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CPRT Research Survey 7 (new series)

# THE DIGITAL AGE AND ITS IMPLICATIONS FOR LEARNING AND TEACHING IN THE PRIMARY SCHOOL

Cathy Burnett

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**THE DIGITAL AGE AND ITS  
IMPLICATIONS FOR  
LEARNING AND TEACHING  
IN THE PRIMARY SCHOOL**

Cathy Burnett

A report for the Cambridge Primary Review Trust

July 2016

This is one of a series of research reports commissioned by the Cambridge Primary Review Trust (CPRT), a not-for-profit company established in December 2012 with the aim of consolidating and building on the evidence, findings and principles of the Cambridge Primary Review. Cambridge Primary Review Trust is supported by Pearson Education, based at the University of York and chaired by Professor Robin Alexander.

A briefing which summarises key issues from this report is also available. The report and briefing may be downloaded from the Trust's website: [www.cprtrust.org.uk](http://www.cprtrust.org.uk). The website also provides information and other reports in this series, and about the many publications of the Cambridge Primary Review.

We want this report to contribute to the debate about the future of primary education, so we would welcome readers' comments on anything it contains. Please write to: [administrator@cprtrust.org.uk](mailto:administrator@cprtrust.org.uk). The report contributes to the Trust's research programme, which includes both funded research projects and this series of specially-commissioned research reviews relating to the Trust's eight priorities.

This report relates to CPRT priorities 5 (aims), 6 (curriculum) and 7 (pedagogy):

**Aims.** *develop and apply a coherent vision for 21<sup>st</sup> century primary education; enact CPR aims through curriculum, pedagogy and the wider life of the school.*

**Curriculum.** *develop a broad, balanced and rich entitlement curriculum which responds to both national and local need, eliminates the damaging division of status and quality between core and non-core, and teaches every subject, domain or aspect to the highest possible standard.*

**Pedagogy.** *develop a pedagogy of repertoire, rigour, evidence and principle, rather than mere compliance, with a particular emphasis on fostering the high quality classroom talk which children's development, learning and attainment require.*

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Suggested citation: Burnett, C. (2016) *The Digital Age and its Implications for Learning and Teaching in the Primary School*. York: Cambridge Primary Review Trust.

**Acknowledgements.** The author offers sincere thanks to the following for their support in compiling this review: Robin Alexander, Caroline Bath, Chris Bailey, Charles Boisvert, Mark Boylan, Teresa Cremin, Keri Facer, Rose Luckin, Nick Hodge, Tim Jay, Guy Merchant, Jemma Monkhouse, Simon Peyton-Jones, Richard Pountney, Jane Stacey and Sarah Williams

Published July 2016 by Cambridge Primary Review Trust,  
The Catalyst, University of York, Heslington East, York, YO10 5GA

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British Library Cataloguing in Publication Data:  
A catalogue record for this publication is available from the British Library.

**ISBN: 978-0-9931032-7-8**

## THE DIGITAL AGE AND ITS IMPLICATIONS FOR LEARNING AND TEACHING IN THE PRIMARY CLASSROOM

### Introduction

This review was commissioned by the Cambridge Primary Review Trust to build on the extensive evidence on the opportunities and challenges of digitalisation presented and discussed in the final report of the Cambridge Primary Review (Alexander, 2010). The implications of digital technologies for children's current and future lives are far-reaching. Digital technologies are engrained in our institutions and infrastructures, in commerce, politics, manufacturing and administration. They are central to many of the ways in which we form and sustain relationships, communicate ideas, and generate, share and distribute knowledge. They have become part of our social life, with implications for how we follow our interests and passions, the nature and extent of our participation in civic and political life, our relationship with the environment, and our position within multiple communities, local and dispersed. For many children digital devices and the possibilities they enable are threaded through everyday life from the earliest days, and their early experiences and understandings are patterned by technology use. As the Cambridge Primary Review final report concluded, much of 'children's out-of-school learning is electronic and beyond the reach of either parents or teachers' (Alexander, 2010: 269). In education, therefore, there is a need to explore the significance of the digital age not just in terms of preparing children for an uncertain future, but in ensuring they are confident, safe and discerning users of digital technologies *now*. The digital age has implications for curriculum, pedagogy and schools' wider role in supporting children's emotional and social life, and indeed raises questions about the purpose and nature of schools themselves, and how schools' work relates to the wider political, economic and commercial context.

As the Cambridge Primary Review explored, understanding children's lives in a digital age is a complex task, and considering the implications for primary education is fraught with tensions. On one hand there are calls to recognise the sophistication of children's everyday uses of digital media and for much greater integration of technology in education to equip children effectively for their current and future lives. On the other hand there are anxieties about the implications of extensive screen-time and about what or whom children may encounter in digital environments that are hard to police and difficult to confine. Moreover while many children gain understanding and experience of digital environments from birth (Merchant, 2015), their access to devices and experience of using technologies varies considerably. This unevenness is not just linked to economic circumstances but to the different ways in which digital toys and resources are taken up within different families (Mayall, 2010; Stephen et al., 2013; Marsh et al., 2015). Indeed often digital technologies simply provide new ways of doing the same kinds of things that people were doing already. As Selwyn and Facer (2013: 9) argue, 'there is neither an inevitable "technological future" to which schools need to adapt, nor a set of universal technological impacts from which young people need to be protected.'

In helping schools navigate this complex terrain and building on the findings of the Cambridge Primary Review, this research survey starts from the premise that curriculum and

pedagogy need to take account of what we know about relations between digital technology and everyday life. It begins therefore by drawing on research on digital technology use, including that by children, to identify challenges and opportunities facing primary education in a digital age, and indeed to signal how school use relates to the wider context in which it occurs. Next it explores different ways in which research is shaping how schools might respond to these challenges and opportunities. In order to distinguish between different areas of interest, the review focuses on five broad ‘traditions’ which – while not exclusive - represent different perspectives on how curriculum and pedagogy might take account of the digital age. The broad scope of each tradition is explored along with relevant research findings. The review ends by considering how schools might respond to these diverse findings and the barriers they may face in doing so. It summarises implications for policy-makers and education leaders, and makes recommendations for schools and teachers. In doing so, it attempts to steer a path between exploring how technology can be used to support existing curriculum imperatives, and considering how curriculum and pedagogy might be re-framed in a digital age.

The review is structured in three parts.

Part 1 explores the implications of the digital age for children’s current and future lives. It considers:

- Possibilities and challenges for education in a digital age
- Children’s engagement with digital technology in everyday life
- Concerns about risks
- Implications of the digitisation of data in educational contexts

Part 2 briefly summarises research from five ‘traditions’ that have generated different kinds of recommendations for curriculum and pedagogy in a digital age. These are defined as:

- Technology across the curriculum
- 21<sup>st</sup> century skills
- Computing
- Participation, learning and digital media
- New literacies

Part 3 explores possible barriers to technology use in schools, and arrives at a series of implications and recommendations for policy-makers, educational leaders, schools and teachers.

The available research on this topic is extensive and it is not possible to synthesise all relevant work in a survey of this size. Moreover, in the current period of rapid technological innovation, conclusions related to specific technologies and their uses have a limited shelf-life. As new devices, applications and associated practices gain or decline in popularity, the opportunities and challenges for education may also shift. The survey draws therefore upon selected studies from a series of fields including technology-enhanced learning, computing, neuroscience, literacy and media studies. It references studies that have sought to quantify trends in technology use and measure impact on learning, and also draws on qualitative

research that has examined children's digital practices in detail and in depth. The evidence presented in this review is therefore perhaps most usefully read in terms of the questions it raises rather than as a comprehensive overview of research.

## 1 - THE IMPLICATIONS OF THE DIGITAL AGE FOR CHILDREN'S CURRENT AND FUTURE LIVES

### 1.1 - Possibilities and challenges for education in a digital age

In recent years there have been multiple attempts to outline the skills needed to effectively engage with life in a digital age. Recently, for example, Go On UK have promoted a Basic Digital Skills Framework (<http://www.go-on.co.uk/get-involved/basic-digital-skills/>). This proposes a series of activities with which people need to be confident in their everyday lives. Including a strong emphasis on online safety, these relate to: managing information, communicating, transacting, problem-solving and creating. Frameworks such as this one can provide a useful starting point for schools in evaluating their provision. However, by considering some of the ways in which digital technologies are used in everyday life, it quickly becomes apparent that there is a need to do far more than equip children with skills.

Consider, for example, how people have taken up three technological developments that have been particularly significant for everyday life: easy-to-use multimedia resources; increased connectivity; and relatively cheap, small mobile networked devices such as tablets and smart-phones. These have been associated with an increase in what Jenkins et al. (2006) called 'participatory practices', through which people join with others to 'participate' in producing and sharing ideas and creations using digital media. As people have found ways of working with multimedia resources, increased connectivity and mobile networked devices, there has been:

- *A growth in self-sponsored multimedia production:* For example people making their own videos, games, animations, websites, etc.
- *Increased access to wider audiences:* Linked to the above, connectivity means that anyone with access to the internet and a networked device can create, publish and distribute their ideas or creations with relative ease.
- *New patterns of collaboration:* Online communities form - sometimes very briefly - around shared interests or passions or in order to exchange ideas, expertise and experience. Through these communities, people may provide others with feedback.
- *Access to networks on the move:* The growing popularity of mobile devices means that, more than ever before, technology use is embedded in much of what we do. Wherever we are, pending a reliable internet connection, we can access information and each other.

(Davies and Merchant, 2009; Jenkins et al., 2006; Gee, 2007)

Such practices have continued to evolve, particularly given the recent rapid growth in popularity of tablet devices and increasing ubiquity of social media. The ways in which people engage in participatory practices however vary. Self-sponsored multimedia production, for example, ranges from taking photos and videos to more elaborate media production often

through re-working existing material, e.g. creating games or animations or writing fan-fiction using characters and locations from novels and films (Curwood et al., 2013). Some may share photos and videos with families and friends through social networking sites such as Instagram or Facebook, while others distribute to a wider public through wikis, blogs, vlogs, and so on (Davies and Merchant, 2009). Practices may involve sustained creative projects and collaborations, or more fleeting exchanges. People may use review sites to help choose a hotel, gain advice on a DIY dilemma, or engage together in sustained activity, for example through online gaming sites or political activism. Mobile technologies mean that, for many, divisions between work and leisure or life with family and friends are becoming more permeable (Davies, 2014). Of course some people do not engage in these digitally mediated practices at all. Importantly, research, in the UK and elsewhere, has highlighted how broader inequities linked for example to gender, ethnicity and income play out in patterns of access and use of digital technologies, (Beavis and Charles, 2007; Walkerdine, 2007; Graham and Smith, 2011). The vast majority of those who contribute or edit content for Wikipedia, for example, are male, and these patterns, and indeed the ways in which they are reported and commented upon, have been seen to reflect particular constructions of gender (Eckert and Steiner, 2013).

