Teaching, learning and new technology: a review for teachers

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Abstract

This paper reviews the effects of new technology on teaching and learning by considering examples of studies carried out with five kinds of teaching in five contexts. The five teaching situations are direct instruction, adjunct instruction, facilitating the skills of learning, facilitating social skills and widening learners' horizons. The five contexts are primary schools, secondary schools, higher education, special education and out of school. The aim of the paper is primarily to inform teachers about current work in these different areas.

Introduction

Backed up and stalled in a traffic jam, I found myself idly gazing through a window into a primary school classroom. What I saw astonished and alarmed me. I was astonished by the fact that the class was full of 5-year-olds busy writing on an electronic whiteboard. I was alarmed because I knew, as a Professor of Psychology in my 60s, that I could not do what these 5-year-olds were already skilled at. This set me ruminating. New technology has infiltrated practically everything that human beings do. We cannot travel, communicate, teach or learn without it. Most of my students at Keele have not known life without personal computers.

Table 1 illustrates this infiltration of new technology into schools in the UK, listing as it does the numbers of pupils per computer from 1985–2004.

In this paper, I want to review the effects of new technologies on teaching and learning. But in order to do this I need to impose some sort of structure on this enormous topic. So what I propose to do is to consider different kinds of teaching, and to illustrate the effects of new technology on them in a variety of settings.

Table 1: The changing face of technology in UK schools

| | Numbers of pupils per computer | | |
	Primary schools	Secondary schools	Special schools
1985	105	60	
1990	40	18	
1995	15	9	4
2000	13	8	4
2004	8	5	3

Source: Becta, 2005 and the Department of Education

I have in mind five kinds of teaching with different purposes as follows:

1. direct instruction
2. adjunct instruction
3. facilitating the skills of learning
4. facilitating social skills
5. widening horizons

and five settings:

1. primary school
2. secondary school
3. higher education
4. special education
5. out of school.

This gives me a 5×5 array—or 25 cells to consider. Clearly a tall order! What I shall do then in this paper is to concentrate on my five teaching aims, and try to illustrate them with at least one main example from one of my five settings. I shall also provide additional references in the text where appropriate. An additional summary table is provided in an Appendix to help the reader to locate recent and more particular studies in specific areas. Throughout the text I shall use the phrase 'new technology' rather than differentiate between 'CAI', 'CAL', 'CBL', 'CBT', 'CML', 'IT', 'ICT', 'e-learning', etc.

Direct instruction

With direct instruction, new technology is used to take over and replace traditional teaching. This may occur in a classroom where a particular lesson might be taught by computer, or in a stand-alone situation where there is no teacher present (eg, on a distance-learning course).

Much of the early research on any new technology is concerned with this sort of situation: a new technology is pitted against an old, traditional one, to see 'which is best'. Thus, there have been comparison studies of the effectiveness of radio, educational television, programmed instruction, computer-assisted learning, electronic white-boards, palm-held computers, virtual learning environments and so on. Such studies

obviously fail to capitalise on how one might use different technologies for different reasons, as each has different strengths and weaknesses. Radio can focus on the importance of sound and listening; television can provide coloured, moving images with audio accompaniment; and so on.

Comparison studies

Be that as it may, the most common form of enquiry when it comes to assessing the impact of any new technology on teaching and learning is the comparison experiment. And, because the comparison study is so popular, we can find in the literature a number of 'meta-analyses' that pool together and assess the overall results from several such enquiries. Lipsey and Wilson (1993), for example, summarised the findings from 12 separate meta-analyses that between them assessed the results of over 300 studies comparing computer-assisted learning with conventional teaching in a variety of instructional settings. The pooled results suggested that students working with computer-based instruction in the 1980s performed slightly, but significantly, better overall than did students receiving traditional teaching.

Similar results were reported by Fletcher-Flinn and Gravatt (1995) who conducted another meta-analysis of a further 120 studies published between 1987 and 1992. Here, the effects of learning with computer-assisted instruction appeared to be greatest with pre-school and kindergarten children, followed by learners with special needs. After this, the gains were more modest with elementary school, high school, college and university students and students in adult training situations.

