The big pICTure:
The Impact of ICT on Attainment, Motivation and Learning

Vanessa Pittard, Phil Bannister and Jessica Dunn, Department for Education and Skills

department for
education and skills

Introduction

This review summarises and discusses recent large-scale studies of the impact of ICT (information and communication technologies) on pupil attainment, motivation and learning. It focuses on national studies rather than smaller scale and local case study research, so reflects a 'big pICTure' in terms of impact of ICT in schools in England.

ICT can be used to support learning in many different ways in schools. This extends beyond individual pupils' use of learning software on a computer to include, among other things, interactive presentations using touch sensitive whiteboards, specialist devices like data loggers for the collection of data in science lessons, email based applications to support learning communities and links between schools, and schools' use of enhanced pupil information systems.

Since the launch in 1998 of the Government's National Grid for Learning (NGfL), now called the ICT in Schools programme, there has been significant investment in ICT in schools, resulting in large improvements in ICT provision. This includes increased access to computers, internal networks and the Internet, use of educational and other software, and ICT training for teachers (DfEE 1998, 1999, 2000, 2001, DfES 2002, 2003a). The Government's investment, therefore, has had an impact in terms of access to and types and levels of ICT use. The overall goal, though, is to drive up standards of achievement in schools and the Government believes that ICT can play a key role in this (DfES 2003b). In this context it is essential to also understand the educational value of ICT investment and the impact of ICT in schools on pupil attainment and related outcomes.

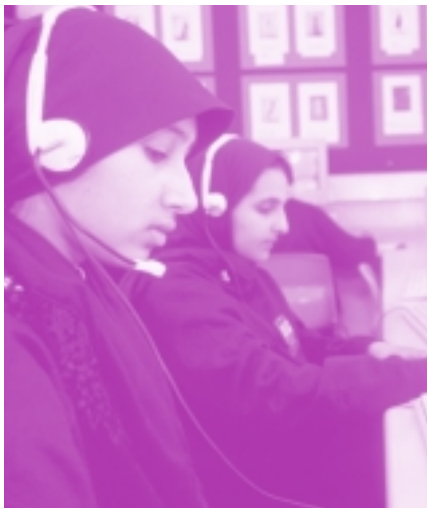
Though it is evident that ICT has potential to contribute to transforming educational achievement, potential benefits cannot be taken for granted. Like any other area of public spending, there is a need to understand whether investment decisions are being made which maximise educational and related economic benefits. This is not just about asking 'Does ICT have an impact on educational outcomes?', it is also about understanding the nature of any impacts, the factors associated with them and the conditions which enable positive change. Large-scale impact research offers insights into this and also helps us to understand what works, so that wise investment decisions can be made and ICT can be put into practice effectively. This review will be of interest, therefore, to researchers, policymakers at all levels, and educational practitioners.

Like all good research the findings prompt questions which take the research agenda forward, but the key findings from this review appear to be that:

- Generally something positive happens to the attainment of pupils who make (relatively) high use of ICT in their subject learning
- School standards are positively associated with the quality of school ICT resources and quality of their use in teaching and learning, regardless of socio-economic characteristics
- Use of ICT in class generally motivates pupils to learn
- Achieving positive impact of ICT on attainment, motivation and learning depends critically on the decisions of schools, teachers and pupils on how it is deployed and used

Conducting robust impact research is far from straightforward. Before presenting recent evidence, we consider some research design issues.

Contents



2 Research Issues

Researching the impact of the use of ICT on pupil attainment presents a significant challenge because a range of interrelated factors and processes impact on learning - at school, organisational and pupil levels. It is difficult to isolate any single aspect, including use of ICT, from the other mediating influences. While a study may be able to demonstrate an improvement in pupil attainment over time, it is very difficult (and sometimes impossible) to determine whether the use of ICT was critical, or played a role in improved attainment because so many other factors will have played a part (Rudd, 2000). Additionally, ICT provision and use is likely to be very closely related to factors like quality of teaching and learning more generally, pupil characteristics, and quality of school leadership. For these reasons, isolating 'ICT' as a separate factor is often not meaningful or desirable, and understanding its links with other factors is a key facet of studying its impact.

Putting these issues aside for a moment, although proving causality is virtually impossible, there are methodologies which allow researchers to find associations between ICT use and learning outcomes. Randomised controlled trials (in which people are allocated at random to receive an intervention) would be the most rigorous method for assessing whether ICT actually results in improved learning outcomes (EPPI 2002). However in practice this methodological approach is not generally used in educational research in the UK for ethical reasons, it being important that individuals are not knowingly disadvantaged by decisions about whether they will or will not receive a particular intervention.

Other more 'acceptable' alternative methodologies are sometimes used, such as the use of naturally occurring control groups (comparing groups of pupils in schools where ICT is used, with groups with similar characteristics but who do not use ICT) and pupil level value-added approaches (which measure individual progress and so use the pupil as his/ her own control before and after an ICT intervention) along with multi-level modelling statistical techniques, that 'control' for (or hold constant) other factors.

Despite the quest for hard statistical evidence of an association between ICT use and attainment, qualitative investigations also provide important evidence, particularly relating to other outcomes such as pupil and teacher motivation, attitudes and approaches to learning etc. The triangulation (or combining) of statistical and qualitative findings, helps us to build up an evidence base of what actually works in practice (Rudd, 2000). For national policy purposes, we generally need to consider large scale, representative or generalisable studies, rather than single case or other small-scale localised research. Small-scale research can be useful if methods are robust and the cumulative weight of evidence from a number of studies is systematically reviewed.

Given that the overall aim of educational policy is moving towards embedding ICT use in the wider learning environment, then it is important to develop studies of the effectiveness of using ICT as part of the whole learning context, as well as trying to isolate the specific contribution made by individual ICT components (Newhouse, 2002).

3 Impact of ICT on pupil attainment

ImpaCT2: Attainment
(Harrison et al 2002)

ImpaCT2 is possibly the best known recent UK study of the impact of using ICT on pupil attainment. Of the studies presented here, it has certainly attracted the most interest from the media. Commissioned in 1999, *ImpaCT2: Attainment* was the first large-scale study of its kind to assess the impact of ICT use on individual pupil attainment in national tests. This research met many methodological challenges, including establishing robust and reliable ways of measuring individual pupils' ICT use, finding ways of controlling for factors like socio-economic background which are known to have a positive relationship with pupil attainment, and obtaining large enough samples at each Key Stage (2, 3 and 4), in each subject, to engage in meaningful statistical analysis.

At its core, the study focused on the collection of three types of information for each pupil:

- Attainment in the previous Key Stage test (initial attainment)
- Pupil ICT experience (how much pupils used ICT for learning, for what subjects, and where they used it)
- Attainment at their current Key Stage test (final attainment).

Sixty schools, representing the national picture in terms of socio-economic characteristics, took part in the study. A key decision was made to sample schools which had been rated highly by Ofsted for the quality of ICT learning opportunities. There were good reasons for this. NGfL had been launched just one year previously. At the time of the start of the fieldwork, though there had been large investment in ICT, provision was still very new in many schools. So this investment had not yet translated into large changes in levels of classroom use. Sampling schools with relatively well-established ICT provision was a means of avoiding the pitfall of discovering very low levels of subject use across the board and consequent difficulties in identifying 'high' ICT users[1].

[1] Nonetheless, as the final report states, "Given the rapid increase in schools' levels of connectivity throughout the period of the study, the analysis … is inevitably based on a 'snapshot' in time, rather than an overview of embedded practice" (Harrison et al, 2002, p. 7).

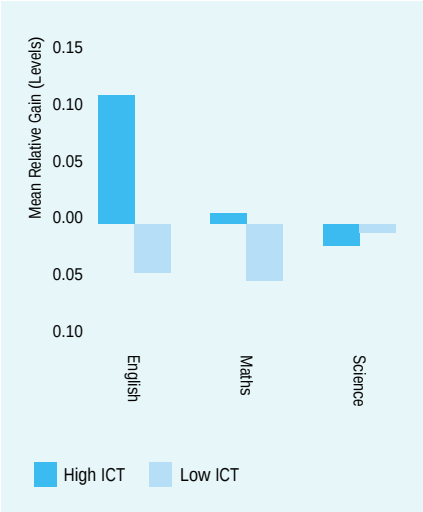


Figure 1: Mean relative gain in level equivalents at Key Stage 2 for high ICT users versus low ICT users by subject (ICT use data drawn from a total of 700 questionnaires administered during 2001)
Source: Harrison et al (2002) ImpaCT2

