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Becta leading next generation learning

The impact of digital technology

A review of the evidence of the impact of digital technologies on formal education

Contents

Biography of the author

Jean Underwood, formerly Reader in Education at Leicester University and now Professor of Psychology at Nottingham Trent University.

Jean started her career as secondary teacher before becoming a teacher educator. She has spent more than thirty years investigating factors leading to effective learning at all ages, particularly the role of digital technologies for learning. Examples of the major research projects she has been involved with include the evaluation of Integrated Learning Systems, the ICT Test Bed Project and Impact 2007 and 2008 funded by Becta; and Mediakids and the Telepeers Project funded by the European Commission.

In summary

- Digital skills are important to social and economic participation and the broader UK economy.
- There is now a growing body of national and international evidence demonstrating the positive impact of digital technologies on measurable learning outcomes.
- The so-called hard evidence is supplemented by softer observational evidence, which has an important role in explaining why the positive outcomes have or have not accrued.

The evidence tells us that integrated use of technology enables a range of positive outcomes for children and young people.

Impact on attainment at Key Stage 1

4.75 months' progress for high attaining girls in maths.
Improved progress for girls, average and high attaining boys in science.
Improved progress for average and high attaining pupils in English.

Impact on attainment at Key Stage 2

An average gain from ICT use was equivalent to:

- a term's additional progress in English.
- 2.5 months of progress in writing for low attaining boys.
- 2.5 – 5 months' progress for some groups in maths through effective use of whiteboards.
- 7.5 months' progress for some groups in science through effective use whiteboards.

Impact on attainment in secondary school

The equivalent to a term's additional progress in KS3 science.
An average gain in GCSE science equivalent to 52,484 students moving from grade D to C.
Improvements to the overall percentage of pupils 5+ A*-Cs at GCSE in the year after broadband introduction.
After controlling for KS3 results, the availability of a computer at home is significantly positively associated with Key Stage 4 test scores. This association amounts to around 14 GCSE points (equivalent to 2 GCSE grades).

Wider outcomes

Classes with online learning, whether completely online or blended, on average produce stronger learning outcomes than learning face-to-face alone.

Young people with a computer at home are less likely to play truant at ages 14 and 16 than those without computer access. For example, having access to a computer at home is associated with a 5.8% reduction in the likelihood of playing truant at age 16.

Part 1
Introduction

i The context

"The ICT revolution is a deep cultural revolution changing all modes and patterns of our lives and hence bound to lead to dramatic changes in education. It is characterised by its recognition of two basic facts:

a. ICT has a powerful defining impact on all important aspects of our lives and hence our culture (in terms used often in this context: it is a 'defining technology')

b. The ICT revolution is a part of a group of intertwined revolutions that in the past 20 years have been transforming Western culture from a modern into a postmodern culture. (Aviram & Talmi, 2004, p.4).

In 2003 the then Department for Education and Skills published *The big pICTure: The Impact of ICT on Attainment, Motivation and Learning* (Pittard *et al.*, 2003). This was the first review of large scale studies of the impact of technology in England since the launch of the NGfL (National Grid for Learning) in 1998.

Six years later this review does the same, but within a radically different context. Home access to computers has risen sharply over the past decade such that over three-quarters of young people aged 12 – 15 have access to broadband at home, and over 60 per cent use it every day. The internet is frequently used at home to do school work – reported by 80 per cent of 12 – 15 year olds (Ofcom, 2008).

Though the assumption that resulting change to the educational system is inevitable is subject to debate, there are likely to be consequences, particularly relating to equity if the educational system does not respond to a fast-changing socio-technical context.

ii: Education with or without technology: the old debate

The argument for digital technologies' positive impact on learning has been questioned by some (see Higgins, 2009). But the need to establish the value of technology to education remains important, particularly where there is an emphasis on standards-based accountability and also because of the substantial cost of implementing technology innovation in the classroom.

Researchers have pointed to well-crafted use of technology benefiting, for example:

- increased learner effectiveness or performance gains
- increased learner efficiency
- greater learner engagement or satisfaction
- more positive student attitudes to learning.

A counter argument is that the same could be said of well-managed non-technology supported lessons (Baker *et al*.,1997). Capturing the complexity of the educational process is fraught with difficulty. It is not feasible to control all the variables in the imperfect research environment of schools, so the evidence rarely allows us to state unequivocally that technology has had an efficient and effective impact on student achievement (Herman 1994; Lesgold, 2000; Protheroe, 2005). Furthermore, impacts are rarely directly causal and new affordances tend not to be quickly embedded in the fabric of the educational practice.

But despite these caveats, there is growing evidence that learning benefits arise from the use of digital technologies (see Schacter & Fagnano, 1999; Underwood et al., 2008, 2009a; U.S. Department of Education, 2009).

iii: The rise of connected Britain

Yet, while this debate rumbles on, continuing to be a focus of much attention for policy makers and researchers alike, there is a more fundamental argument for embracing technology underpinned by its centrality in our twenty-first century culture.

As technology has spread through our society, new behaviours and new ways of working have emerged. For example, few would have predicted the impact of technology on news reporting; an impact that has led to a new enfranchisement for citizens. Such changes necessarily affect the structures of a society and new or transformed institutions emerge (after Heath & Luff, 2000).

