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Technology and literacy in early childhood educational settings: a review of research

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Abstract

This literature review provides an overview of research into technology and literacy for children aged 0-8 in educational settings from 2003-2009. The paper begins by exploring the different assumptions about the role of digital texts that underpin the studies considered, identifying three loose categories of studies which position technology as: deliverer of literacy; site for interaction around texts; and medium for meaning-making. Following this, actor-network theory (Latour, 2005) is used to consider other ways that technology and children may be 'acting upon' literacy in educational settings through recontexualising meanings from other domains. The paper concludes by arguing that there is a need for more extensive exploratory research in this field, which considers how digital practices within educational settings relate to other dimensions of children's literacy learning, in order to better understand how new technologies are and could be contributing to children's literacy within educational settings. It also suggests that actor-network theory may offer a way of destabilising the assumptions that frame research into young children's engagement with new technologies in order to conceptualise this in new ways.

Key words: literacy, technology, digital literacy, new technologies, young children, actor-network theory

Introduction

Describing the 'textual landscape' in which young children grow up, Carrington (2005) lists varied ways that children may be active in multimodal global spaces, as they play and interact with and within environments created through digital technologies such as computer games and virtual worlds. Whilst the last decade has seen increasing calls for educational settings to reflect and build upon young children's experience of this landscape in their literacy provision, debates about the role of new technologies in early years settings continue. Some have argued that new technologies are a distraction from more 'natural', 'healthy' and 'developmentally appropriate' activities, or raised concerns that young children may access inappropriate content, risk personal safety through developing online relationships or engage uncritically with information (Miller, 2005). At the same time, studies have highlighted a lack of confidence and competence amongst early childhood educators in relation to new technologies (Chen and Chang, 2006; Plowman and Stephen, 2005), national policies relating to early literacy have implied conflicting messages about the relationship between technology and literacy, and there is still variance in children's access to and use of technology within and outside school. There would seem therefore to be an urgent need for those involved in educational policy and practice to understand better the possibilities for integrating new technologies within early literacy provision and gain informed insights about children's experience and response to such opportunities. This review focuses on how recent research is contributing to this understanding by describing the scope of empirical research into technology and literacy within educational settings for children aged 0-8 between 2003 and mid-2009. Following an analysis of the role that seems to be ascribed to new technologies through the practices being researched, Latour's work (Latour, 1988; 2005) is used to prompt hypotheses about *how else* children and technologies may be acting upon these practices and highlight how a shifting of the researcher's perspective might reveal other relevant dimensions of children's interactions with new technologies.

Literacy, technology and education for young children: perspectives from policy and research

Research into the practices surrounding digital texts has supported calls to re-conceive the nature and significance of literacy provision. Lankshear and Knobel note how, whilst some textual practices involving new technologies replicate those associated with print texts, or 'old literacies', others are associated with what they call 'new literacies', patterned by distributed relationships, multiple identities, multimodality and global participation (Lankshear and Knobel, 2006). Movements from 'old' to 'new' literacies are evident in shifting practices on the Internet, as characterised by movements from Web 1.0 to 2.0 to 3.0 with their respective emphases on widening access to

knowledge, enabling social participation, and providing ever more personalised and co-ordinated access to information and networks (Davis and Merchant, 2009). It has been argued therefore that educational contexts should provide children with opportunities to explore digital environments, and develop their critical evaluation of digital texts and critical participation in digital worlds (Media Literacy Task Force, 2004; Snyder, 2001).

In considering the significance of this for the early years, it is worth noting that studies of children's interactions with digital texts in informal settings have highlighted the playfulness, agency and creativity with which very young children may engage with digital texts. Marsh's study of 2 ½ - 4 year-olds at home draws on interviews and observational data to describe the active meaning-making in which young children engage as they encounter a range of new technologies including computer games and mobile phones (Marsh, 2004). Studies of individual children provide specific examples of children's experimentation and sense-making around digital texts. Smith (2005), explores how her 2 ½ -3 ½ year-old daughter developed and articulated her understanding of hypertext through role play about computer games. Pahl, reporting a longitudinal ethnographic study of children's communicative practices, describes how three 6-7 year-olds drew on narratives and characters encountered in console games as 'cultural resources' which they used and 'recontextualised' in their play and their drawings (Pahl, 2005:135). Mavers (2007), analysing an email exchange between a 6 year-old and her uncle, highlights design choices the child made in order to enhance the impact of her messages. These studies remind us that children can participate in meaningful exchanges that are relevant to their current lives: engaging with digital texts then is about 'being rather than becoming' literate (Mavers, 2007: 172). Such explorations of young children's digital practices are useful in highlighting the 'funds of knowledge' (Moll, Amanti, Neff and Gonzalez, 1992) that young children bring to educational settings.