While access to resources (e.g. multimedia, connectivity, mobile devices) is increasingly ubiquitous, practices vary. Digital technologies may offer new possibilities but individuals and groups will use them in different ways, shaped by personal, social, cultural, economic and political circumstances as well as their individual needs, commitments, interests and passions. Sometimes practices are associated with our families, friends or leisure interests, sometimes with education or employment, and sometimes with political or economic activity. These uses may generate new kinds of relationships between individuals, groups, institutions and organisations, or they may simply re-work existing ways of doing things. Practices may of course be advantageous or disadvantageous. They will be influenced by the actions of nation states, commercial organisations and other institutions, which have implications for our work and leisure, the choices available, and our sense of security, safety and agency. While digital media may enable new forms of democratic participation and community, they may equally be used to mediate aggressive consumerism, oppression and illegal activity. Digital technologies, in summary, are not neutral (Selwyn and Facer, 2013).

Existing practices will be replaced or joined by others as technologies, and the social, cultural, economic and political context in which they are used, continue to evolve. For example, as devices have become smaller, interfaces more advanced, and connectivity facilitated by the spread of super-fast broadband, we have seen a growth of interest in the Internet of Things: internet-enabled digital technology is increasingly embedded in the environment, in household appliances for example and wearable technology, such as smart watches and google glass. As objects are fitted with sensors and enabled to communicate with each other, digital technologies are less and less visible and digital/non-digital distinctions increasingly blurred. Opinion is divided about how influential the Internet of Things will be (Pew Internet Research, 2014). However digital devices are certainly becoming smarter, smaller and cheaper and more embedded in environments and objects, and devices are likely to become increasingly responsive to personal needs and environmental conditions. As they do so, organisations and institutions will be able to track people's activity more easily, targeting them with information, resources, requests or demands that map onto their experiences,

interests and preferences. While such possibilities may be helpful and enabling in many ways, they raise concerns about privacy, personal and financial security, and state surveillance.

Connectedness and the easy dissemination of ideas, concepts and experiences also have implications for how we understand knowledge. While the publication and dissemination of knowledge was previously in the hands of a select few, knowledge in an internet age is more 'distributed' (Fagin et al., 1995). Increasingly people share or pool their expertise through YouTube videos and online fora, for example, or through multi-authored sites such as Wikipedia. This can enable access to powerful knowledge but capitalising on such opportunities requires an ability to negotiate and evaluate multiple sources, and to contribute expertise and viewpoints. Again this potential may be limited as power elites, professionals and publishers are able to control access and erect paywalls, and some nation states control knowledge and information through restricting internet access. Easy-to-use multimedia resources, increased connectivity, and cheaper, smaller mobile networked devices therefore can enrich everyday life in multiple ways but may also be used in ways that are oppressive, disempowering, intrusive or dangerous.

### *Summary*

- Responding to the digital age involves more than skills.
- Digital practices vary, linked to social, emotional cultural, economic, and political circumstances.
- Use of digital technologies can be associated with changing relationships between people, things and their environment.
- Digital technologies are taken up differently by individuals, groups, organisations and institutions.
- Practices will be affected by how nation states, commercial organisations and other institutions shape and use digital resources.
- Existing practices will be replaced or joined by others as technologies, and the social, cultural, economic and political context in which they are used, continue to evolve.
- Digital technologies are associated with changing patterns of knowledge production and distribution.
- Access to and use of digital technologies are uneven, and technologies can be used in ways that intensify inequalities.
- Uses of digital technologies may be empowering and enabling, or oppressive, intrusive and dangerous.

## **1.2 - Children's engagement with digital technology in everyday life**

When they enter educational settings, many young children in the UK bring with them extensive understanding and experience of digital devices, applications and environments (Alexander, 2010; Levy, 2010; Childwise, 2012). At the time of writing, the range of devices which many children of primary school age access includes games consoles, smartphones laptops and PCs (Broadbent et al., 2013). Increasingly families are using internet-enabled tablet computers or smartphones: in 2014, four in ten children aged 3-4 used tablets at home, and four in ten 12 year-olds owned a smartphone (Ofcom, 2014). Indeed a recent survey suggested that smartphones are now the most popular device for going online (Ofcom, 2015).

Some of this use has replaced television watching (Marsh et al., 2015). Children therefore become familiar with phones and tablets from the earliest years as mobile devices are used for play, communication, and documenting everyday life (Merchant, 2015). They may have opportunities to operate, control and interact with programs and applications using touch-sensitive screens and play with augmented reality toys featuring screens and internet connectivity (Marsh et al., 2015).

Many children appear to be using these digital tools confidently for a variety of purposes, often driven by personal interest and with agency and creativity. For example:

- In 2013, 94% of the 11,757 young people (7-11 year olds) surveyed stated that they faced few problems in finding the information they need (Broadbent et al., 2013).
- A large proportion of children engage in on-screen play using virtual worlds such as *Club Penguin* and *Minecraft* (Marsh, 2010; Holloway et al., 2013).
- As well as revisiting familiar picture-books, sharing picture-books and watching television, children may replay favourite YouTube videos, share e-books or play with apps on a tablet (Davidson, 2012; Kucirkova et al., 2013; Marsh et al., 2015).
- A growing number of children create their own digital resources or artefacts: in 2012, 31% 7-11s surveyed by Broadbent et al., (2013) said they had created a game online and 12% that they had made an app.

While recognising the extensive experience of digital environments that many children bring to school, research into children's lives has challenged generalised assumptions about the nature and quality of that experience. Many, for example, have criticised the way children and young people are often referred to as 'digital natives' (Prensky, 2001) as this smooths out differences (Bennett et al., 2008). Surveys suggest that the distribution and use of digital resources such as tablet computers and high-speed internet access remains uneven, and that uses of technologies may reflect, exacerbate and reinforce inequalities. Technology use is patterned by inequalities associated, for example, with gender, social economic status, ethnicity, and there is a need to be alert to how these inequalities shape children's experiences within and outside school. For example, Marsh et al.,'s (2015) survey of 2000 parents of 0-5 year-olds in the UK found that,

Thirty-one percent of all children [0-5 year olds] owned their own tablet, although this differed in relation to age, social class and gender, with more boys than girls and more older children (3-5yrs) than younger children (0-2s) owning tablets. There were social class differences in relation to the access to particular types of tablets. For example, children in families in social groups ABC1 were more likely than children in families in social groups C2DE to have access to iPads in the home (56% v 48%) with children in lower socio-economic groups more likely to have access in the home to cheaper tablets, such as Samsung Galaxy (46% v 27%) (Marsh et al., 2015: 8).

While many children have access to multiple devices at home and at school, others rely on smartphones to go online and those in families with low incomes tend only to have access to free apps. This is concerning as,

Given that many free apps contain in-app advertisements and in-app purchases, this means that children in the families with lower economic capital are the ones most likely to encounter these features, which often have a negative impact on the quality of game play. (Marsh et al., 2015: 43)

For these children, there is a critical role for school in providing access to digital technologies and supporting diverse, creative and critical uses.

A recurrent theme in the popular media is that children are becoming increasingly isolated as they spend more time on screen. However, as noted in the Cambridge Primary Review final report (Alexander, 2010), children often use digital technologies in ways that stimulate or mediate interaction. Alexander (2010: 269) cites Hargreaves (2008) in arguing that children, 'are not merely passive "surfers" who read, watch and listen, but "peerers" who use electronic media to share, socialise, collaborate and create.' There are many small scale studies that describe children's interactions with peers and family members around PCs and tablets at home and at school (Davidson, 2009, 2012; Lim, 2012; Kenner et al., 2008). Marsh et al.'s recent study found that parents reported that their 0-5 year olds were more likely to use a tablet with an adult than on their own, although case study data suggested that much of this use was supervised independent use, rather than shared activity or 'co-use'. They did note however that there were, 'no statistically significant differences in this pattern across age, gender, ethnicity or social class' (Marsh et al., 2015: 11). A recent European study of children 0-8, however, found that, despite examples of collaboration, children mostly used digital technology individually rather than socially (Chaudron et al, 2015).

When children do sit alone at screens, they may be in contact with others located elsewhere. Older children particularly use tools such as FaceTime, Skype, text messaging and email to communicate with family and friends (Broadbent et al., 2013) and these devices can play an important role in maintaining social and family networks within and beyond the UK. Social media use by primary-age children is increasing (EU Kids online, 2014) and while some of children's interactions are 'friendship driven', arising within established friendship groups, others are 'interest driven' (Ito et al., 2009: 16), linked to shared interests, such as music, sport and gaming. Connections made around interests sometimes develop into friendships conducted both on and offline, through virtual world play for example. Ching-Ting et al.'s (2014) review of studies of technology and young children identified social interaction as a recurrent theme in children's online play. Many children therefore are using digital applications in ways that enable them to be *more* connected with others not less so.

Playing with others appears to provide rich opportunities for learning *about* digital environments. As Mayall (2010), concluded,

These technological resources for learning operate in social environments where children interact with other children and/or with adults. Children's use of computers (for fun or learning) will be mediated by the help ('scaffolding') given by other children and adults [...] As newer technologies become commonplace in households, they will take their place alongside, but not dominate the range of family activities (Mayall, 2010: 64-65).

Many children learn how to use digital tools and how to operate within digital environments through playing with others. In homes, children may learn from and with their parents and siblings (Davidson, 2011) and at school from their peers. For example, children playing in virtual worlds often learn from each other as they try and emulate what others are doing, guide each other through activities or locations, or go online to learn from YouTube videos and online forums (Wohlwend et al., 2011; Burnett and Bailey, 2014). This discussion highlights that, while childhood may look quite different in a digital age, many of the things children are doing - playing, making socialising, enjoying popular culture, spending time with families - remain much the same as in the pre-digital age.

At the same time, more research is needed to explore how young children are using digital technologies. There appears still to be what Jenkins (2006: 12) called a 'participation gap' between those using digital technologies for creative, collaborative or empowering purposes and those whose uses are far more limited: EU Kids Online (2014: n.p.) found that across Europe, many children 'do not reach the level of creative, collaborative or civic activities online'. We also need to know more about how other family members are participating in and mediating these practices, and how such practices differ between families. Snyder et al. (2002), for example, explored how four families used information and communications technologies in the home during a year-long Australian study. They noted how uses reflected and reinforced broader inequities as technologies became 'socialised' in different ways for the different families. In higher income families, these uses - e.g. searching for information online - reflected and reinforced the kinds of practices likely to gain them recognition and approbation at school. In low-income families, however, children tended to use technologies in other ways, e.g. virtual world play, social media, gaming. Such use was often 'active, creative and complex, and requires imagination and the making of multiple judgements as cyber relationships and situations are negotiated' (Angus et al., 2004:16). However it did not align to computer use at school, and consequently children's knowledge, skills and experience were unlikely to be recognised, capitalised on or further developed in class. Concerns about inequities then,

...are not just questions about physical access to the best and most expensive technology (or to any at all), which is largely a matter of income, but also about the quality and nature of such access as mediated by the cultural resources that individuals and families can bring to bear on their relationship with technology (Snyder et al, 2002: 382).

There is a need therefore to know more about the varied uses of technology in practice, particularly given the diverse patterns of family life. As Mayall (2010:57) argued in her research survey on 'Children's lives outside school and their educational impact' for the Cambridge Primary Review, technology use needs to be seen in relation to and in the context of 'the exceptional pace of social and family change'. Use needs to be seen in relation to,

structural changes in employment, the constitution of the family as a social unit, migration, and significant changes in the allocation of public housing, all of which create a set of circumstances for parents of young children that in themselves have a great influence on the lives that their children lead (Sefton-Green et al., 2016: 4).