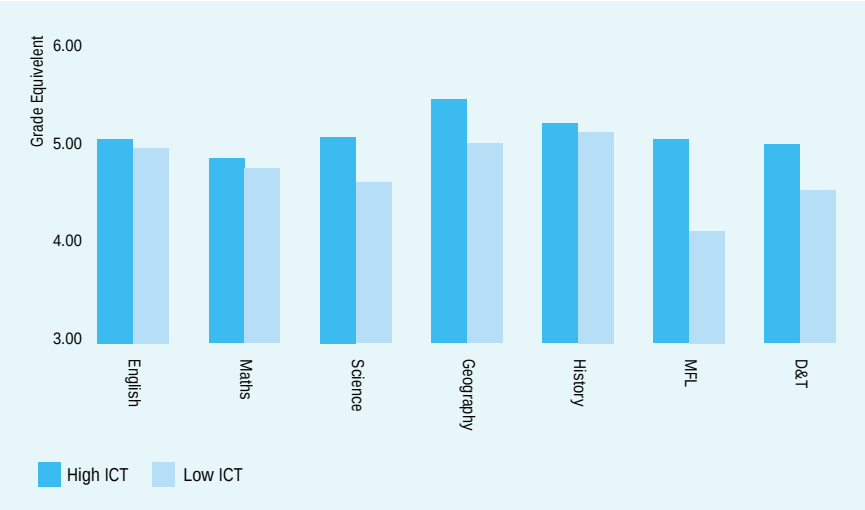


Figure 3: Mean relative gain scores in grade equivalents at Key Stage 4 for high ICT users versus low ICT users by subject (ICT use data drawn from a total of 700 questionnaires administered during 2001)
Source: Harrison et al (2002) ImpaCT2

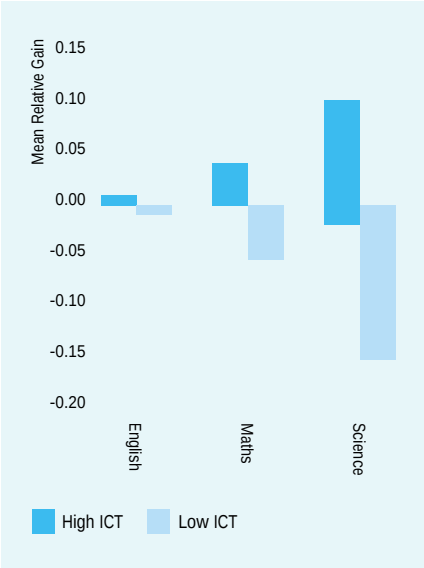


Figure 2: Mean relative gain at Key Stage 3 for high ICT users versus low ICT users (ICT data drawn from a total of 700 questionnaires administered during 2001).
Source: Harrison et al (2002) ImpaCT2

In total 2100 pupils with different levels of initial attainment were recruited from these schools. Each pupil was asked to complete a questionnaire on her/his use of ICT for learning over the academic year. For each of the subjects included in the study, pupils were asked "How often have you used the computer for school work in the last year [2000-2001] in [the subject]". This was measured on a 5-point scale from 'never' to 'most weeks'. Data from other sources, including interviews and activity logs, confirmed that answers to this question accurately reflected actual ICT experience.

In some ways the study can be seen as akin to a 'natural' experiment, comparing the attainment of 'high' and 'low' ICT users. In order to do this robustly other factors were controlled for. It is possible, for example, that high ICT users are generally more likely to come from higher socio-economic groups, and that 'high' ICT use is a proxy for socio-economic background. This problem was solved via the use of PIPS and YELLIS 'value added' methods developed at the University of Durham[2]. The PIPS and YELLIS schemes, which all sampled schools took part in, allowed reliable and valid predictions of pupils' final attainment based on both initial attainment (in the previous national test) and a range of known factors including socio-economic and home characteristics.

ImpaCT2 established how well pupils had performed compared to what was predicted of them. This was each pupil's relative gain score. If the relative gain score was positive, the pupil had performed better than predicted. If, however, it was negative, s/he had performed less well than predicted.

At each Key Stage, for each subject, ImpaCT2 asked 'Did high ICT users have significantly higher relative gain scores than low ICT users?'. Analysis focused on core subjects (English, mathematics and science) at Key Stages 2 and 3, and core and some other subjects at Key Stage 4[3]. 'High' and 'low' ICT use were based on a 'median split' – those above the median being defined as 'high' users, and those below as 'low' users.

Full results of the study and further interesting analysis are documented in the final report. Key findings were that there were statistically significant positive relationships between relative gain score and level of ICT use in:

- English at Key Stage 2 (a difference equivalent to 0.16 of a National Curriculum level – see figure 1)
- Science at Key Stage 3 (a difference equivalent to 0.214 of a National Curriculum Level – see figure 2)
- Science at Key Stage 4 (GCSE) (a difference equivalent to 0.56 of a GCSE grade – see figure 3)
- Design and Technology at Key Stage 4 (GCSE) (a difference equivalent to 0.41 of a GCSE grade – see figure 3)

No statistically significant negative relationships were found (for example the slightly lower relative performance

[2] Pupil questionnaires, sent by Durham University to schools, completed by pupils, and returned to the University of Durham for analysis. Data gathered includes, for example, pupil gender, number of books in the home and level of parents' involvement with homework.
[3] Additional subjects at Key Stage 4 were geography, history, modern foreign languages and design & technology.

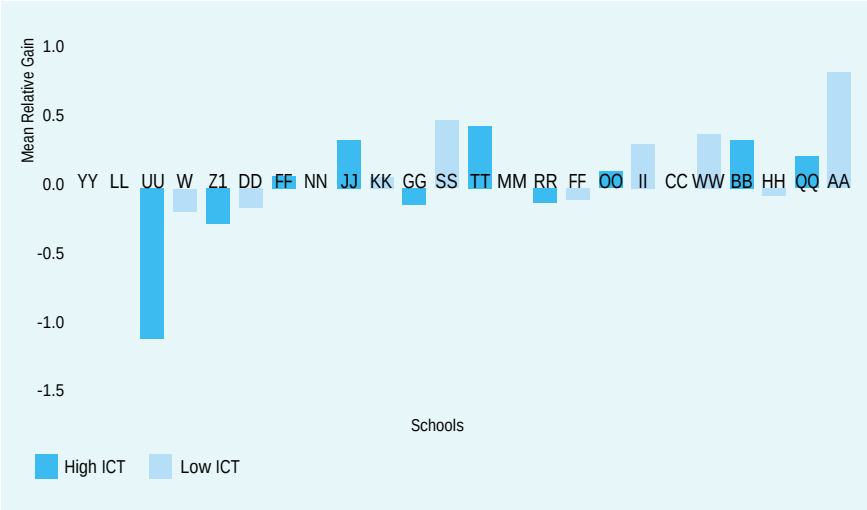


Figure 4: Mean relative gain for schools in order of ICT usage for Key Stage 4 modern foreign languages from low (left) to high (right) (ICT use data drawn from a total of 700 questionnaires administered during 2001)*

Source: Harrison et al (2002) ImpaCT2

** Where a school has been plotted on the graph but no relative gain score is shown, this is because the study team was not able to obtain the value-added data for this subject.*

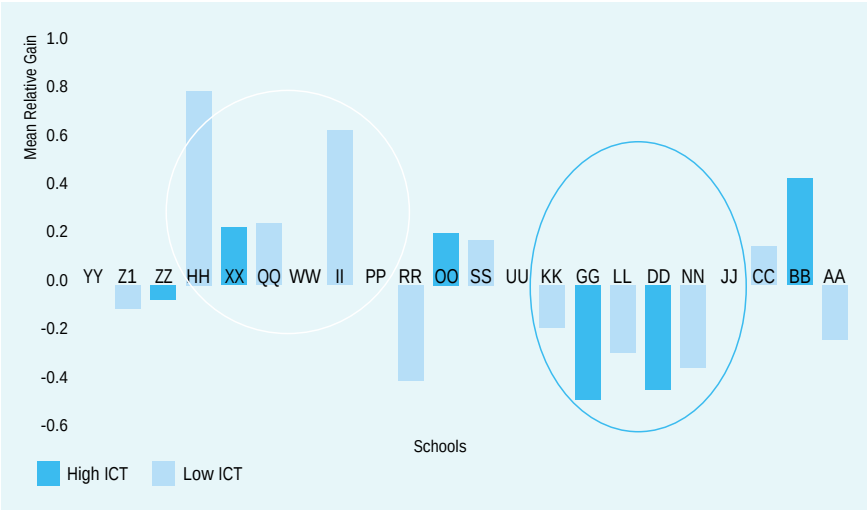


Figure 5: Mean relative gain scores in grade equivalents at Key Stage 4 for high ICT users versus low ICT users by subject (ICT use data drawn from a total of 700 questionnaires administered during 2001)

Source: Harrison et al (2002) ImpaCT2

of high ICT users found in Key Stage 2 Science was not significantly different to that of low ICT users).

Though other associations were not statistically significant, it is notable that in all but one Key Stage subject, a positive relationship between level of ICT use and relative gain score was found. These are the much-quoted 'headline' findings from ImpaCT2. The study, however, produced some findings which help shed further light on the nature of the impact of ICT on learning:

- 'Added value' (in terms of mean relative gains of pupils) at school level from high ICT use in a subject varied depending on the subject. For example, attainment gains in GCSE Modern Foreign Languages were strongly related to level of subject ICT use, aggregated to school level (see figure 4). But the opposite could be argued for Key Stage 3 English – attainment gains were not at all related to the level of pupils' ICT use, in individual schools, in Key Stage 3 English (see figure 5).
- In schools where pupils were using ICT less often, but relative gain scores were high in that subject (e.g. school 'QQ' for KS 3 English in figure 5), ICT was found to be used in a wide range of ways.
- There were indications that where high use for a 'significant'[4] subject was found in a school, but there was not generally high use across that school, attainment gains were not achieved in that subject. Though more evidence is needed on this, it seems that pupil use of ICT more generally than in a particular subject is a pre-condition for positive impact.