Despite increased recognition that new technologies should be effectively integrated within early years curricula (Plowman and Stephen, 2005), state-sponsored guidelines relating to literacy and technology could be seen as inconsistent. In England, for example, the government has published case studies exemplifying use of new technologies in early years settings (DCFS, 2009a). However, the 'early learning goals' for 'communication, language and literacy', which establish expectations for what most children will achieve by the age of five (DCSF, 2008), contain no reference to children's engagement with digital texts. From age five onwards, the government currently recommends that children's literacy learning is structured by the Primary National Strategy Framework for Literacy (PNS, 2006). Whilst this requires teachers to plan to use on-screen multimodal texts, assessment criteria still reflect the skills and knowledge associated with print-based alphabetic literacy. Gomez, Johnson and Gisladottir (2007), describing a similar context for early literacy education in the United States, note how this emphasis on acquiring skills for use in later life, described by Freire (1972) as a 'banking approach', can focus teachers' attention away from the task of developing their students as engaged and flexible literacy users and ignore the literacy experiences children bring with them to school. Given the social and participatory dimension of new literacies described above, such provision would seem to reflect a limited and outdated vision of literacy education.

Studies which have explored relationships between home and school literacies have highlighted discontinuities and tensions in relation to the use of new technologies. McTavish's (2009) case study of 8 year-old Rajan exemplifies how children may differentiate between literacy practices at home and school: whilst Rajan's school-based practices were book-based, individual and print orientated, his home-based practices were multilingual and often associated with networked, multimodal texts embedded in meaningful, social contexts. Occasionally, these literate practices crossed boundaries. Homework associated with school-based literacy was done in Rajan's bedroom or dining room and he wrote about MSN and included graphics from video games in handwritten schoolwork. Despite such fluidity, Rajan seemed to sustain separate literate lives within and beyond school. Levy (2009) describes how such contrasts may impact negatively on young children's literate identities. Like the studies cited above, her work draws attention to children's meaningful interactions with multimodal screen-based texts in the home. However, her longitudinal study of young children's perceptions of reading explores how children's emerging perceptions of literacy, based on wide-ranging encounters

with texts, changed as they entered formal educational settings. She notes how their understandings of the meaning-making process seemed to shift as they engaged with 'schooled' approaches to literacy, and for some this led to a loss of confidence in themselves as readers. Whilst further work exploring children's digital practices is needed to complement these small-scale studies, these insights into the breadth and agency associated with digital practices beyond institutional settings suggest there is a need to address possible discontinuities between home and school literacies. Given this, it is worth noting the findings of previous research reviews which have mapped the scope and range of research into literacy and technology for young children.

Reviews of research into technology and literacy for young children

As Lankshear and Knobel (2003) explore, conducting meta-analyses of research in this field is problematic as technologies and associated practices evolve so quickly. Drawing conclusions about the effectiveness of using computers, or how children use their digital experience in classrooms, may conceal differences in both the technologies and practices explored by different studies. Indeed such an exercise could be seen as reifying existing approaches and resources rather than informing future possibilities. Previous reviews in this field, however, do highlight trends in how the relationship between technology and literacy has been conceived.

Labbo and Reinking's review of research into computers and literacy in early childhood from the 1960s until 2002 (Labbo and Rienking, 2003) identified five broad categories of research, which relate variously to the use of technology to support existing literacy provision and to explore digital literacy. These included the use of computers to promote: writing composition; individualised drill and practice in phonics; individualised reading; social interaction and collaboration; and engagement with digital texts. Lankshear and Knobel (2003), reviewing studies of technology and literacy for the 0-8 age range between 1999 and 2002, noted the scarcity of research in this field. They explored the assumptions about literacy underpinning different studies, noting the prevalence of studies from a psychological-cognitive perspective, that focus on literacy as a set of isolated skills. The majority of studies focused on the use of standalone technology designed to support encoding/decoding of alphabetic print. No studies investigated what they call 'discursive prowess' in using networked texts. Merchant (2007), reviewing digital writing in the early years, concluded that this area had been under-researched and states the urgent need for 'exploratory research that looks at how digital writing can infuse and transform the early years' curriculum.'

Reviews of research into literacy and technology for wider age-groups (Andrews, 2004; Burnett, 2009a) noted similarly that the surprisingly small amount of research in the field was dominated by assumptions and practices associated with a psychological-cognitive model of print-based literacy. My work (Burnett, 2009) distinguishes between those studies which involve children in 'digital literacy', focusing on practices involving the production and consumption of digital texts, and those which investigate the use of technology to develop skills associated with alphabetic print-based literacy. Whilst this earlier review of studies related to the 5-11 age group did generate studies focusing on digital literacy, it suggested that relevant research was still limited in quantity and focus. Together, these reviews yielded little which enables educationalists to understand the connections between children's digital lives within and outside educational settings, or to consider the processes or possibilities associated with new literacies. It seems that research in educational settings has focused primarily on the use of new technologies as tools to support existing literacy provision.

This review therefore provides an updated overview of research related to technology and literacy in educational settings. References to 'educational settings' are intended to include the range of institutions in which children aged 0-8 engage in planned learning, including schools, children's centres and other early years settings. It is worth emphasising that this emphasis on educational settings is not intended to sideline learning within 'non-formal' (Sefton-Green 2009) contexts but to explore the limitations and possibilities associated with digital practices within institutional contexts. The first part of this paper considers what research tells us about *how* new technologies are being used with young children in educational settings but also explores the focus and breadth of *what* is being investigated. defined by the researcher's positionality or 'gaze'. In the second part of this paper,

Latour's work is used to consider other kinds of understandings that could be generated by broadening or re-directing that gaze.