Fletcher-Flinn and Gravatt (1995) attributed these results to the endless patience of machine instruction for young children (and for learners with special needs), and to better instructional materials in the more typical situations. For example, we might note that whilst a teacher may mark $7 \times 6 = 24$ 'wrong', and a poor drill and practice program just say 'wrong: try again', a sophisticated program will detect what error is being made (24 instead of 42) and provide appropriate remedial instruction before retesting.

Parr (2005) reported similar results in her summary of 17 early meta-analytic studies covering over 600 such comparison studies in a variety of different disciplines. Parr, however, detected stronger gains in subjects like science and mathematics than in literacy, and particularly drew the readers' attention to a meta-analytic study by Christmann, Badgett and Lucking (1997) in this respect. Here, the gains for new technology in the teaching of English were in fact negative for three out of four studies considered—in sharp contrast to those obtained for nine studies in science.

Similar negative or equivocal results for English studies have been reported in another recent review by Torgerson and Zhu (2004). Here, in 18 high-quality studies, the effects of computer-based techniques were positive for the teaching of writing (four studies) but much more mixed—positive and negative—for the teaching of reading (10 studies) and spelling (four studies).

The meta-analytic analyses described above convey the flavour of the main findings and indicate the massive numbers of comparison studies that have been carried out. By their very nature, however, they do not convey the flavour or report the details of any individual study. To overcome this, I have listed some individual studies (as opposed to meta-analyses) in the Appendix table. The results of these individual studies, like those of the meta-analyses, usually, but not always, favour new technology. However, these individual papers are perhaps more direct and interesting to read.

Studies of innovation
As noted above, a second, different way of looking at the effectiveness of new technologies for direct instruction is to consider studies where the technology introduces something entirely new. The titles of papers by Gubernick and Ebeling (1997)—'I got my degree through e-mail'—and McVay, Snyder and Graetz (2005)—'Evaluation of a laptop university: A case study'—make the point. Many institutions in higher education now provide the whole or part of their instruction online (see eg, De Freitas & Roberts, 2003; Zhang, Perris & Yeung, 2005).

Adjunct instruction
With adjunct instruction the teacher and the technology work together—one is not pitted against the other. Other terms here are 'computer-aided instruction' and, more recently, 'blended instruction' (Davies, Ramsay, Lindfield & Couperthwaite, 2005). These approaches reflect a more typical use of educational technology in our schools. Studies of adjunct instruction focus upon the gains in effectiveness achieved when the teacher and the technology each support or enhance the work of the other. The meta-analysis reported by Christmann *et al* (1997) discussed above is in fact an analysis of studies of adjunct rather than direct instruction.

Integrating new technology with traditional instruction
The most detailed studies in the UK of the effects of adjunct computer-assisted instruction in traditional classrooms have been those sponsored by the British Educational Communications and Technology Agency (Becta) (see Becta, 2005).

The results from a recent UK Becta study are described by Harrison, Lunzer, Tymms, Fitz-Gibbon and Restorick (2004). These researchers examined how the performance of pupils aged 11, 14 and 16 in English, Maths and Science changed over a 2-year period according to whether or not they reported a high, medium or low use of new technology at school. At age 16 the analysis also included performance in four more subjects: Geography, History, Foreign Languages and Design Technology. Approximately 1100 pupils were surveyed in the study, drawn from 27 primary and 28 secondary schools.

The results varied a little according to age group and subject discipline. Thus, for example, at 11 years there was a significant advantage associated with higher levels of computer use and performance in both English and maths but not in science whereas at 14 years, there were fewer gains in English and maths, but more in science. Of the 13 comparisons made, five showed significant differences favouring high use of new

technology, and two more were very close. Only three comparisons did not confirm the prediction that high computer use would lead to better performance, and none of these was statistically significant. Harrison *et al* (2004) conclude: 'Overall the findings constitute very strong evidence in favour of the hypothesis: greater ICT experience is strongly associated with superior performance in public examinations' (p. 334).

Harrison *et al* (2004) acknowledge several weaknesses in their study: the pupils were selected as representative ones in their particular schools, they filled in self-reports about their use of computers and, of course, there was a significant use of the Internet at home as well as at school. These other factors might well have contributed to the findings discussed above.