Learners of all ages are also exhibiting new behaviours as a result of ubiquitous high functioning technologies. Changes may be relatively mundane, such as replacing the school folder with a memory stick, or more profound, as when learners voluntarily seek out expertise beyond the traditional classroom.

Though these developments are not necessarily transformational, there are very real changes in behaviour that have resulted from the exponential change in both the functionality and the cost of technology.

iv: Which way forward? Setting the technology compass

The question therefore is how do we take advantage of these new behaviours for the benefit of education? There is a need to make a realistic assessment of what technology can and cannot do to reach a plateau of productivity when the technology consistently delivers to realistic goals.

So what is the way forward for education in this digital world? There are broadly three strategies: *A minimum emphasis* on technology – not a comfortable option in the context of digital inequity; *Getting technology to serve the system* – identifying how technology supports the current business of education to good effect; or *Merge and evolve* – allowing ourselves to adapt and respond to the possibilities from technology through innovation.

Digital technologies are already requiring us to think differently about how learners learn and how teachers teach. From this perspective we need to think about how schools or learning ecologies are organised, including the role of technology to support meaningful student achievement.

But any innovation must first and foremost have an educational purpose and that purpose should be to improve the outcomes for learners of any age, because through learning people can live happier, healthier, more productive lives. The consensus is that for formal education a skilled teaching workforce is the key to success (Hernadez & Goddison, 2004; Waddoups, 2004; Somekh *et al*., 2006).

The following section details a growing body of research to assess in more detail the relationships between the digital, learning and educational worlds.

Part 2
What the evidence says

There are still some who would argue that the value of digital technologies for learning is at best unproven. However, there is now a growing body of evidence detailing the very real impact of technology on both formal and informal learning. For clarity, that evidence will be presented here under two headings:

- impacts that bring about changes in behaviour at learner, teacher and school level
- those that bring about changes in academic performance.

Much, but not all of the former, relies on formal and informal observation. Evidence on academic performance involves measurement of impact with statistically verifiable results and clear associations between the process and outcomes of that learning process.

i: Changes in behaviour

There is a vast array of evidence related to behavioural changes when working with digital technologies. Here two areas of impact have been highlighted to represent this corpus of evidence. These are:

- readiness for learning
- integration of learners into the educational process.

Readiness for learning:

Learner performance in schools is a product of the characteristics of individual learners and the opportunities to learn provided not only by the school but also the home. Technology can enable the learner to fully benefit from formal education.

At the **school level**, strategies may include the efficiencies in monitoring of behaviour to reduce persistent absenteeism, a factor in academic underachievement, or more subtle profiling of underachieving pupils to produce a personalised programme of work, and so increase the school's percentage of pupils attaining the national target of five GCSEs (Underwood *et al*., 2008).

Research into the role of technology within strategies for school improvement backs this up. This study showed that of 181 schools that had been removed from Special Measures and Notice to Improve, 82 per cent reported that technology had played a key role in improvement. Strategies for using technology in these schools included greater use of information systems for monitoring and analysing learner achievement and progress; IT systems for managing and monitoring attendance and behaviour (lesson registration, parental alerting); greater use of technology to engage under-achieving pupils, especially creative and applied learning using technology; and supporting learner voice through online polls and forums (Hollingworth *et al*., 2008).

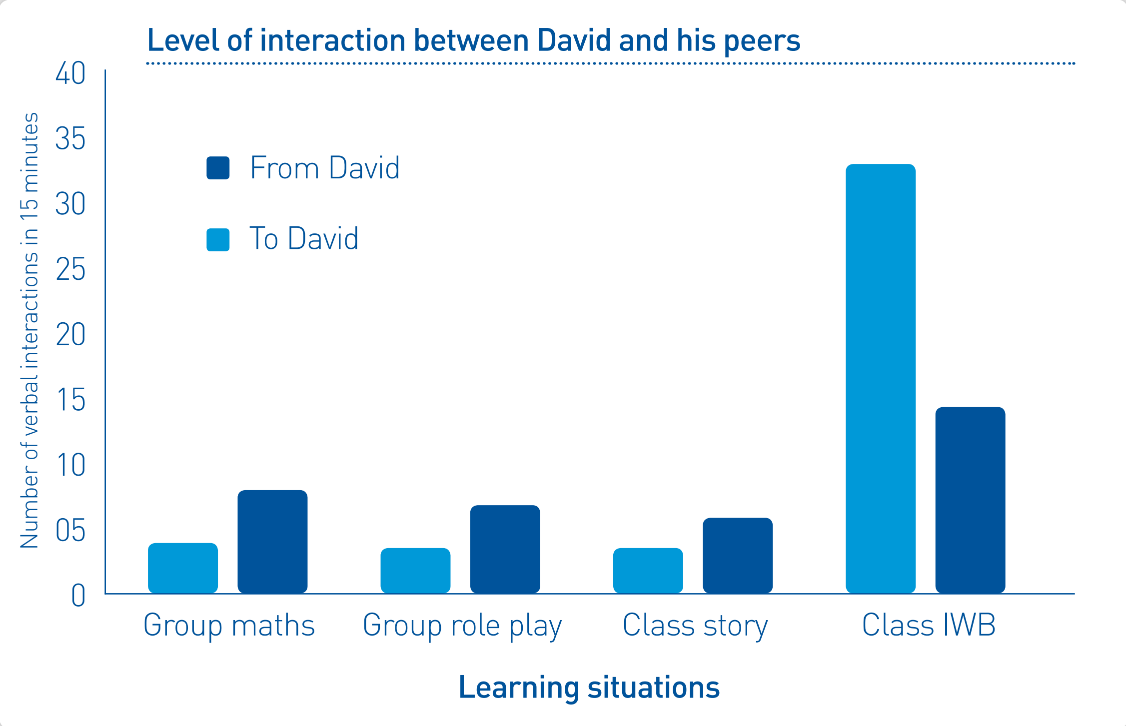
At the **learner level** the cognitive resources that learners bring to their learning has profound effects on whether their experiences will prove fruitful or not (Diamond, 2007; Gathercole *et al*., 2008). Many low and under-achievers have weak basic cognitive skills and are not prepared for the act of learning; that is, some children are ill-equipped for school (Davidson *et al*., 2006). Such children, who enter school with poor inhibitory skills, are often seen as disruptive, rude and out of control by teachers. However, children can be trained in acquiring these skills effectively and efficiently and the results can be very positive not just for the individual but for the class as a whole. The listening programme, a computer-delivered 10-week intervention, has been shown to not only improve listening skills but also to develop attentional skills necessary for a child to be integrated effectively into the classroom (Underwood *et al*., 2009b).