Methodology

In order to provide continuity with the reviews by Lankshear and Knobel and Labbo and Reinking, this review focuses on studies of technology and literacy within educational settings for children aged 0-8 published from 2003 until May 2009. Only empirical studies, rather than project descriptions, analyses of programs or guidelines for practice, were considered for inclusion. Selected articles therefore included a clear statement of methodology. Whilst all articles were derived from peer-reviewed articles and chapters from edited collections, there was no further screening in relation to rigour, originality or significance. The intention here was to consider the breadth and scope of recent research and it was considered that even small-scale studies were relevant here in highlighting orientations towards practice in this area.

The search strategy was designed to generate studies exploring both digital literacy and the use of new technologies to support print-based literacy. Whilst debates about definitions of 'digital literacy' continue (Lankshear and Knobel, 2006), 'digital literacy' was seen to refer to any practices that involved the production or consumption of digital texts. 'Print-based literacy' was used to refer to the skills and practices associated with traditional, paper-based texts. The search potentially included studies of the use of a wide range of technologies, such as educational software, computerised toys, generic programs such as PowerPoint, digital and networked environments, mobile technologies, and simulations of technology, such as toy mobile phones. Studies identified, however, were all based on computer-based applications and represented a very narrow range, as explored below. Notably, however, the review focuses on children's use of new technologies, so studies of practitioners' perceptions or practitioners' use of technologies are excluded.

The search used a series of databases to identify relevant articles written in English: Eric CSA, British Education Index, Pro-quest, Australian Education Index and Education Research Online. Database searches of full articles were completed using all combinations of search terms drawn from three groups. The first included 'literacy', 'reading' and 'writing' (abbreviated to 'liter', 'read' and 'writ' to maximise the number of sources generated). The second included technology (abbreviated to 'technol'), 'ICT', 'Digital', 'Multimedia' and 'computer'. The third group included early childhood (abbreviated to 'early child'), 'early years' and 'young child'.

Titles and abstracts of 698 articles generated through the database searches were screened for relevance. Once relevant articles were identified, all those readily available were accessed and read in their entirety. A number were eliminated at this point as they did not meet the selection criteria. Following this, reference lists of relevant articles were scrutinised to identify any further studies that might fit the selection criteria. The contents of four key literacy journals, *Journal of Early Childhood Literacy*, *Journal of Research in Reading* and *Reading Research Quarterly* and *Written Communication* were also handsearched for any further articles that had been missed by the database searches. In total this strategy generated 36 papers from the United States, United Kingdom, Australia, the Netherlands, Canada, Taiwan, Netherlands, Israel and France.

Trends in the scope of research

Studies were methodologically diverse, including case studies, ethnographies, discourse analysis, action research and a randomised control trial. The majority however (nineteen) used quasi-experimental studies to gauge the impact of particular approaches. Sample sizes for these quantitative studies were typically low, with as few as three participants. Just six drew from sample sizes of more than a hundred. Whilst quantitative approaches were used therefore, the sample sizes of many would limit generalisation.

The distribution of studies across age groups was uneven. Of the 36 papers reviewed, no studies focused on the under 3s and only eleven included children under 5. These patterns may reflect the

emphasis on literacy and technology for children of school-age or the perceived difficulty of researching the experience of very young children.

Whilst it is recognised that this review was limited in design, the small number of studies generated is concerning. Moreover, these studies focused on only a limited range of new technologies. Given considerable investment into interactive whiteboards (IWBs) particularly in the United Kingdom, it was surprising that only one study focused on use of IWBs within literacy provision for this age group. Significantly, the majority of studies investigated the use of computer-based 'standalone' (Lankshear and Knobel, 2003) technologies specifically designed to focus on aspects of literacy instruction. Studies of networked technologies were rare and there were no studies of mobile technologies or simulated technology use.

Whilst designed to identify studies using a broad range of technologies, the limited range of studies generated means that this review focuses primarily on links between literacy and classroom-based activities mediated through computers. The focus of the studies varies, however, between studies of children's engagement with: particular programs; the computer itself; and the texts and virtual spaces accessed on screen. The following analysis organises studies into three categories, which reflect the different ways in which researchers seemed to be characterising the role of technology within literacy:

- Technology as deliverer of literacy;
- Technology as site for interaction around texts;
- Technology as medium for meaning-making.

The boundaries between categories are somewhat blurred, as activities researched sometimes included more than one use. However, it is argued that these categories are useful in highlighting some of the limitations and possibilities associated with the studies reviewed. Following an overview of studies in each category, Latour's work is used to highlight how a shifting of the researcher's gaze might highlight other relevant dimensions of children's interactions with the technologies.

Technology as deliverer of literacy

This category includes twenty-three studies which describe the use of computer programs to support the development of print literacy skills. All focus on teacher/researcher led interventions and in each, the research focuses tightly on the relationship between child and computer program.