It is helpful to see digital technologies as ‘placed resources’ (Prinsloo, 2005) that get taken up by children and their families in certain ways relating to local needs, resources and practices, and the specific economic and political context. Technology use cannot be extracted from the social and cultural context in which it occurs, particularly given that, as highlighted in the Cambridge Primary Review, ‘Britain is certainly a complex and in many aspects divided and unequal society’ (Alexander, 2010: 487). There is a need therefore to know more about how digital technologies are used in practice, and how these uses reflect and reinforce inequalities.

### *Summary*

- Many children have extensive use of a range of digital media and many are using digital technologies with agency and creativity.
- Technology use is embedded in many children’s social and family lives and features in play.
- Screen-based play may be highly social, as children interact around, through and on-screen, although research has produced mixed results in relation to how far play is individual or collaborative.
- Playing with others appears to provide rich opportunities for learning *about* digital environments.
- While childhood may look quite different in a digital age, many of the things children are doing remain much the same as in the ‘pre-digital’ age.
- Ownership, access and use are uneven and linked to economic, personal, social and cultural factors.
- More research is needed to explore how young children are using digital technologies, how other family members are participating in and mediating these practices, and how these diverse practices may reproduce and intensify inequalities.

### **1.3 - Concerns about risks**

The Cambridge Primary Review highlighted common concerns about the impact of children’s technology use on their wellbeing:

Doubts about the power and negative influence of information technology, consuming children’s leisure time disproportionately, damaging their verbal communication skills and potentially exposing them to unsuitable violent and sexual imagery. (Alexander, 2010: 55)

Plowman et al. (2010) cite a series of reports that similarly warn of the dangers of young children’s technology use to their physical, social, emotional, moral and cognitive development: screen based play has been viewed as a distraction from first-hand experience, possibly damaging to long-term memory, an impediment to imagination and physical activity, and as undemanding cognitively (e.g. American Academy of Pediatrics Committee on Education, 1999, 2001; Cordes and Miller, 2000; Alliance for Childhood, 2004). While many of these concerns rest on opinion not evidence some have been bolstered by studies that have linked too much screen-time to health risks (American Academy of Pediatrics, 2010) or school attainment (Corder et al., 2015). Others have identified correlations between screen-time and sleeping difficulties (Wood et al., 2013). Other studies however have challenged popular

opinion. Blanchard and Moore (2010), for example, cite a series of reports that suggest screen-time may be positively related to aspects of attention. For example, they note positive correlations between: regular short bursts of computer use and visual discrimination (Li et al., 2006); and gameplay and visual selective attention (Green and Bavelier, 2003).

It is not possible here to provide a systematic review of research evidence emerging from neuroscience or cognitive psychology. However, it is important to note that relationships between digital technologies and social, physical and cognitive development are hard to gauge. The 'impact' of digital technologies under experimental conditions may be very different to assess in everyday life, and it may not be possible to identify the direction of cause and effect. Conversely, in studies of 'real-life' practices, it is difficult to isolate technology use from other social, economic and cultural factors (e.g. see Byron, 2008 for discussion of issues). Studies citing correlations between technology use and social, physical and cognitive development or academic attainment will be of interest to schools as they raise important questions about the balance of children's activities. There is much more research to be done in these areas and findings need to be treated with caution, and their implications weighed in relation to a variety of contextual factors, for example regarding: the relationship between screen-time and time spent on other activities; the kinds of activities in which children engage on screen; and how these activities are related to others in which children engage. Various studies have highlighted that parents and carers would welcome support and guidance on the kinds of activities and resources that may be supportive to their child and on how to minimise risks (Chaudron et al., 2015; Marsh et al., 2015; Kucirkova and Littleton, 2016).

Qualitative studies of children's online and on-screen activity may lack the persuasive power of experimental research but they can provide more nuanced insights into children's experiences. Case studies have shown how on-screen play often complements rather than displaces off-screen activities (Marsh et al., 2005; Plowman et al., 2010). Indeed it seems that many children integrate on- and off-screen play: Wohlwend and Buchholz (2014) for example describe how 6-7 year olds used screen-based resources alongside equipment for making paper dolls and puppets as they created animations; and Giddings (2007) how 3-4 year-olds made Lego tracks across the floor that were like those they played with the Lego Racers videogame. Plowman et al. (2010), drawing on survey and case study data related to technology use in the early years, note that technologies tend to be absorbed alongside existing practices and, while recognising the need for long term large scale studies, found no evidence from parents to suggest that children's technology related activities were having a 'detrimental effect on their behaviour, health or learning' (Plowman and McPake, 2013: 28).

Common concerns associated with children's internet use relate to child safety, cyber bullying and exposure to unsuitable material. Surveys have suggested that these concerns may sometimes be over-stated for this age group, but that there is a need to take these risks seriously. For example:

- A large-scale pan-European survey of 9-16 year-old children's experience of using the internet found that 9% of 9-10 year olds had been bothered or upset by going online (Livingstone et al., 2011). Children reported being upset by videos of pornography, violence, animal cruelty and bullying (Livingstone et al., 2013). When

faced with something disturbing or upsetting, the majority (65%) told an adult, whereas others reported that they left the website, told friends or reported it online. A minority (8%) said they did not do anything.

- While children viewed the social dimension of internet use very positively, 20% said that bullying stopped them having fun on the internet and 40% knew someone who had experienced cyber-bullying (Broadbent et al., 2013). The EU Kids Online study found that most children (93% 9-16 year olds) have neither bullied or been bullied online (Gorzig, 2011).
- 19% of those surveyed by Broadbent et al. (2013) had been contacted by people they had not met offline. Some children have said they are more likely to report problems to peers rather than adults as they were concerned that parents might restrict their internet use (EU Kids Online, 2014; Broadbent et al., 2013).
- In the EU Kids online study 13% of 9-10 year olds said they had made a new contact online and 2% had met someone offline that they had met online (Livingstone et al., 2011). Children said they did not always use tools designed to help them report inappropriate behaviour, even if they knew how to.
- 58% of primary school age children (7-11s) using social networks stated that they had changed privacy settings, but 42% were unsure whether they had done this or did not know how to do this (Broadbent et al., 2013).

Levels of risk are associated not just with access, but with practices surrounding internet use. Safer behaviour appears to occur within families where there is 'active mediation', where parents share online activities with their children, and sit and talk to them when they are online. Risks magnify with increased use and those most likely to take risks seem to be those most vulnerable in other situations (Livingstone and Helsper, 2007). EU Kids Online concluded that:

Not all risk results in harm: the chance of a child being upset or harmed by online experiences depends partly on their age, gender and socio-economic status, and also on their resilience and resources to cope with what happens on the internet. (EU Kids Online, 2014: n.p.)

Tightly controlled use however can be frustrating and limit possibilities for learning and for children to learn how to manage risk (Broadbent et al., 2013; Hope, 2013). As Byron (2008) argued in her review of the available evidence, concerns about child safety should be balanced with opportunities for children to use the internet, learn to navigate it safely and develop strategies to deal with any difficulties. Byron called for support for children to ensure better self-regulation, and support for parents as their children may engage in practices which are unfamiliar to them. There is a need, she argued, to assess risks and tailor support in relation to each child's experience. This is likely to involve talking with children to explore their experiences of and perspectives on risk which may differ from those of adults. Cranmer et al. (2009) for example found that 7-11 year-olds' understandings of e-safety were often characterised by exaggerated fears that did not relate specifically to likely risks. Hope (2013) argues that schools need to work closely with children to learn more about their experiences and what concerns them.

## *Summary*

- More research is needed to explore relationships between children's technology use and their learning and wellbeing.
- Children tend to engage in screen-based activities alongside other kinds of activity.
- Many media claims about the risks associated with screen-time or online play are unsupported by evidence.
- Studies drawing conclusions about impact of technology use will be of interest to schools, but results need to be treated with caution.
- Levels of online risk are lower for this age group than for older children, but do exist.
- The level of risk is associated with practices surrounding internet use and with children's ability to navigate the internet safely.
- Children's perspectives on risks may differ from those of adults.
- Many parents would welcome guidance on the kinds of activities that are appropriate for children and on ensuring safety online.

### **1.4 - Implications of the digitisation of data in educational contexts**

While Part 2 of this review explores different perspectives on the relationships between digital technologies, curriculum and pedagogy, this section considers the use of data for the purposes of planning, monitoring and accountability, and its implications for what happens in schools and the education system more broadly. The digitisation of data has facilitated a massive growth in the amount and diversity of data it is possible to generate, and speed with which it can be analysed (Selwyn, 2015) and this has fuelled an enthusiasm for a data-driven system.

Digitisation has been associated with, and arguably intensified, requirements for schools to use statistical data to monitor what pupils and teachers achieve in relation to measurable outcomes, and such requirements are far-reaching. For example,

- Analyses of pupil achievement are used to hold to account countries, regions, local authorities, schools and individual teachers.
- Readily searchable databases provide information about school inspection reports, pupil attainment, attendance and so on, exerting pressure on schools and teachers to prioritise the kinds of activities and experiences that will register on such databases.

This 'datafication' (Williamson, 2016: 124) - identified as a likely area of future development for schools in the Cambridge Primary Review (Alexander, 2010) - has been seen as problematic as it shapes how we understand educational priorities and practices, and consequently leads to certain kinds of educational responses (by systems and schools). For example, the use of statistical data can translate 'complex (and unsolvable) social problems' into 'complex (but solvable) statistical problems' (Selwyn, 2015: 72); and statistics can imply a scientific rigour and objectivity that belies the assumptions and value positions that inform who and what is measured, the choice of measures, and the ways that data are processed, presented and made public. There are problems associated, for example, with the over-simplistic generation and analysis of data related to race, class and gender (e.g. Gilborn, 2010). As Ainscow et al. (2010:

213) explored in their survey for the Cambridge Primary Review, 'currently dominant constructions conceal as much as they reveal, and mislead as much as they guide.'

Moreover statistics on achievement used for school-focused, national or international comparisons typically draw on scores in standardised tests which may be imprecise or privilege certain aspects of learning over others (Goodman, 2006; Hilton, 2001; Carnoy, 2015). Statistical data can therefore work to reinforce rather than challenge inequalities (Ainscow, 2010; Selwyn, 2015); over-simplifications about what groups of children are (or are not) achieving can lead to inappropriate educational solutions. Regional and national responses to statistics on boys' lower attainment than girls in literacy provide an example here. Moss (2011) describes how attempts to address such differences through 'boy-friendly' programmes that focus on gendered interests and learning preferences have distracted from processes through which girls and boys are constructed differently *in classrooms*. She argues that analyses of performance data - however sophisticated - may do little to help teachers understand the processes through which such construction occurs, processes which she suggests contribute to these differences in attainment.