Equally technologies to help dyslexic and dyspraxic children (laptops, voice recognition software and text-to-speech software) are relatively cheap, but can make a big difference to children's academic performance.

There is a large body of scientific research documenting the effectiveness of neuro-feedback for ADHD and many areas of psychological or neuro-developmental difficulty. In partnership with NASA, SmartBrain Technologies has created a number of interactive games. One such game is a non-violent driving game to improve visual tracking skills, hand-eye co-ordination, planning, attention to detail, concentration, memory and patience. Orlandi and Greco (2005) tested the impact of playing the driving game on boys aged 9 – 11 years with a primary diagnosis of ADHD. The results showed that a non-game playing group experienced a 47 per cent study drop-out rate from clinical support but that the experimental group had only 6 per cent study drop-out rate and a number of positive behaviour changes.

Facilitating integration:

Technology can overcome barriers that prevent learners taking a full part in the educational process. Digital technologies have also proved a boon to children across a range of disabilities. The example here shows the increased level of social interaction with peers for one 7-year-old autistic boy when using an interactive whiteboard (IWB) as a mediating tool.



Within the mainstream school population the use of the use of presentational software has been shown to aid less confident students in putting forward their thoughts and ideas to their peers (Underwood, *et al.*, 2009b).

A further example reflecting how socio-economic background interacts with technology use in the classroom comes from the NetSchools [www3] programme, whose purpose was to improve the academic performance of at risk students. On this programme, low-income Latino middle school students showed improved writing skills, had higher homework completion rates and actively used web resources (OECD, 2001). Teachers in those schools were able to communicate with parents more effectively through the students' laptops, used NetSchools' databases to improve teaching, and used the teacher-student connection.

ii: Changes in performance

While learners' responses to technology-supported learning are highly positive, links to measurable performance outcomes has been more ambiguous. However, there is now a growing body of evidence linking the use of digital technologies to improved academic performance (Carnoy, Daley & Loop, 1986; Taylor *et al.*, 2007; Chandra & Lloyd, 2008; Underwood *et al.*, 2008; 2009a; U.S. Department of Education, 2009).

Large scale meta-analyses

A series of meta-analyses, starting in the mid-1980s, have shown moderate positive achievement gains at all educational levels from computer mediation in traditional subjects, especially mathematics and also for lower-achieving students (Carnoy, 2004). A current detailed meta-analysis of online learning conducted for the U.S. Department of Education confirms the value of technology for learning. Though previous summaries from pre-internet studies of distance learning concluded that learning at a distance was at best as effective as classroom, when learning moved online there were positive gains. These gains were moderate but noticeable if learners spent as much time in face-to-face instruction as online. In a number of the studies the online learners increased the time they devoted to the task and this increased effort led to larger gains over learners not using technology. Classes with online learning, whether taught completely online or blended, on average produced stronger student learning outcomes than learning face-to-face alone.

A view from the UK

Here in the UK, a number of Becta commissioned projects have provided evidence of impact. As with the US meta-analysis, collectively the findings from these studies confirm the value of ICT to learning.

Some studies have compared either the performance or improvement of the target schools to schools with similar characteristics, or with expected attainment of students based on their prior performance and other factors. Other studies have used robust statistical methods to look at the effect of technology across schools and learners, controlling for factors which are known to affect attainment, assessing the extent to which the use of technology predicts outcomes for learners or school performance and improvement.

