who were registered with the programme showed consistently superior levels of performance, although this varied somewhat by subject and grade achieved. However, as with the Passey (2005) study, there was an absence of links between in- and out-of-school use. Teachers showed little awareness of, or indeed interest in, how students were using the online components of the programme out of school.

3.3.5 Social sciences and the humanities

There is wide applicability of ICT in the area of social sciences and humanities, which would include geography, history, citizenship and, in Scotland, modern studies. In all of these areas ICT increases opportunities for communication and collaboration and makes the subject of study more authentic and relevant. The internet, in particular, provides access to a comprehensive range of communities and events as well as access to information and views about global issues.

In geography, as well as engaging and motivating pupils about important concepts, ICT has been found to enhance geographic knowledge through access to resource materials, improve presentation of reports and written assignments, and facilitate communications which broaden experience of people, place and environments (Becta, 2004d). Becta also concluded that use of ICT makes geography more authentic and relevant, increases opportunities for communication and collaboration and can, by taking away or reducing mechanical processing, offer more time for observation, discussion and analysis.

ICT offers new and powerful tools (particularly GIS – Geographic Information Systems) to improve geographic enquiry, statistical and spatial analysis and mapping skills (importantly, the manipulation of maps at a variety of scales). GIS has been shown to enable pupils to quickly explore patterns and distributions and to identify and investigate underlying relationships. It also facilitates the construction, testing and refinement of hypotheses (Ofsted, 2004c).

The use of simulation and modelling tools enhanced the understanding of key topics like erosion and agriculture (Cox et al., 2003b), and enabled the development of higher-order thinking skills. Communication with other pupils in different environments via email, webcams and video conferencing can heighten appreciation of place, of environmental problems and of cultural identity. The available communication tools and the resources on the internet extend the reach of the classroom and allow pupils to explore parts of the world as well as the processes and phenomena active in the world which they might never otherwise experience.

Davitt (2005) reported on how schools have been capitalising on the new technologies by setting up digital radio broadcasts and are using the built-in video cameras on fieldwork. Some are also investigating geo-tagging. Here, digital photographs of environmental features – farms, river or estuarine features, urban landscapes – are electronically tagged or labelled with a description of the photograph and associated information on the location. These photos can be incorporated into online maps and when the tag is clicked the photograph and the descriptive information are displayed. More comprehensive environmental resources are therefore available to pupils.

In history, a major benefit of ICT is the enhanced access to a wide range of historical sources and resources which could not be assembled in the classroom any other way. These resources can be more effectively presented by teachers using ICT and stimulate motivation, collaboration and historical enquiry skills (Becta, 2004e). Databases are particularly effective in helping pupils to look for patterns and relationships and to frame hypotheses, while simulations allow complex historical processes or events to be presented most effectively (Hillis and Munro, 2005). Examples of databases include the decennial Population Census material, the First Fleet (convicted people shipped to Australia in the 19th century), workers in an industrial concern such as a jute mill in Dundee, a school log of pupils and events in a Victorian school, records of war grave deaths and the occupants of a 'poor house'.

The development of a virtual archive for the acquisition and practice of skills of historical interpretation is another example of the use of ICT to support learning in history (Ruthven et al., 2005). Commonly, a virtual archive would be located on a site accessed through the internet such as the Scottish Cultural Resources Access Network (SCRAN) [http://www.scran.ac.uk] or World War 1 – Trenches on the Web [http://www.worldwar1.com/]. These resources would be accessed either by the teacher pre-selecting images and mounting them on a specific school site or directing pupils to a particular site with a view to their browsing the available material in order to gain an appreciation of its variety. Such images can be used to enhance an existing unit of work.

In history, for example, pupils could engage with archived documents and artefacts relating to the First World War, and accumulate insights into the part played in historical enquiry by interpretation of diverse types of historical sources. They could then write an essay exploring issues of interpreting evidence, involving reference to the full range of archival material they had encountered. This approach was found to foster independent learning, allow teachers to spend more time working with individuals and

encourage a more collaborative approach between pupils and teachers (Ruthven et al., 2005).

One conclusion from the literature is that ICT is most beneficially used when coupled with effective teacher intervention and support and where pupils are encouraged to concentrate on the history rather than the mastery of ICT competence (Munro, 2000).

3.3.6 Other areas of the curriculum

Research into other areas of the curriculum is less common, although increasing. In religious education, the evidence gleaned from a set of Ofsted inspections concluded that many teachers had found ICT applications which enhanced their teaching and opened up new and effective learning opportunities for students (Ofsted, 2004f). When pupils used ICT well, teachers observed clear improvements in presentation, in the range of information accessed and in pupils' understanding and analysis of key concepts. As in other studies, ICT had a positive impact on motivation and pupils were observed to work with a far greater degree of concentration and application than was normally the case. The impact was most noticeable where pupils had regular access to ICT resources (Ofsted, 2004f).

In physical education, conclusions from Ofsted inspections in 2002/3 indicated that the quality of teaching using ICT was good or very good in only 25 per cent of schools and that the use of ICT to enhance teaching and learning at Key Stage 3 continued to be limited (Ofsted, 2004d). They found that the majority of teachers were competent in the use of computers and that there was a growing use of word processing, school intranets and multimedia presentation software and that the quality of display material was improving due to digital photography. In addition, the use of data collection equipment such as heart rate and blood pressure monitors and timers, provided immediate feedback on health issues and the interrogation of data supported hypothesis formulation and evaluation.

The use of ICT led to the creation of exciting learning environments. Those teachers who were able to use more sophisticated software were exploring a wider range of teaching styles, developing pupils' evaluation skills and engaging them more in peer- and self-assessment. Pace and purpose became more explicit to pupils and the use of a wide range of visual images motivated them to engage more fully in the learning process.

Ofsted also noted that the use of video analysis was making a significant difference to the quality of teaching and learning in dance, for example, where pupils were very enthusiastic. There was an industrious atmosphere characterised by high expectations, the efficient handling of equipment and greater attention to detail in learning. All of these were regarded as indicators of very effective learning. The effect of ICT on achievement was most marked at Key Stage 4 and with post-16 students where it helped learners to improve the coursework which was part of their final examination. Pupils found that video analysis helped them move more accurately and develop skills of observation and analysis, resulting in a better understanding of movement analysis. Video imagery and performance analysis software increased motivation to learn, improved evaluation skills and led to more consistent and accurate performance.

This report has already discussed how ICT can benefit creative activity in schools – in the areas of art, music and design – through the use of presentation software, digital video and creativity tools such as PowerPoint, Kartouche, DreamWeaver, i-Movie and Garage Band.

3.3.7 Summary of key points

- To date, certain areas of the curriculum have benefited more than others from the introduction of ICT. The more obvious

ones include modern foreign languages (communication), history (learning objects) geography (geographical information systems), the sciences (animations and simulations), physical education and the creative arts (digital videos and photography). There are pockets of good practice that should be disseminated further – through electronic networks and resource banks, for example.

- Much of the evidence on specific subjects is derived from small-scale studies which tended not to use scores from standardised tests to determine impact on outcomes such as attainment. More systematic investigation, using harder measures of impact, should be undertaken, preferably re-visiting initiatives over a longer time period to determine long-term impact.
- ICT can support the development of basic literacy and numeracy skills, particularly where pupils are experiencing difficulties.
- Learning has been enhanced where computers and word processing and/or presentational software were combined with other technologies, most notably interactive whiteboards.
- The use of ICT improves presentation of pupils' work and has also been shown to support collaboration, improve the quality of discussion and facilitate the development of problem-solving skills.
- In modern foreign language teaching and learning, ICT has underpinned considerable development in the provision of materials for teachers and pupils via online and digital resources, and improved language skills (through digital video and photography) and communication (through video conferencing and blogging).
- In science, ICT allows pupils to grasp more abstract or complex concepts and appreciate microscopic processes through animations and simulations.
- The newest technologies, such as GIS, are available within the geography classroom, while online resource banks of artefacts and documents can be used to support learning in history and religious education.

More systematic investigation, using harder measures of impact, should be undertaken, preferably re-visiting initiatives over a longer time period to determine long-term impact.

3.4 Impact of specific technologies and strategies

This section considers the evidence of the impact of the use of specific technologies on learning and teaching, identifying where benefits have been realised. The technologies reviewed are mainly those in which schools have recently invested heavily or which have been perceived as offering considerable potential for application in schools and thus have attracted nationally funded research. Emerging technologies such as mobile phones, personal digital assistants and media players (PDAs and PMPs), portable games consoles and laptops are discussed although they are less visible, as yet, in the classroom (Stead et al., 2005).

3.4.1 Interactive whiteboards

The use of interactive whiteboards (IWBs) has been investigated and evaluated more than any other presentational technology (see, for example Wall et al., 2005; John and Sutherland, 2005; Ofsted, 2005; BESA, 2005; Beverton et al., 2005). This may be as a result of the general government endorsement of the technology to schools and particular initiatives (the Schools Whiteboard Expansion project, for example) which have provided major funding specifically for the purchase of IWBs. The general conclusion from qualitative research studies is that IWBs rank highly as whole-class teaching tools and there are a number of educational benefits which can result from their use.

While Higgins et al. (2005) conclude that there was a significant impact on classroom interactions when IWBs were introduced into primary schools, they were more cautious regarding long-term impact on attainment in literacy, mathematics and science. The study, which involved both quantitative and qualitative data gathering and measured impact on attainment in terms of change in Key Stage test scores, found some improvement in the first year of the two-year study but no significant difference in performance in the second, in comparison to non-IWB schools. One conclusion is that the initial intervention had led to an improvement as a result of the novel approaches used. Alternatively, where schools were performing at above average levels, as was the case in some of the schools studied, it was difficult to sustain year-on-year gains in attainment.

Overall, the researchers found evidence of some improvement for low-achieving pupils in English, particularly in writing, although they noted no significant differences in performance levels by gender.

The Higgins et al. study was one of the more rigorous explorations of the use of IWBs encountered, in that it used standardised tests, classroom observations and interviews with pupils and teachers. The findings included the observation that teachers' questioning strategies changed, such changes being consistent with the kinds of interaction associated with more effective teaching. The frequency of use of the IWBs, the strategies used with them, the pace of lessons and the aspects of classroom interaction all showed positive change in both years of the study. Both teachers and pupils were extremely positive regarding the use of the IWBs in the classroom and teachers believed that attainment levels had improved as a result of their use, although the supporting evidence for this was limited. While teachers felt their workload had increased, they felt this to be a temporary state of affairs that would subside once they had mastered the technology and developed their own materials (which many were beginning to do by the end of the second year).

Apart from the evidence on the impact of IWBs, this study indicates the need to investigate impact through a range of measures, hard (test scores) and soft (perceptions), and over a period of time, allowing for initial enthusiasm to die down and the technologies to become embedded in

classroom practice (or not). Small-scale studies, in term of timescale and data-gathering instruments, provide useful snapshots, but any perceived impact should be examined more closely to determine whether or not it withstands the passage of time.

The review of the literature undertaken as part of the Higgins et al. (2005) study states that IWBs can help teachers to improve the quality of their presentations, increase pupil involvement through interaction with the technology and each other, raise pupil motivation, extend communications skills (speaking and listening), make the curriculum more relevant and immediate through presenting concepts in novel ways, facilitate group work and cross-curricular links and increase the efficiency of knowledge transfer. In primary schools, visual representations on IWBs can help pupils grasp abstract ideas, bridging the concrete–abstract gap, and allow teachers to increase the pace of lessons (Ofsted, 2004a).

A study of primary pupils' responses to aspects of ICT found that they believed that IWBs made them think more deeply about their learning, that is, there was a metacognitive impact. They provided real, concrete examples to illustrate or stimulate discussion points, facilitated remembering and helped them to concentrate. In other words, the pupils thought that the boards helped teachers explain concepts more effectively (Wall et al., 2005). The technology supported collaborative working in line with social constructivist principles, encouraged the contribution of ideas, sharing of tasks and generated knowledge and understanding. Reluctant readers and mathematicians were more motivated (Ofsted, 2004a) and, in special schools, IWBs were found to help autistic pupils work together in, for example, literacy lessons, where digital photographs were used in combination with the IWB to stimulate involvement (Ofsted, 2005).

These benefits were found where IWBs were effectively integrated into classroom use, but there is also evidence that their availability and the skills of teachers in using them were frequently limited (Beverton et al., 2005; Smith et al., 2005). The message is that the acquisition of interactive whiteboards must be accompanied by good training provision in order that staff can develop both the technical skills required to make them function effectively and an understanding of how best they can be integrated into learning and teaching, both generally and in relation to specific areas of the curriculum; this does not always happen (Ofsted, 2005). Somekh et al. (2006) noted that the use of IWBs was more sustained and widespread in primary than in secondary schools and, in turn, skill in using them was consistently higher in primary schools.