Four studies address reading comprehension. Segers, Takke and Verhoeven (2004) compare the effects of story reading by a computer and teacher on comprehension and vocabulary learning, whilst Silverman and Hines (2009) consider teacher and multimedia-supported vocabulary instruction (using videos to reinforce vocabulary). De Jong and Bus (2004) evaluate the role of electronic books in supporting story understanding, whilst Eshet-Alkalai and Chajut (2007) explore the use of Living Books in supporting second language acquisition. A further ten studies investigate the use of programs to support phonological awareness and word attack skills. These range from studies of the impact of the personalised support provided by an integrated learning system (Bauserman, Cassady, Smith and Stroud, 2005; Cassady and Smith, 2003) to studies of programs, such as talking books or computerised games, designed to develop specific aspects of phonological awareness and letter/sound correspondence (Watson and Hempenstall, 2008;Wood, 2005; Chera and Wood, 2003; Comaskey, Savage and Abrami, 2009; de Graaf, Verhoeven, Bosman and Hasselman, 2007; Chambers, Cheung, Madden, Slavin and Gifford, 2006), letter recognition (Brabham, Murray and Bowden, 2006) or word recognition (Lewandowski, Begeny and Rogers, 2006). Korat and Shamir (2007) compare independent reading of an electronic book with an adult-read story in terms of the impact on children's decoding skills and vocabulary.

Sometimes, findings were seen as relevant for specific groups of children, for example those learning an additional language (Eshet-Alkalai et al, 2007) or children of different ages (Wood, 2005). A sub-

set of studies considered the particular use of programs for children deemed to be 'at risk'. Verhallen, Bus and DeJong (2006) found that computer-animated stories were more effective than a series of still images in supporting narrative comprehension and language development. Macaruso, Hook and McCabe (2006) concluded that using programs to give oral support and feedback for word attack skills could be beneficial. Campbell and Mechling (2009) describe the use of computer-assisted instruction to support teaching of letter sounds via an interactive whiteboard.

In contrast to the studies above which focused on impact, two studies investigated children's responses to programs more qualitatively. Lefever-Davis and Pearman (2005), exploring children's engagement with CD-Rom storybooks, observed how children seemed to transfer reading behaviours from other contexts, noting that children used them in ways that suited their reading preferences. Lee and O'Rourke (2005) considered use of computer-based reading instruction, which used animation to teach target words for four 6-7 years olds considered to have 'developmental disabilities'.

Just two studies involved children in creating their own texts. Voogt and Mckenney (2007) reported the use of PictoPal, a program that supports reading and writing using images and texts. A small-scale study with 4- to 5-year-olds suggested that children who used the program showed improvements in early literacy development, although it is unclear which aspect of early literacy had improved. Similarly, Labbo, Love and Ryan (2007) describe a digital photograph project, in which children wrote captions about photographs, making gains in their expressive vocabulary. Whilst these studies focus on supporting children's own compositions, in each technology was seen as a tool designed to support the development of alphabetic print literacy skills.

Whilst the studies of reading explored literacy learning as a process of interaction between child and computer as surrogate teacher, the studies of writing used the computer as stimulus for children's composition. In both sets however, the focus is on literacy as an individual endeavour with multimedia elements designed to meet objectives associated with the existing print literacy curriculum. Technology is positioned as deliverer of literacy, as represented in Figure 1.

**Figure 1 Technology as deliverer of literacy**
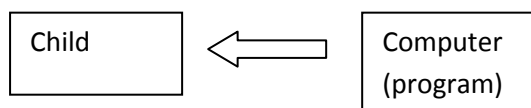
Whilst findings vary, children who used these programs often did no worse than those who had received similar instruction from an adult, suggesting that such resources might be useful in supplementing adult support in busy classrooms. The studies also suggest that multimedia elements may be useful in supporting and motivating reading development. Such findings will be valuable to those designing educational programs or in guiding teachers' selection of resources. However, they suggest a continuing emphasis on studies of technology use to support a psychological-cognitive model of print literacy.

Technology as site for interaction around texts

The second group of four studies focuses on children's interactions around digital texts on classroom computers, as represented in Figure 2.

Figure 2 Technology as site for interaction around texts
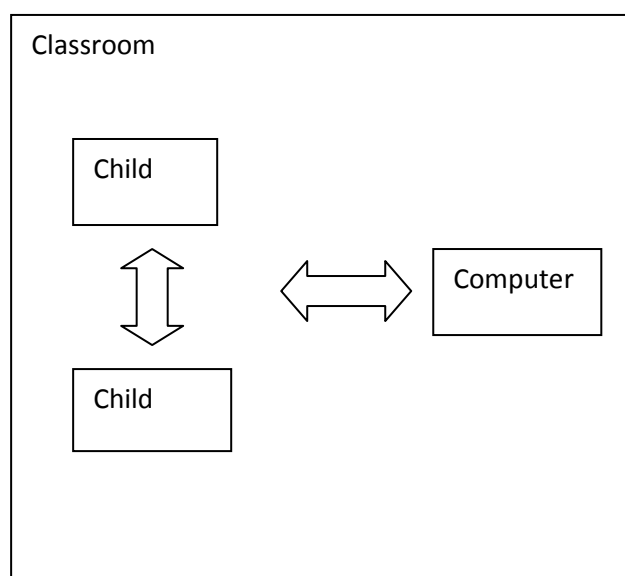
Yang and Liu (2005) describe how 3rd grade children talked together as they accessed information from the internet and word-processed their findings. Similarly, Hyun and Davis (2005) investigated the dialogue amongst 5-6 year-olds around computers. Using discourse analysis, they note how children's interactions evolved over time, becoming increasingly exploratory. Chung and Walsh (2006), arrive at similar conclusions highlighting the role of screen-based text as 'an object of reference' (p.402), the displayed text providing a shared visual stimulus around which children collaborate.