The ***'Impact2'*** study (Harrison *et al.*, 2003), a large scale and detailed assessment of the impact of the use of ICT on learning across the curriculum found a reliable positive relationship between students' level of technology use to support learning and student-level 'value-added' scores. Significant positive impact was found in:

- KS2 English, where the average gain from ICT use was 0.16 of a national curriculum level (equivalent to a term's additional progress)
- KS3 Science, where the average gain from ICT use was 0.21 of a national curriculum level (also equivalent to a term's additional progress)
- GCSE Science, where the average gain from ICT use is 0.56 of a grade (52,484 students moving from grade D to C)
- GCSE D&T the average gain from ICT use is 0.41 of a grade (10,020 students moving from grade D to C).

Interestingly, this study found that schools' use of technology *across the curriculum* was a key factor in learning gains suggesting that the impact was not solely achieved from using technology in individual subjects. Use across the curriculum was important in both developing learner skills in using technology to support learning and in promoting an orientation towards independent learning with technology. Some uses of technology, including the use of the internet to support revision at GCSE level, were particularly strongly linked with improved performance.

The Impact of Broadband in Schools showed a link between levels of use of the internet in schools and school-level outcomes of pupil performance, including GCSE A*-C grades. (Underwood *et al.*, 2005), Compared to comparator schools, target schools who made good use of connectivity in the classroom, demonstrated statistically significant improvement to the percentage of pupils gaining 5+ A*-Cs at GCSE in the year after broadband introduction.

The researchers suggest that broadband to the classroom played a particular role in GCSE learning. It had an impact on GCSE results through providing greater opportunities to support pupil-led research in the classroom, using the internet in real time to support project-based learning. This was likely to be linked to the development of higher-order skills, which were reflected in GCSE assessment.

This study supports a view that opportunities provided by technology lead to actual learning gains when they are linked explicitly to a model or framework for learning.

In short, targeting the use of technology to improving (making more efficient or effective) specific aspects of learning based on a systematic understanding or model will lead to results.

For example, technology can support improvement by, for example, enabling development and sharing of lessons and learning resources, and enriched, enlivened and structured delivery through the use of interactive whiteboards. Independent study and research can be made more effective through constant access to the right resources (as is the case with GCSE project work and revision cited above).

School-based approaches like the Cramlington learning cycle,[1] which has led to significant improvement in learning outcomes, identifies the overall learning approach and ethos, and uses technology in specific ways to enable and enhance activities as part of this, with the aim of building a community of learners and thinkers.

The evidence therefore tells us that approaches to using technology in schools should start with an understanding of learning, leading to a vision and framework for learning. Schools should then plan on the basis of how technology will enable and support this, prioritising where technology adds particular value. This reflects the broad approach taken through Becta's self-review framework and BSF (Building Schools of the Future) planning.

1. www.cchsonline.co.uk/school/transformation/cramlearncycle

The impact of key technologies

In the UK, two key technologies have been introduced across the nation. These are presentational medium, interactive whiteboards (IWBs) and visualisers and integrative technologies collectively termed learning platforms (LPs). The former can be described as easy-entry technologies because they fit with many teachers' current practices; the latter are more challenging and require greater effort by practitioners before they can be utilised effectively (Underwood *et al*., In press) although there are examples of highly effective practice.

Trucano (2005) has argued that positive impacts occur when ICT is used appropriately to complement a teacher's existing pedagogical philosophies. Current research shows clear benefits of the use of IWBs but the benefits of learning platforms (LPs) are less visible. Potentially transformational technologies such as LPs and Web 2.0 tools are, as yet, rarely exploited to their full functionality.

But LPs can be effective, as is shown in this quote from one primary head. It is just that integration into practice is slower and requires more support than for the IWB.

"The VLE has been a major influence in developing the personalisation agenda. Teachers can tap into or tailor for small groups of pupils. The parents are involved therefore there is a whole group approach to learning, and it helps parents to understand where the pupils are. The teachers' planning and assessment has always been good, but the VLE has focused the mind and sharpened the offerings." (Primary 28; Underwood et al., 2009).

The evaluation of the Primary School Whiteboard Expansion project (SWEEP) (Somekh *et al*., 2007a) found that the length of time students were taught with IWBs was a major factor in student attainment across core subjects at Key Stage 2. There were positive impacts on literacy and mathematics at Key Stages 1 and 2 once teachers had experienced sustained use and the technology had become embedded in pedagogical practice.

After an embedding stage, improvements in outcomes which could be attributed to the use of the interactive whiteboard included:

- In Key Stage 2 maths (age 11), average and high attaining boys and girls who had been taught extensively with the IWB made the equivalent of an extra 2.5 to 5 months' progress over the course of two years.
- In Key Stage 2 science (age 11), all pupils except high attaining girls made greater progress with more exposure to the IWB, with low attaining boys making as much as 7.5 months' additional progress.
- In Key Stage 2 writing (age 11), boys with low prior attainment made 2.5 months of additional progress.
- In Key Stage 1 maths (age 7), high attaining girls made gains of 4.75 months, enabling them to catch up with high attaining boys.
- In Key Stage 1 science (age 7), there was improved progress for girls of all attainment levels, and for average and high attaining boys.
- In Key Stage 1 English (age 7), average and high attaining pupils benefited from increased exposure to IWBs.

This study is particularly significant in identifying the importance to outcomes of levels of teacher experience and expertise in using technology in teaching and learning. *It was only in the second cohort, at least a year into using the technology, that an impact on attainment could be identified. Similar findings of an initial technology dip before benefits accrued was found in the TEST BED project (Somekh et al.*, 2007b). There are strong arguments for longer term studies of impact and those which focus on sustained and embedded use of technology rather than its initial uses.