It is easy to see how 'datafication' has been appealing to policy-makers and become commonplace in schools. Not only can data be aggregated to inform policy, but rapid and detailed analysis of data can be used to inform provision for individual children, (a possible benefit of digital technologies highlighted by the Cambridge Primary Review). For example, 'adaptive technologies' use student data to 'personalise' provision (often through 'learning analytics' which use data on children's performance in a task to generate subsequent tasks designed to be suited to their 'needs'). Such analytics, however, work from certain assumptions about learning that may limit what is offered to children. The implications of these assumptions may intensify if technologies used to generate such individualised data are increasingly used, as Williamson predicts, in tandem with those designed to collate data to inform policy-making:

This is a fully recursive arrangement where learners produce data to be calculated, compared and used for prediction; the result is that differential feedback then flows directly into the classroom in the shape of pedagogic prescriptions intended to sculpt learners' conduct to fit algorithmically inferred global norms, leading to a situation where the data produce the learner as much as the learner produces the data. (Williamson, 2016: 139)

Other concerns relate to the sharing of personal data about pupils (and teachers) without their knowledge or permission and use of digital technologies for the purposes of surveillance (e.g. CCTV). Such practices have implications for relationships between teachers and learners, and for the privacy of teachers and children, particularly in the context of recent developments such as the Prevent Strategy (Davies, 2015). The implications of digital technology for schooling therefore go beyond curriculum and pedagogy. Digital technologies mediate relationships between individuals, schools, policy-makers, other institutions and organisations (commercial and otherwise), and their use is always inflected by and constructive of particular assumptions, values, beliefs and practices.

Selwyn (2015:75-77) raises a series of questions that he argues could usefully drive future research: 'which data exist in educational contexts? What are the 'primary' uses of these data? What - if any - are the 'secondary' uses of these data? What are the consequences of these uses of data? What organisational cultures have formed around the use of data within educational settings, and with what outcomes? How might data work be more efficiently and equitably arranged in educational contexts?' Given the involvement of commercial organisations as well as governments in this activity, we might add: who is involved in the collection of data, and how does this data collection serve their interests? Such questions will not only be useful to researchers, but to schools, and indeed educational policy-makers, that are seeking to review how their use of data shapes what happens in school, and whether or not this is in the best interests of children and the wider community.

### *Summary*

- The digitisation of data has facilitated a massive growth in the amount and diversity of data it is possible to generate, and speed with which it can be analysed.
- Digitisation has been associated with, and arguably intensified, requirements for schools to use statistical data to monitor what pupils and teachers achieve in relation to measurable outcomes.
- This emphasis has been seen as problematic as it shapes how educational priorities and practices are understood, and leads to certain kinds of educational responses (by systems and schools).
- 'Adaptive technologies' which use student data to 'personalise' provision work from certain assumptions about learning that may limit what is offered to children.
- Other concerns relate to the sharing of personal data about pupils (and teachers) without their knowledge or permission and use of digital technologies for the purposes of surveillance.
- Digital technologies mediate relationships between individuals, schools, policy-makers, other institutions and organisations (commercial and otherwise), and their use is always inflected by and constructive of particular assumptions, values, beliefs and practices.

### **1.5 - Part one: summary**

Part 1 has identified numerous implications of the digital age for primary education. It highlights considerations for the curriculum, for pedagogy and for the primary school's broader role in supporting children's social, emotional and physical wellbeing. The issues raised also have implications for thinking about the purpose and nature of schools themselves, and how schools' work relates to the wider political, economic and commercial context. It demonstrates the need for an education appropriate to children's lives now and in the future, but also highlights the complexities involved in designing educational responses that challenge rather than sustain inequalities. The following list identifies a series of questions related to different dimensions highlighted through the preceding discussion. It is hoped that these questions will prove useful in supporting review of current policy and practice.

1. **Skills dimension:** What skills do children need to use a range of digital technologies effectively and with discernment for multiple purposes?

2. **Knowledge dimension:** How can we support children to navigate, synthesise and evaluate a range of online resources and information?
3. **Cultural dimension:** How do we respond and build upon children's diverse experiences of using digital technology in their lives outside school?
4. **Social dimension:** How can we encourage children to interact confidently and safely in a range of ways, both on-screen as well as off? How can we capitalise on opportunities to learn with and from others beyond the classroom? Which kinds of relationships do we foster, e.g. how might we generate opportunities for inter-generational or international collaborations?
5. **Design dimension:** How do we provide opportunities for children to explore the look and feel their digital creations? How can we ensure children are adept at representing themselves on-screen in ways that fit how they want and need to be perceived?
6. **Creative dimension:** How can we encourage children to explore the potential of new devices and applications and put them to use for a variety of meaningful purposes? How might we encourage them to capitalise on opportunities to play, create and innovate with resources?
7. **Ethical dimension:** What values and beliefs are associated with uses of technology within and beyond education? What are the implications of such use for the natural environment?
8. **Civic dimension:** How do we work with children to help them reflect on how they position themselves and are positioned by others in digital environments? How do we ensure children can capitalise on digitally mediated opportunities for participation in social and civic life?
9. **Safety dimension:** How do we ensure children are cognisant of possible risks associated with online activity and extended screen-time (e.g. related to child protection, bullying, health and fitness) and confident in using strategies for minimising these?
10. **Critical dimension:** In what ways are digital practices empowering or disempowering? Which groups are advantaged/disadvantaged? Whose interests are served by the use of technology in education, and how far do these uses sustain or challenge inequalities? How does use of digital resources and the digital infrastructure in school relate to broader political, economic and commercial activity? How does the data-fication of education shape curriculum priorities, pedagogy, and other priorities and practices in schools?

## 2 - RESPONSES TO THE DIGITAL AGE

### 2.1 - Introduction

To some extent, thinking about the implications of the digital age is a technical issue. Schools need to be able to provide and service equipment and connectivity, and children and teachers need the skills required to use these resources. This requires adequate funding, professional development for teachers, and an educational infrastructure that can respond flexibly to change. These requirements are challenging given the rapid pace of technological evolution, a strong accountability culture and budget constraints. For many schools, equipment is scarce, faulty and out-of-date, and innovation may be stifled as schools and teachers juggle

competing pressures. However, in responding to the digital age, schools will want to go further than providing access to digital technology and equipping children with skills. They will want to ensure that all can draw on the potential of digital technologies in ways that are personally fulfilling and economically, socially and politically empowering.

Education in a digital age is not just about ensuring children have digital skills, but supporting them to navigate and negotiate possibilities enabled by technologies. As the discussion above indicates, developments in digital technologies are changing what many children know and do, and what they need to know and be able to do. If much of our lives is conducted onscreen and online, then children need to be equipped to make the most of available opportunities in ways that are 'advantageous' to them and also be aware of possible risks (Greenhow and Robelia, 2009:136). Children need, for example, to be able to:

- put resources to work for their own purposes, to draw on them flexibly, creatively, critically and safely;
- draw on opportunities to contribute to the larger community, through collaboration with others, for example, or through participation in the political process, or in recognising and responding to diverse individuals, identities and viewpoints;
- be alert to the structures, systems and activities of institutions and commercial organisations.

Responding to this changing landscape is particularly challenging for schools as children's experiences are uneven. There are implications however for curriculum, for pedagogy and for supporting children's social, emotional and physical wellbeing.

If digital technologies and their uses in everyday life are not neutral, then it follows that digital technology use in schools is not neutral either. Choices about which digital technologies are deployed and how they are put to use through curriculum and pedagogy will reflect certain beliefs about how children learn and what they need to know and be able to do. In thinking about responses to the digital age, therefore, schools will want to consider how use of digital technologies relates to the values and aspirations that underpin their wider vision for children's learning within and beyond the curriculum. This includes considering the ways in which systems and practices are digitised and the uses that are made of this digitisation (by the school as well as by other organisations and institutions). In this section, however, the focus is on curriculum and pedagogy. It explores five 'traditions' that have generated different kinds of recommendations for curriculum and pedagogy in a digital age, each underpinned by different perspectives and priorities.

This first section, 'technology across the curriculum', explores the varied uses of digital technologies to support or enhance learning and explores why decisions about purchase or use of digital technology cannot be divorced from discussions about pedagogy. The three shorter sections that follow address '21<sup>st</sup> century skills', 'computing', and 'participation, learning and digital media'. Each of these has implications for pedagogy but also provides perspectives on *what* should be learned in a digital age. The final section on 'new literacies' directly addresses the multiple calls in the Cambridge Primary Review (Alexander, 2010) to re-think the nature of language and literacy provision in a digital age. The broad scope of

each as defined in this review is summarised in Table 1 and described and exemplified in the sections that follow.

<b>Traditions</b>	<b>Key questions for the primary school</b>	<b>Examples</b>
Technology across the curriculum	How can digital technology be used to support learning within and across curriculum subjects?	Use of game-based learning, mobile learning
21 <sup>st</sup> century skills	What kinds of skills, aptitudes and attitudes will children need for future economic and social success in a digitised world?	Digital skills; 'soft skills' such as collaboration, problem-solving
Computing	How do computers work? How can children use programming to make new artefacts and systems? How may computational thinking support other aspects of learning?	Programming, including coding; Developing computational thinking
Participation, learning and digital media	How can we enable children to draw on digital media to support participation in social, recreational, economic, civic and political life?	Developing online communities; collaborative production & knowledge sharing, e.g. wikis
New literacies	How do people make meanings using digital technologies? How is this meaning-making significant to children's lives? How does this meaning-making vary?	Assured, creative and critical use of digital media, such as film, social media sites, virtual worlds, games

**Table 1 – Traditions, questions and examples**

Distinctions between these 'traditions' are somewhat contrived, not least because many examples of practice cut across more than one category and because terminology use varies. However these distinctions are used in this review as they help to demonstrate different emphases and different possibilities that schools will want to consider as they review and revise curriculum and pedagogy. A discussion of each is followed by Section 2.7, which highlights some common themes, but also suggests that curriculum and pedagogy in a digital age may involve working across the traditions explored in Part 2, and considering different ways in which they complement one another.

It is worth noting that some commonly used categories for thinking about technology and education are omitted as they overlap with the five or because they are particularly ambiguous. The term 'digital literacy' for example is not included as some use this specifically to 'digital skills', some use it more broadly to include creative and critical dimensions of digital practices (e.g. Belshaw, 2012), and others to refer specifically to communicative practices involving digital technologies (e.g. Gillen, 2014).

## 2.2 - Technology across the curriculum

This section considers research related to technologies designed specifically to support learning, and to the educational use of devices and applications produced for general use (e.g. Skype, tablets). It is not possible in a survey of this size to do justice to many of the innovative practices that have been developed by researchers and practitioners, e.g. linked to game-based learning or mobile learning. It is also not possible to explore the application of digital technologies subject by subject, or indeed consider how subjects themselves may need to be reconceptualised in response to digital practices.<sup>1</sup> Instead this section raises more general questions about technology and learning within and beyond the curriculum.

Much has been written about the power of technology to transform education, and with it, the learning environment and relationships between teachers and learners. Digital technologies, it has been argued, offer possibilities to: motivate students; provide new spaces for learning, e.g. using virtual environments or facilitating learning beyond classroom walls; engage with real-life projects involving the wider community; support inclusion; empower children to take charge of their learning; and use assessment more effectively to support personalised learning. (Wellings and Levine, 2009).

Digital technologies have made an important contribution to inclusive practice. Certain innovations have been brought about by adopting technologies developed for use outside education. Some schools for example have introduced one tablet per pupil and this means children can use mobile devices flexibly at the point of need. These tablets also facilitate opportunities for learning outside school and making better connections between home and school (Shuler, 2009). Passey (2014) explores multiple ways in which digital technologies have been used by different groups of learners, for example apps have been used to reduce anxiety or support pupils who have difficulties with organisation. Children may revisit activities or information more easily online, use translation apps, gain support for spell-checking, for transcribing ideas or stories (e.g. using voice recognition software), use different media to represent their ideas, or use a range of specifically designed ICT interventions (e.g. see Checkley et al., 2010; Starcic and Bagon, 2014).