Whilst these studies focus on the classroom as micro-culture, a fourth study (Siegel, Schmier and Ennquez, 2008) explores how such collaboration may not only be patterned by classroom culture but by experiences gained through home literacies. Siegel et al's longitudinal case study of one multilingual child, Jewel shows how her literacy identity shifted as she moved between writing on paper and screen. Whilst the teacher expected her class to compose texts in the same way in either medium, Jewel, working with another child, drew on expertise developed at home to depart from the teacher's instructions and experiment with design as she composed texts on screen. Her interactions in the classroom were patterned by other interactions at home. Moreover the significance of the task became re-framed within a discourse of friendship, as the two girls worked together on the text, chatting, for example, about favourite colours as they selected fonts. Jewel drew from her out-of-school experience to create social capital and new social spaces.

In these studies, technology can be seen as a site for children's interactions. Unlike those in the previous section, these studies reflect a sociocultural model of literacy, seeing children's engagement with digital texts as patterned by and contributing to the classroom culture and, in Siegel et al's study, inflected by experiences from out-of-school settings. The studies are valuable to practitioners in helping to understand the classroom dynamics which may shape children's engagement with texts on screen. Perhaps, however, with the exception of Siegel et al's study, they underplay the relationship between these interactions and the meaning-making that occurs through and around the texts themselves.

Technology as medium for meaning-making

In this final category, the technology itself, so materially evident in the two previous categories, moves out of focus and the emphasis is on using technologies to make and engage with meaning through digital texts. The nine studies cited, however, use digital texts in diverse ways, with children involved to varying degrees in textual production and consumption.

Two studies describe interventions which seemed to use digital texts in ways that replicated those associated with printed texts. Beck and Fetherston (2003) note how children who were previously reluctant writers became more motivated when using word-processing as anxieties about untidiness were removed. Tancock and Segedy (2004) describe a project which compared children researching from printed texts and summarising findings on paper with those researching online texts and summarising their findings on screen. On the strength of comprehension questions administered after the exercise, the study suggested that children learned more from the printed texts but were more motivated and felt they learned more from those online.

Whilst these two studies used digital texts to help children locate and present texts associated with classroom-based activities, three further studies sought to use networked technologies to create new audiences for children's writing, through engaging in new communities or managing existing communities in new ways. Teale and Gambrell (2007) describe a project in which email was used to mediate discussions about texts between young children and adult penpals. This seemed to have significant impact on children's attainment in reading, which Teale et al attribute both to the value of the online community and the opportunity to engage meaningfully with high quality texts. Pelletier, Reeve and Halewood (2006) explored using a networked learning environment to enable 4-year-olds to post, review and comment on their own and others' photo-journals whilst Cohen (2005) used email to support international collaboration amongst children aged three to six.

Two further studies locate the significance of technology differently. Rather than using digital texts as media for exploring a wider world, they are used to make connections between different domains of children's lives, addressing notions of identity and community. Auld (2007) described a project which involved recording the telling of indigenous Australian stories as talking books for use by children at home. She recognises a number of cultural tensions inherent in the project but describes how, by being flexible with how computers were used, the sharing of these stories was accommodated within existing social practices. In Taylor et al's (2008) project, technology was used to scan dual-language home-made books which captured 4-5-year-old children's home experience to be shared with the wider family. This was designed to highlight the significance of family members' multilingual literate practices to children's ongoing literacy development and legitimise community practices. In so doing, they aimed to draw on family members' 'cultural' and 'linguistic capital' (p. 270), in supporting their children's literacy development and in so doing, 'reconceptualise their literacy practice' (Taylor et al, 2008: 286). In these examples, attempts were made to use new technologies to create new spaces which gave status to established but marginalised communities and identities.

A further set of studies examines children's experimentation within more open-ended opportunities to engage in digital environments, highlighting the relationship of children's identities and digital practices. Schiller and Tillett (2004) describe an action-research project through which 7-8 year-old

children used digital images to capture their perceptions of school. This provided them with a rich medium through which to voice their perspectives, but moreover positioned both teacher and children as learners as they grappled with how to use the technology and explored the potential it offered. This, Schiller et al note, seemed to affect how the teacher interacted with the children and her pedagogy became more aligned with constructivist, enquiry-led approaches. Merchant (2005) draws on observations in a children's centre, noting children's interactions with a variety of technological tools, toys and applications. He reports how one 3-year-old experimented with the design of her text, playing with font colour and content to create a text that embodied her interests. Marsh (2006) describes her work with 3- and 4-year-olds to create short animated films. Having noted how they developed existing understandings about composition (or design) of multimodal texts, she argues that there is a need to supplement knowledge of children's development as readers and writers of printed texts with knowledge of their involvement in broader 'communicative practices' (Marsh, 2006:504).

Whereas the first category focused on a relationship between child and computer and the second located literacy firmly in the classroom context, this third category includes studies which situated literacy far more broadly, as represented in Figure 3.

