The Impact of Technology on Children's Attainment in English: A Review of the Literature

Aims and Scope

This review considered the impact of ICT on children's attainment in the key curricular areas of *Reading, Spelling, Writing* and *Speaking and Listening*. The review examined research published since 2004 which considered how technology may be used to support the learning of English in children aged 5-16 years. It should be noted that previous reviews of the impact of ICT on literacy[i] and written composition[ii] concluded that the research evidence at that time was equivocal and there was a need for large scale, randomised controlled trials (RCTs) that would enable a direct examination of such questions. International studies have been included in this review to enable consideration of all evidence. Studies that used matched or within group designs rather than randomised designs have also been included for completeness.

Key Messages

- Multimedia e-books and activity-based software can improve literacy attainment in Foundation and Key Stage 1, although not all systems yield benefits.
- Activity software can improve children's written summarising skills and topic-based writing in primary school children.
- The spelling performance of children with literacy difficulties can be enhanced by programmes that include text-to-speech feedback or multisensory associations with letters and sounds. Typically-developing children's recreational use of text message abbreviations also appears to contribute positively to children's spelling attainment, although there is no significant educational benefit of giving phones to children per se.
- Interactive 'listening' toys can benefit children's oral storytelling, and can facilitate peer collaboration in the early years. Multimedia e-books can also foster collaborative learning between peers and story understanding.
- Adoption of an interdisciplinary ICT curriculum can benefit the English attainment of children in Key Stage 2.

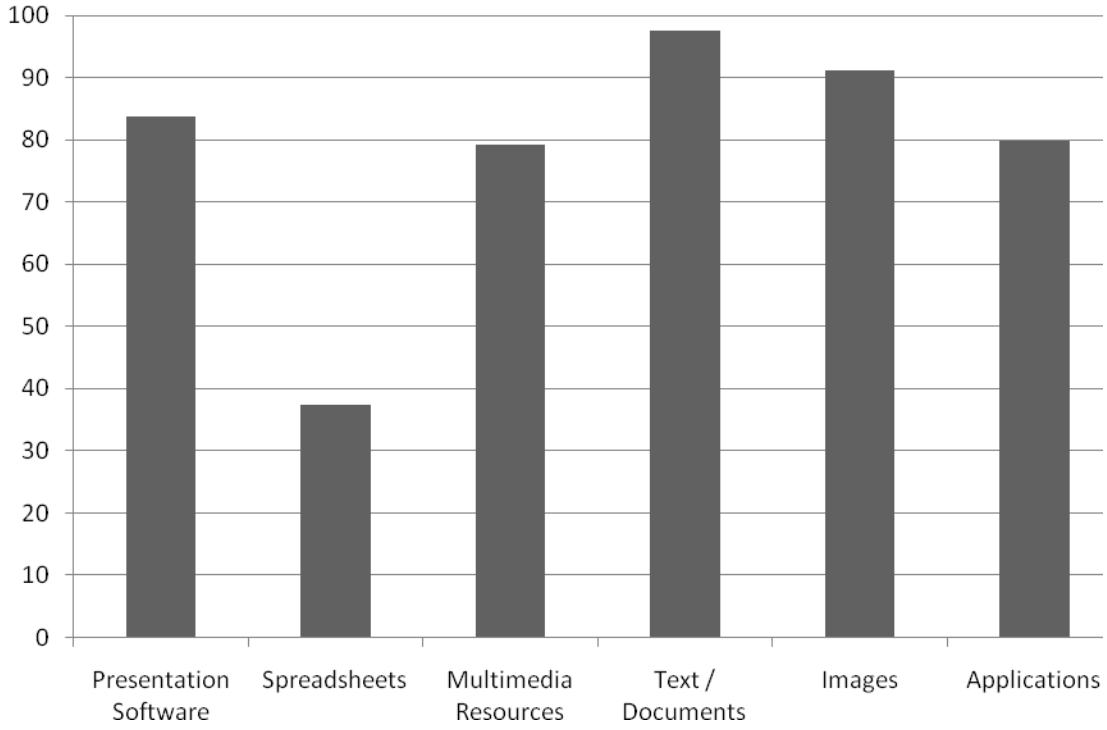
Current Use of ICT in English teaching and learning

The government is currently falling short of its target of 85% of 11-year-old children reaching Level 4 in English SATs, with 81% and 80% of children achieving this standard in 2008 and 2009 respectively. Level 4 is the standard of literacy competence deemed appropriate for a child about to enter secondary level education.

The National Curriculum emphasises the importance and potential of ICT in raising children's attainment in English both at primary and secondary level. The statutory requirements for Key Stage 1 and 2 are the provision of ICT-based texts (including

reference works and the internet), including those with 'continuous text and relevant illustrations' for children in Key Stage 1, and provision of opportunities to develop and compile ideas in print and on screen. With respect to secondary school pupils, guidance is provided on how to improve student attainment in English through effective use of ICT with a particular emphasis on 'hard to teach' concepts[iii], based on case studies provided by experienced teachers.