Findings from the ***DfES Secondary interactive whiteboard programme*** evaluation, which assessed impact on outcomes from early use unsurprisingly, given the time-scale, was unable to establish a link between performance and exposure to the use of IWBs. However, it did find a positive link between the introduction of IWBs and student perceptions of the quality of learning and teaching (Moss *et al.*, 2007). These indicate a positive effect from the introduction of the technology on the learners' experience of classroom teaching.

School-level e-maturity and school improvement

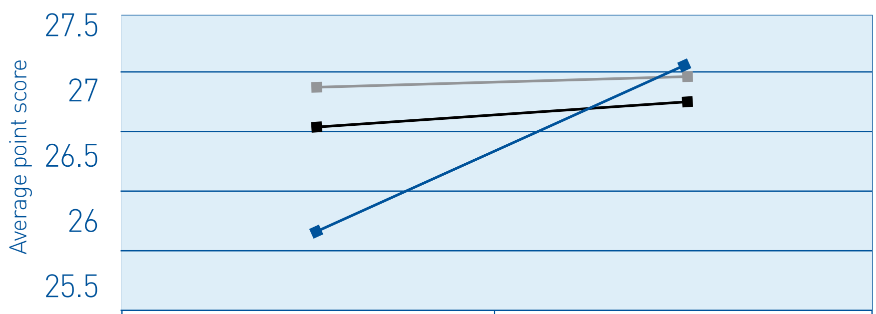
Drawing from a nationally representative sample of schools in England, Butt and Cebulla (2006) analysed the relationship between school outcomes and indicators of 'e-maturity', controlling for known factors in school performance. 'E-maturity' is the extent of provision, management and use of technology to support learning across the curriculum.

- The relationship between technology provision and outcomes was not a simple one. However, the study found that secondary schools exhibiting strong development in e-maturity over the previous four years demonstrated a statistically significant decrease in absence rates compared to other schools. They displayed statistically significant improvements in KS3 average points scores and GCSE point scores and the percentage of A*–C grades at GCSE, as well as better KS3 – KS4 value added scores.

- The researchers concluded that there is a link between performance and e-maturity, albeit this may not be a simple one. Mediating and contextual factors such as school ethos and general leadership approach are likely to be important. This analysis does, however, indicate that e-maturity is an important part of the mix in school improvement strategies. Findings from the IMPACT 2008 study confirm this symbiotic relationship (Underwood *et al*., 2009).

The *ICT Test Bed* evaluation (Somekh *et al*., 2007b) compared improvement to school average point scores and outcomes at KS2 to matched comparator schools and the national average. School performance at Key Stage 2 improved faster than comparator schools (those with similar characteristics, including size and socioeconomic makeup). They also improved faster than the national picture during that period, as is shown by the graph.

Comparison of Test Bed schools with the national picture and comparator schools in core subjects



	APS 2002	APS 2006
Test Bed schools	26.2	27.59
Comparator schools	27.1	27.3
National	27.4	27.5

(Somekh *et al*., 2007b)

Home use of technology to support learning

A study of secondary-aged students used multiple linear regression modelling to establish the relationship between Key Stage 3 and GCSE outcomes and ICT-related behaviours, including in the model other indicators of social capital and attitude to school (Valentine *et al*., 2005). Relative performance was obtained by comparing each student's actual achievement with predicted achievement, derived from 'baseline' scores.

The researchers found a statistically significant positive association between pupils' home use of ICT for educational purposes and improved attainment in national tests for:

- Maths KS 2 (PIPS added value 6.00)
- Maths KS 3 (YELLIS added value 0.30)
- Maths GCSE (YELLIS added value 0.38)
- English GCSE (YELLIS added value 0.29).

The use of ICT to support learning at home delivered a range of benefits including motivational and self-confidence effects, particularly for under-achieving learners.

Importantly, the study demonstrated the role of the school in guiding and building learning-oriented behaviours with technology. Students from schools where the use of technology was more common were more likely to use technology to support learning. Given that the study also demonstrated some negative relationships between using technology at home for leisure purposes and GCSE attainment, building learning-oriented behaviours with technology in school is likely to be critical important in enabling learners to achieve educational success.

Student ownership and use of computers

The Institute of Fiscal Studies looked at both attainment and behaviour differences between socioeconomic groups using data from the DCSF Longitudinal Survey of Young People in England (LSYPE) of 15,000 teenagers born in 1989 and 1990 (Chandra & Lloyd, 2008).