Separate components

A rather different kind of adjunct instruction occurs when one specific aspect of the instructional process is automated but the rest remains as before. Bonham, Deardorff and Beichner (2003), for instance, compared the effects of web-based versus traditional homework done for calculus and algebra based physics courses given in the first semester of an American university. In the physics course, the students with web-based homework outperformed the traditional homework students on the homework assignments, but this did not happen with the algebra based courses. Also, there were no significant differences on other measures made (such as multiple-choice questions) for both courses between the groups that had done the homework electronically or conventionally. In other similar studies there are gains for the separate components, but not always (eg, see Mottarella, Fritzsche & Parrish, 2004; Pereira & Murzyn, 2001). Sometimes these gains can be measured in terms of student enrolment and retention as well as by examination results (De Freitas & Roberts, 2003).

The studies of direct and adjunct instruction outlined above tend to be content-focused. New technology is used to teach or to enhance the teaching of specific topics. The next areas of instruction that I wish to discuss are more skills-focused and the actual topics taught may have less significance.

Facilitating the skills of learning

Successful learning requires certain skills. Here in this section I have particularly in mind the skills of reading, writing and thinking. These involve both cognitive and 'metacognitive' skills. Metacognitive skills are fundamental to learning a range of more particular skills. They include planning, organising, monitoring and assessing one's own competencies in a variety of different areas (eg, see Azevedo, 2005).

Reading

Work with new technology in the field of reading has largely concentrated on (1) helping young and disabled readers to acquire reading skills, and on (2) how the text itself might be presented in different ways to aid instruction. The results of the meta-analytic studies reported above suggest that this can sometimes be done with some

success but that the results are not always as positive as some commentators would suggest.

Of particular interest to me in this context is the development of 'talking books'—although these vary considerably in what they can do and in the ways in which they can supplement conventional instruction. Typical talking books replicate traditional books but add in features such as whole word pronunciation, segmented word pronunciation, highlighting words or phrases on screen as they are spoken, as well as speaking the story out loud. More sophisticated talking books can use voice-recognition systems to evaluate the readers' input, ask for repetitions and respond to requests for hints or help. Several studies evaluating the effectiveness of these techniques have been reported by Wood (2005). Generally, these evaluations are positive but many difficulties are outlined. Underwood (2000), for instance, argues that talking books enhance motivation, and that motivation leads to learning, but that gains over and above those already achieved by teachers are not assured.

Spelling
A good deal of research has taken place in the more specific context of spelling. Torgerson and Elbourne (2002) assessed 374 potentially suitable titles for their meta-analytic review of computer-assisted spelling, but finally assessed only six high-quality studies that had used control groups and where the participants had been allocated at random into either the experimental or the treatment conditions. The overall results showed a small, but nonsignificant, difference in favour of the computer-assisted groups.

Van Daal and Reitsma (2000) described a typical suite of programmes for spelling instruction. These involved:

• vocabulary—matching pictures with spoken words;
• position of sounds—indicating where a sound is heard in a spoken word;
• letter with sound—indicating which letter sound is heard;
• point at letter—pointing at a requested letter in the context of a word;
• word closure—filling in a missing letter;
• word and picture—matching words with pictures;
• which word—selecting a word by its sound;
• visual dictation—spelling a word that is already known in the screen; and
• building a word—spelling a word by its sound.

Van Daal and Reitsma (2000) reported that with these programmes, spelling progress was enhanced for kindergarten children and reading-disabled students. Other researchers have found success with teaching reading to reading-disabled students more difficult to achieve (eg, see Bishop, Adams, Lehtonen & Rosen, 2005; Wood, 2005).

Modifying the printed text
Portier and van Buuren (1995) developed a distance-learning course that allowed the students to access it in a more flexible way. Students using this course were able to

choose whether or not they wished to see any text-support devices such as examples, exercises, illustrations and simulations. The authors found that the students learned as much from the electronic version of their text as they did from the printed one, but that students with higher prior knowledge made greater use of the support devices in the electronic text than did the ones with low prior knowledge. The students with low prior knowledge preferred to keep to the basic text. The students with high prior knowledge were able to accommodate the extra information more easily.

More creative approaches to redesigning text can be seen in examples like Landauer's Superbook programme (Landauer *et al*, 1993). Here, original textbooks are scanned into the system. Then, when the readers indicate which topics they wish to study, the programme displays a contents page (which is not necessarily that of the original author) and indicates where this topic can be found and how many times it is mentioned in a particular place in the text. If the topic is then called up for inspection, it always appears at the top of a fresh screen page. The index to the Superbook version of the text also contains all the words in the text and related synonyms (that do not necessarily appear in the original).