Miller et al. (2005), in investigating how 'best practice' teachers used the interactive whiteboard in mathematics and modern foreign languages, concluded that three features encouraged pupils' motivation in lessons. Firstly, the lesson was organised such that there was an interactive and participatory focus on the IWB throughout and that, secondly, the combination of visual, kinaesthetic and auditory features led to intrinsic stimulation. Thirdly, lessons using the IWB took a stepped learning approach – that is, concepts or new terms were presented in a logical way, in small steps rather than leaps of understanding, and these were supported by regular feedback, either from the software or the teacher.

Other features of the enhanced learning classroom included teachers who recognised that planning and preparation were key, and who selected tasks carefully, both for appropriate content and to encourage pupil–pupil and pupil–teacher interactions. Pupils in such classrooms were familiar with working constructively with others to develop their own and each other's knowledge, understanding and skills.

Miller et al. (2005) identified three stages in the development of teachers using IWBs. Initially, they made some use of the IWB but only as a visual

support or stimulus to the lesson and not as integral tool in concept development (termed 'supported didactic'). There was little interactivity, pupil involvement or discussion. In stage two, they made some use of the potential of the IWB to stimulate pupils' responses at points during a lesson, and to demonstrate some concepts (termed 'interactive'). They challenged pupils to think through the use of a variety of verbal, visual and aesthetic stimuli. Stage 3, 'enhanced interactive', was marked by a change of thinking on the part of the teachers. Here they sought to use the IWB as an integral part of most lessons, integrating concept and cognitive development in ways that exploited the interactive potential of the technology. Teachers were confident and competent in their use of the whiteboard and lessons were structured to encourage pupils to respond to the stimuli presented, whether as individuals or in pairs or groups.

In summarising the literature on IWBs, Smith et al. (2005) concluded that, while teachers and pupils were overwhelmingly positive about their impact and potential, there was insufficient evidence to identify the actual impact on learning, in terms of either classroom interaction or attainment. Little had been done to differentiate between the broader benefits of the presentation techniques employed and the specific advantages of IWBs. The review identified similar benefits to those already mentioned, including flexibility, versatility, the ability to meet a wide range of pupil needs (including special needs) and the promotion of collaborative working, motivation and participation. However, the authors also concluded that IWBs had not transformed teaching practice. One reason given was that teachers had not received adequate training to allow them to realise the potential of the whiteboards – a conclusion that Ofsted (2005) also reached. In addition, they argued that problems of location, accessibility and technical reliability needed to be addressed.

Other technologies such as tablets and visualisers also lend themselves to whole-class interactive display. In the evaluation of the ICT Test Bed Project, Somekh et al. (2006) indicated that most primary pupils had experience of working with them, and had had the opportunity of using them to present their own work. They also noted that, while they require much less in terms of specialist skills than do IWBs, they had had a radical impact on the teaching of those members of staff who used them.

Increasingly, the use of combinations of electronic slates or tablets, visualisers, large screens and/or IWBs is being referred to as 'whole class technologies', indicating a shift from the technology itself to a focus on the purposes for which it is being used.

3.4.2 Digital video and photography

Analysis of the literature on the effective use of digital video and digital video editing found evidence that their use greatly increased motivation, improved literacy (particularly writing and speaking skills), allowed differentiation with regard to learning styles, facilitated collaborative working and promoted deeper conceptual understanding in many subject areas. Effective use, that is, where ICT was integrated into the learning activities and used to support the achievement of learning outcomes, produced learning gains above and beyond what could have been achieved without technology (Becta, 2003a; Burden and Keuchel, 2004).

In a review of the impact of a number of projects on the use of digital video in modern foreign language teaching, the key benefits identified were: greater focus on pronunciation; increased opportunities for memorisation; increased pupil motivation; improved class dynamics; the development of collaborative skills; and a better understanding of film language and audience (CILT, 2005).

There were many uses identified. Digital video clips in the different languages were inserted into

electronic documents to create multi-sensory and culturally informative materials for whole-class teaching and independent learning. Activities included planning, filming and editing digital video footage, including the insertion of sub-titles and sound track, often drawing on television shows and news broadcasts, the creation of a local tourist brochure or, more simply, the production of a weather forecast.

A number of small-scale case studies in the ICT Test Bed project, carried out by teachers with particular groups of pupils, focused on the use of digital video and images. One used short video clips of demonstrations and practical work to allow pupils to 'catch up' on work missed through, for example, illness (Cooper, 2005). Transferred to CD-ROM or memory sticks, they could be viewed on a computer at home or in the school learning centre out of class time. Students found these very useful in compensating for missed learning. Although this was in the context of further education, the strategy could readily be adapted to the school situation.

Another ICT Test Bed case study (Jayes, 2005) focused on the use of multimedia to encourage the development of literacy skills in pupils with English as an additional language. The majority of pupils were from a Muslim background and some were from refugee families. They worked collaboratively, producing stories that they then displayed on IWBs, evaluating them together. They showed more interest in reviewing their work in this different format and made more contributions to discussion, gave more praise and listened to others' views more carefully. They were observed to take more pride in their work and the increased control they had over editing and evaluating their work appeared to improve their understanding of the writing process.

In other ICT Test Bed studies, the use of digital video cameras to support the transition from infant to junior school increased self-esteem and collaborative working (Roberts, 2005), while in another school, pupils developed an understanding of the persuasive power of advertising through the analysis of television adverts and, subsequently, created their own using digital video (Mangle, 2005).

Robust, cheap and easy to use video cameras were used to make simple film clips which were then put together, by mixed-ability pairs, into a short film/video showing important facts about a science topic (Scott, 2005). Pupils worked in a range of ways, collaboratively and independently, at their own level and pace, and displayed the ability to engage in considerable, focused discussion. It was possible to use the clips to assess the science skills and concepts acquired and to test mastery of ICT skills. The technique was used over a range of subjects – fieldwork in geography, movement in physical education and news reports in literacy lessons. It was noted that pupils of lower ability, in particular, participated very enthusiastically, were highly motivated and gained in confidence.

Digital image techniques were also found to have a positive effect on nursery pupils with poor speaking and listening skills and low general levels of literacy (Hayton, 2005). In this study, the pupils took photographs at home over the weekend and used them as stimulus materials on their return to school on the following Monday, when the photographs were displayed on the IWB. The pupils developed their ICT skills in addition to improving their levels of speaking and listening. Other benefits included greater self-confidence, articulation and enthusiasm to contribute. It is important to note that, in many studies, while digital video or digital photography used on its own accrued learning gains, it was found to generate greatly enhanced benefits when combined with digital video editing and digital voice recording.

The most recent evaluation of the ICT Test Bed Project (Somekh et al., 2006) reported that over half of Key Stage 2 pupils had experience of using

digital cameras and felt very competent and confident in their use. They also noted evidence that digital cameras appeared to benefit both primary and secondary pupils with special educational needs.

One of the more substantial evaluations of the use of digital video and digital assets (video clips, audio files and still images) is that by Burden and Kuechel (2004), where a combination of questionnaires, interviews and case studies was used to determine the impact on teaching and learning in primary and secondary classrooms. They found that teachers used the resources in novel ways but to enhance existing practice rather than to teach in new or innovative ways. Digital voice recordings manipulated by pupils and added to multimedia learning resources enhanced the impact of teaching resources. Pupils' digital photos could be integrated into creative language projects for publication, presentation or exchange. The researchers argue that the linking of digital video or photography and editing meant that kinaesthetic learners could contribute along with auditory and visual learners (Burden and Kuechel, 2004).

Burden and Kuechel anticipated that other benefits would accrue as school connectivity increased to broadband and as teachers gained confidence in using digital assets and began to use them to teach in new and innovative ways. Flexible classroom organisation and linking to IWBs added to the impact on teaching and learning. On a more cautionary note, Burden and Kuechel concluded that digital video and digital video editing should be used in ways that add value to the learning experience and not used to achieve outcomes that might well be achieved without the intervention of ICT. Teachers need to be clear about the intended outcomes, whether it be, for example, improved conceptual understanding in science or enhanced language skills, and integrate digital resources, commercial or teacher-produced, appropriately into the lesson.

...digital cameras appeared to benefit both primary and secondary pupils with special educational needs.

In terms of learning, they observed that pupils became more discriminatory and selective in their use of digital assets and that attainment gains observed in one area of the curriculum transferred to other areas, most noticeably literacy. Digital assets could be used to meet the needs of pupils with different learning styles and, interestingly, pupils responded more positively to digital assets produced by their peers and teachers than they did to those produced commercially, where the language and professional gloss was found to be demotivating.

Their conclusions are extensive, pointing to considerable potential for digital video and associated activities where there is school and local authority strategic commitment to its implementation and support for the development of appropriate pedagogies. They also noted that, while they did identify benefits and were optimistic that the initiatives had become self-sustaining, there was a need for further monitoring and evaluation over an extended timescale in order to determine the extent and nature of any long-term impact.

3.4.3 Video conferencing

Video conferencing has been slower to become a regular feature of pupils' experience, in part due to the need to have broadband connectivity and appropriate technology (Condie et al., 2004). Research into the use of video conferencing in mainstream schooling has been limited – most attention has been focused on uses in commerce

and higher education. In the late 1990s, many of the Superhighways Initiative projects (Scrimshaw, 1997) involved the use of video conferencing and major research lay dormant until the evaluations of the Motivate Project (Gage et al., 2002) and the DfES Videoconferencing in the Classroom project (Comber et al., 2004).

The research indicates that a wide range of social and educational benefits can accrue from the use of video conferencing – benefits in curriculum learning, the development of social and communication skills and increased cultural awareness. Conclusions from the DfES video-conferencing evaluation were based on an analysis of projects in 28 schools, with varying lengths of video-conferencing experience, and principally from the subject areas of English, geography, history and modern foreign languages (Comber et al., 2004). Video conferencing was highly motivating to students, it enabled links and cultural identities to be formed with other cultures, supported a shift to learner autonomy and enabled authentic learning experiences.

The evaluation team noted that provision of equipment varied widely, along with stand-alone mobile systems and internet connectivity. The most frequent forms of use were those of conferencing with outside experts and small group working, where video conferencing was used to enhance or add value to existing activities. Teachers' perceptions were that it had raised attainment but there was no statistical evidence to support this.

Video conferencing appeared particularly suited to modern foreign languages where synchronous, face-to-face interaction with native speakers helped develop student confidence and competence above the level expected in traditional lessons. A number of examples reflected its value in raising cultural awareness, often as a result of exchanging environmental information, through linking rural and urban communities together or establishing links to major science investigations, such as those with NASA undertaken in Birmingham and Glasgow schools. The evaluation team identified a number of factors that were associated with its effective use, which together formed a 'fitness for purpose' framework (Comber et al., 2004, p.10). The recommendations included suggestions for action at national level, including support for the dissemination of good practice and a directory of expert guidance and advice, as well as at authority and school level. More pertinently, they identified areas for further research such as longer term investigations of schools where video conferencing was embedded in practice in order to look more closely at the impact on attainment and to determine the long-term effects of its use.

Rural schools have used video conferencing successfully to share lessons and communicate with other schools and external agencies (HMIE, 2005) and it has been used effectively in a cross-border project aimed at promoting citizenship and tolerance in Northern Ireland and Eire learning (Austin et al., 2003). Exploiting broadband connectivity has also been used effectively to promote multi-cultural education (Thurston, 2004). Reporting on a study involving pupils in a Scottish school conferencing with a school in the USA, Thurston noted that attitudes to ethnic minorities became more inclusive and pupils developed a better understanding of their community environment and ethnicity issues. Essentially, pupils interviewed individuals from ethnic minority groups living in Britain and subsequently edited the video footage for presentation to the American pupils. This involved consideration of what to leave in or to cut, reflecting on the issues that they wanted to raise and report during the video conference. While the pupils in this study recorded their own video, the findings also indicated that the judicious use of news footage could be used to develop critical thinking skills and improve perceptions of diversity.

Martin (2005) reported that video conferencing, combined with other technologies such as digital video and photography, supported independent learning, delivered content more effectively and encouraged the processes of listening, reflecting, questioning and discussing. It could accommodate different learning styles and preferences and enhance motivation and was suitable for any area of the curriculum. Video conferencing and IWBs were used successfully to deliver CPD and appeared to promote self-esteem in teachers and pupils. Martin anticipated that the real challenge for teachers was to enhance teaching and learning through creative uses of the technology, arguing that the adoption of broadband enables video conferencing from almost anywhere, particularly using mobile technologies such as videophones and webcams (ibid).