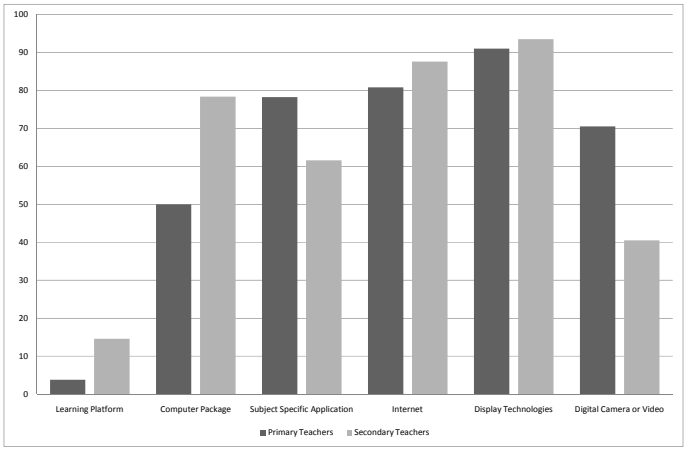
Figure 1: Percentage of English / Literacy teachers who were confident using various forms of ICT resource



Data collected from 265 UK teachers by Becta in 2009 reveals that generally Literacy / English teachers are confident users of ICT (see Figure 1). However, there is variation in terms of the different forms of ICT that are used during lessons (see Figure 2). Both primary and secondary teachers of English / Literacy use display technologies and the internet to a broadly similar degree. However, overall there is limited use of learning platforms, and secondary teachers reported using subject specific software and digital cameras less frequently than primary school teachers. However computer packages were used more frequently by secondary school teachers.

It appears from these data that although English teachers are able users of relevant ICT resources, there remains some scope for further integration of ICT into this area of the curriculum. The review of research evidence is intended to inform which aspects of ICT have the greatest potential to impact on children's English attainment at different stages of their development.

Figure 2: Percentage of English / Literacy teachers who reported using ICT in lessons more than once a week



Reading

Reading refers not just to the ability to 'decode' words on a page, but also to read with appropriate speed and expression (fluency), and to understand what is being read (comprehension). In relation to early reading skills, the development of phonological and alphabetic awareness is also a key outcome.

Children learn to decode print initially by recognising words on the basis of their key visual characteristics, without understanding that letters represent speech sounds. They then learn about the alphabetic principle, and letter-sound correspondences ('phonics'), before moving on to reading more efficiently by processing longer letter strings that are common in English. Reading comprehension can be thought of as the product of decoding and language skills – if either decoding or language processes (e.g. vocabulary level or inference making) are compromised, then reading comprehension will be poor. Reading fluency is also implicated in reading comprehension, as appropriate intonation when reading is necessary for the intended meaning of the text to be conveyed.

The types of technology that have been shown by research to support reading development are multimedia e-books and activity-based software. These are typically aimed at Foundation, Key Stage 1 and Key Stage 2 aged children.

Multimedia e-books

E-books are storybooks that are presented on a computer or other electronic device, and can vary from those which simply present text electronically to those that include multimedia features, such as pictures, animations, audio presentation of the text and on-screen activities, in some cases without the presentation of text on screen.

The performance of Foundation stage children using multimedia e-books has been compared to matched controls[iv] and randomly allocated controls[v] who received one-to-one support from an adult using the paper versions of the same texts. These studies revealed that the e-books were just as effective as a one-to-one adult tutor in terms of the improvement observed, but there were qualitative differences between the two groups in terms of the reading strategies that the children adopted[vi], and these effects were equivalent, regardless of socioeconomic status of the children[vii].

Analysis of Key Stage 1 children's behaviour during one intervention found that the children used the e-books in a way appropriate to their level of literacy, and this pattern of interaction differed from that of the children working with the adult[viii]: the e-books afforded the children greater opportunity for dialogue about the text and characters. Similarly, it was found that although children reading an e-book with a parent spent less time using them compared to paper books, they engaged in more talk around the story which was abstract and cognitively demanding (in the case of both pre-school and primary age children)[ix].

Mary teaches a class of mixed ability Year 1 children. During the literacy hour, she uses the interactive whiteboard in the classroom with the multimedia Oxford Reading Tree (ORT) for Clicker software. She starts the literacy hour by using the whiteboard with the whole class where she takes the children through the story called 'Strawberry Jam'. Mary shows the cover of the book and asks the children what they think the story is about. Together the class read the title then Mary explains the purpose of the 'loudspeaker button'. When she clicks on the button, a narrator reads each word aloud as it is highlighted visually. Mary shows the children how they can use this feature to give pronounciations of words they do not know by clicking on words in the title. She then turns to the first page and the class start to read the story together. As the children read the story with Mary she uses the 'loudspeaker' button to repeat individual keywords targeting in the story and the children listen to their pronunciation and intonation. As she works through the story, Mary points out capital letters, full stops and speech marks and asks the children questions about what is happening in the pictures that accompany the text. The children enjoy the engaging narrator, bright pictures and repetition and highlighting of the keywords. After reading the story together, the children work, at their own pace, through the story and

accompanying activities, using individual laptop computers with headphones attached. The children practice pronunciations of unfamiliar words using the 'loudspeaker' button. Struggling readers find this particularly helpful, tell Mary that they enjoy reading with the software more than reading with books. Mary also enjoys working with the software as it enables her to extend her role of providing instructions, feedback, and practice to individual children.