Other techniques have been used to make reading easier for learners, especially the reading-disabled ones. These include allowing readers to choose the size and the colour of the print, and the background colour of the 'pages' (eg, Arditi, 2004; Bradford, 2005; Gregor, Dickinson, Macaffer & Andreasen, 2003). Increasing the type-size is usually a sensible precaution, but there are no consistent results for colour changes.

Writing
Today nearly everyone writes with a word processor, even pre-school children. Studies of the effectiveness of using word processors for writing have a long history, especially as the techniques have got more sophisticated.

One area of enquiry has concerned itself with whether or not using new technology for writing changes (or enhances) the ways that people think. Some people argue that the new technology releases us from dealing with many of the problems associated with writing by hand—like letter formation and alignment—and that it facilitates editing, rewriting and spelling. Freedom from these chores allows us more time for thinking about the content. Others argue that new technology facilitates the skills of writing— making it easier—but that this does not necessarily change the nature of the finished product. Hartley, Howe and McKeachie (2001) for instance, assessed the outputs of three well-known academic writers over a period of 30 years. They showed that, although each one had changed the technologies with which they wrote over this time period, the actual products did not vary much in terms of measures like average sentence lengths, use of passives and readability scores. Each author maintained his own 'writing signature', 'voice' or 'style'.

But this study was done with skilled academic writers who were using new technology to facilitate what they were already good at. The question of whether or not new

technology changes the writing and thinking skills of children—or of novice writers—is still subject to debate. The most recent evidence that I have to hand on this topic comes in a meta-analysis conducted by Goldberg, Russell and Cook (2003). These authors updated earlier research by concentrating on 26 high-quality studies published between 1992 and 2002. They concluded that, on average, pupils who use computers in learning to write are more engaged and motivated in their writing, and that they produce lengthier texts of higher quality.

Music
Similar accounts, but not so many, have been provided of changes in music education (eg, see Gall & Breeze, 2005; Jennings, 2005; Reynolds, 2005). Here, for example, advanced software has been used to remove the barriers of learning to write musical scores. Learners can sing, or play directly into a microphone and the musical score is printed out. Without such compositional difficulties, and with new electronic instruments, learners are able to draft, revise, experiment and play their pieces in entirely new ways.

Thinking
New technology has been used specifically to develop the thinking skills of very young children. The early work by Seymour Papert (see Papert, 1980, 1993) was instrumental in challenging the value of direct instruction in this context and substituting for it the idea that children could learn to think for themselves by teaching others—or more particularly in this context by teaching an electronic robot to carry out certain movements. Thus, the behavioural model of instruction was challenged by a constructivist one (see, eg, Griffiths and Blat, 2004).

Stanton *et al* (2004), for example, describe the development of collaborative storytelling tools for children aged 5–7. Here, the investigators created a device that used 'drawing, typing and hyperlinked capabilities in a large, zoomable two-dimensional canvas'. This device used a large single display screen, although it accepted inputs from other devices and sources. Different coloured pencils controlled different functions, and multiple mice were available, one for each user. Stanton *et al* (2004) assessed the quality of the stories told over a 2-year period for both an experimental and a non-experimental control group. In pre and posttests the children were told the same story and then asked to construct another story by themselves. The authors reported that the stories created by the experimental group ($n = 7$) were better developed than those produced by the control group ($n = 12$) (but no data are provided).

The authors of studies such as these (see Siraj-Blatchford, 2004 for an edited collection) reject the view that education consists of a one-way flow of information from the teacher to the learner, and they suggest that education is best described as a set of conversations of various types between teachers and children. And thus they draw attention to the fact that much cognitive learning involves learning in groups.

Facilitating social skills

Most learning is done with and from other people, and learning is a social activity as well as a cognitive one. As Philip Jackson (1968) pointed out long ago, pupils in classrooms have to learn to deal with problems arising from overcrowding, different sources of power, pupil–pupil and pupil–teacher relationships, and success and failure. It is partly for these reasons that debates repeatedly occur about the values of 'setting' or 'streaming' and of peer-assisted teaching, learning and assessment (see, eg, Ireson & Hallam, 2001; Topping, 2005).