A summary of the research evidence indicates that where video conferencing is used effectively, something unique is introduced into the classroom experience – it has the potential to enhance subject learning and to generate additional cross-curricular benefits. The DfES evaluation (Comber et al., 2004) clearly identifies the conditions associated with effective use. These include that the initiative has the support of senior management, is embedded into school planning and that staff development and examples of good practice are made available. In addition, the evaluation points out that there is potential for resistance from pupils and/or their parents and the authors advise that this should be explicitly addressed though involving them in developments, explaining and illustrating the kinds of learning activities that will result. However, a number of constraints remain that inhibit the use of video conferencing in schools – the lack of a national policy on video conferencing, the need for school development policies to encourage more widespread use, the resolution of financial constraints and more thoughtful training for teachers in the use of the technology.

3.4.4 Mobile technologies: laptops, PDAs and tablets

Investigations into the use of mobile technologies, including laptops (in and out of school), personal digital assistants (PDAs), mobile phones and tablets, are becoming more numerous, with enthusiastic advocates citing evidence of a range of potential benefits (see, for example, Facer and Owen, 2005; Prensky, 2004; Savill-Smith, 2005). The terms used in the literature vary. Savill-Smith and Kent (2003) use the generic term 'palmtop computers' to encompass a range of small, mobile computer technologies, including those specifically referred to as palmtop computers, personal digital assistants (PDAs), pocket PC-based handheld computers, some specialised handheld devices, e-book readers, dictionaries and spell-checkers and graphical calculators (see the glossary of specialist terms at the end of their report). Tablets tend to be larger, while laptops are larger still.

The use of laptop technology in the classroom, by either pupils or teachers, to support learning and teaching, has been the subject of several studies and is regularly an element in broader surveys and reports. The evidence indicates that laptops are motivating and engage pupils' attention, particularly when used in conjunction with whiteboard technology (Cunningham et al., 2004).

The Simpson and Payne (2004) evaluation of laptop provision to pupils and teachers in one Scottish local authority sought evidence of impact from primary and secondary pupils, their teachers, parents and local authority staff. Although relatively small in scale, a number of significant findings emerged which have been echoed by other studies. In the primary schools, changes were observed in the teachers' approaches to classroom management and organisation where laptops, a projector and/or an IWB were used, for example, to introduce topics to the class and to structure ICT lessons. In secondary schools, staff were almost universally positive in their appraisal

of the project, although the authors note that this was in regard to the use of the laptop as a teaching or presentation tool.

The authority's vision of laptops as a personal learning resource for pupils in and out of school was not realised. Technical difficulties reduced pupils' enthusiasm for laptops, as did having to carry them around all day. While pupils' skills did appear to benefit, the organisational and technical problems that they encountered limited the impact of the initiative. Their parents were also of the view that the difficulties and problems experienced had prevented the potential of the laptop project being realised; parents of primary pupils were generally more positive.

The impact was greater in the primary schools than in secondary. Primary pupils grew in confidence, using laptops at home as well as in school and developing skills across a range of applications, notably presentation skills. Some parents reported increased enthusiasm for and attention to homework when the laptop was involved. There was evidence of greater collaboration amongst primary staff in preparing for and during the project and as pupils did not move around as much as they did in secondary, there was greater consistency in their learning experiences. In addition, it was felt that both the curriculum and timetabling were more flexible in the primary school and that the primary staff had a greater commonality of approach to teaching and learning. There was no evidence of impact on attainment other than with regard to ICT skills. At the end of the project, the local authority decided that introducing laptops for teachers and pupils would not achieve their aim of transforming learning and teaching and developing personalised ICT support within schools.

Ofsted (2004b) also noted a significant impact on pupils' learning as a result of involvement in an e-learning programme in the primary sector where pupils used laptops, often in wireless environments, for independent study. The approach used fostered individual and group research and promoted peer discussion, and learning was reinforced and consolidated through the laptop environment.

Much of the evidence indicates that the impact of providing laptops for teachers tends to be on administration and communication rather than on learning and teaching and, in consequence, appears to benefit teachers more than pupils. In England and Wales the Laptops for Teachers initiative received £300m between 2002 and 2006, reflecting government commitment to supporting and resourcing teachers' personal access to computers and encouraging the integration of ICT into teaching practices. Research and evaluation feedback on this initiative indicated that teachers welcomed having the personal access laptop computers provided at home, but also needed personal access at school (Becta, 2005c).

Feedback on the Laptops for Teachers initiative indicated that, with improved access to the internet, teachers used a wider range of sources to prepare lessons, found the laptops an excellent demonstration tool and reported that their ICT competence and confidence markedly increased. Where laptops were used in lessons, pupils were found to be more highly motivated and spent more time on-task. The impact on administrative tasks was significant – contributing to more efficient time management, more professionally produced work (particularly with the use of presentation software) and effective recording of assessment data.

Other mobile technologies, such as PDAs and tablets, are increasingly available for educational use. Prensky (2004) argues that young people find mobile technologies extremely motivating and that teachers should capitalise on this to foster learning, integrating them into the educational experiences of pupils. Used creatively, they have the potential to change practice radically and to

improve the learning and teaching process. This might involve more collaborative learning, one-to-one tutoring, research, communication and debate, foreign language learning, and a range of literacy skills.

This is borne out by the evidence from the Learning2Go Project (Perry, 2005), where primary pupils were supplied with handheld computers (PDAs) for full-time use, in and out of school. Significant gains were recorded across a range of indicators, most obviously those related to improved general ICT capability. The unfettered access to the Web and the freedom of choice of when to use them, and for what, encouraged the creative use of other technologies, most notably desktop computers. There was a positive impact on intermediate outcomes such as motivation and enthusiasm for learning, attendance (especially for boys) and collaborative working. Technical vocabulary improved, as did communication skills. Gains in attainment generally were noted, with boys reading more (notably e-books).

Other anticipated outcomes included increased efficiency in teachers' planning and preparation tasks and improved home–school links, including a reduction in the impact of the 'digital divide' – the learning gap between those who have and those who do not have access to ICT out of school. While these outcomes had not been realised, it was considered that more time would be necessary before any impact might be identified. (Issues around communication with parents and the wider community are discussed further in Section 4.)

The project has since expanded to over 1000 PDAs in 18 institutions and is regarded as having had a transformational effect on learning opportunities in schools as well as improving home–school links (Davitt, 2005). The Learning2Go team were joint winners of a Becta ICT in Practice Award in 2006 and more research is planned on the wider implementation of the initiative in order to assess its impact more rigorously.

[http://www.becta.org.uk/corporate/display.cfm?section=21&id=4995]

In a similar vein, a detailed literature review investigating the use of palmtop computers (PDAs) for learning (Savill-Smith and Kent, 2003) found that palmtops assisted student motivation, helped to develop their organisational skills, encouraged responsibility, facilitated independent and collaborative learning, acted as reference tools and were used as assessment tools, including tracking pupils' progress. They helped with the acquisition of literacy and numeracy skills, were good for presenting simulations and were effective in science fieldwork and in physical and sport education. In addition, they could be used as reflective logs (Savill-Smith, 2005).

However, it seems that certain criteria are required for the successful use of PDAs with school children. These include the provision of a variety of tools, such as keyboards, electronic pens and styluses, to enable appropriate choices to be made and, depending on the task at hand, the availability of information in a range of formats. It was observed that pupils benefited in a number of ways. The use of PDAs provided opportunities to learn that addressed pupils' preferred learning approaches, they allowed simple and quick ways of securing work and they enabled pupils to share their work with various audiences, including publishing on the Web (NESTA Futurelab, 2004). A general principle that has emerged from the research is that the technology should mediate the learning but it should in itself present no barrier to learning, being as simple to operate and as intuitive as possible.

The use of tablet PCs or 'tablets', which are more portable than laptops but less so than PDAs, has been the subject of considerable investigation. Research into their use in schools, conducted by a team from The Open University, found that they were used to support existing practice and, importantly, to extend practice (Becta, 2005c;

Becta, 2005d). In the first instance they were used to help pupils improve handwriting, to present or share work or to mark and annotate documents (such as homework) at different stages of development. They extended practice in art, facilitated the integration of ICT in the curriculum, were of value in fieldwork, fostered collaboration and promoted continuity of use between school and home.

Researchers concluded that they promoted curriculum access – their portability meant they could be used wherever required – for cross-curricular work, for use in the field and with hospitalised or excluded pupils. Pupils who experienced difficulty controlling a mouse or lacked keyboarding skills found the tablet's 'pen' easy to use and the simple modification of text, colour and audio supported students with impaired vision or hearing. They improved communication – handwritten notes could be instantly converted into typed text, diagrams (such as mind maps, geographical sketches or scientific experiments) could be drawn and annotated easily prior to sharing with others and presentations were relatively easy to create. Textual or audio annotation of homework contributed to improved communication between pupils and teachers and with parents. They led to improved pupil motivation, especially where pupils had sole ownership of the tablet. Many pupils reported tablets were easier to use than other computers.

The review of the project identified over 90 schools in England and Wales where tablets were used (Becta, 2005c). They were widely used across primary schools and in a comprehensive range of subjects in secondary schools. In one primary school use ranged over English work in Journal (homophones) and Word (an edited fable), interactive mathematics on the internet, history internet research and the use of Publisher software to write a newspaper-focused article on the battle of Marathon, and interactive (internet-based) science activity (Becta, 2005d). In one of the secondary case-study schools considerable use was made of annotation of diagrams, sketches and mind maps, by teachers as well as pupils, particularly in English and in modern foreign languages (Spanish and German). Other schools found them extremely versatile tools in sports analysis and for digital artwork and design. In one Scottish case study [http://portellentablet.blogspot.com], tablets were found to promote a high sense of motivation in the classroom, an urgency to learn, collaborative work, peer-to-peer learning and enhanced teamwork. In addition, there was evidence of an accelerated pace of learning. Tasks were completed more speedily and to a higher standard than previously. There was evidence of renewed motivation and more independent working. Tablets were flexible, being used in a wide variety of classroom contexts and pupils moved into new areas such as posting weather recordings on the internet and writing weblogs.

For maximum benefit the researchers noted that tablets should be used in conjunction with a wireless network and should be introduced in a planned way that took account of the school's vision (Becta, 2005d). Used with a wireless data projector they were a more effective teaching and learning solution than a desktop or laptop with the interactive whiteboard. One advantage was that the teacher could move around the classroom rather than having to stand at the front during the lesson. In addition, the tablet could be passed to individual pupils in a way that would not be possible with a laptop. This caused less disruption than did pupils coming out to the whiteboard. Furthermore, everyone could see what was happening and the issue of where to position the whiteboard was less of a concern because direct access was less crucial. One school also found the touch screen on the tablet PC far more sensitive than the interactive whiteboard. Although they were more versatile than laptops, they were also much more expensive.

There is little evidence, as yet, on the adaptation of mobile phones to support learning and

teaching, although there have been initiatives to post blogs on school websites by mobile phone during visits to France within a modern foreign language programme (Condie et al., 2005). Many schools and authorities have established policies against the use of mobile phones by pupils within the school grounds which may inhibit developments in this area.

Mobile technologies permit greater learner choice and provide learners with an ICT toolkit that can be personalised and tailored to match individual learning styles and preferences. Mobile technologies have a particular role in supporting games and gaming (Prensky, 2004).

3.4.5 Games and gaming

There is limited robust research on the use of computer games (both general commercial products and those specifically created for educational purposes) and the application of gaming skills and techniques in educational contexts, although much has been written in their favour. This may be due in part to the fact that computer games have typically been discouraged in, if not excluded from, the classroom. Pupils continue to spend considerable amounts of time playing computer games and using gaming machines such as Playstation and X-Box out of school (Condie et al., 2005; Stark et al., 2002).

There is some evidence that they can motivate pupils to learn, at least in the short term. Games and game-based learning activities are gradually being introduced into the classroom, often in specifically targeted curriculum areas, to capitalise on the reported benefits of engagement and interest (Facer, 2005). Some of the evidence in earlier sections on ICT use within subject areas indicates that this is happening.

Research indicates that, rather than being counter-productive, they can help to develop new cognitive abilities, faster processing of information, enhanced selection of relevant material or key elements of concepts from a range of sources and promote shared learning and communication. Facer (2005) argues that games support learning by doing, in line with the principles of situated learning, and provide diverse ways of supporting pupils as they engage with learning. In particular, role-based, goal-directed play which challenges and has a fun element can develop key skills and dispositions that can be transferred to other contexts with appropriate support, such as communication, working with others, problem solving and critical thinking skills.

Kirriemuir and McFarlane (2004) concluded that games promote communication, collaboration and problem solving and are valuable in mathematics and where thinking skills development is desired. Some games – the Sim genre in particular – have already been used in schools to explain socio-economic development issues. Educational software developers, including national organisations such as Learning and Teaching Scotland (LTS) and the BBC, are incorporating principles and design features from commercial software into their edutainment resources. LTS has released 'The Serf's Quest' for primary school pupils and the BBC's online curriculum offering 'BBC Jam' intends to deliver learning experiences which embody video, games, audio and animation. There is a danger, however, that the adoption of games for educational ends can reduce their appeal to young people – especially if the quality and speed of graphics and animation compares unfavourably with games on the commercial market.