Various attempts have been made to synthesise research on the impact of digital technologies on learning. Results however have been rather mixed, concluding that in general there has been little or no significant impact (e.g. Higgins, 2003; Higgins et al., 2012; Cheung and Slavin, 2013). Partly this may be because 'technology' is used to encompass such a wide range of resources and activities, because 'learning' is understood in different ways, or because assessments do not capture the impacts. These reviews have emphasised however that the contribution of digital technologies is influenced by the wider context for learning, including the extent and quality of dialogue, and whether or not the classroom environment feels safe and supportive (Higgins et al, 2012; Ching Ting et al., 2014). For example:

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<sup>1</sup> For example mathematics in everyday life is changing (Hoyles et al., 2010) and these changes have implications for how we conceive mathematics in school.

- Perrotta et al. (2013) found that that game-based learning was most effective when academic aims were integral to the game (and the game's fictional world) and where teachers mediated the game where necessary, supporting children's play.
- Evaluations of interactive whiteboard use have explored how boards are used differently according to teacher expertise and teacher style (Shenton and Pagett, 2007); and that use does not necessarily make lessons more 'interactive' (Smith et al., 2006).

The argument that 'technology does not teach, teachers do' is a common refrain in the literature on technology and education, most recently in the report on the 2012 PISA survey (Schleicher, 2015). It concluded that the potential of digital technologies in supporting learning has yet to be realised, and that educational institutions and policy makers need to focus on the relationship between digital technologies and pedagogy: 'technology can amplify great teaching but great technology cannot replace poor teaching' (Schleicher, 2015: 17). Of course, as the increasing popularity of instructional short-form video such as YouTube illustrates, online resources may well provide an alternative to face-to-face teaching on occasion. However, in schools as elsewhere, while digital technologies may offer new possibilities, what matters is how they get taken up in practice, for example, what children and teachers do with and around them, and how they are used alongside other resources. Part Three of this survey explores barriers to and opportunities for such innovation and experimentation.

More radical shifts in pedagogy have tended to emerge when technology use is associated with physical changes to learning spaces and a more general commitment to pedagogical innovation. Thibaut et al. (2015), for example, explored teachers' perspectives on blended learning in one primary classroom in Australia. This school had a Bring Your Own Device (BYOD) policy: children could bring their own tablets or smartphones and use these to access the internet across lessons. Children also had access to an online environment and a large open-plan classroom that enabled more flexible grouping of children face-to-face. New opportunities for enquiry-led learning seemed to be supported by a mixture of digital and non-digital tools, on and offline spaces, and support for teachers to be flexible and creative. This study highlights the importance of considering how digital and non-digital resources, opportunities and spaces interact. Children are likely to need to draw on a range of available resources alongside digital technologies that include physical resources, each other and space. Wolfe and Flewitt (2010), for example, found that when digital resources were made available alongside other resources in early years settings, children moved between these and made connections between the different understandings they generated.

Given the rapid pace of technological change, schools will want to be aware of the range of likely future developments. In 2015, The New Media Centre Horizon Report predicted that the following innovations will become more commonplace in schools in future:

- Consumer technologies, such as wearable technology, robotics;
- Digital strategies, such as BYOD (Bring Your own Device), OERs (Open Educational Resources), makerspaces and flipped classroom;
- Internet technologies, such as cloud computing and networked objects;
- Learning technologies, such as adaptive learning technologies and digital badges;
- Social media technologies, such as crowd sourcing and social networking;

- Visualization technologies, such as 3-D printing and augmented reality apps such as Aurasma (<https://www.aurasma.com/>).
- Enabling technologies such as speech-to-speech translation and mobile broadband.

(Adapted from Johnson et al., 2015: 36)

Of course there is no guarantee that these predictions will materialise but they do illustrate the diverse range of digital technologies and applications that might become increasingly popular. Schools will want to evaluate applications carefully. In recent years, for example, there has been much enthusiasm for promoting games-based learning (Gee, 2007; Howard-Jones et al., 2011). Available games however differ considerably in their educational potential, some offering very low level tasks and others providing rich opportunities for investigative learning (Luckin et al., 2012). Similarly, the educational value of apps for young children varies. Marsh et al. (2015), for example, analysed young children's use of a range of apps and identified design features of those that facilitated or scaffolded young children's play and creativity. They concluded that the apps most likely to do so: are open-ended; embed problem-solving, reasoning and critical thinking; and/or may promote physical activity or play with other non-digital games and toys.

Whether working within or across subjects, one of the challenges for schools is that digital technologies can be used in ways to support different pedagogical principles; they might just as easily serve teacher-directed, closed learning, for example, as facilitate open-ended problem solving and critical thinking. In helping schools navigate the many different possibilities available, Luckin et al. (2012) draw on a review of research to list a range of learning opportunities generated by different technologies:

- *Learning from experts*: for example, learning concepts are presented in an engaging or dynamic way, e.g. through animations, videos, podcasts, tutoring platforms (such as iTalk2Learn, <http://www.italk2learn.eu>). 'Expertise' is mediated by technology rather than relying on direct access to people as 'experts.' Children may also use communicative technologies to communicate with experts beyond the classroom, e.g. primary pupils using video conferencing to access specialist modern foreign language teaching (Pritchard et al., 2010).
- *Learning with others*: for example, working through ideas and plans with others; providing feedback and critique; sharing perspectives in relation to work in progress and finished projects or outcomes; collaborating with those in other places, e.g. using Skype, Google Docs, or wikis.
- *Learning through making*: for example, developing understanding of electrical circuits through making wearable technology e.g. fashion garments with embedded electronics (Peppler and Glosso, 2013); reasoning through making animations using Scratch (Kafai and Peppler, 2012);
- *Learning through exploring*: exploring experiences or places through virtual worlds such as Barnsborough (Merchant, 2009; 2010), simulations, or technology augmented virtual spaces.
- *Learning through inquiry*: learning through investigations in the context of a quest or challenge, e.g. investigating the life of a lion pride using Savannah, which involves the mapping of a virtual savannah onto a real place which is navigated using a hand-held device (<http://archive.futurelab.org.uk/projects/savannah>).

- *Learning through practising*,<sup>2</sup> using game-like applications that allow learners to engage in repetitive activity, e.g. a digital dance mat which involved learners in moving about to demonstrate and compare different numbers, and in doing so, improve understanding of magnitude and basic numerical skills.
- *Learning in and across settings*, e.g. using mobile devices to enable students to take more control of their learning and make connections with life outside school. Auld et al. (2012) for example explored the use of mobile phones to connect the diverse worlds of school and home in an Australian Indigenous community.

(Adapted from Luckin et al., 2012, with additional examples)

### *Summary*

- Digital technologies can be used in multiple ways to support inclusive practice.
- The contribution of digital technologies is affected by how they get taken up in practice, by what children and teachers do with and around them (e.g. quality of dialogue), and how they are used alongside other resources.
- More radical shifts in pedagogy have tended to emerge when technology use is associated with physical changes to learning spaces and a more general commitment to pedagogical innovation.
- Digital resources offer different kinds of potential for supporting learning and are of varying quality.

### **2.3 - 21<sup>st</sup> century skills**

This section explores calls for education to focus on the development of ‘21<sup>st</sup> century skills’ (also sometimes referred to as ‘21<sup>st</sup> century literacy’ or ‘21<sup>st</sup> century learning’). Those working in this field have set out to define the skills, aptitudes and attitudes people need for economic and social success in a world that is seen as increasingly digitised and globalised. Recently, for example, a World Economic Forum report argued that,

To thrive in a rapidly evolving, technology-mediated world, students must not only possess strong skills in areas such as language arts, mathematics and science, but they must also be adept at skills such as critical thinking, problem-solving, persistence, collaboration and criticality. (WEF, 2015: 1)

These sentiments reflect those expressed by many governments and organisations, those concerned with the economic success of nations in an increasingly globalised and technologised world, and those concerned for individuals to live fulfilling lives. While different countries have offered slightly different interpretations of the scope and nature of 21<sup>st</sup> century skills, some common themes emerge:

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<sup>2</sup> Luckin et al. found that while many applications could be categorised in this way, very few were of high quality. They note that ‘games that integrate the knowledge and skills to be learnt directly into the structure of the game activity are both more fun for children to play and more effective than those where the game is used as motivation but without connection to the learning content.’ (Luckin et al., 2012: 36).

- a recognition of the changing practices associated with the increase of digital connectivity;
- an emphasis on learning both *with* and *about* technology;
- a restatement of the importance of 'basic skills';
- a recognition of the importance of soft skills or 'competences' (WEF, 2015) such as criticality, collaboration and problem-solving;
- a view that flexibility, creativity and innovation and dispositions such as curiosity, 'persistence' or 'grit' (WEF, 2015) are important;
- a recognition that learning continues outside of school contexts, and beyond the span of compulsory education;
- an idea that quite specific skills are needed to compete in the digital economy.

(Adapted from Burnett et al., 2014)

These themes reflect the premise that the 21<sup>st</sup> century poses new challenges for education systems. They assume these will be best met by re-emphasising some familiar aspects of schooling (e.g. 'basic skills', collaborative learning, problem-solving) and adding others (related to technology and associated practices). The emphasis of these reports tends to be on the role of schools in nurturing economic competitiveness in a hi-tech global future. As Williamson (2013: 55) argues, specifications for 21<sup>st</sup> century skills tend to position schools, 'as responsible for the cultivation and promotion of habits of mind and the emotional capital required for the nation to remain innovative and competitive.'

Often frameworks for developing 21<sup>st</sup> century skills are rather generalised. McPhail and Rata (2015) for example have argued that the New Zealand model for 21<sup>st</sup> century learning may be visionary but is not rooted in research, and that some rather vague educational aims seem to ignore more specific issues that have implications for how we conceive curriculum and pedagogy. Other 'traditions' have proposed more clearly defined recommendations for the digital age which have implications for primary schools. Three of these are explored in the sections that follow.

### *Summary*

- There have been multiple attempts to define 21<sup>st</sup> century skills: the aptitudes and attitudes that are judged to be needed for economic and social success in a world seen as increasingly digitised and globalised.
- Lists of 21<sup>st</sup> century skills combine some familiar aspects of schooling ('basic skills', collaboration, problem-solving) with those related to technology and associated practices.
- Frameworks for 21<sup>st</sup> century skills have been criticised as being rather vague and lacking firm foundations in research.

## **2.4 - Computing**

'Computing' has been defined as: 'the study of how computers and computer systems work, and how they are constructed and programmed, and the foundations of information and computation' (Peyton-Jones, 2009: 3). In recent years there has been a growing interest in computing for primary aged pupils as evidenced in England by the replacement of National

Curriculum programmes of study for ICT with new programmes of study for Computing include a focus on computer science (DfE, 2014). This move has been justified on three fronts: first that a knowledge of computing will equip children with skills valuable to them for future employability, for example within a buoyant games design industry (Livingstone and Hope, 2011); second that computing as a discipline - and computational thinking in particular - can nurture cognitive and attitudinal benefits, for example linked to reasoning and problem-solving; and third that computing is engaging and empowering, through enabling children not just to *use* computers but to gain access to 'the creative process of understanding, designing, and building new systems' (Peyton-Jones, 2009: 2). Equipping children to program may mean children can participate in a range of other design-based and creative activities, such as game-making (Royal Society, 2012).