Teachers can capitalise on social situations by building them into learning activities. Thus, there is much interest in extending the traditional work on learning in pairs and in small groups by using new technology (eg, see Kirschner, 2005; Lazonder, 2005; Ligorio & Veermans, 2005). Indeed, Lou, Abrami and D'Apollonia (2001) were able to report the results of a meta-analysis of 122 separate studies that compared individual with group learning with new technology for various age groups. These authors found that learning in pairs was slightly more effective than learning individually despite the fact that there were differences according to:

- how the groups were composed (mixed-ability pairs did better than similar ability ones);
- the difficulty of the task (groups did better than individuals on more difficult tasks);
- the nature of the task (learners performed better on closed than on open-ended tasks); and
- gender (same-sex pairs did better than mixed-sex ones).

Lou *et al* (2001) also found that groups with 3–5 members did better than pairs who, in turn, did better than individuals.

Learning in class with interactive whiteboards is also partly social. Here, students of whatever age work in a whole-class situation rather than individually or in pairs sharing a computer. Interactive whiteboards allow teachers and students to write on them, insert information, move text about, recall earlier material, correct and erase it, etc. What is written can be automatically stored on the Web for later access, and digital slides and other media can also be incorporated.

Glover, Miller, Averis and Door (2005) provide an overview of the research literature on interactive whiteboards. Most of this research is of the evangelistic kind, discussing what teachers need to know and do in order to work effectively with this device. Some of it simply describes the value of the system and its effects in a particular classroom without feeling the need for any control group comparisons. One exception here is the study by Clemens, Moore and Nelson (2001). These authors reported the results of an American study where two parallel classes, each containing approximately 20 5-year-olds, were taught mathematical analysis and reasoning, one with the aid of an interactive whiteboard and one without it (and a different teacher). The pupils in both classes came from impoverished backgrounds (with 50% receiving free or reduced-cost lunches) and they had low pretest scores on communication, reasoning and problem

solving. Data are provided to show considerable gains from pretest to posttest for the children with the interactive whiteboard, and these are compared with the (considerably lower) posttest scores obtained by the control group. The pupils in the interactive whiteboard class responded enthusiastically to the new method. Wall, Higgins and Smith (2005) report additional similar data from enthusiastic British children on how interactive whiteboards help them to learn, and Armstrong *et al* (2005) focus on the teacher's role in providing quality interactions.

Widening horizons
One of the aims of good teaching is to expand the horizons of the learner. Television does this by taking the viewer out of the classroom (or the armchair). And other newer technologies do it too, in different ways.

The computer at home
Recent studies of children's use of computers in the UK suggest that over 60% of children have access to home computers. It is also clear that parents purchase computers partly for their educational potential. Nonetheless, it also appears that the use of this new technology by children at home for educational purposes is rather limited, and that most of the time is spent on computer games. (Some investigators suggest, of course, that game playing is not always mindless—arguing that it can enhance cognitive and spatial skills—see eg, Kirriemuir and McFarlane, 2004 and Mitchell, 2005).

Livingstone, Bober and Helsper (2005) reported that 84% of 9–19-year-olds in a national survey used the Internet at least once a week and that, for 72% of them, email was the most popular form of communication. However, more girls than boys, more middle-class than working-class and more older than younger children sent and received emails. Other authors suggest that there are gender differences in how children use computers at home. Murphy and Beggs (2003), for instance, reported that girls spent less time than boys on the computer at home but used it more for homework. Kuiper, Volman and Terwel (2005) found that boys asked fewer questions and used fewer keywords than girls did searching on the Internet. Table 2 shows the percentages of schoolchildren in the study by Livingstone *et al* (2005) who used the Internet for various activities. Teachers who ignore these home activities in their instructional settings will doubtless be seen as out of date by their students.