In many ways the move to blend gaming techniques and computer game technology to serious educational software development attempts to capitalise on the theories of Prensky (2004). He identified 'digital natives', the younger generation who have grown up steeped in and surrounded by new technology. They are effectively the pupils who use games and mobile technologies on a regular daily basis out of school

and who expect to have the opportunity to use the technologies in their classrooms.

Prensky argues that there is an opportunity for teachers to capitalise on the motivation that mobile technologies generate. To do so, they have to take the principles of gaming and combine them with the content that they want pupils to learn. Games, he argues, allow for multiple players and encourage creative thinking, collaboration and competition – all of which can be used to enhance learning in the classroom. They can and should, according to Prensky, be developed for use by pupils on mobile phones. The key task is to transform the features of games into educationally-oriented transferable knowledge and to identify ways this can be achieved across the curriculum.

For games, and for ICT use in general, the issues around motivation, the translation of motivation into greater understanding and, eventually, attainment, appear to be more complex than this might imply, as earlier discussion indicated. We need to understand better how ICT interacts with learning and how teachers can develop effective pedagogic strategies to capitalise on the benefits the different technologies bring. Increasing motivation does not necessarily lead to improvements in understanding and attainment in the longer term.

While much has been written about the potential of games as learning tools, the evidence is as yet limited. Valentine et al. (2005), as mentioned earlier, found statistically significant association between pupils' out of school use of ICT for leisure purposes and decreases in attainment. How the technology was used appeared to be important: the more time spent playing computer games, the less time for other tasks, including homework and study, with a subsequent detrimental effect on achievement. While a few parents argued that playing games on computers or consoles supported the development of, for example, thinking skills, Valentine et al. found it difficult to identify and measure any such gains.

The evidence base has been strengthened through the findings of the 'teaching with games' project [www.futurelab.org.uk/research/teachingwithgames.htm]. The project was a partnership between education and industry that focused on the use of games within the formal classroom context and aimed to provide practical and informed evidence on the potential of mainstream computer games in the classroom in supporting learning.

The findings indicate that the majority of teachers, and students, thought that games could motivate and encourage engagement with learning (Sandford et al., 2006). Teachers considered that the use of games could improve pupils' motor and cognitive skills, higher-order thinking skills and subject knowledge as well as developing their ICT skills. Teachers also expressed some concern that the use of games could lead to anti-social behaviour and/or the acquisition or hardening of stereotypical views as a result of the content of some games.

While the majority of teachers (72 per cent) never played games for leisure, 82 per cent of the pupils played games at least once a fortnight outside the classroom, with boys more likely that girls to do so. In the case studies, the use of games within the classroom was found to be particularly motivating when the pupils were given a degree of autonomy

Teachers also expressed some concern that the use of games could lead to anti-social behaviour and/or the acquisition or hardening of stereotypical views as a result of the content of some games.

in playing them and where they were similar to those used in the home environment, such as The Sims 2 or Roller Coaster Tycoon 3. The use of games in the classroom met with a number of hurdles. Firstly, teachers were surprised to find that the pupils' competence levels were less than anticipated and varied considerably across pupils and there were some problems in their ability to cope with the key concepts or elements within the games. More generally, obstacles included technical issues such as lack of access to equipment and often systems within schools were configured such that installation was problematic. (These are problems frequently reported by teachers as new technologies are introduced, and raised elsewhere.)

Teachers were concerned that games should serve curricular objectives but the way in which games were introduced, supported and developed as learning tools varied with the individual's teaching style and her/his perceptions of 'best practice'. It was found that learning was particularly effective when teachers focused on particular elements of games which supported key skills and concepts. The authors concluded by highlighting the need to gain a more sophisticated understanding of the factors that engender motivation and engagement in learning through game play, which they saw as, fundamentally, just another teaching tool.

3.4.6. Learning Platforms: Virtual and Managed Learning Environments

Generically, learning platforms describe ICT systems which deliver and support learning, combining functions such as organisation, mapping and delivery of curriculum activities and offering facilities for learners and teachers to enter into dialogue about the associated learning activities (Becta, 2005e). Thus both Virtual Learning Environments (VLEs: software tools which bring together resources for curriculum mapping, delivery, assessment, tutor support, communication and tracking) and Managed Learning Environments (MLEs: a range of information systems and processes that support learning and the management of learning) are examples of learning platforms.

In 2004, a review of the literature on the use of managed and virtual learning environments concluded that, while VLEs were becoming more commonplace in the further and higher education sectors, they were still a relatively new phenomenon in schools. The research concluded that there was potential applicability to the schools sector. The main benefits identified were that they could enhance teaching and learning, provide flexible access for pupils in a protected environment, extend the reach of education beyond the classroom and ensure greater parental involvement in the education process (Becta, 2004c).

Specific benefits observed in the HE/FE sector (where VLE/MLE use is relatively well established) included improved motivation and engagement, flexibility of access, learning gains in ICT, in writing, understanding and presentation, enhanced communication and interaction, plus the adoption of new approaches to learning. These were all identified as realisable in the school sector. (See Becta, 2002, for a selection of abstracts and references.) However, while they promised much, there was little evidence of any impact of VLEs in schools at that time although advances had been made with regard to content management systems to assist administrative processes.

By 2006, the position had changed considerably, particularly in the secondary school. The Becta LANs in Schools survey (Becta, 2006a) reported that 30 per cent of primary, 57 per cent of secondary and 26 per cent of special schools in England were using some form of learning platform, usually through the selection of a number of the core functions that best served their individual needs. It was noted that primary schools favoured learning portals (a website that offers learners access to learning and resources

from a range of different sources), whereas secondary schools tended to adopt VLEs.

Where learning platforms were in place, Becta found that learners benefited from them in that they could extend their learning experiences beyond the confines of the classroom, submit and track electronic activities for assessment and manage aspects of their personalised learning. Teachers could share resources and planning with colleagues, create and communicate learning plans, import educational teaching and learning materials and access communication, management and planning tools in and outside school. All users could participate in, or contribute to, personalised learning in school or at home (Becta, 2005e).

Where VLEs are used, they allow any time, anywhere access to online resources, communication software and information and give young people the opportunity to express their views and post comments, often anonymously, in discussion forums or on message boards. Depending on the topic, allowing anonymity allows pupils to discuss sensitive issues or provide feedback without apprehension. There is, in consequence, a need for someone, a teacher or similar, to monitor or moderate the discussion. In some schools they are used to post blogs for others to access, such as reports from trips abroad, promoting literacy and fostering collaborative learning (Davies et al., 2005). In addition, the establishment of virtual learning environments has provided a focus for collaboration between institutions where it is used as a repository of resources for sharing (Somekh et al., 2004).

Implementation of a learning platform within a school is affected by four main issues. These are: an evaluation of the financial outlays required and the potential benefits; technical factors; training; and change management. Together they ensure the technological competence of staff and a consideration of how the platform will enhance and enable learning and teaching practices (Becta, 2005e). Hanlan et al. (2006) provide guidance on how this might be achieved, with hypothetical scenarios describing how they might be implemented and some of the practical implications.

Virtual learning environments can be used to support personalised learning programmes or e-learning activities where pupils engage in completing online activities which have been specifically designed or repurposed to promote learning and take advantage of ICT. However, teachers are not content developers, and often VLEs have been used as little other than repositories. The evaluation of the South Yorkshire e-learning programme looked at the use of professional content developers working with schools to develop resources. As teachers acquired skills in working with the new technologies and their schools developed the technological capacity to support VLEs, more and more lessons were produced for online delivery, with pupils using message boards and individualised project work (SQW Ltd, 2006). However, the evaluation also found that, while individual schools were moving in this direction, there was little evidence that they were working together to build a wider, regional network and sharing their experiences. Cross-curricular use of the VLE was more likely where the VLE champions were not from an ICT background; computing specialists tended to focus on the technical specifications and outcomes rather than the educational dimensions.

In one case study where a secondary school had introduced a virtual learning environment, there was an increase in the reliance on ICT to teach across the curriculum and for administration and management tasks (Fox, 2004). Teachers, students and parents could access the 'virtual school' when the building was closed, schoolwork or homework could be accessed from anywhere, at any time, and it was found that students used the VLE extensively, often until 10.30 at night. The initiative was found to improve the quality of teaching at Key Stages 3 and 4. Students received

instant feedback from online tests and teachers could access information on how students interacted with the VLE. It provided an accessible resource for teachers, engaged reluctant learners and helped to establish effective learning relationships between staff and students.

The initiative came from the senior management team who, deciding that a clear strategy was needed for ICT, purchased a VLE to support teaching and learning, extend links with parents and provide students with access to learning materials via the internet 24 hours a day, 7 days a week. Teachers were encouraged and supported in integrating the technology with practice, including through involvement in the production of e-learning content.

3.4.8 Summary of key points

- Interactive whiteboards (IWBs) have generated a great deal of interest, both in schools and amongst those studying the impact of ICT in the classroom. The findings are positive where a number of conditions have been met – meaningful tasks, clear pedagogical reasons for their use and the effective integration of other technologies, including laptops, mobiles and video conferencing. Not all teachers are using them effectively, however, as many have not had the staff development that allows them to realise the full potential of the technology. Nor is there evidence that any initial impact is sustained over the longer term.
- Laptop technology has proved to be very beneficial in reducing teachers' administrative burdens and in planning and preparation, as well as in improving the quality of presentations. Pupils have been less impressed with laptops – smaller mobile technologies such as PDAs and mobile phones are perceived as more manageable.
- Most progress has been made where a whole-school approach to the development of ICT use has happened, whether by design or by the nature of the working environment. The size and organisation of the secondary school, and the diversity of practices across disciplines, have limited the extent to which some initiatives have become embedded in practice. Implementation appears to have been easier in primary schools, where practices are more similar and the organisation more flexible.
- Digital video and photography, particularly when combined with presentational technologies, provide a visual stimulus in classrooms for a range of activities including the development of critical thinking skills and group discussion. In addition, putting pupils behind the cameras has engendered a sense of ownership and control of the learning process, increasing engagement.
- Effective video conferencing depends on good broadband connectivity and planning. Like digital video and photography, it can be used with specific groups of pupils to address issues such as cultural diversity and accommodate different learning styles and preferences. It can bring a number of benefits to the personal and social development of pupils, raising self-esteem and enhancing motivation.
- Evidence is growing of the power of mobile technologies to engage pupils and of the development of creative strategies to use them to meet educational objectives. Combined with other technologies, such as virtual learning environments and the internet, they can enable personalisation of the learning experience for pupils, in research and communication, and for teachers in accessing online resources,

staff development and support.

- One potential benefit of mobile technologies – the erosion of the home–school divide through improved communication with, and involvement of, parents – has not yet been realised.
- There are projects looking at the potential of mobile technologies to reduce the 'digital divide' between those who have computers linked to the internet at home and those who have not. There is little clear evidence that these are successful beyond the initial period, when the novelty of the equipment can appear to generate increased motivation and engagement.
- Games and gaming, once frowned upon in the classroom, are being developed to capitalise on their positive features, to exploit those aspects that can be harnessed to support the development of skills such as information processing, decision-making and team working. This will have to be undertaken carefully: 'educational' games as such do not have much credibility with young people.
- Learning platforms are also at an early stage of development. At present, the evidence indicates that, where they exist, they are frequently used as repositories for resources, content management systems and/or communication devices.
- Combined with mobile technology, however, VLEs can support blogging, discussion forums and collaborative activity across considerable distances, between schools within the UK and internationally. However, they are not as yet widely used to support home–school links.
- Learning platforms have been shown to support multi- and cross-disciplinary work. However, unless deliberate steps are taken, they can replicate the stage- or discipline-oriented divisions that exist in some schools.
- Wider sharing and networking has been limited in some instances by the lack of interoperability within and across schools and regions: common standards and specifications are becoming increasingly important if ICT is to transform learning and teaching in schools and to develop effective and rewarding links with out-of-school learning.
- E-learning developments require hardware and sophisticated software, as well as access to high-quality resources, particularly learning objects, and fast connectivity. They build on the potential of virtual learning environments to provide flexible, personalised learning opportunities that bridge the gap between in- and out-of-school learning – although this last aspect is little developed and evaluated. What evidence there is indicates that good e-learning resources can have an impact on motivation, independent learning and, in turn, attainment.
- Online learning packages are not simply another resource that can be assimilated into existing practice. Rather they demand different pedagogical strategies to support learners and, it seems, there is a paucity of appropriate staff development in this area. Understanding of the more effective pedagogies is still developing.

3.5 Impact on specific groups of learners

Various initiatives have been established to support the learning of specific groups of pupils who cannot or do not participate readily in, or benefit from, mainstream learning and teaching practices. Such pupils include those with special or additional educational needs and the 'hard to reach', including the disaffected and the children of Travellers. This section considers the ways in which ICT has been deployed to meet their specific needs and the evidence of impact.