At the time of writing, it is too early to say how and how far the new Computing programmes of study will be significant to children's learning or for broader curriculum and pedagogy in primary schools in England. Many schools are however experimenting with a variety of programs and devices to support programming as part of their computing provision, including: Raspberry Pi, the 'low cost credit card sized computer' (<https://www.raspberrypi.org/>); block based tools such as Alice (Alice.org), Snap (<http://snap.berkeley.edu/>) or Scratch (<https://scratch.mit.edu/>); and game-making programs like Kodu (<http://www.kodugamelab.com>).

A number of studies have suggested that children are most likely to develop aspects of programming when opportunities are embedded in projects that are intrinsically motivating. For example, The Make-to-Learn Initiative (particularly in the US) is based on principles developed through the 'makerspace' movement through which people get together to make things together, sharing knowledge, skills and equipment. Building on this model, Peppler and Glosson (2013) describe how 7-12 year-old children used e-textiles, 'fabric artifacts that include embedded computers and other electronics' (Peppler, 2013a: 38) to create various items such as puppets and fashion garments. Peppler and Glosson found that, through making their artefacts, children addressed misconceptions about electricity. Peppler and Glosson attribute this learning partly to the fact that design and aesthetics were at the fore and that participants were motivated to engage with programming because it enabled them to develop their artefacts.

Others adopting similar approaches have highlighted how e-textile projects offer opportunities to challenge gendered assumptions about computing (Buchholz et al., 2014; Jacobs and Buechley, 2013). Projects, with older children or with mixed age-groups have involved students in computing through creating videogames and interactive art (Peppler and Kafai, 2007), crafting with paper, electronic components and conductive ink (Mellis et al., 2013), and construction and robotics (Mills et al., 2013a). Some have explored how children and young people can explore creative and critical dimensions of new media through designing computer games. This might involve a sustained process of multimedia design (Burn and Durran, 2013) or more short-lived 'do-it-yourself' activities using programmes such as Scratch (Kafai and Peppler, 2012). Looking across these studies, the programming component is addressed in the context of motivating tasks that matter to children in their own right. Children learn as part of a design brief that draws on a range of skills from across the curriculum.

## Summary

- Computing may: develop skills useful for future employability; nurture cognitive and attitudinal benefits; and be engaging and empowering.
- Programming can be learned through motivating projects that involve design and production.
- Projects involving programming may draw on a range of skills, knowledge and attitudes from across the curriculum.

## 2.5 - Participation, learning and digital media

This section explores work focused on the educational potential of the ‘participatory practices’ described in Section 1.1. In summary these practices use digital media to facilitate collaboration and the making and sharing of ideas, creations and perspectives. The emphasis here is not just on economic success. As with the previous section there is an emphasis on learning through production, but this is linked here to increased social, civic and political participation. In an influential white paper from the US, Jenkins et al. (2006) identified the possibilities for learning generated through what he called ‘participatory culture’, i.e. one:

- with relatively low barriers to artistic expression and civic engagement;
- with strong support for creating and sharing one’s creations with others;
- with some type of informal mentorship whereby what is known by the most experienced is passed along to novices;
- where members believe that their contributions matter;
- where members feel some degree of social connection with one another (at the least they care what other people think about what they have created).

The increased use of participatory practices using digital media raises two questions:

1. If such practices provide rich and motivating opportunities for learning outside school, then how might we create similar conditions for learning inside school?
2. If such possibilities have implications not just for employability but for personal, social and cultural life and for learning throughout life, then how do we ensure children are increasingly confident in using digital media to participate in and move between different communities?

Various projects have been designed to address the first question. These have capitalised on opportunities to use connectivity and mobile technologies, strengthening connections with those outside school, sometimes engaging in community projects or collaborations with experts or children in other locations. Recently, an extensive programme of work has been conducted through Connected Learning, which supports educational initiatives within and beyond formal schooling that are:

- ‘production centred’ (involving in making or producing, designing and producing);
- underpinned by ‘shared purpose’, supported through collaboration, including opportunities for cross-generational learning;
- ‘openly networked’, linking school, home and community. (<http://connectedlearning.tv/>)

As a movement *Connected Learning* aims to both develop ‘new learning environments that support effective learning and educational equity’ and ‘the opportunities and risks for learning afforded by today’s changing media ecology’. A key focus here is on experimenting, or ‘tinkering’ with what might be possible, and creating spaces where children and young people feel safe to do this. For example in one US school, 11-year-old children are regularly given challenges: e.g. to create a machine, write and perform short plays based on fairy tales, to research and construct a travel website featuring local neighbourhoods. In designing and discovering solutions, pupils take the lead and work together in teams. They are encouraged to draw on their own interests, access expertise from outside experts, use the internet for research, and communicate what they have done using digital media (Ito et al., 2013).

In response to the second question, Milhaidis and Thevenin (2013) have explored how this kind of participation requires a ‘culture of participation’ that is encouraged by support for: collaboration with known and unknown others; for effective communication and engagement with others; and for critical engagement. A critical orientation is important to enable children to consider and reflect upon the significance of connectivity to their lives. For example, how do we support children to use an internet that increasingly tracks their interests, preferences and activities? How are individuals, groups and organisations enabled or disadvantaged by the connectivity around them, and what are the implications of this for civic participation and social justice? This may involve working with children to reflect on how they achieve these different purposes, and think critically about how they position themselves as they do so. Such questions have implications for how we think about literacy provision, questions that are explored in the next section.

### *Summary*

- Some of the conditions associated with learning through participatory practices include: encouragement for all; support for creating and sharing; mentorship; a sense of audience and community.
- Engaging in digitally mediated participatory practices requires not just technical skills but a culture that supports creativity, criticality and collaboration.

## **2.6 - New literacies: re-thinking literacy in a digital age**

Building on the focus in the previous section on relationships between digital media, learning and life, this section explores research focusing the implications of the digital age for conceptualisations of literacy. The need to re-work the language and literacy curriculum was a key finding of the Cambridge Primary Review which argued that in addition to supporting technology use across the curriculum,

The more fundamental task is to help children develop the capacity to approach electronic and other non-print media (including television and film as well as the internet) with the degree of discrimination and critical awareness that should attend reading, writing and communication of any kind. (Alexander, 2010: 270).

Calls for educational policy-makers and practitioners to recognise the implications of digital technology for the changing nature of literacy are longstanding (New London Group, 1996; Lankshear and Knobel, 2003; 2010; Burnett et al., 2014). Confident, creative and critical use of new media resources is increasingly essential to how people represent themselves to themselves and others and how they conduct their lives (Dowdall, forthcoming). More than ever, for example, people are producing as well as accessing texts, negotiating and 'curating' their lives online (Potter, 2013), and engaging in diverse forms of narrative linked to gaming and film (Beavis, 2014; Colvert, 2015; Parry, 2014). Researchers and educators have therefore argued for a re-working of the literacy curriculum to recognise the wide range of media that children use and encounter, and the kinds of practices in which they do and could engage in their current and future lives. Merchant (2013) identifies five aspects of digital media practices that have implications for how we think about literacy:

- Multimodality: digitally mediated texts work through a combination of images, moving images, hyperlinks, icons, etc. as well as words.
- Online communication has been associated with playful linguistic innovation, e.g. uses of emoticons, abbreviations.
- Re-mix: many practices involve combining existing media texts in playful ways, e.g. editing existing animations and re-dubbing with new music.
- Participation: practices involve joining with others to share, create and give feedback.
- Connection with known and unknown others: it is now much easier to reach multiple audiences, audiences that are interested and provide a genuine response.

Much of children's learning about new literacies happens out of school, through on-line, on-screen literacy practices. While schools will want to avoid appropriating children's out-of-school practices in school, research has explored what can be gained by enabling children to draw on their experience of using diverse modes and media within school. As the Cambridge Primary Review concluded, 'research has shown that children's motivation increases when their own cultural knowledge- including that acquired from TV and computers- is acknowledged at school' (Alexander, 2010: 67). Parry (2014), for example, notes how the 'hierarchy of learners' (21) shifted in one primary school when children were invited to draw on knowledge learned about film outside school to inform their film-making in school, while McPake et al. (2013) explored how the communicative practices children learned at home, such as karaoke, taking photographs, and texting, complemented understandings about texts encountered at school. However, the picture is uneven, and schools have a role to play in ensuring all children are supported to engage productively, creatively and safely with a range of media, and challenging them to extend what they know and can do. Addressing new literacies is about more than facilitating economic growth and competitiveness (through 21<sup>st</sup> century skills). New literacies enable (or impede) our present and future participation in a range of communities and activities, and we therefore need to ensure children are aware of and confident in using a range of meaning-making opportunities, and reviewing how they position themselves, and are positioned by others, as they do so.

A number of researchers and projects have used Green's 3-D model of literacy to help structure this kind of work (Green, 1999), which highlights the importance of addressing 'operational', 'cultural' and 'critical' dimensions of literacy (Green, B. & Beavis, C., 2012; Sefton-Green et al., 2016). While these three dimensions are inter-linked in practice,

considering each in turn highlights different aspects of new literacies that might be addressed. The *operational* dimension relates to the processes of making meaning in a digital age. Children, for example, need opportunities to develop their ability to locate and evaluate information, to draw on a range of digital resources - for example, using images, moving images as well as words - and to reflect on how they represent themselves and communicate with others. For over a decade there have been calls for the primary literacy curriculum to be more 'multimodal', to acknowledge that children need to be adept at using a range of modes and media (Bearne, 2003). Children may need support to explore the approaches and strategies they need, to be confident in experimenting with new possibilities, and to reflect on what they want to achieve and how others might respond.

Supporting the *cultural dimension* involves recognising the role of digital literacy within varied contexts and encouraging children to reflect on their existing and developing uses of technology in these contexts. Educators need to support children's participation, generating opportunities for sharing with audiences, creating texts with others, and gaining feedback enabled through digital media (Curwood, et al., 2013). The *critical* dimension explores how texts position readers and writers and the power relations evident within social contexts mediated by digital technology. Such criticality has often been nurtured through critical analysis of texts, but also through involving children in media production through which they can present their own perspectives and experiences and in doing so challenge existing power relationships (e.g. Crafton et al., 2007). Given that so much of life is played out online, more recent work has suggested that this critical dimension needs to go beyond a focus on text analysis or production. Children also need to think critically about how they present themselves online, the kinds of online communities they participate in, and how broader social, economic, political and commercial interests are served (or not) by what they do (Burnett and Merchant, 2011).

Considerable work has been done by educators and researchers working in the field of media education and new literacies to develop appropriate frameworks and approaches for developing children's creative and critical engagement with a range of media, for exploring how texts position readers, players and consumers. These range from activities designed to engage children with issues of power, social justice and equity (e.g. Vasquez, 2014), to guidance for facilitating primary children's critical engagement with and production of specific media (e.g. the BFI's *Look Again* <http://old.bfi.org.uk/education/teaching/lookagain/>) to broad frameworks designed to support radical re-workings of literacy in schools, such as Jenkins et al.'s 'new media literacies' (Jenkins et al., 2006) or the influential 'pedagogy of multiliteracies' (New London Group, 1996), which has been used to inform literacy provision in a number of localities around the world (although not extensively in the UK). There is not space here to explore these diverse frameworks and approaches in detail, but they do provide rich alternatives- or complements - to the current National Curriculum for English.