Self-presentation on the Web
The last row in Table 2 provides a particularly interesting example of the use of the Internet. Seale (2001) reported the results of a survey of Personal Home Pages displayed on the Web written by 20 adults with Down syndrome. Here, the aim was to see how these people referred to themselves, their disability and to other non-disabled people. Thematic analyses of the text, graphics and links showed that these Home Pages could be categorised in three main ways:

Table 2: Children's use of the Internet at different ages in 2004 (%)

	9–11 years	12–15 years	16–17 years	18–19 years
Seeking information (not for school)	89	94	96	97
Playing games online	78	78	61	42
Sending/receiving emails	45	71	87	92
Instant messaging	18	58	72	65
Downloading music	23	47	54	61
Seeking advice online	N/A	21	29	32
Looking for news online	N/A	17	34	41
Visiting sites or clubs they are members of	14	17	26	22
Using chat rooms	11	23	26	26
Looking at other people's Home Pages	N/A	12	19	14

Adapted with permission from Livingstone *et al*, 2005

1. This is me. I am a member of a family (8 examples).
2. This is me. I am a member of the Down syndrome community (5 examples).
3. This is me. I am a member of a family and the Down syndrome community (6 examples).

These analyses suggest that Personal Home Pages in this context allow adults with Down syndrome to express multiple identities: identities that are the same and different from other people with Down syndrome. However, we need to be cautious here as eight of the pages were written in the third person and a further five used both the first and the third person, suggesting that others (family members?) had helped them construct these materials. But perhaps this is no bad thing?

Globalisation and the Web
It is now possible, using email and the Web, to send messages electronically all over the world. Computer and video-conferencing facilities have been set up between institutions, and people join special interest groups to communicate electronically. Web searching is likely to include voice communication in the future.

Ho (2000) described a project that linked up (via email) two primary schools, one in the UK and one in Singapore, with officers on board a British warship on route from UK to Hong Kong via Singapore. Ho's account provides a good example of how new technology can be used to widen primary children's experiences. Ho reports that the children involved were highly motivated, that they had a positive attitude towards writing and that there were cognitive gains over time. Nonetheless, as Ho points out, the success of the project depended a good deal upon prior initial contacts between individual members of the staff in the two schools, their initial setting up of the exchanges and on the careful planning of the objectives of the exercise.

Fabos and Young (1999) reviewed over a dozen such studies and pointed to their limitations. Indeed, they concluded that much of the research was contradictory, inconclusive and possibly misleading because of its overoptimistic tone.

Computers on the move
How people physically use new technology is changing. Computers no longer need to be positioned in fixed places—'laptops' and mobile technologies allow interaction via text messaging and the ability to query the Web wherever one wants. Today, mobile phones, video cameras and palmtop computers (or Personal Digital Assistants [PDAs]) are becoming commonplace.

Attewell and Savill-Smith (2005a) provide a useful overview of work with mobile technologies. They described in their paper research with PDAs with adults aged 16–24 who are at risk of social exclusion (Attewell & Savill-Smith, 2005b). In this situation, they report, PDAs assist motivation, help organisational skills and encourage a sense of responsibility. Proctor and Burton (2005) discuss rather different applications: how PDAs can replace conventional 'audio-tours' in museums and art galleries. Mifsud (2005) describes a study of 11-year-old American children who were given two palmtop computers, one to take home and one to use in class for educational purposes. This study describes the different uses of these computers in these different situations. Students used the 'home' computers in the car and at home, largely when they did not have anything else to do. However, they also used them when travelling to and from school both for finishing off assignments as well as for playing games. In class, the students generally worked in groups of four and used the PDAs for developing concept maps, word processing and creating scrapbooks.

Waycott (2002) reported that university students found PDAs hard to use because of their small screen size. It was difficult for them to skim the text, to locate different sections, and to take notes. Nonetheless, the students liked their portability and being able to link them to more traditional technologies. Bay and Ziefle (2005), Rainger (2005) and Sweeney and Crestani (2005) discuss in more detail the limitations of PDAs and mobile phones in terms of their accessibility and design.

The language that users use (especially teenagers) when text messaging on mobile phones has aroused considerable interest. Some commentators (eg, Merchant, 2001) see this language as a linguistic innovation, radically changing the face of literacy. Others (especially teachers) are appalled when the language of the mobile is used in the wrong context. The following perhaps shows why:

Writer 1. Hey babe wt u up 2 dis weekend?
Writer 2. Not a lot, just chilling, going down factory's bar.
    1 Ya cumin up
    2 Neh ur ok but I've got go up there l8a 2 c sm pplz
               (No, you are ok, but I've got to go up there later to see some people)

Mobile phones allow us to talk to anyone anywhere (provided they have a phone) and with voice and video technology we can leave audio or written messages too. Similarly,

'chat rooms' allow speakers to exchange voicemail messages with friends and with other people that they have never met. This, of course, can be a matter of concern—eg, see Wishart (2004).