3.5.1 Impact on pupils with special educational needs

There is a substantial body of research into the ways in which ICT can support pupils with additional or special educational needs. Some of these relate to pupils in mainstream schools, while others focus on the use of assistive and adaptive technology within special schools. Most of these are relatively small scale, essentially qualitative studies, although findings tend to have the common themes of improved communication, participation and self-esteem.

In general, the figures for technological capability such as computer-to-pupil ratios, tend to be higher than in mainstream schools (and have historically been so), but this includes a range of assistive technologies that link to or are supported by computer technology (Prior and Hall, 2004). In terms of learning and teaching, such as access to the internet and email, they were more in line with primary schools than secondaries.

Ofsted (2005) noted a number of ways in which ICT was supporting the learning of pupils with special and additional needs, observing that the use of ICT generated considerable improvement in attitude, concentration span and motivation. Particular activities included the use of a graphic design package which allowed a hearing-impaired pupil to participate in a group task alongside non-hearing-impaired pupils, and internet revision lessons that helped pupils develop English skills in a specialised hospital school for disturbed young people.

Ofsted, in an overview of the impact of government initiatives in schools, concluded that pupils with a range of special educational needs were helped, through the use of ICT, to overcome barriers to learning, thereby raising achievement, increasing self-esteem and encouraging participation in group and class activities (Ofsted, 2004a). In one study, ICT enabled an autistic pupil to participate and achieve in literacy lessons, with the result that motivation, self-esteem and performance all improved (NERF, 2005).

The Royal National Institute for the Deaf (RNID) education guidelines, which apply to pupils in mainstream and special schools, report that the effective use of ICT with deaf pupils can result in benefits such as reduced staff load, improved pupil attainment and increased motivation (RNID, 2004). The guidelines draw on research published by Becta and advice from a number of agencies, including the British Association of Teachers of the Deaf (BATOD) and Deafax (a charitable company, established in 1985 with the aim of promoting the use and benefits of technology by deaf people). Two specific projects have also contributed to the guidelines. One project, Blue Skies, which was funded by the DfES, was established to develop CD-ROM and web-based resources to assist in raising awareness of the ways in which ICT can be used effectively with deaf children and young people. In the second project, the Deaf Children's Communication Aids Provision (DCCAP) initiative was one of six centres running the Communication Aids Project, managed by Becta, which had the aim of enhancing the provision already in place.

The Blue Skies project [http://www.blueskiesproject.org.uk/blueskies.asp] is aimed primarily at teachers of the deaf and provides resources and

information on using ICT with deaf children and young people. The website supports a range of interactive tools that allow teachers to share their own experiences and ideas online. It also gives advice on using ICT in administration and further training, as well as learning and teaching. Particular aspects cited as helpful include simulations, predictive text and the use of digital video and photographic images.

On the basis of the available evidence, the RNID have concluded that ICT can stimulate deaf learners and provide opportunities for reinforcement and extension activities, as identified in earlier sections. Staff can tailor approaches to the individual learning needs of each child and share strategies and records with other professionals. Together, they argue, this means that the classroom becomes truly inclusive. The publication, Using information and communications technology (ICT) with deaf pupils (RNID, 2004), provides practical guidance for teachers of the deaf and support staff, as well as having some relevance for teachers in mainstream schools. Reference has been made earlier to ways in which specific technologies can help deaf children (see for example section 3.2.1).

The Communications Aid Project [http://cap.becta.org.uk/index.php], which was funded from 2002–2006, was concerned with supplying technological aids to support pupils who cannot readily access the school curriculum due to significant difficulties in communicating with others. Thus its remit extended beyond the deaf community to pupils with a broad range of disabilities such as cerebral palsy, visual impairment and dyslexia. The website contains information on the communication aids as well as a series of case studies of individual children who have been assisted by the new technologies. The aim is that, while the project has come to an end, the impact will continue as a result of the numbers of trained personnel in schools and centres across the country and the publications produced, including two CD-ROMS.

The findings from the evaluation of the CAP project (Wright et al., 2004) noted that it had met a real need and that both parents and children regarded the initiative positively, with children reporting a positive change in their functional abilities and the quality of their lives. A series of individual child case studies provides detail of the impact of the use of ICT. For one boy, the provision of a DynaWrite allowed him to talk in front of the class, tell his news and ask questions. For another, a notebook computer and specialist software led to improved writing and handwriting as well as helping with spelling and punctuation. Several children reported feeling less embarrassed and frustrated and more able to do things for themselves. Much of the evaluation focuses on the nature of provision and the services to children with disabilities, raising issues to do with access to equipment, funding and assessment of needs.

Abbott et al. (2004) reported on a study where ten special schools in Northern Ireland and Eire, with the full spectrum of disabilities, were paired and connected through ICT. The pupils worked collaboratively, carrying out joint tasks using asynchronous computer conferencing and video conferencing. Teachers reported that pupils had developed greater cultural awareness, as far as cognitive ability allowed, that those with sufficient keyboard ability benefited from computer conferencing, that ICT competence improved and that valuable, transferable social and communication skills were acquired. In addition, pupils preferred video conferencing as it allowed all but the most dependent pupils to participate in collaborative, inter-school work.

A key advantage of ICT is the opportunity it offers for developing a more personalised learning environment. Practical advantages include freeing pupils with poor or limited motor skills from problems of manipulating materials such as physically cutting and pasting (Williams, 2005). One small-scale study (Faux, 2005) found that the use of a multimedia software environment

encouraged high-quality presentations which allowed pupils greater autonomy in their work.

Some of the case studies in the ICT Test Bed Project focus on the impact that ICT can have upon pupils with special educational needs. For example, the use of digital cameras provided the basis for collaborative learning in literacy (Russell, 2005). Pupils who were reluctant to communicate, due to low self-esteem and lack of confidence, created stories through recording images and adding animations and other effects. As a result, ICT skills improved, confidence and self-esteem grew and a number of literacy skills were enhanced. More generally, the activities encouraged communication, independent learning and working together.

3.5.2 Impact on disaffected and 'hard to reach' learners

'Hard to reach' learners include young people who are not in school for various reasons including illness, pregnancy, bullying, school phobia, disaffection, exclusion and reluctance to learn. Notschool.net is an online learning community offering alternative education to young people in this category, or those whose needs cannot be met through home tutoring or specialist units. It aims to re-engage teenagers in learning, to rebuild their confidence, self-esteem and social skills, and to provide a pathway to further and lifelong learning. Participants are given internet tools, take an active research role as members of an online community and are supported by core and LEA teams, mentors, subject experts and virtual buddies. The programme has had some success in re-engaging learners, developing self-confidence and social skills, and raising self-esteem (Duckworth, 2005). Learners have acquired ICT skills and developed as independent learners. Some have subsequently returned to mainstream education.

The evaluation of notschool.net by Duckworth also indicated that critical issues of scalability and robustness needed to be addressed in order that the model, wherein participants are given the role of 'researchers' within an online learning community, could be readily transferred to new areas and sustainability secured.

Other 'hard to reach' learners include Travellers' children. The report of the e-learning and mobility project (E-LAMP) identified how developments in ICT have opened up new ways of approaching distance learning for young gypsy, fairground and circus children and Travellers (Marks, 2004). Investigations into the impact of ICT on such young people concluded that ICT-supported distance education offered potential solutions and the promise of further enhancement. Attendance at school when possible and links with the school sector were encouraged; ICT could foster this linkage, with a blended approach to learning (online/distance and traditional learning approaches) and was considered to be of value, with partnerships between the school sector and parents to be fostered.

Another group within the 'hard to reach' category are the disaffected and disengaged – those who have dropped out of formal education because it has not met their needs in one way or another. Passey et al. (2004) found that the incorporation of ICT into school work motivated disaffected pupils and enabled high achievers and pupils with special educational needs to demonstrate the extent of their abilities more readily (Valentine et a.l, 2005; Passey et al., 2004).

One report detailed how disaffected students within the 14–19 age range have been supported through the Virtual College. Each student had a tutor and both had a laptop, email and fast internet connections (Cook, 2005). Much of the curriculum was delivered by the internet and students worked towards a nationally accredited qualification. Most (70 per cent) were eventually reintroduced to the formal education system (usually a further education college). Retention

rates were high (> 90 per cent) and students displayed enhanced self-esteem, improved confidence, increased motivation and greater engagement with the educational process.

Higham and Yeomans (2005) observed that groups of disaffected and disengaged students in the 14–19 age range made significant progress when using ICT to support learning in projects within the 14–19 Pathfinders initiative. They noted significant progress in projects which focused on innovative approaches to work-based learning, enterprise learning and introduced variations in the pace of learning. They also noted, however, that while there was some evidence that both attendance and behaviour appeared to benefit, this had not been systematically tested.

3.5.3 Summary of key points

- Much of the research in these areas comes from small-scale studies, although some of the initiatives involve sizeable numbers, for example, the Notschool.net cites 1300 participants in the 2005 evaluation (Duckworth, 2005).
- Many of the initiatives are relatively intensive in terms of the support for learners, which may pose problems for increasing the scale and sustaining impact.
- Common themes include raised self-esteem, improved communication and literacy skills and participation in learning activities.
- One area where there is a considerable body of literature on the impact of ICT is that of special or additional educational needs. In addition to the benefits of assistive technologies for pupils with particular needs, ICT can allow the personalisation of the curriculum for most, if not all, pupils and help them to overcome barriers, raising self-esteem as well as achievement, in both generic and subject-specific skills learning.
- Mobile technologies have been shown to support learning in disaffected and hard to reach groups where attending school was problematic for personal or family/cultural reasons.

In addition to the benefits of assistive technologies for pupils with particular needs, ICT can allow the personalisation of the curriculum for most, if not all, pupils and help them to overcome barriers, raising self-esteem as well as achievement.

3.6 Personalisation of the learning experience

The debate on personalisation of the learning experience is part of a wider discussion on how individual choice can be exercised and needs met within society through, for example, the reform of the public services and online access to support, advice and information [www.direct.gov.uk]. Personalisation, for pupils in schools, means access to a greater range of content, varied ways of accessing that content, online progress monitoring and assessment, an organisational framework that supports choice and access and links to the local community and beyond (Becta, 2005b). For teachers, it means accessing support and resources, as well as development materials, that can aid them in acquiring greater understanding and skills in using ICT within the classroom. Consequently, there is the opportunity for greater personalisation in meeting both their own staff development needs and those of their pupils through the selection of appropriate resources and methodologies.

3.6.1 Using ICT to personalise the learning experience

Becta (2005b) presents evidence that, already, developments in ICT are supporting learning in ways that afford a degree of personalisation to learners and better meet the needs of individual pupils. Learning platforms provide the means by which pupils can manage and record their own learning through e-portfolios and records of their successes across the curriculum, as well as providing access to a range of resources to support development in specific disciplines. Broadband connectivity allows access to the external world through the internet, allowing pupils to research topics of interest and gain more immediate experience of other countries and cultures than ever before, particularly if coupled with video-conferencing facilities, instant messaging and discussion forums.

In addition, mobile technologies allow pupils to gain greater control over where and when they learn and communicate, and blur the division between in- and out-of-school learning. Being less expensive than desktop computers or laptops, they allow more children access to the benefits that ICT can provide across areas of cognitive, personal and social development, reducing the impact of the digital divide.

ICT is of particular benefit in personalising the learning experiences of pupils with disabilities or special educational needs, as well as those who are disaffected or whose lifestyles make regular attendance at school problematic. In addition to benefiting from the opportunities that ICT in general brings, the increasing range of assistive and adaptive technologies helps pupils to overcome specific barriers to learning and meet individual needs.

These developments have not necessarily taken place with the intention of allowing greater personalisation of the learning experience and, as a result, do not yet form an integrated system. Becta (2005b), drawing on the DfES definition of personalised learning [http://www.standards.dfes.gov.uk/personalisedlearning/about], sets out five elements of a personalised learning system: curriculum choice; the use of appropriate learning and teaching strategies; ICT-supported management; information and resource systems that facilitate personalised learning; and the ability to access and communicate with the external world electronically. It is intended that, as schools develop their e-strategies towards personalised learning, these elements can provide a framework for identifying priorities.

The DfES website identifies a range of research studies that support the personalised learning policy, and it has commissioned additional

research to develop further the evidence base to inform developments. The ESRC-funded Teaching and Learning Research Programme (TLRP) has, in turn, published a commentary on personalised learning, identifying various strategies and potential benefits along with a number of possible issues that pose a degree of risk unless they are resolved (Pollard and James, 2004). These included: a lack of clarity in the definition of personalised learning (although it is acknowledged that considerable progress is being made here), the challenges to the teacher workforce in its implementation, the nature of the teacher–learner relationship, and the need for the key agencies to be co-ordinated and coherent in their support. Above all, they identified the risk that the education community may not be able to rise to these challenges. The ESRC has recently issued a call for proposals to investigate the role of digital technologies in learning (under the heading 'technology enhanced learning'). Proposals have been sought under a range of topics, including personalised learning [http://www.tlrp.org/tel]. The findings from the funded projects should provide greater insight into the implications of implementing personalised learning approaches in the classroom, and their likely impact.