As the authors state, "There is no consistent relationship between the average amount of ICT use reported for any subject at a given Key Stage and its apparent effectiveness in raising standards. It therefore seems likely that the type of use is all important" (Harrison et al, 2002, p. 3). Though overall there were some significant associations, we cannot conclude what exactly accounted for differences in attainment. What were high use/high relative gain pupils doing, for example, that added the value to their learning? Though additional evidence from *ImpaCT2: Perceptions* and *ImpaCT2: Case Studies* offers some insights, there are not yet definitive answers to this.

It is useful to reflect overall on what *ImpaCT2: Attainment* does and does not tell us. Though it was cleverly designed to control for a range of factors which are known to impact on attainment, it is important to remember that it was not a causal study. It did not show that high ICT use caused higher attainment where the relationship was statistically significant. It did show, however, that generally something positive happened to attainment in the case of (relatively) high ICT users in those subjects. There could be a range of reasons for this - it may be that ICT use served as a general motivational trigger for learning, it may be that pupils who utilised ICT learning opportunities were more likely to be keen learners, or it may be that exposure to ICT in subject learning in itself helped reinforce subject understanding – or a combination of

[4] One of the four subjects where an overall significant positive relationship was found between amount of pupil ICT use and relative gain score (KS2 English, KS3 Science, KS4 Science + D&T).

reasons. The nature of this ICT-related effect needs to be explored further.

ImpaCT2 represented a breakthrough in terms of research linking ICT to attainment. It offered clear indications of the added value that pupil ICT use delivers to learning. However, like all good studies, it raises as many questions as it answers and suggests directions for future research which are discussed in the final section of this review.

***Statistical Analysis of National Data ('SAND'): Primary Schools – ICT and Standards: An analysis of national data from Ofsted and QCA* (Becta 2003a); *Secondary Schools – ICT and Standards: An analysis of national data from Ofsted and QCA* (Becta 2003b)**

The *ImpaCT2: Attainment* study represents one way of measuring the impact of ICT on pupil attainment in national tests. A different kind of evidence can be found in ongoing work by Becta, where Ofsted inspection data on the quality of ICT provision and use within schools has been linked to QCA school-level data on pupil achievement in core subjects (at Key Stages 2 and 3 and at GCSE level). Carried out annually since 2000, most recently this has involved analysis of Ofsted and QCA data from the 2582 primary and 430 secondary schools which received a full Ofsted inspection (including the grading of ICT) during the academic year 2000-01. The analysis highlights a number of ways in which the ICT provision and use in schools is statistically related to pupil attainment.

Quality of school ICT resources and pupil attainment

Average percentages of primary school pupils achieving Level 4 in tests in core subjects (English, Maths and Science) at Key Stage 2 were higher across schools where ICT resources were judged to be very good than across schools with poor ICT resources (see Figure 6). This has been observed consistently each year since 2000. The relationship appears unaffected by socio-economic factors: comparison of schools in the same socio-economic grade with good and unsatisfactory ICT resources found that those with good resources still achieved better results. At secondary level, the quality of ICT resources was related positively to the quality of ICT learning opportunities, which is in turn associated

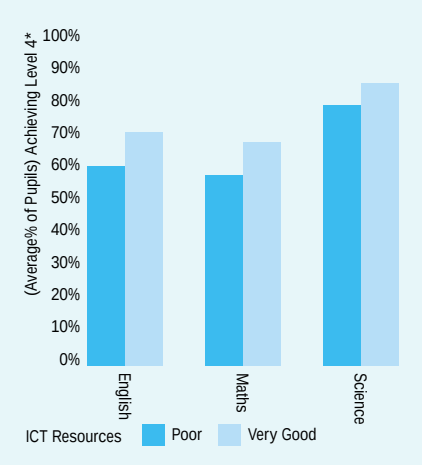


Figure 6: Quality of ICT resources and standards
Source: Becta (2003a).
** The Y-axis indicates the percentage of pupils reaching level 4 in Key Stage 2 tests in each subject; the height of the bar indicates the average percentage of pupils reaching level 4 in each subject within each category of school*

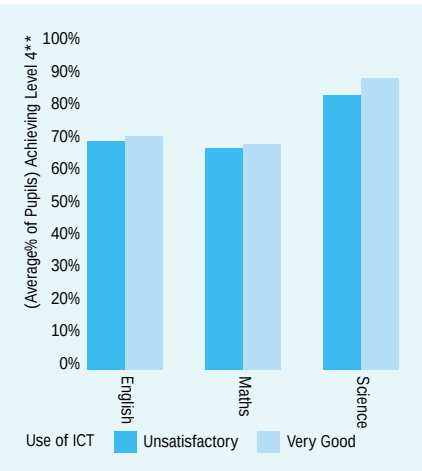


Figure 7: Use of ICT in primary schools with good ICT resources
Source: Becta (2003a)
***The Y-axis indicates the percentage of pupils reaching level 4 in each subject in Key Stage 2 tests; the height of the bar indicates the average percentage of pupils reaching level 4 in each subject within each category of school.*

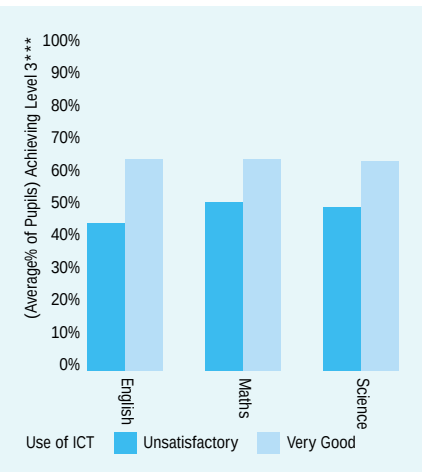


Figure 8: use of ICT in secondary schools with good ICT resources: Key Stage 3
Source: Becta (2003b)
**** The Y-axis indicates the percentage of pupils reaching level 5 in each subject at Key Stage 3; the height of the bar indicates the average percentage of pupils reaching level 5 in each subject within each category of school.*

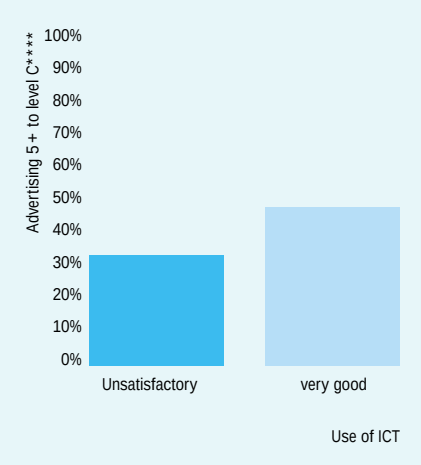


Figure 9: Use of ICT in secondary schools with good ICT resources: GCSE
Source: Becta (2003b)
***** The Y-axis indicates the percentage of pupils reaching level 4 in Key Stage 2 tests in each subject; the height of the bar indicates the average percentage of pupils reaching level 4 in each subject within each category of school.*

positively with pupil achievement at Key Stage 3 and GCSE level (see below).

Quality of use of ICT resources and pupil attainment

Ofsted inspections judge how effectively schools use their ICT resources within teaching. Amongst primary schools with good quality ICT resources, those which used them well achieved slightly better results in core subject tests at Key Stage 2 than those schools with similar resources used less effectively (see figure 7). Amongst secondary schools with good quality ICT resources, the average percentage of pupils attaining Level 5 at Key Stage 3 in English, maths and science was considerably higher in schools which made very good use of their technology than in schools where ICT use was unsatisfactory (see figure 8). A similar positive relationship was found at GCSE level (figure 9).

ICT use in subject teaching is also judged in Ofsted inspections. At primary level, the majority (61%) of schools with good use of ICT in mathematics reached or exceeded national standards in mathematics at Key Stage 2, against 38% of schools with unsatisfactory use of ICT. This difference holds true when schools in the same socio-economic group are compared. A very similar pattern of results was found in both English and science. At secondary level, schools which made good use of ICT within core subjects at Key Stage 3 tended to achieve better results in those

core subjects than those which did not use ICT so effectively. (Schools making good use of ICT within subjects at GCSE level also achieved slightly better results, but this is less pronounced than at Key Stage 3.)

Quality of ICT learning opportunities and pupil achievement in Key Stage 3 and GCSE assessments

Ofsted inspections measure the amount and quality of opportunities provided by a school for pupils to develop their ICT experience. Across secondary schools in which ICT learning opportunities were good or better, the average percentage of pupils achieving 5 or more level C passes in English, maths and science at Key Stage 3, and the equivalent at GCSE level, was higher than across schools where ICT learning opportunities were satisfactory or worse. A positive relationship also existed in secondary schools between the quality of ICT learning opportunities and the overall quality of learning in schools. In particular, where ICT learning opportunities were good, there was a higher likelihood that the learning was good or very good.