More recent work has highlighted the importance of considering how on-screen activity relates to what happens off-screen, and explored ways in which media literacies may be fostered alongside arts-based and creative activities that involve non-digital as well as digital resources. Such work has emphasised the need to acknowledge that children's digital creations - like artwork or creative writing - are often deeply personal. Studies have explored for example how children's film-making is often shaped by individual passions (Wohlwend,

2014), memories (Potter, 2010) or feelings (Mills et al., 2013b), and have argued for making time and space for work that allows children to explore their experiences using a range of media.

Drawing on themes identified through reading across studies of new literacies within and beyond education, a recent 'Charter for 21<sup>st</sup> Century Literacies'<sup>3</sup> (Burnett et al., 2014; Burnett and Merchant, 2015) summarises possible implications of recognising the changing nature of literacy. The Charter highlights the importance of recognising children's out-of-school experience of new media, and encouraging children to select, critique and use different modes and media creatively, persuasively, and for different purposes. In doing so, it recommends providing opportunities for children to use new media for purposes that make sense and matter to them, and enabling them to work on texts together, to re-work the texts others create, and review and respond to what others have created. This process, the Charter suggests, involves planning for activities that recognise that making meaning, through reading, writing, producing or creating, is important to children, and that the meanings they make are shaped partly by what they feel, what has just happened, and who they are with. It involves creating an environment where children feel encouraged to take risks and experiment, and to consider critically the practices in which they engage.

### *Summary*

- Literacy is changing and the ability to use digital media competently, creatively and critically is essential for learning in a digital age.
- There is a need to develop operational, cultural and critical dimensions of new literacies.
- The literacy curriculum needs to reflect the varied and changing nature of literacy, e.g. by including a focus on multimodality and on using diverse digital media for different purposes.
- Schools need to build on children's out-of-school experiences and provide opportunities for children to engage in purposeful activities that capitalise on opportunities to collaborate and gain feedback (on and off-screen), reach different audiences, and experiment and reflect on their use of digital media.

## **2.7 - Looking across the five traditions**

As explored earlier distinctions between the five 'traditions' described above are rather artificial, as there is overlap and many school-based topics or activities in practice address more than one of these areas. Moreover, there is considerable overlap in the recommendations arising from studies across traditions. This is illustrated by the following examples which highlight some common themes.

Kafai and Peppler (2012) describe a project through which children programmed short animations and games using Scratch. They posted their creations on an online forum and gained feedback from others on the site. As they did so, they learned from others, adopting

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<sup>3</sup> '21<sup>st</sup> century literacies' is used here to refer to 'new literacies' and as such has a different emphasis to '21<sup>st</sup> century skills' as described in section 2.3

and improvising with others' strategies and ideas. As the project progressed, students in different geographical locations formed interest groups within the forum based on certain themes: interested not just in the programming, but in the narratives created through animations and the aesthetics of the design. While the initial focus of the project was programming (computing), the project also provided an opportunity for participants to share their products within wider interest-based communities (participation, learning and digital media), and to focus on the aesthetics of their designs (new literacies).

In another project, Pepler (2013b) used Quest Atlantis, a Multi User Virtual Environment, with 9-16 year olds. Children and young people used simple programming to create their own virtual 3D buildings. Again the project certainly included a focus on computing and other ICT skills. It also involved problem-solving (21<sup>st</sup> century literacies) and an opportunity to learn about architectural design through their work in the simulated environment (technology across the curriculum).

Colvert (2015) worked with her Year 6 class to design an alternate reality game to be played by Year 5 children at the school. Alternate Reality Games (ARGs) take the form of a quest: ARG designers seed a series of clues that players draw on to solve problems and complete challenges. Colvert invited her class to create an ARG based on a class novel, Phillip Ridley's *The Mighty Fizz Chiller*. The Year 6 children drew on multiple media (new literacies) to develop a series of texts - videos, maps, websites, and so on - that the younger children could access online and use to solve the mystery of the Mighty Fizz Chiller. Year 6 children had to work flexibly to respond to the questions and conclusions Year 5 children arrived at through play (participatory practices). Acting as designers, they worked with a range of genres across multiple media, but also explored new ways of developing narrative and establishing cohesion across the wide constellation of texts that made up the ARG.

These examples, like other successful projects cited in Part 2, share a number of characteristics that are useful in thinking about how learning in primary schools can be productively organised in the digital age. Many of these characteristics are not new. They reflect principles and practices to which primary schools and teachers have long been committed:

- Children worked across subject boundaries through investigative or enquiry-based projects, similar to the cross-curricular, enquiry led projects that are familiar to many schools in England.
- Children were given opportunities to work on projects that mattered to them and pursued their own lines of enquiry, e.g. linked to their interests, aesthetic preferences, or a cause they cared about. They had opportunities to take the lead and make decisions about the direction of the project.
- The emphasis was on creating or producing something- a game, an artefact - and drawing on digital skills along the way. Projects were sustained long enough for children to develop their ideas fully and be supported to do so.
- Technology use was secondary to the project. Children may have learned digital skills but did so in order to support their creative endeavours. Digital technologies were used alongside a range of other resources.

- Children had opportunities to work with others and to talk about and reflect on what they were doing and what they had achieved. They were able to collaborate and share their ideas with others outside the classroom, e.g. through blogs, online fora.
- Teachers and other adults worked with children to ensure a safe supportive atmosphere in which experimentation was encouraged.
- Children were encouraged to draw on their own prior experiences and expertise developed outside school, including those using digital technologies.
- Children's work was shared so others could easily see, learn from and be inspired by what others had done. They had a sense of audience.

As well as illustrating these common characteristics, the three examples above also demonstrate how curriculum and pedagogy in a digital age may involve working across the traditions explored in Part 2. An emphasis on multimodality as explored through new literacies research, for example, might usefully enhance the kinds of design projects associated with the Computing curriculum. A focus on criticality would go further still, in stimulating reflection on what is and could be achieved through sharing and developing games together, and interrogating what underpins the production of commercially produced games and products. In considering how to complement the Computing curriculum, schools will therefore want to explore how far curriculum and pedagogy relate to their wider aims and intentions with regard to the digital age.

## **2.8 - Part two: summary**

Part 2 has explored research related to five 'traditions' that have generated different kinds of recommendations for curriculum and pedagogy in a digital age. Summaries are provided at the end of each sub-section so are not reproduced here. As explored earlier distinctions between the five 'traditions' described above are rather artificial; there is overlap and many school-based topics or activities in practice address more than one of these areas. The previous section highlights a number of common themes that emerge in projects that have worked across these traditions. However, juxtaposing these traditions highlights the different perspectives and priorities informing each, suggesting that it may be helpful to consider how to draw *across* these traditions when considering technology use in school.

Part 1 of this review concluded with a list of dimensions of technology use which raise different questions for schools and education policy makers:

1. Skills dimension
2. Knowledge dimension
3. Cultural dimension
4. Social dimension
5. Design dimension
6. Creative dimension
7. Ethical dimension
8. Civic dimension
9. Safety dimension
10. Critical dimension

Working across the five traditions may usefully inform schools' thinking about how to address these different dimension. They each provide different perspectives on educational responses to the digital age, and as such support critical engagement with current curriculum frameworks: about what is and what might be addressed. In particular, research on participation, learning and digital media, and on new literacies - two areas that are not explicitly addressed within the current National Curriculum in England - may support schools in addressing social, cultural, design, creative, ethical, civic, and critical dimensions. These traditions may also complement one another. Specifically, for example, studies of innovative project work involving digital technologies often address new literacies within the context of digital media, learning and participation, and such work could provide direction for the rather generalised aims articulated through work associated with '21<sup>st</sup> century literacy skills'. Work in new literacies would also usefully inform much of the creative work being produced as part of the computing curriculum, complementing computational thinking with aesthetic and critical considerations as children engage in digital production.

Part 3 proposes a series of recommendations and implications that are designed to support schools in developing technology use in relation to current curriculum requirements and going beyond these to generate a more far-reaching response to the digital age that addresses broader questions related to the aims and purposes of education, such as those identified in Part 1 of this review.

### 3 - CONCLUSIONS AND RECOMMENDATIONS

The Cambridge Primary Review acknowledged concerns about young children's use of digital technologies, but also highlighted their contribution to relationships, leisure activities and learning. While arguing that risks associated with extensive screen-time need further investigation, the review concluded that technology should be used to support learning across the curriculum, used in contexts that promote talk, and that children need to be supported to approach digital media with 'the degree of discrimination and critical awareness that should attend reading, writing and communication of any kind' (Alexander, 2010: 270).

Part 1 of this survey built on this argument by exploring recent research related to living in a digital age, the opportunities and risks associated with children's digital practices, and issues associated with the digitisation of data. Part 2 explored possible responses to this changing context drawing on five different 'traditions', each associated with different priorities and value positions. This discussion illustrated how different kinds of research (often involving different communities of educationalists and researchers) are generating different kinds of insights and consequently there is a need to explore how different traditions, whose aims are sometimes complementary and sometimes not, intersect. In particular the discussion reiterated calls from the Cambridge Primary Review for re-working literacy provision to recognise and support children's creative and critical use of digital media in their current and future lives.

The review highlights a series of considerations for schools and identifies features of practice that appear to have been successful in relation to digital technology use in education. These are used to inform the implications for schools and teachers identified at the end of this

review. The review also suggests however that these practical considerations need to be addressed in relation to broader questions. Technology use in education is never neutral but always reflects particular values relating to the aims and purposes of education and the workings of society - social, cultural, political - more widely, whether implicitly or explicitly. It is therefore important for policy-makers and educational leaders to think about how digital technology use relates to the broader context, and to encourage children to do so too. The following section explores issues associated with navigating this complex context, and ends with implications for policy-makers and education leaders, and recommendations for schools and teachers.

### **3.1 - Navigating technology use in school: opportunities and barriers**

The provision of curriculum and pedagogy in a digital age depends of course on having sufficient and working devices and reliable internet access that is not unnecessarily restricted. Children can only use digital technologies flexibly and at the point of need if they are constantly accessible. When schools have to share a single class set of laptops or tablets, the opportunities to integrate technology use alongside other resources will be severely limited. However, as the Cambridge Primary Review concluded, while lack of equipment is a problem, other factors work to inhibit technology use in schools:

...media-related work at school is hampered by many factors: demands of the national curriculum, teacher resistance to new technologies and the challenge of keeping up with the pace of media development (Alexander, 2010: 67).

Six years later, and despite pockets of inspirational practice and repeated calls for a transformation of education in the digital age, for the most part schooling continues to look much the same. One reason for this is that new ways of organising learning may sit uneasily with existing practices, demands and structures. A series of studies have explored the barriers and challenges that teachers face when integrating digital technologies, including not just practical issues associated with connectivity, availability and reliability of equipment, but resistance from management, and pressure to demonstrate progress using measures that bear little relation to the digital (Burnett, 2011; Ottesen, 2006; Honan, 2008). The high stakes culture of accountability that exists in the English education system, for example, may not be conducive to the experimentation and risk-taking often associated with more creative applications of digital technologies. While many teachers are 'digikids' too (Graham, 2008), and use social media, mobile devices and multimedia extensively in their own lives, they may lack confidence in drawing on this potential to support children's learning in school (Burnett, 2011; Honan, 2008; Lynch and Redpath, 2014). More flexible open-ended opportunities may sit uneasily with the tightly framed and fast paced lessons that are often devised to ensure children meet the targets that will enable them to do well in high-stakes national tests. Merchant, for example, describes work with primary schools to explore the potential for using a virtual world, Barnsborough, within the literacy curriculum (Merchant 2009; 2010). While Barnsborough provided rich opportunities for children to engage with a wide variety of texts in a motivating context, there were tensions between the open-ended, play-based learning associated with the virtual world and existing literacy pedagogy linked to high-stakes assessments.