3.6.2 Summary of key points

- Personalised learning is an all-encompassing policy for learning and teaching within schools, part of which sees ICT as a means of achieving greater learner autonomy and meeting the individual needs of learners.
- A recurrent theme in the ICT literature is that of personalisation of the learning process in the classroom through the flexible nature of many of the technologies (hardware and software) and the availability of choice in relation to content, learning preferences, where to learn and when to learn.
- The judicious and deliberate use of ICT puts greater control of the learning experience into the hands of the learner. This may not always be a welcome experience for either the learner or the teacher, however defined, as it challenges the traditional relationship of teacher and learner.

...mobile technologies allow pupils to gain greater control over where and when they learn and communicate, and blur the division between in- and out-of-school learning.

Impact on practitioners and schools

4

The introduction of ICT into schools has had an impact on teachers in terms of their overall workload, including planning, lesson preparation and the administrative functions of their role, as well as on the ways in which these are co-ordinated and managed within the school and wider educational context. This section considers how the literature sheds light on the extent of that impact and the ways in which schools and practitioners are responding.

4.1 Impact of ICT on practice: integrating ICT into learning and teaching

The availability of ICT is not, in itself, sufficient to enhance learning and teaching and, in turn, increase attainment. Analyses of the literature indicate that while ICT can be motivating and engage pupils in learning more effectively, sustained impact depends on the ability of the teacher to integrate or embed ICT into the learning experience of pupils in such a way that the potential of the technology is fully realised. Teachers have to be confident in their own ICT capacity and understand the potential benefits of using ICT in a planned and pedagogically sound way. As discussed in Section 1, significant proportions of teachers in each sector do not yet appear to be at this level, and further CPD or in-service training is required to support them in gaining the knowledge and skills that they need.

4.1.1. Using ICT to support teacher development for e-learning

Like pupils, teachers learn in different ways and they need to be able to access support as and when needed, at times that are convenient and in formats that meet with their own preferences for learning. Where there are multiple ways to access personal professional development, the outcomes have been positive. For example, the Ofsted case studies, or School Portraits, describe ways in which teachers have developed their professional practice through laptop schemes, peer teaching and ICT skills programmes (Ofsted, 2004b) and present the consequences of practitioners trying out new ideas, approaches and techniques as well as adopting the newer technologies. Much of this development depends on teachers being motivated to take the initiative and extend their use of ICT with the aim of increasing the effectiveness of the learning opportunities they provide.

More formally, in-service training events and extended programmes are provided by national and local agencies. In at least one local authority teachers are required to access and store details of their CPD engagement in an online environment managed by the authority itself. Course details are published online and teachers book sessions and record their involvement within the online environment. (See, for example, http://eastdunbarton.cpdservice.net.)

Looking beyond the development of competence in basic ICT skills and confidence in managing the technology, ICT can have an impact on the ways in which experienced and ICT-confident teachers modify or adapt their teaching to integrate ICT into their classroom practice. At one level this can involve accessing new resources, learning about new technologies and/or finding innovative ways of deploying them. The literature contains examples of how this can be achieved and the

impact it can make on teachers' strategies for facilitating learning.

The provision of improved connectivity, amongst other developments, has allowed teachers to take advantage of online access to resources and advice. Granville et al. (2005) found that teachers felt that this was one of the key benefits of CPD – it improved access to resources, encouraged innovation, fostered the sharing of good practice and helped teachers to create or plan lessons and learning schemes. As a result of improved confidence and access to resources and advice at convenient times, teachers have greater control over the planning, preparation and content of their lessons.

The internet is a significant source of ideas for learning and teaching across the curriculum. A search of the internet for teaching resources in the UK resulted in over 84,500,000 hits, with sites hosted by commercial firms, local authorities, educational institutions (universities, colleges and schools) as well as teacher networks, formal and informal, and bodies such as Becta and Learning and Teaching Scotland. Some sites are subject-specific, while others focus on the primary, secondary or special school sector. They offer a wide range of resources, including lesson plans, worksheets, books to purchase, help facilities and assessment activities.

Teachers have expressed concerns about knowing which resources are worthwhile, and more research on the impact and availability of online resources and websites for teachers would be beneficial. The Evaluation of Curriculum Online (Kitchen et al., 2006) goes some way to providing information on teachers' use of online resources and their views on their usefulness. The qualitative studies undertaken as part of the Curriculum Online evaluation in earlier years highlight how teachers have used various technologies to support learning within subject disciplines and across the age range (Dixon et al., 2004, 2005). Such case studies provide the evidence of changes in the ways in which teachers are approaching their role within the classroom. It is difficult to determine the extent to which it is possible to generalise from this evidence, but a better understanding of how teachers interact with the online environment, the criteria they use in selecting which sites to use and how their knowledge is shared with others is just beginning to develop – more research is needed, however.

The DfES produced a series of videos to support the implementation of Curriculum Online which give real-life examples of ICT use in the classroom, including comments from teachers on their experiences of using the technologies involved [http://www.curriculumonline.gov.uk/casestudies/casestudygeneric.htm]. While they cannot be classified as reliable evidence in themselves, they do depict the ways in which teachers can modify their teaching strategies to make effective use of the new technologies and may well lead others to try new approaches using ICT.

A number of agencies have developed online support systems for teachers. One example is Direct2U. Until recently, primary teachers in England, Wales, Scotland and Northern Ireland were able to subscribe to Direct2U, an online service which delivered lesson plans to teachers' personal computers weekly [http://forum.ngfl.gov.uk/direct2u]. A different curricular subject was covered each week and teachers could choose to receive lessons for their own stage only, or for all stages of the primary school. The lesson plans provided all the resources necessary to teach the lesson and gave detailed guidance on how to use any technology involved, with key stage and curriculum guideline references included. The initiative, developed as one of the Becta online communities, has since been discontinued although teachers can still access the archive of lesson plans and advice. As yet, there has been little evidence of the impact that it has had on the day-to-day classroom practice of those registered.

Support is increasingly provided for school leaders, too. The National College for School Leadership (NCSL) has established 'talk2learn', an online community learning environment that is open to a wide range of school leaders including headteachers, deputy heads, middle leaders and bursars. Essentially, talk2learn provides access to networks of experts, policy-makers and colleagues, providing advice and assistance on the new technologies and the skills required to facilitate e-learning [http://www.ncsl.org.uk/onlinecommunities/index.cfm]. There is a network specifically for headteachers (Talking Heads), one focusing on innovation in e-learning and one providing support in financial management for school leaders. Similarly, Learning and Teaching Scotland (LTS) provides online support for teachers as well as specific advice and guidance for school leaders and managers through the Masterclass and Heads Together programmes [www.ltscotland.org.uk].

An evaluation of talk2learn online communities (NCSL, 2002), found that those participating in the Talking Heads Community felt that online access to others in similar roles helped reduce headteachers' isolation and enabled them to share insights into the use of ICT in learning and teaching as well as ways in which it could be used to support school improvement. This was an important area for heads, who found that the expertise within the online community provided a valuable resource in planning for school improvement through ICT.

A second online community, Virtual Heads, forms part of the National Professional Qualification for Headship (NPQH). Those who were involved in the evaluation were of the view that participation in the NPQH was enhanced by online participation, which encouraged and supported participation, reflection and learning. Unsurprisingly, those who were most active within the community tended to be competent and confident ICT users, with good access to the internet. As well as gaining skills and understanding in relation to the NPQH, they also developed their own ICT skills further. For all communities, a significant factor was the effectiveness of the facilitator and the role s/he played in supporting participants [http://www.ncsl.org.uk/media/F7B/B0/t2l-summary-onlinecomms-report.pdf].

In the pre-service sector, there are proven benefits to integrating ICT with training programmes for the students themselves in order to ensure that they have the opportunity to gain an understanding of the support that ICT can provide in enhancing learning and teaching processes, as well as in the wider aspects of the teacher's role. Falconer and Benjamin (2002) investigated the use of video conferencing specifically in pre-service training and found that students benefited from the increased contact with university staff made possible through video conferencing, and that video observation of classroom practice was less disruptive and more efficient than on-site observations. Similarly, digital video of classroom practice has been used to good effect in pre-service training as a means of providing relevant and timely examples of practice for students to analyse (Beck et al., 2002), although its application for peer assessment is still underdeveloped.

The use of online communication groups to support students in pre-service training has also shown considerable benefits. Students appear to find the computer mediated communication (CMC) environment a comfortable one, and enjoy the opportunity for reflection and peer discussions (Clarke, 2002). Student teachers using CMC environments have shown a greater level of participation (Dutt-Doner and Powers, 2000), and there is evidence of additional benefits, including increased social interaction and peer support (Clarke, 2002) and the potential for discussions with experienced teachers and experts in the field (Levin and Waugh, 1998). That said, CMC environments need moderation and to be embedded in the teaching practice to have real impact (Sime and Priestley, 2005). Structured topic

discussion, video conference discussion groups and clear objectives are all integral to the successful application of CMC environments in teacher education (Nonis et al., 2000; Galanouli and Collins, 2000). Student teachers are therefore gaining experience of interacting with ICT as learners, giving them an appreciation of difficulties in mastering new technologies and software, experiences that will have relevance in future teaching situations (Barton and Haydn, 2004).

4.1.2 Impact of ICT in the classroom on the teacher's role

While gaining confidence and competence in the use of the technologies is a crucial dimension to supporting e-learning, evidence is accumulating on the impact of the use of ICT on other aspects of the teacher's role. For example, Sutherland et al. (2004) argue that the support of the teacher is critical in gaining pupil engagement, and Hennessy et al. (2005) found that the successful use of the internet depended on planned, structured and focused lessons, often with pre-filtered information and prescribed hyperlinks. Significant benefits accrued when teachers addressed the whole learning context, including classroom organisation (using, for example, collaborative and inquiry-based strategies), links with home and out-of-school learning, when they involved parents and provided for a range of learning styles and preferences.

More generally, Wheeler (2000) argues that the role of the teacher has to change for four main reasons. Firstly, many of the traditional resources, such as chalkboards and overhead projectors, will become obsolete – not just because they will be replaced by more effective ICT tools but because learners will not necessarily all be located within the one room but distributed across sites. Secondly, educational policy and the curriculum are less concerned with knowledge and more with the development of skills in, for example, critical thinking and literacy. Thus the role of the teacher becomes one of encouraging and facilitating development rather than imparting knowledge. A third reason draws on better understanding of human thought processes and the kinds of learning experiences, methodologies and curricula that will more effectively meet children's learning needs. Human thought processes are non-linear, he argues, and ICT can provide non-linear means of supporting concept and cognitive development.

Turning to assessment, Wheeler points out that online testing can provide far more information on pupil performance than the traditional methods, such as multiple choice tests, typically did. Assessment software can provide a wider range of question types and analyse pupil responses for patterns of understanding and errors, comparing performance over time and providing the basis for individual action plans for further learning.

Holmes and Gardner (2006) identify a new role of the teacher on the basis that e-learning requires different types of engagement by learners which they categorise in a framework of key practices or skills such as: searching and selecting; exploring; testing hypotheses or trying out ideas; collaborating and discussing; and creating new knowledge and making it available to others in the form of learning objects. Based on communal constructivist theory, Holmes and Gardner outline the role of the e-tutor (teacher) as 'a content facilitator, a resource provider and an overall e-learning activity manager and administrator' (p.90). It is the also the teacher's responsibility to create an environment that is supportive of the diversity of abilities and needs that learners bring with them. Holmes and Gardner provide practical advice as well as discussions of the theory underpinning approaches to, and strategies for, e-learning.

The extent to which teachers are ready and willing to develop new strategies is a moot point. In 2000, Wheeler noted a polarisation in teachers' views regarding the introduction of ICT, anticipating

that several features of an ICT-supported learning environment might pose problems for some. Aspects such as the distributed nature of some forms of learning through ICT, the use of shared resources, shared working spaces, collaborative learning and the move towards autonomous learning, where the teacher facilitates rather than directs learning, might be difficult for some to accept (Wheeler, 2000).

Condie et al. (2005) concluded, in the survey of the impact of ICT in Scottish schools, that it was difficult to determine any impact on teachers' pedagogies. Although there was clear evidence of changes in the activities that teachers and pupils undertook, further research was required to determine whether this meant a fundamental change in the strategies deployed and in the interactions and relationships within the classroom, between the teacher and the learner as well as between learners. Most teachers believed that while ICT had enhanced existing practice, it had not been necessary to alter that practice to accommodate it.