Furthermore, the findings suggest that where secondary school pupils had good ICT learning opportunities, they were able to apply and develop their ICT capability in subject specific work, which in turn had a positive impact on their achievements in other areas.

The quality of school leadership as a factor

Generally schools in which the quality of school leadership was judged to be very good had the highest proportion of pupils achieving level 4 or above in English, mathematics and science at Key Stage 2. It may be, therefore, that quality of leadership can account for ICT-related performance. When quality of leadership was factored into the relationship between ICT learning resources and pupil results (2001 data), however, better ICT resources were associated with better Key Stage 2 results regardless of quality of school leadership. However, in 2000 it was found that the positive association between quality of ICT resources and results only applied where school leadership was judged to be very good, good or satisfactory, and was not apparent where it was poor. In accounting for this change, the report

authors suggest that poor leadership had more of a negative impact during the early stages of ICT development in schools, and becomes less important as general levels of ICT confidence in the school rise.

Amongst secondary schools where the quality of leadership was good or very good, better quality ICT learning opportunities were associated with higher pupil achievement in English, mathematics and science at Key Stage 3 and GCSE level. This positive association did not exist across schools where the quality of leadership was satisfactory, unsatisfactory or poor, implying that school leadership influences the relationship between ICT learning opportunities and pupil achievement.

ICT and pupil attitudes

The percentage of primary schools whose pupils' attitudes were judged to be very good was highest amongst those which were very good in terms of adequacy of ICT learning resources and quality of ICT learning opportunities. A positive relationship was also found at primary level between pupil behaviour and quality of ICT learning opportunities, and also (to a lesser extent) with the adequacy of ICT learning resources. The same relationship was found in secondary schools.

These relationships need to be treated with some caution, since schools with good leadership and good teaching are more likely to have better ICT resources and offer better ICT learning opportunities, and generally foster an enhanced school ethos. However, there are indications that ICT has motivational benefits in its own right.

Overall findings from analysis of national data

Notable findings from this statistical analysis of national data are that:

- the quality of ICT resources and pupil attainment are associated positively at Key Stage 2
- a positive association exists between the quality of use of ICT (as judged at both school and individual subject levels) and pupil attainment at Key Stages 2 and 3 and at GCSE level
- the quality of ICT learning opportunities and pupil attainment are associated positively at Key Stage 3 and GCSE level
- the quality of school leadership appears to be a factor in the relationship between ICT learning opportunities and pupil achievement at Key Stage 3 and GCSE level

In interpreting the findings of this work, however, the limitations of the method it uses must be taken into account. Ofsted data on ICT quality in schools is derived from judgements made by HMI inspectors during school visits, and as such is qualitatively different from data collected by social researchers within dedicated research studies. Perhaps

more importantly, the cross-tabulation of inspection and national test data does not serve to establish causal relationships between the quality of ICT provision and use in schools and pupil achievement, but demonstrates the existence of statistical associations.

Nonetheless, taken together, ImpaCT2 and 'SAND' provide reasonably convincing evidence that pupil ICT use and school ICT provision impact positively on individual pupil attainment and on overall school performance. Together they also show that this relationship is not simple, and is related to types of ICT use, use of ICT across the curriculum in particular subjects and at different key stages, and the strength of school leadership.

***Young People and ICT 2002 survey* (Hayward et al 2003)**
It is interesting to relate these findings to pupils' and parents' perceptions of the role of ICT in learning, to provide an experiential perspective on the relationship between ICT use and attainment which is interesting in its own right – and also to 'triangulate' this with the 'harder' impact research.

The Young People and ICT 2002 study was a comprehensive survey of young peoples' access to and use of ICT – both at home and in school. It was conducted via computer-assisted in-home interviews with 1804 young people aged 5 to 18 (in full time education) and their parents. (Young people living away from home and those in higher education were not included).

On the topic of the relationship between young peoples' ICT and attainment, it found that:

- The majority of young peoples' uses of ICT (excluding games) happened at home, rather than at school.
- 49% of children in Key Stage 2 felt that using computers at school helped them to get better results, 43% said that it made no difference and 2% felt that it made their results worse.
- Boys (58%), and those who did not have access to a computer at home (62%), were more likely to say that using computers helped them get better results than girls (41%) and those with access to a computer at home (46%).
- In households with a computer, 41% of parents believed that their child achieved better results at school as a result of having a computer at home. This increased directly with the child's age - from 26% of parents of children in Key Stage 1 to 61% of parents of post 16s. 1% felt that their child got worse results and 51% felt that it made no difference.

While this is not a study of actual impact of ICT use on attainment, it tells us something about pupils' and parents' experiences and expectations of the relationship between pupils' ICT use and attainment at school. The overall picture is mixed – clearly many children and parents believe that ICT use leads to better results, but a significant proportion do not think this. Perceptions of impact on attainment are related to certain factors. Of particular interest is the fact that boys report an impact more than girls. The issue of differential impact based on gender is returned to in section 6.

Clearly the most powerful evidence of the educational value of ICT is to be found by examining the effects of its use on pupil achievement in standardised national tests. Yet it is important that any appraisal of the impact of ICT on attainment considers other, less readily quantified learning gains which are associated through research studies with ICT use, as these may in turn have a positive influence on pupil performance within formal assessments.

4 Impact of ICT on motivation

Findings from several recent studies indicate that ICT can play an important role in motivating pupils and encouraging them to engage in learning, within and beyond the classroom. They also provide insights into uses of ICT which are particularly motivating for young people.

***ImpaCT2: Perceptions* (Somekh et al 2002a)**
ImpaCT2: Perceptions focused on the wider context of pupils' learning with ICT, particularly their informal learning (in the home and other out-of-school settings, and at school in relatively informal settings such as computer clubs). During Autumn 2001, selected samples of pupils (approximately 20 from each of the 60 schools involved in the project) completed logs of their ICT activities; a questionnaire on Internet use; a report on a key learning event with ICT; interviews with peers on attitudes to computer games, mobile phones or the Internet.

Two important findings relating to motivation from this study:

- ICT plays an important role in young peoples' culture - it was found to be integrated with a variety of social practices which belong primarily to young people, such as pop music and games cultures.
- ICT allows young people to connect with a range of social ideas - in talking about their experiences of ICT, young people mentioned issues of importance to today's world, such as health, gender and the role of the media.

The authors concluded that as well as having an impact on attainment in national tests, ICT may also enable motivating and stimulating teaching "connected in a real way to a wealth of curricular issues" (p. 22).

***ImpaCT2: Case Studies* (Comber et al 2002)**
ImpaCT2: Case Studies involved 15 schools (7 primary, 7 secondary, 1 special) from the 60 taking part in the ImpaCT2 Attainment and Perceptions studies. The research focused on perceptions of ICT and learning at

school and home, and involved pupils (in Years 6, 9 and 11), their teachers and parents. Data was collected through a range of methods including interviews, lesson observations, diaries, focus groups and questionnaires.

The teachers interviewed perceived a broad range of ways in which ICT was likely to have an effect on pupil attainment. Motivation was commonly cited, often linked to shifts in pupils' attitude to and involvement in learning activities. Some teachers saw ICT as having enhanced the performance and cognitive functioning of pupils who previously had been on the margins of classroom activity or performed poorly. One of most immediate benefits of ICT frequently mentioned by teachers was improved production and presentation of work, which was sometimes seen as connected to increased pupil self-esteem and motivation.

***Young People and ICT 2002 survey* (Hayward et al 2003)**

These findings are also reflected in the most recent large-scale survey of young people and their parents/guardians. A significant proportion of children (48%) in Key Stage 3 and above felt that using computers motivated them in their schoolwork. An even higher proportion (76%) of children in Key Stages 1 and 2 said that using computers made schoolwork more fun. At Key Stage 3 and above, 69% said that using computers made schoolwork more enjoyable. In terms of fun/enjoyment, boys and girls had fairly similar views, but at Key Stage 3 and above boys were slightly more positive than girls.

66% of young people in Key Stage 3 and above felt that using computers made it easier to produce work of which they were proud and 62% thought that they made it easier to understand and learn about the subject that they were studying (see figure 10). Boys were more likely than girls to agree with both of these statements.

***Computers for Teachers: Phase 1 survey evaluation* (Becta 2001) *and Phase 1 qualitative evaluation* (Kington et al 2003)**

The message that ICT use impacts positively on pupil motivation is repeated in this study of teachers who received a computer through phase one of the Computers for Teachers (CfT) initiative. The evaluation was in two parts: a quantitative survey of 2,558 teachers and qualitative research - telephone interviews with 24 beneficiaries and interviews with a further 20 teachers in eight case study schools.

Two thirds of survey respondents (67%) believed that their personal ownership of a computer had substantially affected pupils' motivation, 28% felt that it had a little effect and 4% felt that it had no effect.

Many of the teachers in the qualitative evaluation of CfT believed that the scheme had an indirect positive impact on pupils. They felt that their greater use of ICT in the classroom since acquiring a personal computer had impacted positively on pupil motivation, learning and behaviour in class. Several teachers noticed that pupil motivation had increased amongst those who had not previously been keen to learn, and some reported that ICT impacted on pupil behaviour by keeping pupils focused and on task.