E-books have also been found to be effective at resourcing literacy teaching and fostering attainment when used in a UK whole class setting. These studies found that software based on the *Oxford Reading Tree* reading scheme promoted word recognition, word naming, rhyme awareness, phonological segmentation and grapheme awareness in Year 1 children after brief periods of exposure[xxi], and also promoted word recognition and enjoyment of literacy instruction in Year 1 children who were experiencing reading difficulties[xii].

A randomised control study of pre-school children in Israel[xiii] compared children who worked on a popular, commercially available e-book (*Just Grandma and Me*) as individuals to other children who worked in peer-tutoring pairs and a control group who received their normal activities. In addition to demonstrating the effectiveness of the talking book in fostering early reading skills within this age group, this research also found that the children who used e-books in peer tutoring contexts gained significantly more in terms of phonological awareness and emergent reading skills than the control group.

Activity-based software

A large US-based RCT study evaluated teachers' use of commercially available technology products for supporting literacy development in both KS1 and KS2 aged children. This found no significant evidence of effectiveness for either age-group for such productsxiv. A follow-up study also assessed whether an additional year of teacher experience using the selected products would result in a greater impact on pupil outcomes. Again, there was no significant evidence of additional improvement in test scores as a result of the additional year of experience with the technologyxv. When individual products were considered, only LeapTrack (used with children aged 9-10 years old) had a significant impact on reading attainment (NB. this system is not currently available in the UK).

A commercial programme of computer-based support for reading that was found to benefit Foundation children was the Waterford Early Reading Program. American Kindergarten children used the program for 15 minutes per day for eight months and were pre and post tested on standardised tests of reading ability and phonological awareness. There was evidence that the programme was effective at improving reading ability relative to control classes within the same schools, but there was no evidence of improvement in phonological skillsxvi (again, this resource is not currently available in the UK).

An alternative software resource which is free and available via the internet is ABRACADABRA. This Canadian resource is a suite of copyright-free multimedia e-books and associated literacy activities which support word reading, phonics, reading comprehension, listening comprehension and reading fluency. Content is levelled and structured, but can be tailored to suit the individual pupil or teacher's needs, and is designed to offer a balanced programme of reading instruction, based on the research evidence on what skills are important. It is currently used in a systematic way across large areas of Canada (Quebec) and Australia (Northern Territories), but is available worldwide. Support materials for teachers and parents are also provided online.

This resource has been found to significantly improve phonological skills in Canadian Kindergarten (Reception) children when used to deliver an 11 week synthetic phonics programme (15 minute sessions delivered three times a week in groups of four children) compared to an analytic phonics comparison group[xvii]. An RCT of Grade 1 children[xviii] showed that pupils who received structured programme of synthetic phonics intervention four times a week (20 minutes) using ABRACADABRA improved significantly more than controls who received regular classroom tuition on measures of phoneme blending, reading comprehension and listening comprehension, and continued to outperform controls on assessments of phoneme blending and reading fluency at a delayed post-test, seven months after the intervention programme concluded.

ABRACADABRA also appears to present children with an engaging learning environment which reduces the impact of attentional difficulties on reading outcomes. In an extension to the Grade 1 study, it was found that although individual differences in attention could account for reading outcomes in the control group during the study, this relationship disappeared in the children engaged in the synthetic phonics intervention[xix].

Sam is aged 6 and has been experiencing difficulties learning to read and spell. He is a lively child - full of energy, but hard to keep on-task as he requires constant stimulation. His teachers are persisting with *Letters and Sounds* at school, and his parents are keen to support him at home. Each night he comes home and gets straight on the family computer. He has taken to playing on the *ABRACADABRA* website after his parents showed him some of the activities, which have a game-like interface, immediate feedback and are suited to his developmental level. He selects a story genre and book, and then works through a range of activities that are linked to the words in that text. His parents let his curiosity lead him to the activities that he is most interested in completing, whilst showing him new ones that he has not explored yet, to ensure that he does not focus on one type of activity to the exclusion of others. Some of the games allow his parents to join in and play the games with him: for example, Sam delights in beating his mother on the reading fluency task in which he has to read at an appropriate pace – she typically reads too fast! Without prompting Sam spends around 1-2 hours a night exploring the activities and texts

available on the website, and reports enjoying them. His parents are pleased to see his new level of engagement with print activities – reading homework is transformed into game play, and his parents feel that they have structured resources to help him catch up with his peers.