Figure 3 Technology as medium for meaning-making
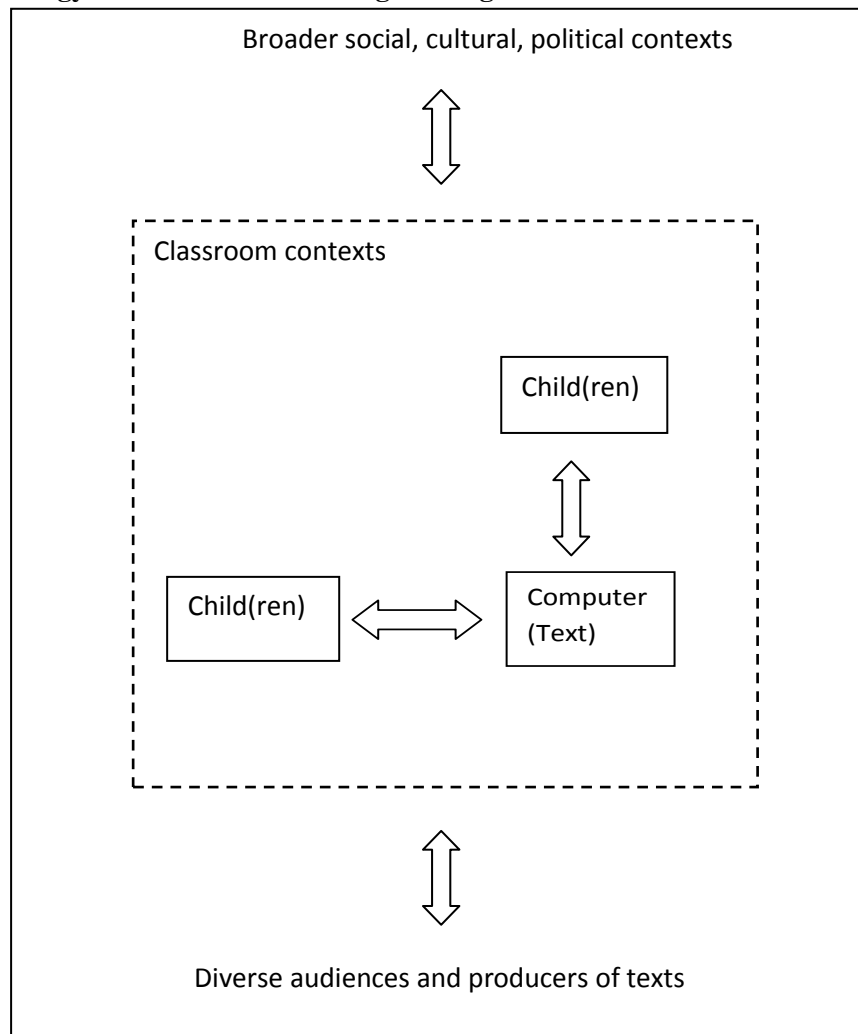
The audience and purposes for children's meaning-making in these studies varied. In some, classroom boundaries dissolved as children entered and interacted with broader contexts. Moreover, the studies draw to varying degrees on broader social and cultural contexts to make sense of children's engagement with digital texts. Whilst some focus narrowly on existing classroom imperatives, others

consider the complex interactions that occur between children, technology, and their varied and wide-ranging experiences of literacy.

Children and technologies as actors in classroom digital practices: an agenda for research

This review suggests that there have been developments in research in this area. A quarter of studies reviewed explore children's meaning-making through digital texts, providing insights into children's interactions within, around and through digital texts and highlight possibilities for classroom digital literacies. Nevertheless, this review suggests that, reflecting the findings of previous reviews, research into technology and literacy for this age-group is still surprisingly scarce and the prevalence of studies into the effect of specialised programs on isolated aspects of literacy provision has continued. (See Table 1.) There is clearly a need for more research into literacy and technology for this age group, particularly for the youngest children, and to investigate children's use of a wider range of digital technologies.

Table 1 Overview of studies

Role of technology	Model of literacy	Number of studies
Deliverer of literacy	Psychological-cognitive	23
Site for interaction	Socio-cultural	4
Medium for meaning-making	Socio-cultural	9

The focus on gaze helps to highlight how far this research addresses the relationship between institutional literacy provision and children's digital lives beyond educational settings. The gaze of some researchers places interactions with technology within a wider context, seeing practices within broader classroom ecologies. However, much of this work focuses tightly on interactions between child/ren and screen. Such studies provide useful insights on their own terms. However, it is suggested that it is necessary to consider the other kinds of meaning-making that may be occurring in and around new technologies that go beyond objectives pre-specified by researchers or educationalists. It is here that Latour's work is useful in highlighting other possible sites for research.In the commentary that folows, Latour's work is used to prompt hypotheses about how else children and technologies may be acting upon these practices. Such hypotheses are necessarily tentative but are intended to highlight other dimensions that may be worthy of research.