Like ImpaCT2 Attainment and Perceptions studies and the Young People and ICT Survey, the Computers for Teachers evaluation does not provide direct evidence of the impact of using ICT on pupil motivation, but it does provide valuable evidence of teachers' experience of using ICT and their professional judgements about it. The message from all studies is very clear – effective use of ICT in the classroom can impact positively on pupil motivation. However, in all studies teachers were reporting relatively early experiences of using ICT in the classroom. This needs to be taken into account, as any impact may reflect short-lived 'novelty value'.

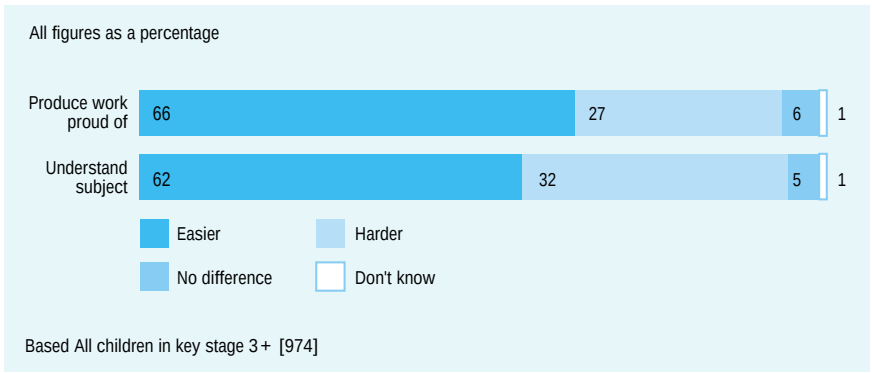
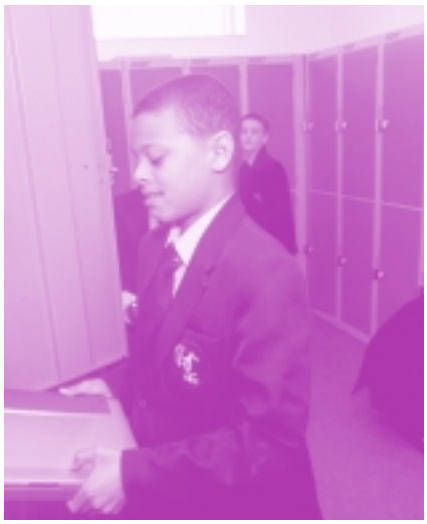


Figure 10: Young peoples' attitudes about whether computers make it easier to produce work of which they feel proud and whether computers make it easier to understand and learn about the subject
Source: Young People and ICT 2002 survey (Hayward et al 2003)



MOTIVATIONAL MEASURE	DEFINITION	IDEAL 'POSITIVE' LEARNING PROFILE
Learning goal	The reason for engaging in the activity using ICT is to further personal understanding and competence	High level
Performance approach goal	The reason for engaging in the activity using ICT is the pursuit of opportunities to gain positive feedback about one's competence	Low level
Performance avoidance goal	The aim of engaging in the activity using ICT is to avoid feedback suggesting a lack of competence, often achieved by finding ways of not engaging in the task	Low level
Academic efficacy	The degree to which an individual believes they have the capacity to design and execute the courses of action necessary to achieve a particular goal using ICT	High level
Intrinsic motivation	The degree to which ICT directly engages the pupil and holds their interest	High level
External regulation	A willingness to engage in work with ICT because one feels obliged to do so by someone else, probably an authority figure such as a teacher	Low level
Identified regulation	Beginning to recognise and share the values that might have been assumed to drive the inducements offered by others to engage in the task using ICT	High level
Amotivation	A lack of any particular reason for engaging with ICT-supported work	Low level

Figure 11: Definitions of motivational measures used in the study

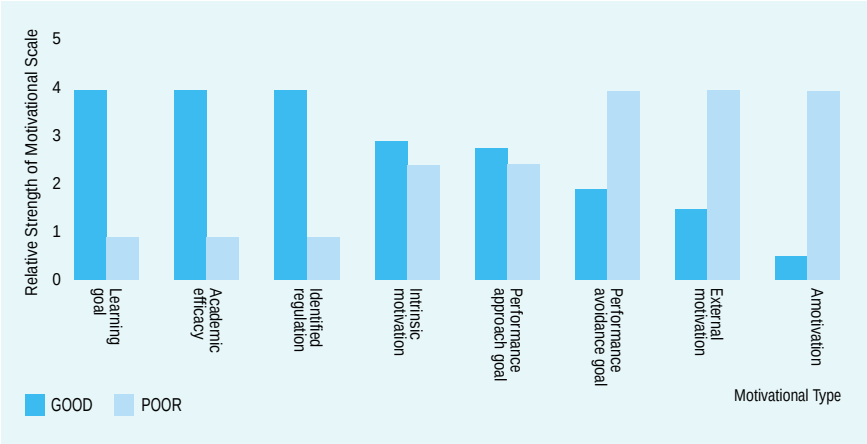


Figure 12: Hypothetical 'good' and 'poor' motivational profiles

***The Motivational Effect of ICT on Pupils* (Passey et al 2003)[5]**

This was the first significant study of its kind. It aimed to establish systematically the impact of ICT use in school on pupil motivation, including quantification of this where possible. Among other things it investigated the specific characteristics of any motivational impact and set out to consider ways in which ICT can be used effectively by teachers to motivate pupils.

Case studies were carried out in 17 schools, including interviews with 121 head teachers, teachers and classroom learning assistants and with 126 pupils. 33 lessons were observed and 1,206 pupil questionnaires were administered. There were also interviews with 24 social workers, youth workers, health workers, careers officers and police officers concerned with school liaison and youth offenders.

The study drew on theoretical approaches to motivation which had been developed and utilised in previous studies. It rightly problematised the concept of 'motivation', in effect breaking it down into a set of motives or drivers for pupils to engage in tasks at school. These drivers include:

- pupil reasons for engaging in an activity (for example, to further personal understanding, to gain positive feedback or because of external regulation),
- 'intrinsic' motivation (engagement, attention holding),
- pupil beliefs about their efficacy in conducting the task.

Researching the role of ICT in relation to the balance between 'intrinsic' motivation and other drivers is critical to understanding whether using ICT in school impacts purely in direct ways (which may be short-lived), or in ways more fundamentally linked to learning.

The eight motivational measures used in this study are explained in figure 11.

Figure 12 shows an example of hypothetical 'good' and 'poor' motivational profiles, according to the measures used in the study. It is the relative strengths of the particular motives in the profile that are important, rather than the actual levels. These profiles offer a general indication of 'ideal' patterns of motivation. Slightly different profiles may be appropriate to different activities and situations.

This framework translated into measures of motivation which formed the basis of

[5] Summary of emerging findings published December 2003, full report due Spring 2004.

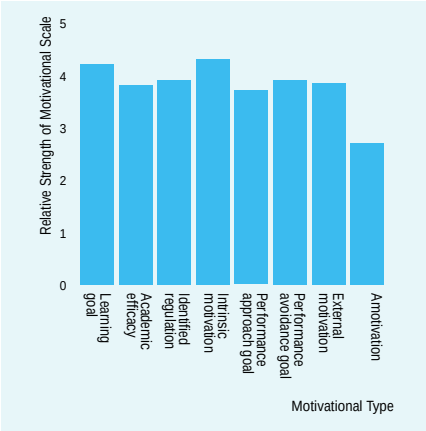


Figure 13: Motivational profiles of primary pupils in the study

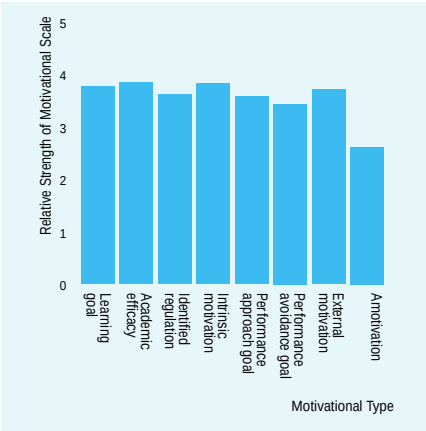


Figure 14: Motivational profile of secondary pupils in the study

the pupil questionnaire. Pupils were asked a series of questions about their experience of using of ICT in the classroom, each of which formed part of a larger scale measuring the motives/drivers above. In answering the questions, pupils were asked to reflect on concrete and recent examples of using ICT in school. Researchers then looked at the relative strength of different motives/drivers, in order to draw conclusions about types of motivation linked to using ICT in school. Figures 13 and 14 show the motivational profiles of the pupils in the study.