A more recent approach which is noteworthy is the phonological awareness training game that has been developed for download onto children's mobile phones by a team of leading Finnish reading researchersxx. Following on from their longitudinal study of children at risk of reading failure, researchers designed a game that trained children to map speech to text in a systematic way that could be used to train children in the two months prior to school entry, through daily game play (support materials are provided for parents and teachers). To date, over 50,000 Finnish children have accessed the game, and it is being piloted in Zambia and an English language version of it is also under development and evaluation. The most recent data suggests that a 12 week programme of use by children experiencing reading difficulties results in significantly greater improvement in reading, spelling and phonological awareness than that observed in children receiving no treatment or an alternative (maths) intervention programmexxi.

In Florida, the State's Department for Education commissioned an internet-based resource to support students working towards state targets in reading and maths. An evaluation of this resource (FCAT Explorer) based on a matched control design found significant improvement Grade 4 (9-10 year old children's) reading scores amongst schools using itxxii.

Another Florida-based study examined the potential of software, which was originally intended to teach children to sing, to support children's reading developmentxxiii. The software offers children the opportunity to practice reading song lyrics (which increased in reading difficulty) over the course of the nine-week study. The lyrics were also shown visually in a way which was intended to represent the relative pitch and timing that they should be sung to. The software was used three times a week (30 minutes per session) with a group of 24 children who were underachieving in reading relative to State norms. These children were compared to a closely matched control group from the same school. Results showed that use of this commercially available software (Carry-a-Tune) significantly improved the children's reading development, and follow up assessments showed that there was improvement equivalent to improving 1.4 grades in six months.

An Italian study examined the impact of a software programme, which highlighted the syllables in words, on the reading speed children with reading difficulties aged 8-9 years xxiv. The programme was found to be effective, but as Italian is a more regular orthography than English the results of this study may not generalise to a UK population.

A small scale (N=12) US study considered whether a series of cloze reading and anagram exercises delivered via an internet-based software programme could support the reading development of Grade 1 children at risk of reading difficulties because of socio-economic need[xxv]. All children took part in both the computer-mediated intervention and pen-and-paper versions of the same exercises. There was some evidence of improved word reading in the software group, and the children tended to read words aloud more when using the computer-mediated activities than when performing the same tasks on paper.

Writing

Writing comprises various aspects: text generation (the production of appropriate words and sentences); transcription (handwriting, typing and spelling); and executive function (conscious attention, reviewing, planning, revision strategies). There has been limited research into how technology can support written composition skills, and this reflects a general lack of research into written composition in general. There were some studies that showed that a technology-based approach to teaching writing and summarising can be effective. However, there is research evidence that typing on a keyboard rather than writing by hand can result in poorer compositions, because typing requires more cognitive resources than handwriting does.

A US study suggests that appropriately designed software can positively impact on the quality of 6th Grade (11-12 year old) children's ability to summarise texts[xxvi]. The *Summary Street* software enabled children to compose written summaries of specified texts and then request a structured sequence of feedback on how well they had done: the first stage highlights misspelled words, the next stage indicates whether the summary is of an appropriate length, and how well key topics have been covered. Once acceptable levels have been reached on these elements, the children are further able to request feedback on the relevance of each sentence and potential redundancy between sentences. The evaluation study showed that children who received all levels of feedback from the software outperformed the matched control group who received only feedback on spelling and length of summary: they spent more time editing their work; they achieved higher content scores; and there was evidence that the skills learned from the computer feedback were maintained when subsequently summarising without access to feedback.

Another US study considered the impact of an internet-based programme (TELE-web) on the writing composition of a small group of primary school children with special educational needs[xxvii]. The TELE-web software is based on a concept mapping approach to developing aspects of a piece of written work and was compared to pen and paper based intervention which was identical in all features to the computer based tool, which only offered children easier manipulation of their ideas on the screen. The TELE-web children showed significant improvement in their writing: overall the quality of the writing was rated as better, and there was better clarity, more breadth and depth evident in the treatment of the topics covered, and they were more likely to include a conclusion than the children who had received

the paper-based training. Moreover, there was unexpected improvement in basic writing skills, such as use of punctuation. However, it should be noted that the children were not randomly allocated to groups or matched: the teachers in the two conditions were different and the TELE-web group were taught by teachers who were experienced users of ICT.

A UK study of Year 5/6 children in Nottingham evaluated the impact of a visual approach to using technology to support story composition. The children were asked to write a story and then produce a cartoon version of the same story either on paper on using a specially designed piece of software for generating cartoons. They were then asked to write their story again, based on either their paper-based or computer-generated cartoons. The results suggest that there were no strong benefits for the children using the software in terms of the quality of their written stories[xxviii].

A cautionary note is flagged by the results of a UK investigation of the impact of computer use on the quality of children's written work[xxix]. Forty-eight Year 5 and Year 6 UK primary school children were assessed on their handwriting speed, typing speed and their ability to produce a piece of creative writing to standard prompts using either pen and pencil or a word processor. Their written work was scored according to standardised criteria, and the written compositions produced on a keyboard were rated as significantly poorer than the handwritten compositions were – the standard scores indicated that the typed assignments were typically 18-24 months below the standard of work produced by hand. It is suggested that this may be because typing requires more conscious effort than handwriting, leaving less cognitive resource for the composition aspect of the activity. Practice at making typing highly practiced and fluent is advocated to counteract such effects.