Actor-network theory: de-stabilising paradigms of research into literacy and technology

The review draws on actor-network-theory (Latour, 2005) to help both describe the gaze implicit within studies reviewed and consider alternative perspectives which may benefit from further research. Latour (1988) argues that any activity is acted upon by varied 'actants' which include both the people present and the objects and spaces with which they interact. Each of these actants brings with them values, assumptions and practices, developed in other times and spaces, which help shape the significance and performance of that interaction. Describing the complexity of any interaction, Latour notes how:

> A bewildering array of participants is simultaneously at work in them and which are dislocating their neat boundaries in all sorts of ways, redistributing them away and making it impossible to start anywhere that could be said to be 'local'. (Latour, 2005: 201)

This perspective helps us understand the porosity of home and school practices described above. Children's interactions within classroom spaces may be shaped by understandings from other contexts, and understandings developed in educational settings may transfer to the home. Latour's work, however, goes further in highlighting how interactions may be inflected by global dimensions from beyond these local contexts. Of particular significance to this review is his notion that it is not just people but objects that operate as actants. Latour notes how meanings associated with objects,

developed in other contexts, are brought into play as they are used. In this way, he argues, objects 'act' upon interactions, framing them in certain ways, connecting local practices to practices from other times and places and their associated belief systems, priorities and relationships. As Latour (2005:200) writes, 'What is acting at the same moment in any place is coming from many other places, many distant materials, and many faraway actors.' This notion of object as actor is useful in considering the taken-for-granted assumptions and relationships that become embedded in new technologies and activated in use.

It highlights how engagement with digital texts may become inflected with values and relationships associated with technology use in situations that extend far beyond young children's immediate experience. In the following commentary, the three categories used above are used to prompt questions about how both young children and digital texts may operate as actants on classroom practices.

Educational *programs* used to deliver aspects of literacy may be acting on classroom interactions in a variety of ways. Firstly, designed to support particular skills, they position literacy learners very much as passive recipients in the learning process and, in so doing, may influence how children (and their teachers) see the process of literacy learning and their role within this. Secondly, whilst not intended to address digital literacies, they do involve children in engaging with digital texts. The images and narratives contained within educational computer-based stories and games will reflect the assumptions and perspectives of particular social and cultural worlds and, in doing so, may *act* on individual children's engagement in different ways. Thirdly, children will draw from other digital experiences which may or may not involve programs similar to these. Consequently, what they do with, and the sense they make from educational programs may differ for different children. Whilst these programs are designed to address specific literacy skills, their use may have implications for how we think about children's literate identities. Broadening the gaze to consider both child and computer as actants draws attention to the variety of influences that may shape their engagement. Such insights may help practitioners to evaluate more comprehensively the role such programs may have in children's literacy provision.

This focus on the computer as site for interaction highlights the materiality of technology in the classroom, the physical relationship between children and screen. Here, the *computer* can be seen as acting through its material presence. Designed for individual use, it holds the children in a particular relationship with itself and each other; as they gather round they must negotiate how to manage keyboard, screen and mouse within a shared space. However, again interactions are acted upon by children who may draw from experiences from beyond the classroom in managing such encounters. This is illustrated in Siegel et al's study. Jewel draws on her confidence and competence associated with screen-based literacies at home to re-shape a teacher-directed classroom activity. Seeing children as actors draws attention to the significance of out-of-school experiences and how they do, or do not, draw on these as they engage with technology in educational settings. This would seem to be helpful in understanding how children's literacy learning in educational settings sits within broader 'learning ecologies' (Barron, 2006). Of course, other actors such as practitioners, fellow pupils, classroom spaces and the curriculum will also be significant. Moreover, as Siegel's study illustrates, any activity is likely to serve more than one purpose: the interactions within actor-networks may not just create one social relationship, but multiple, over-layered and intersecting interactions.

The use of digital technology as a medium for meaning making also prompts questions about how *digital texts* may act on the classroom practices. Tancock and Gambrell's study, for example, suggests that digital texts may disrupt existing patterns of engagement. The flexibility of working online motivated the children but they were distracted from the meanings necessary to answer the fixed assessment questions. The Internet brings with it assumptions about the nature and location of knowledge which perhaps do not sit well alongside notions of fixed knowledge associated with traditional models of literacy provision. It also mediates multiple texts which all bring their own localised meanings. This raises questions about what happens as bounded classrooms are connected to diverse and fluid networked spaces with new possibilities for presenting, exchanging and making

meaning. Others studies (Burnett, 2009; Merchant, 2009) have suggested that teachers feel challenged once children move into fluid networked spaces and begin to explore their own paths.

These hypotheses around how new technologies and children may be acting on classroom literacy provision are necessarily tentative and certainly not exclusive. Indeed, programs, computers *and* digital texts can be seen as actors within the activities described in each of the three categories. Moreover, this positioning of technology as actor is not intended to imply a kind of technological determinism but rather to highlight the complexity of children's interactions with digital texts.

Together these categories highlight a number of ways that both technologies and children may be operating as actants within classroom literacy provision. It draws attention to the significance of out-of-school experiences and how children do, or do not, draw from these as they engage with technology in educational settings. Of course, other actants such as practitioners, fellow pupils, classroom spaces and the curriculum will be significant too. Perceiving objects as actant is useful in considering the taken-for-granted assumptions and relationships that may become embedded in new technologies and activated in use. This emphasises how technologies may reinforce or challenge the organisation of literacy teaching, the meanings children generate and children's own identities as users of digital texts. From this perspective, engagement with digital texts becomes inflected with values and relationships associated with technology use in other contexts that extend far beyond young children's immediate experience.