The broad findings of this study confirmed the perceptions of teachers and pupils presented above – using ICT in school had an overall positive motivational impact on the pupils studied. The conceptual framework allowed valuable insights into the nature of that positive impact. There was clear evidence that:

- Learning had high importance compared to other motives/drivers when using ICT to complete tasks at school. This suggests that while working with ICT pupils were generally motivated to learn something. This was more the case with primary pupils than secondary pupils, but true of both.
- Other motives/drivers were also important, notably at primary level, where the intrinsic motivation of ICT was high (that is, using ICT was motivating in its own right), but not to the cost of learning goals, or other key drivers, like pupils' perceived efficacy at the task.
- Looking in more detail at pupils' perceived efficacy as a driver, ICT offered a means for pupils with different backgrounds and needs to be able to view success, through enabling them to see end points and recognise that they could work towards these in order to complete tasks. This was dependent, however, on learning through appropriate tasks and provision of pointers by teachers to enable learners to approach their tasks in the right way.
- There were indications that overall the motivational impact of ICT was greatest where there was a focus on both teaching and learning (e.g. clusters of equipment to support subject learning or interactive whiteboards to support learning and teaching).
- Findings from the qualitative part of the study suggest that particular affordances[6] of ICT impacted on motivation: visual, kinaesthetic and to some extent auditory capabilities; the ability to research and select from a wide range of resources; committing ideas during writing more readily and widely, and editing more extensively;

[6] What a technology allows - perceived and actual capabilities or properties

capability to present work well.
- Overall there was very little evidence of reported motivational impact of ICT in relation to developing pupils' subject-specific cognitive processes – that is the development of conceptual skills in specific subjects. The exception to this was in GCSE Design and Technology, where, in four schools at least, ICT use was fully embedded in the delivery of concepts and skills.
- Where ICT use was fully embedded in subject teaching (as in Design and Technology, above) such that its use related closely to the development of subject-specific cognitive processes, there were indications of a related positive impact on pupil attainment (GCSE results).
- Evidence on the impact of ICT on outcomes related to motivation, notably behaviour and attendance, was mixed. There were concrete examples of the use of ICT to support disaffected pupils, and the majority of secondary pupils who were interviewed reported that behaviour in classes where ICT was used was better than when it was not used. Some pupils reported impact on behaviour out of school but youth and community workers and the police did not demonstrate great awareness of uses of ICT to support young people.

Overall this study confirms the perceptions of teachers and pupils from previous research that using ICT in school can impact positively on pupil motivation in school. The additional value of this study is that it offers an analysis of this. There, however, are some notes of caution when interpreting this research. This was not a comparative study – it did not compare schools with 'embedded' ICT to those which were making little use of it. Rather, it focused, as did ImpaCT2, on schools making relatively good use of ICT. Therefore it is difficult to put the findings in an overall context. Nonetheless the research provided some new and valuable insights, including clear indications that the motivational impact of using ICT in school is not purely about pupils enjoying using the technology; it is about motivation to learn. The research also backs up what is suggested by other studies, including ImpaCT2, that many of the motivational impacts of using ICT in school are dependent on the decisions and guidance of the teacher. Finally, the study highlights an area where there has been relatively little impact of ICT – even in schools making good use of it. There is relatively little use of it as a direct means of developing pupils' cognitive capabilities in subject learning.

5 Impact of ICT on approaches to learning

ICT practitioners and theorists have claimed that ICT has the potential to deliver new forms of teaching and learning in schools and to revolutionise pupils' approaches to learning. This area of study is large and complex and cannot be given full justice in this review. It is, however, useful to reflect on what the large-scale studies already presented tell us about changes to teaching and learning. Of particular interest is whether any observed changes are truly 'transformational', that is, qualitatively different from existing approaches.

Though a complex field of study, research in this area commonly focuses on:
- the balance between teacher and pupil control of learning (locus of control)
- individualisation of learning – or personalisation on the basis of individual pupil needs
- new ways of developing and supporting pupils' conceptual understanding

Just as with impact on pupil motivation, there have been indications from recent studies that teachers think that using ICT in class offers capacity to change the nature of pupil learning. For example, in the Computers for Teachers evaluation, several teachers felt that through using a personal computer they had been able to prepare appropriate, individualised work more effectively for pupils with learning difficulties, and these pupils had benefited as a result (presumably also facilitated by pupil access to a computer). Other studies offer further evidence on personalisation of learning and tell us something about the impact that using ICT can have on pupil control of learning and on conceptual understanding.

***ImpaCT2: Case Studies* (Comber et al 2002)**

Many teachers interviewed in the case studies reported that ICT had the capacity to enhance the process of learning itself as well as the products. Through using ICT, learners were liberated from mundane tasks and able to concentrate on higher order skills. For example, ICT enables learners to produce accurate representations of their data speedily (e.g. drawing graphs automatically in a spreadsheet package), allowing the teacher to focus on developing pupils' understanding of the outcome of their investigations.

The research also investigated the role of ICT in facilitating a shift in pedagogy away from a teacher-led, "transmission" model towards one that is more learner-centred and in which pupils experience greater autonomy in learning. Through classroom observations and interviews with pupils and teachers, the research found clear evidence at all levels of learners working autonomously with ICT, although this was not always the result of a conscious decision on the part of the teacher (for example pupils may work independently due to the teacher's lack of confidence in using ICT in their subject area; pupils working at a computer individually or in small groups are by default "independent" of the teacher). However, evidence was found of several teachers having deliberately engineered learning situations where pupils were encouraged to explore software themselves, within a framework laid down by the teacher (who provided support and intervention at appropriate points).

Several teachers observed that where pupils were working in class with ICT, the level of peer interaction had increased, with pupils advising and assisting one another in an informal kind of peer tutoring. Much of this kind of interaction was unplanned and unstructured (pupils offering advice before returning to their own work), but appeared to facilitate a sharing of knowledge which was conducted 'in their own language'. It also relieved the teacher of much basic skills instruction. However, the research found few examples of teachers setting learning activities which explicitly required the collaborative use of ICT by pupils.

***A systematic review of the impact on students and teachers of the use of ICT for assessment of creative and critical thinking skills* (EPPI 2003)**
A systematic literature review conducted by the Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) summarises key findings from a range of published research studies on the use of ICT in assessing the creative and critical thinking skills of learners (from 4 to 18 years old). While many of the findings reported from these studies concern the effectiveness of ICT-based assessment tools from the point of view of the teacher (e.g. how far the computer-based tests automate the process of assessment and feedback), the review does outline research findings on the effects of computer-based assessment on learning.

Two research studies found that where the computer-based assessment provided the learners with formative feedback, their performance improved when they used the same test material at a later date. Nine research studies found that the use of a computer program both to assess and to give feedback to learners could improve the performance of learners in comparison to those who were tested in paper-based form. Computer-based assessment can enable students to demonstrate their ability and skills more effectively, and the feedback helps them to develop better understanding. In several studies, it was reported that learners were more motivated by the computer-based assessment, because of its being technology-based and/or the feedback it provided.

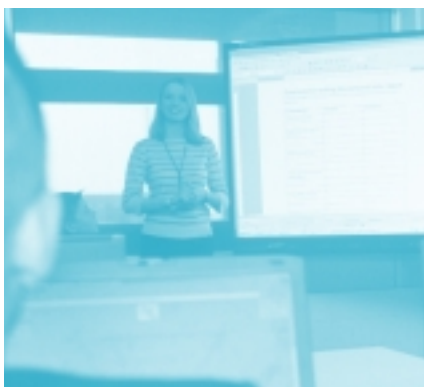
In certain computer-based assessments of creative and critical thinking skills (for example, where the assessment task involved diagrammatic representation and the need to make conceptual links or establishing key relationships), learners benefited from being able to see a visual representation of their thinking processes. Indeed, the capacity of computers to represent sometimes abstract concepts visually and make abstract relationships more concrete (e.g. through concept and knowledge mapping) was held to support meaning-making amongst learners and help improve their performance.

***NGfL Pathfinders Evaluation* (Somekh et al, 2002b; Triggs et al, 2003)**
Between 1998-2002, research was conducted in ten LEAs selected as 'Pathfinders' for their interesting and innovative approaches to implementing the NGfL Programme. One strand of the research studied the impact of the Programme on teaching and learning through a combination of surveys, classroom observations and interviews with pupils and teachers.

There were mixed views amongst the teachers involved in the research on the impact of ICT on learning and teaching (Somekh et al, 2002b), though it is important to note that interviews were conducted relatively early in the NGfL programme. Most primary teachers believed that ICT would enhance pupil learning and attainment, and often linked ICT to increased independence and confidence amongst learners. However, secondary teachers had more diverse opinions. While ICT teachers were most positive about the beneficial effects of ICT, those teaching other subjects were less certain, with some regarding it as detrimental to the development of numeracy and literacy. There was also a lack of consensus as to whether or not ICT had helped to facilitate learner independence.

Interviews and surveys with teachers (Triggs et al, 2003) highlighted the fact that the nature as well as the extent of ICT provision within schools affects the integration of the technology into teaching and learning (and thus its impact on pupil learning). Many respondents stressed the need for the ICT infrastructure to allow teachers flexibility and spontaneity in their access to computer facilities. Without this, the use of ICT in subject teaching will be limited.

So, along with evidence already presented from the Motivational Effect of ICT on Pupils (Passey et al 2003) (above), there is a developing body of evidence that using ICT in the right ways can help personalise pupil learning, develop pupil-centred and collaborative approaches to learning and offer new ways of supporting and enhancing pupils' conceptual learning. But systematic evidence on the extent of such changes to approaches to learning is relatively thin on the ground. This is clearly an area which will benefit from further large-scale systematic research.