Spelling

Although spelling is often the means by which children come to understand how the alphabetic principle works, spelling typically lags behind reading ability. This is because spelling is more dependent upon an understanding of the phonic rules in English than word reading is and these rules are complex and often dependent upon subtle morphological rules of English which are typically not explicitly taught.

The technologies evaluated by studies in this area tend to be more diverse than those examined in relation to children's reading development, and suggest that well-designed multimedia software and children's recreational use of mobile phone technology can impact on spelling attainment.

A Norwegian study examined the impact of software which was designed to allow users to import any text that they wished to read (for example, via scanning) into an interface which: used highlighting to show where the children were in the text; enabled the user to request text-to-speech feedback on specific words or sentences which they found difficult to read; and included a text editor which enabled the children to summarise the text if they wished, or compose their own writing. This

software was evaluated in terms of its ability to support the literacy development of 9-12 year old children who were experiencing literacy difficulties. Children were randomly allocated to either the intervention (seven weeks of daily 20 minute use of the software) or control groups. Control children received regular classroom tuition during the intervention period, including use of other software available. Results revealed that the reading and spelling performance of the children who used the software significantly improved, and gains were maintained at follow-up 11 weeks later. It was also found that use of the text-to-speech facility in the software could account for gains in spelling and a sentence reading (comprehension) assessment[xxx].

George experiences dyslexia, and finds it difficult to proofread his work and to structure his thoughts effectively in writing. He has been trained by the classroom assistant how to use text-to-speech software in a selective way. The texts that he has to work with at school are scanned into a PC using a standard text-scanning package which came with the scanner, and which is then checked by a classroom assistant or parent for any scanning errors that might have crept in. George then accesses the texts on a PC, and is encouraged to read as independently as his abilities will allow. When he gets stuck on a word that he cannot decode, he uses his text to speech software to read just that word aloud to him. He then reads the sentence again. He has a word processing document open in the background where he can make notes and record any ideas as they occur to him, so that he does not have to hold them in memory. The word processor allows George to move sentences around on screen into different orders so that his ideas make the most sense. Again, the text to speech software on the PC enables George to hear the work his is composing read aloud to him. Working on the PC means that Georg can also use mind mapping software to help him to structure his ideas before attempting to write about them.

Multisensory approaches to supporting children's literacy development are known to be effective. In one ICT-based implementation of this idea, German children completed three months of training using a programme (*Dysbuster*) in which pupils were trained to make associations between visual and auditory stimuli. Text was presented with various colour-to-symbol and shape-to-symbol associations, and musical notes were also associated with letters such that melodies were generated by on-screen text. The spelling performance of both children with and without dyslexia was found to benefit from training with this multisensory programme[xxxi].

Mobile phone use by school-age children is controversial, but it is noted that UK some children receive their first phone at age 5[xxxii]. This need not be a cause for concern in terms of literacy development: children's knowledge of text message abbreviations (textisms) is positively associated with scores on standardised measures of reading and spelling ability[xxxiii], and this is attributable to the development of phonological skills which use of these abbreviations appears to foster[xxxiv]. Moreover, textism use could account for significant growth in spelling

ability after controlling for individual differences in verbal IQ and phonological awareness.

However, giving recreational access to mobile phones to 9-10 year old children does not impact significantly on their literacy attainment over the course of an academic term compared to that of randomly allocated controls. However, for the children who did receive the phones, there was again evidence that textism use in this group could account for growth in spelling scores after controlling for IQ and the number of messages sent and received during the study.

A recent study examined the impact of a proofreading tool on the spelling ability of UK secondary children (13-15 year olds) with reading difficulties. The children were given access to the homophone detection tool in *Read and Write* (Gold Version). This group were better at spotting and correcting homophone mistakes, relative to two different randomly allocated control groups (one group simply had the homophones highlighted on the page and the other group received no support). However, there was also evidence that the weakest readers in the intervention group were also incorrectly changing homophones more often. There were no strong benefits for spelling relative to the other two groups after the intervention period, suggesting that simply highlighting the presence of homophones in a text is just as effective at improving spelling attainment as use of the assistive technology was[xxxv].

Speaking and listening

Speaking and listening refers to the ability to articulate and verbally develop ideas clearly, develop 'active listening strategies' and critical thinking skills, participate appropriately in group activities, work collaboratively with others, and to improvise in the context of drama work and produce appropriate 'scripts'.

Recent research in this are has looked at the ways in which technology can support speaking and listening skills, which in turn impacts on children's narrative composition skills, and also how they can be used as a focus for collaborative activity between peers on literacy orientated tasks in the early years.