They established that computer and internet access at home is important in explaining the achievement gap, and plays a role in other behavioural outcomes. Findings include:

- After controlling for KS3 results, the availability of a computer at home is significantly positively associated with Key Stage 4 test scores. This association amounts to around 14 GCSE points (equivalent to 2 GCSE grades).
- Young people with a computer at home are less likely to play truant at ages 14 and 16 than those without computer access. For example, having access to a computer at home is associated with a 5.8 per cent reduction in the likelihood of playing truant at age 16.
- Losing access to a computer is associated with a reduction of 20 GCSE points, even after controlling for prior attainment.
- Gaining access to the internet is associated with 10 GCSE points, again controlling for achievement at KS3.
- Gaining access to a computer is associated with a 4.3 per cent reduction in the probability of playing truant at age 16, while losing computer access is associated with a 5.3 per cent increase in the probability of playing truant at age 16.

iii: Impact in summary

It would be disingenuous to suggest that all learners benefit from a technology-supported learning experience. For example, high-performing girls tended to have lower improvement scores while low or under-achieving boys showed measurable improvement (Chandra & Lloyd, 2008). Further, the simple relationship between enjoyment or motivation and performance breaks down if the learner does not accept challenge (Underwood *et al.*, 2009a).

In evaluations there is sometimes a mismatch between the methods used to measure effects (for example hand written examination answers) and the nature of the learning promoted by the specific uses of ICT. It is even more impressive then, that the evidence of performance gains through the use of digital technologies for learning is too robust to dismiss or ignore.

Further we should recognise that it is difficult to improve learning in schools by whatever means without improving the teachers' knowledge of subject matter and this includes knowledge of technologies. A skilled teaching force is the key to educating learners.

Schools that are well resourced in technology and show the greatest improvement in results have the following characteristics:

- Technology informs rather than leads decisions about learning and teaching (Somekh *et al.*, 2007b).
- Resource deployment issues are addressed head-on, often with a move to more flexible approaches, such as the use of wireless laptops (Oliveira, 2003; Naismith *et al.*, 2004).
- There is effective technical support and this is seen as a central element of the whole-school strategy for ICT (Somekh *et al.*, 2006).
- There is a realistic expectation of the level of support, including development time, needed to change the educational practices of teachers (Fisher *et al.*; 2006; Somekh *et al.*, 2007b).

Part 3
Critical challenges

i: Moving the educational leviathan: the world has changed but education has not changed

Students are different, but a lot of educational material is not. Schools are still using materials developed decades ago, but today's students come to school with very different experiences than those of 20 or 30 years ago. They think and work very differently as well. Institutions wanting to adapt to student needs should identify new learning models that are engaging to younger generations. Similarly, new as well as traditional assessment is required – problem orientated curricula as well as standardised testing.

ii: Access to resources

e-Access:

The extent to which learners and their teachers have access to digital technologies at school and at home impacts on the educational experience that can be provided.

While surveys show technology home access is high it is not universal. This is a concern, as where home technology is available it is proving an important part of the learning process. There is, then, an equity issue for those children who are disenfranchised by the lack of resource. Socio-economic factors are significant correlates of level of e-access.

Individual differences in e-access are related to both structural and individual learner factors. Use of technology in schools takes the form of an inverted u-function. In schools with scores at either end of the continuum of performance, pupils in receipt of free school meals or English as an additional language tend to make less frequent use of technologies for learning (Smith *et al.,* 2008; Underwood, 2008).

User e-Maturity:

The level of skill, confidence, and knowledge learners have when using digital technologies will impact on the quality of their use of the technology. While most learners express very positive attitudes towards technology for learning and are confident users, there are skills gaps. Individual differences including attitudes towards school and using technologies for learning and access to, and use of, technologies for learning at home are key to the development of e-maturity.

The right resource:

Each individual technology has its own affordances for learning – matching those affordances to the desired learning experience is critical. Where technology does match pedagogy take-up is rapid, as for IWBs. However, focusing on such technologies often produces only small step-changes and may fossilise practice. Technologies which move teachers outside their comfort zone tend to have a slower take-up and higher rejection rates. However, perseverance with such technologies can lead to important shifts in practice. Focusing all efforts on either of these two strategies carries a risk. There is a need to establish the balance between short-term gains and long-term change is critical.

iii: Misuse and abuse

e-Safety:

The level of learner knowledge and understanding of e-Safety, that is using technology safely and responsibly, has been shown to be variable and generally is not of a sufficient standard, particularly where primary pupils are concerned. Pupils see both teachers and parents as important sources of e-safety advice.

e-Safety knowledge is shaped by individual characteristics such as gender, home access, e-maturity, and attitudes towards school, learning and using technologies for learning rather than school level characteristics (Smith *et al.*, 2008).

Academic dishonesty:

While the debate on the extent and rates of change over time of malpractice remains active, there is an increasing consensus that the internet has changed the dynamics of dishonest academic practice. At the same time technology has brought its own solutions to plagiarism and cheating, but schools and institutions now need to evolve their practice to take advantage of the tools available (Underwood, 2006).

iv: Future technologies

In seeking to integrate technology into education, it is important to identify the technological trends and the challenges in the short and medium term. The 2009 *Horizon Report* (Johnson *et al*., 2009) envisages the six emerging technologies or practices that are likely to enter mainstream within five years. These are:

- Mobile technologies are currently establishing themselves in schools while cloud computing is already a part of higher education.
- Early adopters are already looking to use geo-coded data and personal webs. The former are central to satellite navigation systems but are entering the classroom through applications such as Google Earth. Students are now able to location and date-stamp their own images.
- Two technologies yet to have an educational impact are semantic-aware applications and smart objects, which have yet to gain a foothold in an educational context.