6 Different groups of learners

The increasing availability of ICT in schools for teaching and learning purposes prompts questions about both the capacity of the technology to promote inclusiveness, and its potentially divisive effects. Does ICT benefit certain groups of learners who are disadvantaged by conventional methods of teaching? Conversely, does ICT-based teaching and learning discourage other types of learner? The following section will look at some of the research evidence on how ICT affects girls and boys, learners at different levels of ability, and pupils with Special Educational Needs (SEN).

ICT and gender

The Young People and ICT survey revealed that boys were more likely to report that using ICT had a positive impact on their attainment. Further evidence from ImpaCT2: Case Studies showed that ICT was widely perceived by teachers to help engage boys in learning activities and to maintain their attention for longer. Teachers regarded the Internet in particular as an effective way of involving less enthusiastic pupils, and mentioned boys regularly in this regard. The question is, are these solely perceptions, or is there further empirical evidence to back this up?

The Motivational Effect of ICT on Pupils **(Passey et al 2003)**
Findings from this research indicate that ICT probably had a greater positive effect on boys in the study, while at the same time not disadvantaging girls. Possible reasons were discussed, including the explanation that boys are traditionally thought to work in 'burst' patterns while girls work in more persistent patterns. ICT appeared to enable boys to move towards a more prolonged engagement with learning tasks than when ICT was absent.

ImpaCT2: Attainment
(Harrison et al, 2002)
Within this strand of the ImpaCT2 study, analysis was conducted of the impact of using ICT in a subject on relative gain scores. Further analysis was conducted on the role of gender in relation to this, to determine whether there were gender differences in levels of relative gain. Contrary to the perceptions of boys and teachers noted above, there was no evidence that boys were more advantaged by using ICT in their learning than girls.

Impact of ICT use across ability groups

ImpaCT2: Attainment
(Harrison et al, 2002)
Statistical analysis was conducted in the ImpaCT2 study to examine the impact of ICT use across the ability range. Pupils were divided into three initial attainment (IA) groups – high, medium and low, and analysis was undertaken to establish whether there was an 'interaction effect', between high ICT use and IA, on relative gain score (for example, did high ICT use have more of an impact for low initial attainers than high initial attainers?).

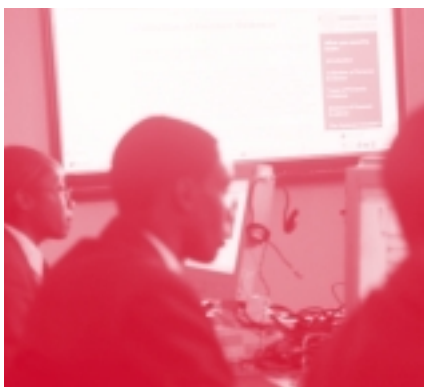
ImpaCT2 found no evidence that pupils at one ability level were more advantaged or disadvantaged by high ICT use than pupils at another ability level. Relative attainment gains on the basis of ICT use were very even across the ability range.

Impact of ICT use on pupils with Special Educational Needs (SEN)

Though the ImpaCT2 research showed no differences on the basis of ability, pupils with special educational needs are often seen as a special case in relation to ICT. However, because 'SEN' covers a hugely diverse range of pupils, including those with specific sensory disabilities (like deaf pupils), those with behavioural problems, and those with learning difficulties, it is impossible to generalise about the impact of ICT on pupils with SEN. However, some studies have addressed the role of ICT in serving the needs of SEN pupils – both those in mainstream schooling and those attending special schools.

Computers for Teachers Phase 1 Qualitative Evaluation
(Kington et al, 2003)
This study found that teachers felt that their increased use of ICT since getting a personal computer was particularly beneficial to pupils with learning difficulties, because they could prepare appropriate work for individuals more efficiently. Teachers also reported that incorporating ICT into the classroom increased learning and communication opportunities for those with learning difficulties (and also those who were less confident).

ICT in Schools: Effect of Government Initiatives progress report
(Ofsted, 2002)
Analysis by Ofsted of data from inspections in Special Schools in 2001 showed that ICT can play a significant role in supporting the learning of pupils with SEN. (As mentioned earlier, Ofsted inspections collect evidence on ICT and its effects under in a different way to dedicated research studies,



so the findings cited below need to be interpreted accordingly.)

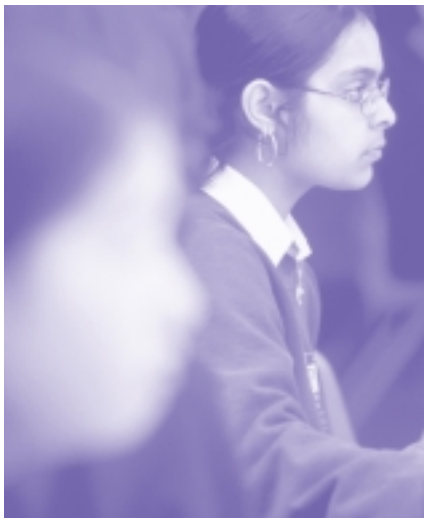
According to inspection data, the use of ICT in the classroom was beginning to improve achievement in almost all special schools. The report stated that the use of age-appropriate software with older pupils promoted improved achievement, self-image and independence. Word processors and specialised software were used to produce personalised 'big books' for the literacy hour and other subjects, which helped enhance class discussion. Through the use of digital images, pupils' experiences outside of school were relived and discussed in the classroom, capitalising on the gains made from educational visits. Making digital images available to pupils to use in their writing was found to motivate those with emotional and behavioural difficulties, who were seen to overcome their reluctance and become keen authors of text to use alongside images in on-screen presentations.

***ImpaCT2: Case Studies* (Comber et al, 2002)**

Teachers saw ICT as especially motivating for many children with SEN. Teachers reported that ICT helped to develop pupils' understanding and enabled them to accomplish tasks which might be found difficult without technology. For example, several teachers reported that ICT enabled pupils with poor handwriting and/or presentation skills to produce work that looked professional, which boosted their self-esteem and confidence. Finished work displayed the efforts of pupils to best advantage, rather than highlighting their shortcomings. This was confirmed in pupil interviews, where a number of children, especially (though not exclusively) those in primary school, identified these features of ICT as particularly helpful.

***The Motivational Effect of ICT on Pupils* (Passey et al 2003)**

The communication aspects of ICT were found to be especially important to those with learning difficulties and 'those at risk', whereas the information aspects tended to be more important to gifted and talented pupils. In special schools ICT was often fundamental to enabling pupil communication, which led to improvements in pupil motivation.



7 Specific technologies and applications

"ICT" is often used as a blanket term to refer to a very broad range of technologies. This hides the fact that there is considerable diversity amongst these different technologies in terms of the curriculum subjects in which they are used, the types of teaching and learning activity that they support, and the nature of their impact on pupil learning. It may be, for example, that there are particular technologies, or technological uses, which are providing real 'bangs for their buck', and contributing more to improvements in attainment, motivation and learning than other technologies.

***ImpaCT2: Pupil attainment* (Harrison et al, 2002)**

ImpaCT2 took a closer look at how ICT was being used in schools where high pupil ICT use was associated with high relative gain scores (i.e. where ICT use was offering added value). It also considered ICT uses in schools with high relative gains, where ICT was used more sparingly. General conclusions are difficult to draw from this exploration, as in some cases this was just a few schools. Some interesting conclusions can be drawn, however, from looking at technologies used in subjects where there was an overall significant relationship (KS2 English, KS3 Science, KS4 Science and D&T):

- At Key Stage 2 English, pupils used a range of technologies, including a balance between subject-specific software (like fun spelling games), generic word processing and graphics software and use of the Internet to support research.
- A similar mix was found for Key Stage 3 Science - use of generic software (like spreadsheets, data manipulation and data presentation software), specific hardware (mainly data logging), subject-specific software, like scientific modelling and simulation, and use of the Internet for research.
- Key Stage 4 Science differed slightly from this. There was evidence that ICT was being used to support GCSE revision, including use of the Internet to search for revision sources, and use of subject software to test knowledge and understanding and provide instant feedback.
- Use of revision websites was also found for Key Stage 4 D&T. Two further technologies were used frequently: CAD packages and computer models for visualisation.

The overall picture suggests that ICT use which is both varied (and therefore helps develop students' general ICT

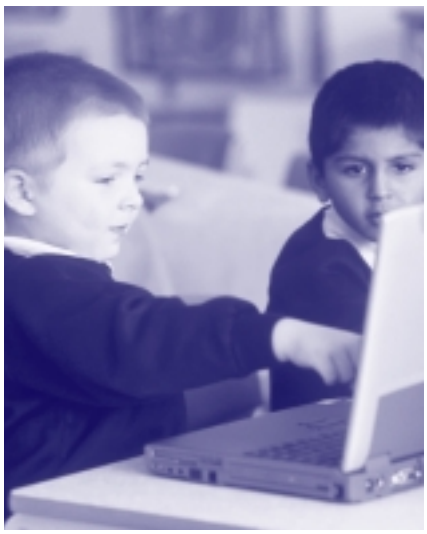
skills), and closely targeted to delivery and assessment of the curriculum, led to gains in attainment.