There has been interest in the potential of technology to support the speaking and listening skills that underpin effective story writing. To engage children who are in the Foundation stage or Key Stage 1, resources have been designed that move children away from traditional computer-based interfaces, as aspects of these were found to restrict children's written story telling in some important respects[xxxvi]. One interface comprised a colourful playmat which children could also use to record their own stories and listen to them replayed. An evaluation of this resource also compared the children's work with the mat when they played alone or with a peer. Children who played with this mat engaged in significantly more symbolic transformations than children who played with an identical but passive mat, and they also adopted the role of narrator rather than a character more often than the control

children. The recognition of the need for a narrative voice is seen as an important step towards mature storytelling.

Another interface type that has been formally evaluated was the use of a projected virtual peer 'Sam' in an environment which included a model (castle) and toy character which the child could use to tell a story. The virtual peer initially modelled developmentally more advanced story telling with the same model and character. The children who engaged in storytelling in this context used significantly more decontextualized language markers than children who played with the castle without the virtual peer[xxxvii]. Pairs of children who played with the virtual peer also engaged in less 'off task' talk than pairs playing with the castle alone, indicating that this resource facilitated appropriate peer-to-peer task collaboration.

A smaller UK-based study of Key Stage 1 children found that children as young as five could collaborate appropriately on a literacy task when pairs of children were asked to share a multimedia e-book. There was no difference in performance in children who were placed in a mixed or same ability pairing. However, it seems that gender was a factor: girls were better able to accommodate their partner than boys (none of the boys could match their partner's use of the software), and that this ability was related to literacy attainment[xxxviii].

As part of an ICT-enhanced approach to supporting literacy development in reception class, pairs of children are directed to use multimedia talking books to hear stories read to them and to explore the relationship between print and speech independently of the teacher. Before each session, the children (one boy and one girl) are given clear instructions about how to use the software. Ground rules for working together around the computer discussed and established, including what to do if there is a disagreement. The children are often observed to enact aspects of the story being told to them, and they prefer to attempt to read individual words on the page independently where this is possible. Connections between their own experiences and the story they are interacting with are often made by the children. The children are asked to retell the story to the teacher or to a classroom assistant once they have completed the joint activity.

A Dutch study has also shown that e-books have the potential to foster the development of speaking and listening in Foundation stage. This study found that multimedia e-books which present no text on screen are just as able to foster story understanding as traditional print books are[xxxix]. Moreover, pre-school children from immigrant homes where the parents had low educational level were found to benefit from such resources when they included multimedia animation, which was found to foster story comprehension/recall, vocabulary development and understanding of syntax[xl].

With respect to older children, in one US-based study, Grade 8 (13-14 year old) students were directed to produce collaborative multimedia mini documentaries

based on a 6 week history unit, and their performance on key outcome measures was compared to that of a control school who had administered a more traditional approach to teaching the same history topic. There was evidence of superior improvement from pre to post test for the students who received the 'technology enhanced' history curriculum on the Knowledge test (50 item multiple choice test developed by the social studies teachers at both schools based on state content standards) and student attitudes towards social studies. The intervention school was also found to outperform the control school on a 'high stakes' state social science test, and analyses of these scores showed that the technology school students outperformed the control school on topic areas outside of the one covered by the intervention[xli]. This is interpreted as evidence of a skills- transfer effect but it may equally be seen as evidence that the intervention school had better levels of social science teaching than the control school did, so care needs to be taken in the interpretation of these data.

Pedagogical approaches to integrating ICT

A key area of consideration is whether it is more effective to integrate ICT across the school curriculum in an integrated and interdisciplinary way, or whether it is better to use ICT resources in specific technology-orientated classes. In the context of the present review, the impact of these pedagogical strategies on the English attainment of pupils is considered.

A recent large-scale randomised control study in a bilingual school in Manila[xlii] assessed the impact on primary level English learning of adopting a thematic and interdisciplinary ICT curriculum, based on the US *International Society for Technology in Education* (ISTE) foundation standards for student use of information technology. Themes adopted as the basis for developing students' ICT skills included: home, school, neighbourhood, city, country and world. Teachers worked collaboratively to develop lesson plans that enabled students to achieve the specified ICT-based learning outcomes in the context of these interdisciplinary themes. Results showed that there was significantly greater improvement in English scores for the children in Grades 2 and 3 (7-9 year olds) who received the interdisciplinary ICT curriculum compared to the control group who received a non-integrated ICT curriculum which aimed to achieve the same learning outcomes. The size of these contributions to English attainment across the school year was modest, however, accounting for only 5.3% and 7.2% of variation in the children's scores respectively.

These findings are consistent with those from the UK *ImpaCT 2* study data. This study also found that an interdisciplinary approach to integrating ICT impacts on children's English attainment in Key Stage 2, but not in Key Stage 3 or Key Stage 4 (NB. KS1 was not assessed)[xliii].