Just as the focus of research has shifted from counting the numbers of computers and access to networks to the impact on indicators of effective learning and teaching as new technologies have become increasingly available, so it is beginning to focus on the changing nature of the learning and teaching process itself: the interactions, relationships and pedagogies required for successful e-learning.

4.2 Impact of ICT on administration and overall workload

The literature indicates that aspects of the teacher's role other than classroom teaching have benefited from the introduction of ICT into schools, with evidence of work-related efficiency benefits. This section considers how ICT is contributing to planning and preparation, including access to resources, and to the other administrative tasks that are part of the teacher's role.

4.2.1 ICT and improved efficiency in teaching-related activities

Once teachers have mastered the technicalities involved with classroom-related hardware and software resources, they can enhance their teaching by delivering content and concepts more effectively and efficiently and release 'time'. This can be used to create additional teaching resources or identify in-depth pupil activities – even simply to provide additional support and scaffolding to learning. Use of ICT for assessment purposes can also release valuable teacher time. VLEs, laptop provision for teachers and access to initiatives such as SCHOLAR can have a beneficial impact on time management (Cunningham et al., 2004). Even simple connectivity improvements which foster access to, and sharing of, digital resources and lesson plans, such as those on the

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Scottish Cultural Resources Access Network, can both reduce workload and disseminate good practice. In the near future, it is anticipated that 'work-time' benefits will be generated by the use (and re-use) of learning objects and the adoption of customisation of blended learning resources as part of the teacher's repertoire.

Within schools, specific technological developments, such as better connectivity via broadband access to the internet/intranets and laptops for teachers, have boosted professional development and confidence in using ICT, particularly with regard to the personalisation of the learning experience.

4.2.2 Impact of ICT initiatives on administrative activities

A key strand in the initiatives designed to embed ICT in schools has been, and continues to be, that of networking within schools, across the education sector and to the external world through intranets and the internet. This has largely been achieved, with most schools networked internally and connected to the outside world, albeit with limited connectivity in many instances (see Section 2). Within schools, networking has a number of potential benefits, including: easier and more effective communication; central record keeping and monitoring; access to shared resources and information; and standardisation across administration processes.

Many schools are developing centralised, computer-supported systems for record-keeping, assessment data and reporting to parents, although this is more a feature of secondary schools than primaries (Condie et al., 2005). Broadly speaking, schools recognise that centralised systems can improve effectiveness and reduce costs. For example, Granville et al. (2005) found that teachers believed that better connectivity improved access to the curriculum, offered secure means of storing confidential information, improved communications, made collaborative work easier and enabled access for people outside the school. In particular, they agreed that administration was easier with regard to accounts, attendance data and the sharing of confidential information. There were better staff-local authority communications and it was easier to develop collaborative work between schools. Unsurprisingly, where broadband was available, school staff were most enthusiastic.

In a similar vein, the BESA study in 2005 reported that 14 per cent of all schools believed that a centralised ICT procurement service would offer better value for money (BESA, 2005); there is little evidence as yet to support this belief. Cunningham et al (2004) found that networks were valued by senior management in developing school systems for administration and easing management tasks. In addition, they improved communication with staff and, externally, with parents. Teachers involved in the Transforming School Workforce (TSW) Pathfinder Project felt that, overall, it had helped to reduce their workload and make them more productive as teachers. Factors contributing to this included: far greater access to ICT facilities (software and hardware at school and home); an increase in the use of ICT by teachers on a daily basis; and an increase in teachers' confidence in using ICT. In addition, teachers were more positive about the quality of the training received, although it was still not highly regarded (Selwood and Pilkington, 2005).

The introduction of laptops for teachers has given the use of ICT for administration and management a significant boost. The BESA report (2005) showed that laptop provision, in both primary and secondary schools, had risen significantly. This was accompanied by a growth in networking, particularly wireless networking, and schools moving from ISDN to faster forms of connection, although they noted that this was more a feature of secondary than primary schools. As well as facilitating administration processes, this has encouraged significant growth in the use of online learning

materials (BESA, 2005). The evaluation of the Laptops for Teachers project (Cunningham et al., 2004) reported a significant impact on time management and improvement in the quality of materials and other documentation such as reports, produced by teachers. Laptops encouraged the use of e-mail, access to other resources and the use of presentation software. They were regarded as vital tools for recording assessment data and for reporting and tracking pupil progress.

Across schools, using ICT to manage data was found to promote teaching and learning by facilitating more effective timetabling, including allocation of staff, monitoring and managing performance and handling transitions and transfers of pupils (Kirkup et al., 2005). In addition, it contributed to target setting and the monitoring of achievement. The most effective tools were found to be school-devised systems and the use of Excel spreadsheets. A key use of school data was in informing the setting and grouping of pupils and in compiling reports to parents, where strengths and weaknesses could be readily identified, with evidence to support judgements. Data on achievement helped to facilitate more personalised or differentiated teaching and learning strategies. The feedback allowed teachers to tailor activities more closely to individual needs. Key recommendations from the NFER/DfES report by Kirkup et al. included the need for an increase in the provision of training in using data and the support for the growth and dissemination of good practice.

The PricewaterhouseCoopers study of teachers' workload (PwC, 2001) established that, while workloads were intensive on a week-by-week basis, annual comparisons indicated that teachers worked at similar levels to those of other managers and professionals. However, it was acknowledged that the number and pace of educational initiatives over recent years had placed additional demands on teachers and headteachers, and the authors identified a significant role for ICT in supporting them. These included electronically assisted approaches to lesson planning, marking, recording assessment evidence and producing progress reports for parents and the provision of more specialist support, such as ICT technicians. Improved access to ICT, school networks and web-based resources for teaching and planning were also identified as potential strategies. The authors did note, however, that the evidence they had gathered indicated that the use of ICT in schools tended to be about raising the quality of the work produced by teachers in, for example, presentations and reports, rather than saving time. They also noted that adequate ICT was the key factor to improving efficiency, along with staff development in using the relevant software and hardware.

A second study in 2004 (PwC, 2004) found that ICT did help address workload issues for some teachers, particularly those who were confident in its use. Combining survey and fieldwork data gathering, the study involved a nationally representative sample of headteachers and statistically sound numbers of teachers across 20 fieldwork schools. The teachers perceived benefits in managing, storing and maintaining information and other work such as preparing reports, with the time saved reinvested in planning and lesson preparation. Some teachers felt that it took longer to complete some of their administrative tasks. At the personal level, a lack of confidence or skills hindered progress, while at the school level, the absence of an ICT strategy that addressed workload explicitly and ineffective networks were significant negative factors. Positive factors in addressing workload issues were identified as good leadership, appropriate training and technical support and effective networks, including connectivity.

Looking ahead, both headteachers and teachers were optimistic that ICT would make them more effective in their work over the following 12 months, while headteachers were the more optimistic group with regard to impact on workload. Teachers were split in their views on whether or

not ICT would, over the following 12 months, reduce their workload. The percentages of teachers who thought it would increase workload were roughly equivalent to the percentage of those who though it would reduce it.

One concern is the extent to which schools are aware of, and complying with, the various ethical and legal requirements regarding, for example, pupil and staff safety, security of data and copyright legislation (Condie et al., 2005). The majority of primary schools in Scotland had been supplied with guidelines on a range of ethical and legal issues. Most primary teachers had received guidance on security (such as the use of passwords to prevent unauthorised access to data or information), the protection of young people from possible exploitation on the internet and the protection of young people from exposure to unsuitable materials including pornography. Most had received advice on a range of legal aspects such as copyright laws and regulations, the Data Protection Act and the suitable and safe use of email by pupils. Up to 20 per cent of teachers indicated that they had not received such guidance and only 56 per cent of teachers had provided guidance for their pupils on copyright implications.

In secondary schools, teachers reported receiving guidance on the importance of security, copyright laws and regulations; the protection of young people from exposure to unsuitable materials; the protection of young people from possible exploitation on the net; and ethical and legal considerations such as licence agreements. Between 10 and 25 per cent had not received guidance on one or more of these. Just over 60 per cent of the secondary teachers surveyed had received advice on the Data Protection Act and the suitable and safe use of emails by pupils. Under half (46 per cent) had provided guidance to pupils on copyright implications, while 43 per cent did not know if this had been provided or not.

As well as learning to use ICT and to access the internet, pupils should learn how to do so in socially responsible ways and develop an understanding of how to ensure their own safety and security in electronic environments, including an awareness of the legal constraints and obligations. This might be less of an issue in schools where access is normally tightly restricted to safe sites through the use of firewalls and internet safety software, but it cannot be assumed that similar precautions will be in place in other areas of access, particularly the home. Becoming e-confident includes developing a critical awareness of the negative and potentially harmful aspects of ICT as well as enthusiasm for and independence in exploring its positive dimensions. Wheeler (2000) points out that part of the teacher's role is to ensure pupils are aware of the potential for inaccurate and misleading information on the internet and gain the skills to discern that which is valid and reliable.

As well as learning to use ICT and to access the internet, pupils should learn how to do so in socially responsible ways and develop an understanding of how to ensure their own safety and security in electronic environments, including an awareness of the legal constraints and obligations.

4.3 The e-confident school

In order to be effective in the use of ICT to support learning and teaching, schools need to be 'e-confident' (Becta, 2004a), which means displaying a number of characteristics at a sufficiently developed level. The Becta Self-Review Framework (Becta, 2006c) was designed to help local authorities and schools to identify the strengths and weaknesses of their ICT deployment and use and to further their consideration of key priorities for future investment. The Framework sets out routes by which schools can develop the effective use of ICT and offers guidance to help them to achieve realistic goals for improving practice and develop the characteristics of increasingly e-confident schools.

These characteristics include a confident and competent workforce; effective leadership; ICT-integrated teaching, learning and assessment practices; effective management procedures; technical and CPD support; pupils/students with high ICT capability; and links with the wider community where the school forms the hub for community learning and information.

Passey (2005) found that few schools in the region investigated (the West Midlands) were deemed to be sufficiently mature across all these characteristics, although there were clear indications of confidence in some. Of key importance were the roles of the headteachers and senior staff in taking forward developments, with a clear focus on learning and teaching as well as positive attitudes to the potential of e-learning in improving attainment. In developing strategies for learning and teaching, it is argued that the emphasis should be on more collaborative learning, with an understanding of what is appropriate at different stages. In addition, schools need to develop activities that can bridge the home–school divide and engage pupils in out-of-school learning.

On a practical note, the consultation document on e-learning states that all schools should have broadband connectivity by the end of 2006 (DfES, 2003). However, a substantial minority of schools still do not have broadband access, while others have lower specifications with bandwidth that is insufficient for their needs. Additionally, many schools are unclear as to the full range of benefits to learning that the use of broadband can bring. Consequently the opportunities to capitalise on the potential benefits of e-learning have often been delayed (Becta, 2006b).

4.4 Impact on communication with home and the wider community

The use of the internet to provide access to resources for lesson preparation and to support learning directly has been discussed in earlier sections. In this section, the focus is on ways in which it can facilitate communication with parents as well as a range of agencies and individuals outside the school.

There is concern in some of the literature over inequalities in respect of pupils' access to computers outside the school and the need for schools to address this, firstly by recognising the issue and secondly by implementing strategies designed to tackle it. In so doing, schools must consider the range of factors that contribute to inequality, including socio-economic status, social capital and gender (Livingstone et al., 2005). There is little in the literature, as yet, on such strategies or their impact. However, the C2K project (Hewlett-Packard, 2004) is an example of a community-wide initiative that has been widely reported and, to a lesser degree, evaluated.

In Northern Ireland, the C2K project is responsible for providing an ICT-managed service for all schools, on behalf of the five education and library boards in the region [http://www.c2kni.org.uk/index.html].

The evaluation of the C2K initiative by PricewaterhouseCoopers (PwC, 2004) indicated that it was rated very positively by users, with reliability of computers and ease of file handling most highly regarded. Overall, users were very satisfied with most aspects of the service provided by C2K, particularly the online help and support. Three recommendations related to supporting teachers were made. These were: to address the demands made by labour-intensive and time-consuming tasks; to provide further staff development for teachers in using the elements of the service; and to provide and share widely more information on the various components of the managed learning service.

Subsequently, the C2K project has been significant in enabling remote access for parents and giving them the means to support their children's learning through information on homework, additional learning resources and access to the outcomes of assessments. Access to a range of services and resources is available from home, libraries or youth centres (Hewlett-Packard, 2004). There is little evidence as yet on how effective the initiative has been in improving home-school links or involving parents [http://www.c2kni.org.uk/news/publications.htm].

Research into ICT-facilitated home–school links has found that they can foster the development of effective relationships between schools and parents, through email communication, for example, resulting in greater parental involvement in their children's education in general (Becta, 2003b). Work can be transferred more readily between home and school and pupils can receive tuition when absent from school, accessing a range of curriculum resources via the school website. Most pupils spend a lot more time using ICT at home than at school, with greater autonomy (Condie et al., 2005; Livingstone et al., 2005).