Despite such pressures, there have been many examples of innovative work by teachers and schools. The JISC Digital Futures in Teacher Education project (<http://www.digitalfutures.org/>), for example, produced case studies of teachers' imaginative uses of digital technologies to support children's engagement with learning, with a particular focus on new possibilities for interaction and collaboration with those beyond the classroom. Other examples include: the Connected Learning Movement (explored briefly in Section 2.5) through which practitioners and community groups have worked collaboratively; and networks of educators, such as Computing At School (<http://www.computingatschool.org.uk/>). Nurturing such creativity and innovation requires a culture that encourages risk-taking and experimentation and that allows teachers the autonomy to work flexibly. Innovation, as with the examples in this paragraph, is likely to be encouraged through opportunities for teachers to share and develop practice together. It may even involve new kinds of partnerships, like those achieved through projects in the UK and elsewhere (Facer and Selwyn, 2013), that are involving schools (teachers and children) collaborating with community organisations and arts organisations to generate new ways of working that reflect what they believe education is for and how technology can be best used to serve such aims.

However, if schools are to go further to fully engage with the complex issues associated with technology use - linked for example to power, commercialism and state surveillance - then encouraging pedagogical innovation is unlikely to be enough. It will also require a critical engagement with how children (and others) are positioned and position themselves through technology use and what this means for their current and future lives and the lives of others. The subject knowledge teachers require will also change as subjects themselves evolve. Section 2.6 of this review explores the changing nature of literacy, which is increasingly concerned with digital and multimodal texts. We might equally consider how the scope and range of other curriculum areas, such as science, mathematics and citizenship, are evolving in the digital age. Addressing these changes involves considering how the curriculum itself is interpreted and revised, and making judgements that are not just framed by current imperatives, but by wider consideration of the values and purposes of education. Teachers will need ongoing and significant support to address these aspects and need to be resourced and empowered to act as professionals as they explore, experiment and think critically about the local and wider context for what they do.

Importantly this process involves not just thinking about digital technologies in terms of potential, but being alert what happens, and the opportunities technologies present (or not) when in use alongside other resources and in relation to other school practices (Luckin et al., 2012; Selwyn and Facer, 2013). Rowe and Miller (2015), for example, described how the 4-year-olds they worked with were reluctant to use multilingual software to create dual language books on iPads. The children only began to take up this opportunity once the profile of their home language was raised more generally.

Responding to the digital age, therefore, involves more than finding out about 'what works' in supporting specific learning outcomes. It also requires provision that goes beyond the scope of the current Computing Curriculum. It involves considering how technology use relates to broader educational aims, and in relation to children's social, emotional and cultural lives. It involves thinking about how technology use sits alongside broader institutional aims and

constraints, and in relation to the institutional, political, historical and economic factors that shape what schools are able to do. Technology is not neutral in everyday life and it is not neutral in school either.

### **3.2 - Implications and recommendations**

The implications and recommendations that follow are designed to support schools, policy-makers and educational leaders in addressing six key questions:

1. How far do uses of digital technology enhance what we are already doing?
2. How can we develop curriculum and pedagogy that are empowering to children now and for their future personal, social, economic and political lives?
3. How might we interpret the curriculum to better account for children's diverse digital practices in their lives outside school?
4. How can we ensure discussions around technology use are embedded in broader discussions about pedagogy? And how might pedagogies need to change?
5. How can we avoid limiting our ideas about what might be possible by seeing possibilities only through existing frameworks (e.g. linked to curriculum, ideas about effective teaching and learning, assessment, and 'established' measures of impact)?
6. How is wider national policy and commercial activity (in education and elsewhere), enabling or impeding change?

#### *Implications for policymakers and educational leaders*

1. It is not possible to address digital technology separately. To fully respond to the digital age we need to engage in fundamental discussions about how we see education, the role of schools and learning and teaching. Much of our response may involve thinking about things that have long been high priorities within primary schools: social justice, relationships, creativity, and community.
2. Schools' response to the digital age should reflect not just what children may do or need in the future, but what they are doing now. This means not just supporting children with skills aimed at employability but considering broader implications related to what children need to know or be able to do, and for who they are able to be. Addressing children's digital lives is about more than equipping them with an appropriate skill-set, it is about nurturing the attitudes and practices associated with their effective participation in social, civic, economic and political life.
3. We need to be alert to the affordances of digital technologies, intended and unintended, and the possibilities and barriers these present for learners. Policy-makers, schools and teachers will want to consider how life is changing as people draw increasingly on digital technologies to mediate their relationships, manage their lives, and find new ways of joining with and collaborating with other. Our education system needs to be flexible enough to respond to changes, to engage critically with the values and assumptions that underpin developments within and beyond the curriculum, and to avoid placing demands on schools through curriculum and assessment that foreground priorities that get in the way.
4. There is a need to review how different subjects, and relationships between subjects, are understood in the 21<sup>st</sup> century. If the production and dissemination of knowledge

is changing, then what does this mean for how we conceive the nature and scope of subjects? For example, how can we foreground creativity and criticality? In particular there is a need to ensure that English provision includes a broader view of literacy that that represented in the current programmes of study, reflecting operational, cultural and critical dimensions of the changing nature of literacy. Schools are encouraged to complement the National Curriculum with a wider curriculum and that might include a focus on new media for example. However if assessment and accountability frameworks foreground other kinds of achievements, then these are unlikely to be priorities.

5. The curriculum needs to be designed in ways that support children's flexible, creative and critical use of digital technologies. There are multiple dimensions of technology use in the digital age that need addressing through curriculum: e.g. cultural, social, creative, ethical, civic, critical and related to safety, skills, knowledge and design. The five 'traditions' outlined above contribute differently to these dimensions.
6. There are implications for assessment. The high stakes culture of accountability that exists in the English education system, for example, - intensified through the proliferation of digitised data- may not be conducive to the experimentation, collaborative production and risk-taking often associated with more creative applications of digital technologies. There is a need therefore to engage in debates about what we are trying to achieve, the kinds of assessments needed to gauge progress in relation to those aims, and how processes of assessment and accountability are significant to what schools prioritise.
7. Adequate funding is needed to ensure schools have reliable, up-to-date equipment and reliable networks.
8. Professional development provision needs to encourage innovation. This will involve opportunities for schools and teachers to share and debate approaches to the integration of digital technologies within and beyond the curriculum. Teachers will need ongoing and significant support to address these aspects and need to be resourced and empowered to act as professionals as they explore, experiment and think critically about the local and wider context for what they do.

### *Recommendations for schools and teachers*

The following recommendations are designed to support schools and teachers with their current work, in consolidating existing practices and planning for future developments.

1. Plan opportunities for children to work creatively with digital technologies in projects that integrate digital technologies alongside other activities. These may involve integrating technology within cross-curricular projects that are motivating and relate to topics or outcomes children care about or are interested in.
2. Plan for use of digital technologies alongside a range of resources, digital and non-digital. This will happen more easily when use of devices is 'normalised' rather than approached as a novelty. For example, where possible, provide opportunities for mobile technologies, such as tablet computers, mobile phones and iPads, to be integrated within learning in and beyond the classroom.
3. Capitalise on opportunities for collaboration on and off-screen and support children to take up such opportunities with confidence. Explore opportunities for facilitating

collaboration across groupings and generations as well as within peer groups. Encourage and support children to explore their ideas using the range of media enabled by digital technologies. This will help provide inclusive opportunities for all children to explore concepts, ideas and responses.

4. Capitalise on opportunities for children to share what they are doing with audiences outside the classroom, using blogs, Twitter, online platforms, etc., and invite and support commentary and review.
5. Encourage children to draw on their own prior experiences and expertise of using digital technologies outside school, and to share their expertise and mentor others.
6. Vary the focus of teaching related to technology use, for example, relating to technical skills, but also on design aesthetics, ethical dimensions, the process of collaborative working, etc.
7. Encourage children to review critically what their own and others' uses of technology enable them to do and be. Encourage them to consider how this is advantageous to them and to others and how it may not be.
8. Balance positive experiences of being online with guidance for children and parents on managing risk and raising awareness of tools and strategies to used when faced with bullying, unpleasant or inappropriate content and/or and contact from unknown others.
9. Work with parents to explore which devices and apps are most supportive to children's learning, play and creativity. Not only will parents welcome guidance but if teachers are to recognise and build on students' existing experience of using digital technologies outside school, they will also need to know more about the range of practices in which children engage. This process will require open dialogue with children and their families.
10. Provide continuing professional development for teachers which gives support with digital skills but also generates opportunities to explore and critique opportunities for more effective integration of digital technologies, and to reflect on their own digital lives and how they might draw on their experiences in the classroom.
11. Ensure a safe supportive atmosphere in which experimentation is encouraged, by teachers and children.

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**Companion research volume.** The original 28 research surveys, revised and re-edited with commentaries. Alexander, R.J. *et al* (ed) (2010), *The Cambridge Primary Review Research Surveys*, Routledge. 856 pp. Obtainable through normal commercial channels. <http://cprtrust.org.uk/cpr/cpr-publications/companion-research-volume/>.

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4. Pickett, K. and Vanderbloemen, L. (September 2015), *Mind the Gap: tackling social and educational Inequality*.
5. Bourn, D., Hunt, F., Blum, N., and Lawson, H. (February 2016), *Primary education for global learning and sustainability*.
6. Jopling, M., and Vincent, S. (April 2016), *Vulnerable children: needs and provision in the primary phase*.
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11. Hall, K., and Øzerk, K. (\*October 2016), *Autonomy, accountability and quality assurance in primary education: England and other countries*.
12. Hogan, D., Kwek, D., and Renshaw, P. (\*TBC 2016), *Research on teaching: what do we know and how should we act?*

\* Expected date and provisional title.

### CPRT Research Briefings

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### Primary Colours

Alexander, R.J. (ed) (June 2015), *Primary Colours: Westminster postcards from the Cambridge Primary Review Trust*. An edited collection of CPRT blogs published between July 2014 and June 2015. View/download at [http://cprtrust.org.uk/about\\_cprt/cprt-publications/](http://cprtrust.org.uk/about_cprt/cprt-publications/).

### Primary Curriculum 2014 (CPRT with Pearson)

*Primary Curriculum 2014: developing an outstanding curriculum in your school*. 86-page Illustrated handbook to support the introduction of the new national curriculum. Contributions from Pearson, CPRT and eleven of the subject associations. Published by Pearson [http://cprtrust.org.uk/about\\_cprt/cprt-publications/](http://cprtrust.org.uk/about_cprt/cprt-publications/).

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Published by Cambridge Primary Review Trust,  
The Catalyst, University of York, Heslington East  
York, YO10 5GA, UK

**ISBN 978-0-9931032-7-8**

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