Conclusions

- Multimedia e-books and activity-based software can improve literacy attainment in Foundation and Key Stage 1, although not all systems yield benefits.
- Activity software can improve children's written summarising skills and topic-based writing in primary school children.
- The spelling performance of children with literacy difficulties can be enhanced by programmes that include text-to-speech feedback or multisensory associations with letters and sounds. Typically developing children's recreational use of text message abbreviations also appears to contribute positively to children's spelling attainment, although there is no significant educational benefit of giving phones to children per se.
- Interactive 'listening' toys can benefit children's oral storytelling, and can facilitate peer collaboration in the early years. Multimedia e-books can also foster collaborative learning between peers and can foster story understanding.
- Adoption of an interdisciplinary ICT curriculum can benefit the English attainment of children in Key Stage 2.

Recommendations

- There is a need for larger-scale UK randomised control trials examining the educational impact of using technology to enhance English learning across age groups and key areas.
- Research into the impact of technology on English in KS3 and KS4 is particularly needed.

---

[i] Torgerson, C. & Zhu, D. (2003). A systematic review and meta-analysis of the effectiveness of ICT on literacy learning in English, 5-16. In *Research evidence in education library*. EPPI-Centre, Social Science Research Unit, Institute of Education, London.

[ii] Andrews, R., Freeman, A., Hou, D., McGuinn, N., Robinson, A., & Zhu, J. (2007). The effectiveness of information and communication technology on the learning of written English for 5- to 16-year-olds. *British Journal of Educational Technology, 38*, 325-336.

[iii] http://nationalstrategies.standards.dcsf.gov.uk/search/secondary/results/nav:46119

[iv] Wood, C. (2005). Beginning readers' use of 'talking books' can affect their reading strategies. *Journal of Research in Reading, 28*, 170-182.

[v] Korat, O., & Shamir, A. (2007). Electronic books versus adult readers: effects on children's emergent literacy as a function of social class. *Journal of Computer Assisted Learning, 23*, 248-259.

[vi] Wood, C. (2005). Beginning readers' use of 'talking books' can affect their reading strategies. *Journal of Research in Reading, 28*, 170-182.

[vii] Korat, O., & Shamir, A. (2007). Electronic books versus adult readers: effects on children's emergent literacy as a function of social class. *Journal of Computer Assisted Learning, 23*, 248-259.

[viii] Wood, C., Pillinger, C., & Jackson, E. (2010). Understanding the nature and impact of young children's learning interactions with talking books and during adult reading support. *Computers and Education, 54,* 190-198.

[ix] Kim, J.E. & Anderson, J. (2008). Mother-child shared reading with print and digital texts. *Journal of Early Childhood Literacy, 8*, 213-245.

[x] Karemaker, A., Pitchford, N.J., & O'Malley, C. (2008). Using whole-word multimedia software to support literacy acquisition: a comparison with traditional books. *Educational and Child Psychology, 25*, 97-118.