There are numerous calls for schools to develop processes for capitalising on the informal learning that goes on in out-of-school ICT use. Passey (2005), in his evaluation of the development of e-learning in a number of case study schools across the West Midlands, reported that although some aspects of e-learning, such as e-portfolios, were at early stages of development, there was growing evidence of the positive impact on motivation and subject attainment. Of the four categories of e-learning activity (in school, out of school, linked learning across the two environments and links with parents) the out-of-school activities and links between in- and out-of-school use were the least developed.

Out-of-school access is perceived as beneficial with regard to personal and social growth as well as cognitive development. Kent and Facer (2004) highlight the role of online messaging systems, where the use of computers in the home is seen as a rich, instant communications system linking young people with peers. They argue that a more open and accessible system will allow young people to create virtual social environments; schools should consider how they might compensate for a lack of access to such opportunities for some pupils out of school.

Combined with school-based learning platforms, the internet provides a range of potential benefits for parents, enabling them to support learners or engage with wider school activities. Learning platforms offer one means by which administrative/support staff can provide help and advice to learners and contribute to the development and adaptation of learning materials. School managers can benefit from reduced administration and can communicate more quickly and effectively with parents (Becta, 2005e).

One dimension of the ICT Test Bed Project was the development of home and community links. This proved more challenging than anticipated, primarily due to funding issues. While connectivity was a problem (not all homes had online access), some success was achieved through a loan system of laptops and digital cameras to pupils and their parents (Somekh et al., 2004). A further

development is the provision of resources on CD-ROM or DVD, which can compensate to a degree for lack of online access. However, there is evidence that, while parents are keen to support their children by buying educational software, the children often end up working on their own at it, without support from parents or others in the home (Kerawalla and Crook, 2005). The school should work with parents so that they understand how they can best support and encourage their children as they work with educational software.

Looking beyond learning, Davies et al. (2005), in a review of the literature on the 14–19 age group and the analysis of four case studies, reported that digital technologies can provide support in seeking out career options from the many possible choices, identifying pathways towards these and guiding young people towards achieving their ambitions. In summing up their findings, the authors concluded that there is not a sufficiently substantial body of research evidence on which to base practice in the use of digital technologies to enhance the learning experiences of this age group. While calling for more research, ideally based on experimental methodology, they acknowledge that it is neither possible nor appropriate to wait for the research to emerge before implementing the new technologies. They also lament what they see as the government's dependence on what they describe as 'narrow accountability measures based on exam success' in determining impact.

4.5 Summary of key points

- The teacher's role changes in e-learning contexts, becoming one of facilitation, support and mediation. There are concomitant demands on those with responsibility for the school and its leaders.
- Teachers may not all readily embrace the new technologies and many appear to be at a stage of development similar to Miller's interactive stage in the use of IWBs, if not still at the 'supported didactic' stage (Section 3.4.1).
- Intranets have developed to support a range of administrative activities within schools, including attendance, assessment records, reporting to parents, financial management and the sharing of information amongst staff.
- Schools are beginning to use the data that is gathered through such processes for various purposes, including monitoring and evaluating performance indicators and pupil achievement, allowing intervention where cause for concern is detected.
- The more schools depend upon intranets for managing data and information and the more they open the school to the external world through the internet, the more they have to

be aware of issues of security and safety, for data, teachers and pupils.

- ICT has reduced teachers' workload as their skills have developed and applications, technologies and networking have become more readily available and easy to use.
- The internet has increased significantly the range of resources to support and stimulate learning and teaching across the curriculum and at all levels.
- It has also provided the means by which access to a range of services, including libraries and careers services, can be brought together, albeit virtually, in the one place.
- As ICT becomes an integral part of the everyday life of the school, there is a need to ensure that inequalities of access do not impede participation in the learning opportunities provided and subsequently in achievement. Inequality can arise through a number of factors including gender, ethnicity and socio-economic status, and schools must develop inclusive e-strategies that are proactive in this regard.
- Teachers can identify their own professional development needs and find solutions that meet their preferences for when, where, how and what to learn – personalising their own learning. They can tailor their own learning experiences, combining individual, collaborative and/or one-to-one formats, using any or all of the available technologies.
- Many schools have yet to develop the capacity to allow parents (and pupils) access from home; many of the links that do exist tend to be in the form of one-way communication – school to home.
- The development of home–school links, coupled with the development of cheaper, mobile technologies, including mobile phones, can help to address inequality of opportunity and support pupils who, for one reason or another, cannot take advantage of the opportunities available within schools.

Conclusions and implications

5

This analysis of the literature on the impact of information and communications technologies on learning and teaching has identified a number of themes which have been used to provide the framework for reporting. Some of the studies were tightly focused on specific technologies and their impact on learning and/or teaching, while others looked for evidence of impact on the outcomes of the learning process, such as engagement with learning, motivation and, ultimately, achievement, across a range of technologies. Some researchers sought evidence of the impact of one or more technologies when used with specific groups of learners, such as those with special needs, the disaffected or those who, due to lifestyle, are more difficult to reach with conventional educational provision. Other studies looked more broadly at the impact on the context in which learning takes place and the wider role of the teacher with regard to planning, preparation and administration. In addition, the role of ICT in developing teachers' confidence and competence was investigated, as well as the impact that the integration of ICT might have on teachers' pedagogies.

The key points from each theme have been summarised at the end of each section and we conclude by setting out the key messages that have emerged and by considering some of the implications for the further development of e-learning. Firstly, we would like to make some reflections on the literature itself.

5.1 Reflections on the literature

In recent years there have been numerous surveys designed to give information on the extent to which schools are developing the capacity to integrate ICT into learning, teaching and management processes. The evidence gathered has shown a steady increase in the number of computers and other technologies over time, with most schools achieving the baseline targets for computer-to-pupil ratios. This finding, to a degree, masks considerable variation within and across schools with regard to regular access to reliable technologies and broadband connectivity. Evidence of the impact on learning and teaching indicates that, where the use of ICT is most effective in enhancing the learning experience, teachers have been able to integrate a number of technologies such as laptops, interactive whiteboards and the Internet. Such combinations of hardware, software and connectivity allow them to develop innovative approaches to learning and teaching.

A critical factor in the effective use of ICT is the existence of a school-level e-strategy that addresses future development and sustainability and includes some means of monitoring progress against identified milestones. While innovations often begin within a stage or subject department, they require a whole school commitment if they are to become embedded in the daily experience

of pupils, providing continuity and coherence across the years. While champions can, and often do, lead the way, new developments need leadership and strategic planning to ensure sustained changes in practice.

5.2 Reflections on the impact of ICT in schools

The overwhelming message is that most pupils and teachers have found the introduction of ICT into the classroom a positive development, motivating pupils and teachers alike and changing radically the learning experiences of both. There has been a shift in the views of teachers, in particular, with initial scepticism and apprehension being gradually replaced by optimism and confidence.

The literature contains a great deal of persuasive argument that ICT is valuable in improving learning, teaching, motivation and achievement, although the volume and consistency of evidence tends to lead to tentative conclusions rather than firm ones. Given all the initiatives in schools at the present time (literacy, assessment and citizenship to name but a few), it is not easy to determine causal relationships between a single initiative and any observed changes in behaviour or achievement. While the evidence does seem to support the view that there has been an impact on learning and teaching as a result of the introduction of ICT, it has not yet reached the point where it can be said to have transformed the educational process.

There are some conditions necessary before a school can be said to have achieved institutional maturity with regard to ICT (Underwood and Dillon, 2005), and schools are clearly at different points on that journey. In many instances, the stories told in the literature are about the technology rather than about learning and teaching mediated by the technology. However, for the new technologies to become an integral part of the learning experience, they must become almost invisible in terms of the demands made on the users' ICT skills and understanding (John and Sutherland, 2005).

At the moment, ICT continues to make significant demands on many teachers who are less familiar with many of the technologies than are their pupils. Both of these developments will take time, strategic planning and the judicious deployment of resources in order to bring about the desired level of e-confidence. There are, however, a number of more specific concerns arising from the literature that need to be addressed.

A key concern is the extent to which teachers fail to appreciate that learning and teaching through technology requires a new approach to pedagogy, to planning and preparation and to how the curriculum is perceived. Much of the literature analysed in this study focuses on the use of hardware, software or peripheral technologies. There was much less systematic enquiry into the impact on the day-to-day teaching practice of teachers, the impact on the teacher–pupil relationship or on the teacher–teacher relationship, as a result of the implementation of ICT initiatives in and across schools. The evidence is that these relationships cannot and will not remain as they have traditionally been.

Miller et al. (2005) observed that teachers' use of interactive whiteboards appeared to develop in a series of stages. Initially, it was a resource, a visual stimulus or support for teaching with little interactivity. As the teacher's skills and confidence developed, it was used to support conceptual development, allowing learners to gain better understanding of specific concepts and processes. Pupils engaged more interactively with the technology, benefiting from its capacity to challenge their thinking through its ability to manipulate images and text. The most advanced stage, which Miller et al. referred to as 'enhanced interactive', was achieved when the technology

itself faded into the background, becoming an integral and accepted classroom resource. Teachers used the technology effectively but unobtrusively to meet intended learning outcomes, and pupils, as individuals, pairs or larger groupings, interacted with the content, manipulating the ideas and concepts to achieve greater conceptual understanding and enhance cognitive development.

This seems to reflect the development of ICT use in the classroom more broadly – from a novel resource which attracts pupils' attention and engages them, to a new way of presenting information and the content of lessons and, further, to a change in the patterns of interaction between pupils, teacher and technology, accompanied by a change in, or modification of, the role of the teacher from 'expert' to facilitator, mediator and guide. It is possible to discern a corresponding shift in emphasis in the literature over the years covered by this study. Initial concerns over access and availability have diminished and understanding of the factors underpinning effective use in specific contexts, often with specific groups of pupils, is gaining in importance.

Although there is evidence of impact, the newness of some of the technologies and the limited period for which they have been in place make it difficult to determine whether any observed impact is the result of short-term novelty or part of a genuine enhancement of learning and teaching that can be sustained in the longer term. Most impact studies tend to take place two to three years after the initiative has been introduced. This is a short time scale in which to observe significant change and tends to reflect the need for rapid evidence of impact by policy-makers to inform further planning.

Systematic and robust longitudinal studies could provide some insight into questions of sustainability and impact over the longer term, although the very nature of what is being studied makes this problematic. The rate at which technologies are developing and the requisite skills and knowledge are changing mean that it would be difficult to compare like with like over an extended period. Such studies also tend to be more expensive.

Conlon (2005) is somewhat pessimistic about the potential for ICT to transform learning and teaching. He questions whether the introduction of broadband connectivity will lead to the developments in online discussion, web browsing, email and electronic conferencing that are promised. The impact of ICT is mitigated by elements such as the curriculum, assessment demands and the structures of the school, he argues, and by the belief systems of teachers, which change far more slowly than does the technology; technology will be used to support existing practices and cultural values unless some of these structural impediments to change are tackled. Some of the evidence discussed here supports this: intranets and laptops have become efficient tools for administration, management, planning and preparation, while VLEs and the Internet have become repositories of resources which can be downloaded and used with little or no modification.

The Becta self-review framework is providing one means by which schools can monitor their development towards becoming e-confident and mature institutions. Key aspects are identified, such as workforce development, teaching and learning strategies and leadership and management, and examples of successful approaches identified from pilot schools. Thus schools can audit their own level of maturity with regard to ICT and draw on the experiences of others to move forward [http://schools.becta.org.uk/index.php?section=lv].

Looking more widely, Heppell (2006) is involved in developing a 'learning metric' to help determine where investment in ICT by education has been

effective. When key variables such as literacy and numeracy, motivation of teachers, parental responses and, in the longer term, growth in national income are identified, it is hoped that it will help answer questions about what works with regard to raising literacy or how we can re-engage the disengaged.

While the aim of this study was to describe the landscape of the impact of ICT in schools, there are important debates that are only just beginning. One of these is the long-term impact on the curriculum as a whole. While this study has looked closely at the impact of ICT on how pupils learn in schools and how this might be enhanced, it has not addressed the impact that it might make on what they learn. This, in turn, raises the question of where learning takes place and whether the schools of the future will be the physical entities that we have today. Scottish teachers were somewhat divided in their views on whether ICT would break down the age- and subject-based organisational structures of the school, as well as the teacher–pupil relationship (Condie et al., 2005). Many also had a vision of a classroom of the future that was very different from that of today: there is some evidence that such a vision could become a reality.

While this study has looked closely at the impact of ICT on how pupils learn in schools and how this might be enhanced, it has not addressed the impact that it might make on what they learn. This, in turn, raises the question of where learning takes place and whether the schools of the future will be the physical entities that we have today.

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Note: all weblinks were accessed between March and July 2006.

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