***The Motivational Effect of ICT on Pupils* (Passey et al 2003)**
This study commented in particular on the motivational impact of interactive whiteboards as a technology. There is currently some interest in the pedagogic potential of interactive whiteboards within classrooms and studies of their impact are currently underway.
An interactive whiteboard is a touch-sensitive display board used in conjunction with a digital projector and a computer. It can be used by teachers and pupils as if it were a computer screen (e.g. moving the cursor, double-clicking on items, writing on it and saving what is on screen).
Levels of school interactive whiteboard ownership are increasingly rapidly (DfES 2002, 2003a).

It was found that where interactive whiteboards were used effectively both teachers and pupils reported a positive motivational effect. Motivational benefits were derived from:

- Enhanced presentation facilities, such as animation and annotation
- 'Kinaesthetic' capability – the ability for pupils to interact with the information through touch
- Quicker lesson pace, due to efficiencies in presentation and interaction

What is not known is whether any motivational benefits arising from the use of interactive whiteboards translate to pupil learning and attainment. Similarly, nothing robust is known at present about the relative impact of interactive whiteboards compared to other presentational technologies (such as digital projectors used in conjunction with tablet PCs). Ongoing evaluative research, due to report in 2004, will address some of these issues.



8 Some Conclusions

In attempting to draw conclusions from the evidence presented here it is important to resist over-simplifying the reality of the impact of ICT in schools. The 'big picture' is a complex one. However, some legitimate overall conclusions can be drawn about the impact of ICT on attainment, motivation and learning. Overall, the weight of evidence presented here suggests clearly that ICT provision and pupil ICT use do in fact impact positively on pupil attainment and on school standards - though there is no definitive study demonstrating causality. There are also some clear messages about the motivational potential of using ICT in teaching and learning, and the opportunities ICT affords for both engaging pupils directly and motivating an engagement in subject learning via the use of ICT.

But any added value of ICT in educational terms is clearly not just based in the fact of ICT provision, or the amount of use pupils make of it. As ImpaCT2 concluded, it is dependent on the types of use to which it is put. Therefore the decisions of schools and teachers (and of course pupils) about how ICT is deployed and used to support subject learning are critical. As Cox (2003)[7] points out in her review of studies of ICT and attainment:

> There is a strong relationship between the ways in which ICT has been used and the attainment outcomes. This suggests that the crucial component in the use of ICT within education is the teacher and her pedagogical approaches... Insufficient understanding of the scope of an ICT resource leads to inappropriate or superficial uses (p.3-4)

The impact of ICT use on educational outcomes is clearly also subject-related. Where ICT can be deployed in a range of ways in subject teaching and learning, and where it can offer qualitative benefits in supporting the development of pupils' subject learning (for example GCSE Design and Technology), then educational outcomes from its use are likely to be positive. Though ImpaCT2 found significant positive impact in diverse subjects, like English and science, it is unlikely, even with imaginative and effective use, that ICT can make the same contribution in every subject at every key stage. This is not, of course, to argue that ICT should not be used in some subjects, as use across the curriculum is critical. However it implies that expectations of outcomes arising from using ICT in teaching and learning should be informed by knowledge of the particular contribution that ICT can make in that subject.

Further issues also come into play in considering how a positive impact on educational outcomes via the use of ICT can be achieved. For example, ImpaCT2 found that pupils' use of ICT across the curriculum was important to whether

[7] Report published December 2003

there were attainment gains in individual subjects. This suggests that the ICT culture of the school, and pupils' general ICT experience are important contributors to pupils' opportunities to gain an educational advantage when using ICT in subject learning. Analysis of national data ('SAND') at secondary level backs this up.

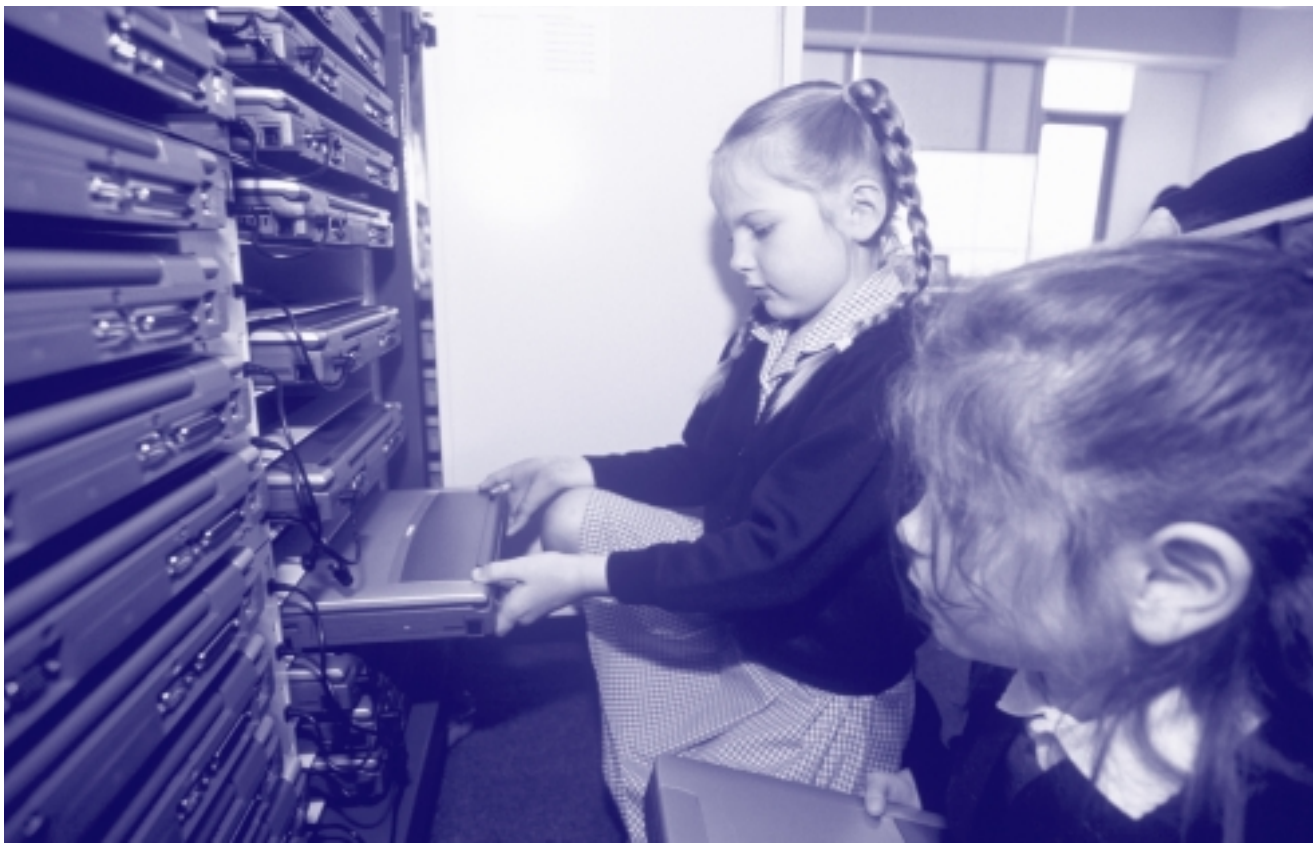
'SAND' also suggests that the quality of school leadership is a factor in whether the quality of ICT learning resources predicts school performance. Notably at secondary level, good quality ICT resources only link to good school performance if the quality of school leadership is also judged to be good. It also found that quality of ICT learning opportunities, as judged by HMI inspectors, is closely related to the overall quality of learning in schools. It is difficult to see how the two would be unrelated, with high quality of ICT learning opportunities likely to be critically dependent on teachers' and schools' ability to deliver generally high quality learning.

So this is the picture so far – not a complete one, but we now have some understanding of the range of factors that mediate the impact of ICT on pupil attainment and motivation.

Some of the findings in this review, like those relating to the impact of ICT on approaches to learning, however, are tentative, and suggest the need for further research. This review has focused predominantly on 'big picture' research – relatively large-scale and national studies. Smaller scale studies can be informative, as long as they are conducted systematically and outcomes are measured robustly. Their findings can supplement those of large-scale studies, sometimes offering a direction where there are gaps in understanding or insights when there is contradictory evidence. Case study research, for example, has the potential to improve our understanding of types of ICT use that are most effective in raising standards, and analysing changes to learning which can occur using ICT.

There are some logical directions for future research in order to fill the gaps in understanding suggested by this review. There is a need to understand more systematically the links between types of use of ICT and pupils' educational outcomes, for example. This links to the need to understand in more detail the impact that specific technologies have, and what factors relate to this. This includes, for example, the impact of using interactive whiteboards in class and, more challengingly, the impact of emerging and innovative technologies such as mobile wireless devices that allow 'anytime anywhere' learning. Systematic research is also needed into the potential and role of ICT in facilitating changes to teaching and learning, like increased personalisation, pupil collaboration and pupil-centred learning.

The more that ICT becomes embedded both in pupils' everyday experiences and in teaching and learning in school, the more important it becomes to study ICT not as something separate, but as integrated into the learning context as a whole. If future ICT research can meet this challenge, and study impact in a robust and systematic manner, then there will be a good evidence base for the effective planning of future investment in ICT in schools.



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ISBN 1 84478 136 4
DfES/0796/2003