These technologies have the potential to change educational practice, just as they are changing the world of work, but many of these technologies represent challenges to staff expertise and practice, linked to uses as outlined in 3:iii on page 22..

Part 4
What questions remain to be answered?

The current demand for more research in education is predicated on the perceived need by policy makers for research of higher quality and greater utility than was previously available (Feuer *et al*., 2002; Heck 2004).

"One of the things most astonishing to posterity about our times will not be how much we understood but how much we took for granted." (Heck, 2004, p.9)

It is imperative to develop concepts, theories and rigorous and appropriate methodologies to provide a robust evidence base and understanding of the impact of digital technologies on the educational process. There is a continuing need to identify, promote and support good practice and models of change to produce sustainable change.

There remain many unanswered questions as to the role and value of digital technologies for learning. Questions such as the following:

- What will be the impact of a technologically-maturing population on teacher practice and performance?
- What is the long-term impact of technology-rich learning? There have been few longitudinal studies.
- How does exposure to and use of ICT in school affect future employment?
- Do some learners gaining more from the use of digital technologies than others? And why?
- What is the impact of formal digital literacy teaching in schools?
- Should and how can we integrate or advantageously exploit the raft of personal technologies that dominate students' out of school lives into the classroom?

References

Aviram, A. & Talmi D. (2004a). The impact of ICT on education: the three opposed paradigms, the lacking discourse. Accessed 20 August 2009. www.elearningeuropa.info/extras/pdf/ict_impact.pdf

Aviram, A. & Talmi, D. (2004b). The Merger of ICT and Education: Should it Necessarily be an Exercise in the Eternal Recurrence of the Reinvention of the Wheel? In F. Hernandez & I.F. Goodison (eds.). *Social Geographies of Educational Change*. Dordrcht, NL: Kluwer Academic Publishers. p. 123-142.

Baker, W., Hale, T., and Gifford, B. (1997). "From Theory to Implementation: The Mediated Learning Approach to Computer Mediated Instruction, Learning and Assessment". Educom Review, 32:5

Butt, S., and Cebulla, A. (2006), E-maturity and school performance – A secondary analysis of COL evaluation data. London: National Centre for Social Research. Becta.

Carnoy, M. (2004). ICT in Education: Possibilities and Challenges. In: Inaugural Lecture of the UOC 2004-2005 Academic Year (2004: Barcelona) [online]. UOC. www.uoc.edu/inaugural04/dt/eng/carnoy1004.pdf

Carnoy, Martin, Hugh Daley, and Lisa Loop (1986). «Education and Computers: Vision and Reality.» CERAS, Stanford University, 87-CERAS-14.

Chandra, V. & Lloyd, M. (2008). The methodological nettle: ICT and student achievement. British Journal of Educational Technology, 39, 1087–1098.

Chowdry *et al*. (2009) Drivers and Barriers to Educational Success - Evidence from the Longitudinal Study of Young People in England. Institute of Fiscal Studies, DCSF

Crabtree, J. & Roberts, S. (2003). *Fat pipes, connected people. Rethinking Broadband Britain*. London: iSociety

Davidson, M.C., Amso, D., Anderson, L.C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4-13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, 44, 2037 - 2078

Diamond, A., Barnett, W.S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control, *Science*, 318, 1387-1388.

Feuer, M. J., Towne, L. & Shavelson, R. J. (2002). Scientific culture and education research. Educational Researcher, 31 (8), 4-14.

Fisher, T., Higgins, C. & Loveless, A. (2006). T*eachers Learning with Digital Technologies: A Review of Research and Projects*. Report 14. Bristol: futurelab.

Herman, J. L. (1994) "Evaluating the Effects of Technology in School Reform." In Barbara Means (ed.), *Technology and Education Reform*. San Francisco: Jossey-Bass: 133–67.

Harrison, C, Comber, C, Fisher, T, Hawe, K, Lewin, C, Lunzer, E, McFarland, A, Mavers, D, Scrimshaw, P, Somekh, B and Watling, R (2002), *ImpaCT2: The Impact of Information and Communication Technologies on Pupils Learning and Attainment. ICT in Schools Research and Evaluation Series No.7*. DfES/Becta.

Heck, R.H. (2004). *Studying educational and social policy: theoretical concepts and research*. New Jersey: Lawrence Erlbaum Associates

Hernandez, F. & I.F. Goodison, I..F. (2004) *Social Geographies of Educational Change*. Dordrcht, NL: Kluwer Academic Publishers.

Higgins, S. (2009). Interpreting the evidence base for the impact of digital technologies on learning. Coventry: Becta.

Hollingworth, S., Allen, K., Hutchings, M., Abol Kuyok, K. & Williams, K. (IPSE) (2008), Technology and school improvement: reducing social inequity with technology? Coventry, Becta. http://partners.becta.org.uk/index.php?section=rh&catcode=_re_rp_02&rid=14541

Gathercole, S.E., Alloway, T.A. , Kirkwood, H.J., Elliott, J.G., Holmes, J, & Hilton, K.A. (2008). Attentional and executive function behaviours in children with poor working memory. *Learning and Individual Differences*, 18(2), 214-223.

Johnson, L., Levine, A., & Smith, R. (2009). The 2009 Horizon Report. Austin, Texas: The New Media Consortium.