Attention to the varied factors which play out as children interact with technologies problematises the process of framing children's interactions for research purposes. Limiting the focus of research to a specific context may pre-empt and interfere with insights into how actors themselves frame their interactions. Rather than establishing the focus of research beforehand, Latour argues that researchers should instead focus on 'what actors achieve by scaling and spacing and contextualising each other through the transportation in some specific vehicles of some specific traces' (p. 184). From this perspective, no context is purely local but is inextricably linked to other global practices and in turn has global significance itself through its connections to other situations.

Acknowledging actor-networks may highlight the possibilities and realities associated with young children's digital practices and support consideration of creative, innovative and ultimately empowering ways of integrating technology within early years settings. It may help educationalists understand how technologies reinforce or challenge the organisation of literacy teaching, the meanings children generate and children's own identities as users of digital texts. A broader, or moving, gaze may see children's interactions with texts as part of what Barron calls a 'learning ecology' (Barron, 2006) and this may help us better understand the connections between learning within and beyond educational settings. Such a gaze may be important in considering the possibilities and realities associated with young children's engagement with digital texts and support consideration of creative, innovative and ultimately empowering ways of integrating technology within early years settings. Gaining critical distance in this way seems particularly important for those engaging with very young children. Imagining or exploring new possibilities may be difficult unless it is possible to move beyond existing paradigms of early years research and practice in literacy education. Whilst young children's learning may be traditionally associated with 'real' and tangible contexts and resources, digital texts offer new opportunities to engage with multiple, if virtual contexts. Attention to actor-networks may challenge some of the polarities associated with children's use of new technologies, such as those between home and school and online and offline environments. It may also prompt new kinds of theorisation around children's interactions with digital texts, which may in turn have implications for long-established assumptions about early years literacy linked to play, interaction and progression.

In developing an agenda for future research, there would seem to be a need to expand the scope of research into literacy and technology for this age group and investigate children's use of a wider range of digital technologies. However, it is also suggested that there is a particular need for further

exploratory studies which explore the relationship between home and school. It would seem that there may be need to consider ways of making the boundaries between home and school 'permeable' and indeed to investigate how that permeability may play out in practice (Comber and Nicholls, 2004:60). The growing body of work which has explored children's production of digital texts would seem to offer a model here. Exploratory studies, such as Marsh's research into children's virtual world play at home (Marsh, 2009) demonstrate how young children may draw from wider experience of multimodal texts in making and recording meaning and develop strategies to cope with complex and even confusing digital environments. Documenting and articulating children's early interactions with digital texts may help early years practitioners consider the complex relationships between digital literacy learning within and beyond school. This in turn may be valuable in considering the implications of changing literacies for key elements of practice such as: play, progression, interactions between reading, writing, and other communicative practices.

Finally, it may be that references to 'use of technology' or 'use of ICT' are unhelpful. Conflating wide-ranging activities into 'technology use' may underplay the diverse ways that new technologies may contribute to young children's literacy education and the different ideologies that underpin such uses. In order to support educationalists in brokering the findings of research from contrasting perspectives, there would seem to be a need to refine our shared vocabulary around literacy and technology. It is argued here that differentiating between the use of technology as deliverer of literacy, site for interaction, and medium for meaning-making is helpful in beginning to differentiate in this way. However, given the continuing predominance of studies of technology use to support print literacy, there would seem to be a need to go further in challenging existing paradigms of research and practice in early years literacy education. Actor-network theory may prove useful in informing a possible agenda for future research and theorisation.

Conclusion

This review echoes the findings of previous reviews in suggesting that the predominance of small-scale studies reflecting a psychological-cognitive model of literacy has continued and far more extensive research is needed into young children's engagement with digital texts. Current educational practices are becoming increasingly anachronistic within a world in which knowledge, learning and relationships are being re-defined in digital environments. As studies of children's home lives indicate, many young children engage in digital practices in the home and such experience needs to be recognised as a resource for their current and future meaning-making. There is a need for more exploratory research which investigates children's sustained engagement with digital texts in educational settings and it is argued that Latour's actor-network theory provides us with a means of deepening our analysis of such practices. In challenging existing paradigms of research and practice, however, there may also be a need to de-stabilise existing assumptions relating to early years literacy education. Latour's actor-network theory offers one way of doing this.

This review would suggest that the predominance of small-scale studies reflecting a psychological-cognitive model of literacy has continued and that far more extensive research is needed into young children's engagement with digital texts. Current educational practices are becoming increasingly anachronistic within a world in which knowledge, learning and relationships are being re-defined in digital environments. As studies of children's home lives indicates, many young children engage in digital practices in the home and such experience needs to be recognised as a resource for their current and future meaning-making. New ways of thinking about the relationship between literacy, technology and learning in the early years are needed. There would seem to be a particular need for more qualitative research which, by adopting a broader gaze, investigates children's sustained engagement with digital texts in educational settings by investigating the meaning-making processes associated with these and their relationship with digital identities and practices forged in more informal contexts.

OR

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