[xi] Karemaker, A.M., Pitchford, N.J., & O'Malley, C. (2010). Does whole word multimedia software support literacy acquisition. *Reading and Writing, 23*, (1).
[xii] Karemaker, A., Pitchford, N.J., & O'Malley, C. (2010). Enhanced recognition of written words and enjoyment of reading in struggling beginner readers through whole word multimedia software. *Computers and Education, 54*, 199-208.
[xiii] Shamir, A., Korat, O., & Barbi, N. (2008). The effects of CD-ROM storybook reading on low SES kindergarteners' emergent literacy as a function of learning context. *Computers and Education, 51*, 354-367.
[xiv] Dynarski, M., Agodini, R., Heaviside, S., Novak, T., Carey, N, Campuzano, L., et al. (2007). *Effectiveness of Reading and Mathematics Software Products: Findings from the First Student Cohort.* Washington, D.C.: US Department of Education, Institute of Education Sciences.
[xv] Campuzano, L., Dynarski, M., Agodini, R., & Rall, K. (2009). *Effectiveness of Reading and Mathematics Software Products: Findings from Two Student Cohorts (NCEE 2009-4041).* Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Educational Sciences, US Department of Education.
[xvi] Tracey, D.H. & Young, J.W. (2007). Technology and early literacy: the impact of an integrated learning system on high-risk kindergartners' achievement. *Reading Psychology, 28*, 443-467.
[xvii] Comaskey, E.M., Savage, R.S., & Abrami, P. (2009). A randomised efficacy study of web-based synthetic and analytic programmes among disadvantaged urban Kindergarten children. *Journal of Research in Reading, 32,* 92-108.
[xviii] Savage, R., Abrami, P., Hipps, G., & Deault, L. (in press). A randomised controlled trial study of the ABRACADABRA reading intervention program in Grade 1. *Journal of Educational Psychology, 101,* 590-604.
[xix] Deault, L., Savage, R., & Abrami, P. (2009). Inattention and response to the ABRACADABRA web-based literacy intervention. *Journal of Research on Educational Effectiveness, 2,* 250-286.
[xx] Lyytinen, H., Erskine, J., Kujala, J., Ojanen, E., & Richardson, U. (2009). In search of a science-based application: a learning tool for reading acquisition. *Scandinavian Journal of Psychology, 50*, 668-675.
[xxi] Kyle, F., Richardson, U., Khan, C., Lyytinen, H., & Goswami, U. (2010). The effect of reading motivation when using a computer-assisted intervention (GraphoGame-Rime) with poor readers. Paper presented at the *Society for the Scientific Study of Reading Annual Meeting*, Berlin, July.
[xxii] Martindale, T., Pearson, C., Curda, L.K., & Pilcher, J. (2005). *Journal of Research on Technology in Education, 37*, 349-360.
[xxiii] Biggs, M.C., Homan, S.P., Dedrick, R., Minick, V., & Rasinski, T. (2008). Using an interactive singing program: a comparative study of struggling middle school readers. *Reading Psychology, 29,* 195-213.
[xxiv] Tressoldi, P.E., Vio, C., & Iozzino, R. (2007). Efficacy of an intervention to improve fluency in children with developmental dyslexia in a regular orthography. *Journal of Learning Disabilities, 40, 203-209.*
[xxv] Englert, C.S., Zhao, Y., Collings, N., & Romig, N. (2005).Learning to read words: the effects of internet-based software on the improvement of reading performance. *Remedial and Special Education, 26 (6).* 357-371.
[xxvi] Wade-Stein, D. & Kintsch, E. (2004). Summary Street: Interactive computer support for writing. *Cognition and Instruction, 22,* 333-362.
[xxvii] Englert, C.S., Zhao, Y., Dunsmore, K., Collings, N.Y., & Wolbers, K. (2007). Scaffolding the writing of students with disabilities through procedural facilitation: using an internet-based technology to improve performance. *Learning Disability Quarterly, 30 (Winter),* 9-29.
[xxviii] Madden, M., Chung, P.W.H., & Dawson, C.W. (2008). The effect of a computer-based cartooning tool on children's cartoons and written stories. *Computers and Education, 51,* 900-925.
[xxix] Connelly, V., Gee, D., & Walsh, E. (2007). A comparison of keyboarded and handwritten compositions and the relationship with transcription speed. *British Journal of Educational Psychology, 77*, 479-492.
[xxx] Fasting, R.B., & Lyster, S-A., H. (2005). The effects of computer technology in assisting the development of literacy in young struggling readers. *European Journal of Special Educational Needs Education, 20,* 21-40.

[xxxi] Kast, M., Meyer, M., Vogeli, C., Gross, M., & Janke, L. (2007). Computer-based multisensory learning in children with developmental dyslexia. *Restorative Neurology and Neuroscience, 25*, 355-369.
[xxxii] Plester, B., Wood, C. & Bell, V. (2008). Txt msg n school literacy: does texting and knowledge of text abbreviations adversely affect children's literacy attainment. *Literacy, 42,* 137-144.
[xxxiii] Plester, B., Wood, C., & Joshi, P. (2009). Exploring the relationship between children's knowledge of text message abbreviations and school literacy outcomes. *British Journal of Developmental Psychology, 27,* 145-161.
[xxxiv] Wood, C., Plester, B., Bowyer, S. (2009). Liter8 Lrnrs: is texting valuable or vandalism? *British Academy Review, 14,* 52-54.
[xxxv] Lange, A.A., Mulhern, G., & Wylie, J. (2009). Proofreading using an assistive software homophone tool. Compensatory and remedial effects on the literacy skills of students with reading difficulties. *Journal of Learning Disabilities, 42*, 322-355.
[xxxvi] Cassell, J. (2004). Towards a model of technology and literacy development: story listening systems. *Applied Developmental Psychology, 25,* 75-105.
[xxxvii] Cassell, J. (2004). Towards a model of technology and literacy development: story listening systems. *Applied Developmental Psychology, 25,* 75-105.
[xxxviii] Wood, C., Littleton, K., & Chera, P. (2005). Beginning readers' use of talking books: styles of working. *Literacy*, 135-141.
[xxxix] De Jong, M.T. & Bus, A.G. (2004). The efficacy of electronic books in fostering kindergarten children's emergent story understanding. *Reading Research Quarterly, 39*, 378-393.
[xl] Verhallen, M.J.A.J., Bus, A.G., de Jong, M.T. (2006). The promise of multimedia stories for kindergarten children at risk. *Journal of Educational Psychology, 98*, 410-419.
[xli] Hernandez-Ramos, P. & De La Paz, S. (2009). Learning history in middle school by designing multimedia in a project-based learning experience. *Journal of Research on Technology in Education.* 42, 151-173.
[xlii] Ching, G.S. (2009). Implications of an experimental information technology curriculum for elementary students. *Computers and Education, 53,* 419-428.
[xliii] Harrison, C., Lunzer, E.A., Tymms, P., Fitzgibbon, C.T. & Restorick, J. (2004). Use of ICT and its relationship with performance in examinations: a comparison of the ImpaCT2 project's research findings using pupil-level, school-level and multilevel modelling data. *Journal of Computer Assisted Learning, 20*, 319-337.