Lesgold, A. (2000) *Determining the Effects of Technology in Complex School Environments*. www.publishers.org.uk Accessed June 15 2001.

Lowendahl, J-M. (2009). Roundup of Education Research, 2009

Moss, G, Jewitt, C, Levaãiç, R, Armstrong, V, Cardini. A, Castle, F (2007). The Interactive Whiteboards, Pedagogy and Pupil Performance Evaluation: An Evaluation of the Schools Whiteboard Expansion (SWE) Project: London Challenge. Institute of Education, University of London. DfES/Becta.

Naismith, L., Lonsdale, P., Vavoula, G. & Sharples, M. (2004). *Literature Review in Mobile Technologies and Learning: Report 11*. Bristol: futurelab.

Ofcom (2008) The Communications Market 2008.

Oliveira, C. (2003) Towards a knowledge society. Keynote address delivered at the IEEE international conference on advanced learning technologies (ICALT). July 2003, Athens, Greece.

Organization for Economic Cooperation and Development (2001). Learning to Change: ICT in Schools. Paris: OECD. Information Economics Press.

Oppenheimer, T. (2003). *The Flickering Mind: The False Promise of Technology in the Classroom and How Education can be Saved*. New York: Random House.

Orlandi, MA., Greco, D. (2004, August). A randomized double-blind clinical trial of EEG neurofeedback treatment for attention-deficit /hyperactivity disorder. Presented at the annual meeting of the International Society for Neuronal Regulation, Fort Lauderdale, FL.

Papert, S. (1993). *The Children's Machine: Rethinking School in the Age of the Computer*, New York: Basic Books.

PR Hub (2009) " Children Fail to Thrive in Britain's Schools. Accessed September 4 2009. http://blog.taragana.com/pr/children-fail-to-thrive-in-britains-schools-2222/

Protheroe, N. (2005). *Technology and Student Achievement. Principal- Effective Intervention - Research Report,* 85, 46-48.

Schacter, J. and Fagnano, C. (1999). "Does Computer Technology Improve Student Learning and Achievement? How, When, and Under What Conditions?" Journal of Educational Computing Research. 20, 329–43.

Smith, P., Rudd, P. and Coghlan, M. (NFER) (2008), *Harnessing Technology: Schools Survey 2008 Report 1*: Analysis, Coventry, Becta.

Somekh, B., Haldene, M., Jones, K., Lewin, C., Steadman, S., Scrimshaw, P., Sing, S., Bird, K., Cummings, J., Downing, B., Harber Stuart, T., Jarvis, J., Mavers, D., and Woodrew, D. (2007a), Evaluation of the Primary Schools Whiteboard Expansion Project. DfES.

Somekh, B., Underwood, J., Convery, A., Dillion, G., Harber Stuart, T., Jarvis, J., Lewin, C., Mavers, D., Saxon, D., Twining, P. and Woodrow, D. (2006), Evaluation of the DfES ICT Test Bed Project Annual Report. Becta.

Somekh, B., Underwood, J., Convery, A., Dillon, G., Jarvis, J., Lewin, C., Mavers, D., Saxon, D., Sing, S., Steadman, S., Twining, P. and Woodrow, D. (2007b), Evaluation of the ICT Test Bed Project Final Report. Becta.

Taylor, L.M, Casto, D.J. & Wall, R.T. (2007) Learning with versus without technology in elementary and secondary school. *Computers in Human Behavior*, 23, 798-811.

Toffler, A. (1970) Future Shock. Bantam Books.

Trucano, M. (2005). Knowledge Maps: ICTs in Education. Washington, DC: *info* Dev / World Bank.

Underwood, J.D.M. (2006). Academic Dishonesty in Tests and Examinations. London: Qualifications and Curriculum Authority.

Underwood, J., Ault, A., Banyard, P., Bird, K., Dillon, G., Hayes, M., Selwood, I., Somekh, B., and Twining, P. (2005), The Impact of Broadband in Schools. DfES.

Underwood, J., Baguley, T., Banyard, P., Coyne, E., Farrington-Flint, L., & Selwood, I.S. (2008). Impact 2007: Personalising Learning with Technology. Coventry: Becta

Underwood, J., Baguley, T., Banyard, P., Dillon, G., Farrington-Flint, L., Hayes, M., et al., (2009a). *Impact 2008.* Coventry. Becta

Underwood. J. Banyard, P. Betts, L. Farrington-Flint, L., Stiller, J. & Yeomans, S. (2009b). Narrowing the Gap: A Literature Review. Coventry: Becta.

Underwood. J. Banyard, P. Betts, L. Farrington-Flint, L., Kerlin, L. & Stiller, J., (In press). *Narrowing the Gap: The Evidence*. Coventry: Becta. (In press)

U.S. Department of Education, Office of Planning, *Evaluation, and Policy Development, Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies*, Washington, D.C., 2009.

Valentine, G., Marsh, J. and Pattie, C. (2005), Children and Young People's Home Use of ICT for Educational Purposes: The impact on attainment at key stages 1-4, DfES

Waddoups, G. L. "Technology Integration, Curriculum, and Student Achievement: A Review of Scientifically-based Research and Implications for EasyTech" (executive summary). Portland, Ore.: Learning.com, 2004.

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