Analyses are thus being made of the contents and the language used on mobiles, in chatrooms, on home pages, and in weblogs—web-based diaries that are updated regularly, sometimes several times a day (see Huffaker & Calvert, 2004). Communication in all of these situations encourages thinking about writing by default.

Lifelong learning and self-instruction
Learning does not cease at the end of schooling, and more and more adults are becoming interested in continuing education, both formally and informally. Hargreaves (2004) and Knapper and Cropley (2000) briefly discuss the potential influences of new technology in this context. Essentially, these authors argue that new technologies can contribute to lifelong learning by the very fact that they typically enhance the motivation to learn. Sharples (2000) offers a more detailed analysis particularly related to the use of mobile technologies. Table 3 shows how concepts within lifelong learning can be aligned with those from new technology.

Adults use the Web for a variety of purposes that may not always seem to be educational but, in effect, they can be. A good deal of information is sought on the Web. Websites on self-help generally, and on medical information in particular, receive enormous numbers of hits, to provide just two examples. Indeed, it is common practice now to search for information on the Web before looking elsewhere—as travel agents, retailers and librarians know to their cost.

The use of new technology by older people has attracted a good deal of interest (eg, see Czaja & Lee, 2003; Morrell, 2002). Email communication between grandparents and their grandchildren is yet another unobtrusive social change brought about by new technology.

Table 3: The match between lifelong learning and new technology

Lifelong learning	New technology
Individualised	Personal
Learner centred	User centred
Situated	Mobile
Collaborative	Networked
Ubiquitous	Ubiquitous
Lifelong	Durable

Source: Sharples, 2000. Reprinted from *Computers & Education*, *34*, 3, p. 179, copyright 2000, with permission of Elsevier and the author.

How far access to the Web is restricted by financial and social circumstances is, of course, also a matter of concern. Carr-Chelman (2005) and Simpson (2005), for instance, detail factors in the US and the UK that restrict access to new technology and discuss, in particular, why many adults drop out of learning from electronic courses.

New technology in different countries
Picture this. Imagine that a computer screen and a keyboard appears in a hole in the wall of some run-down building in an Indian village. What do the local urchins do? In a series of papers, Sugata Mitra has described how such children teach themselves computer skills without adult supervision (Mitra, 2003; Mitra & Rana, 2001). The initial study—known as 'the hole in the wall' experiment—has now been replicated several times. Typically, learning proceeds as follows:

1. One child explores randomly and others watch until an accidental discovery is made (eg, if you press this... then that...).
2. Several children repeat the discovery for themselves by requesting that the first child let them do so.
3. While in Step 2, one or more children make additional accidental or incidental discoveries.
4. All of the children repeat the discoveries made and, in the process, make more discoveries and start to create a vocabulary to describe their experiences.
5. The vocabulary encourages them to perceive generalisations (when you do this... that happens).
6. They memorise entire procedures for doing things (for example, how to open a painting programme and retrieve a saved picture). They teach each other shorter procedures for doing the same thing whenever one of them finds a new, shorter, procedure.
7. The group divides itself into the 'knows' and the 'know nots' much as they did into 'haves' and 'have nots' in the past. A child that 'knows' will share that knowledge in return for friendship and exchange.
8. A stage is reached when no further discoveries are made and the children occupy themselves with practising what they have already learned. At this point, adult intervention is required to introduce new discoveries.

Children learn from 'the hole in the wall' to load and to save files, to set up games, play music and video, to email and to browse and surf the net if a connection is available.

Such a picture of the potential use of new technology in developing countries is perhaps an idyllic one. The authors in *Global Perspectives on E- Learning*   (Carr-Chelman, 2005) provide much more sober and uncomfortable accounts of the development and use of new technology in Asia, Europe, North America, Australasia and Africa. These accounts show that politics and economics play a key role. In some countries, but not all, governments impose restrictions on what can be read and downloaded. Further-more, in many countries, priority has to be given to battling poverty and food shortages before educational needs. What can you do, for instance, if you don't have electricity? Or if it is sporadic? Or if there is a limited amount of paper—or none at all? Finally, why

should different countries take on board what is essentially a Western approach to education?

Concluding remarks

In the early part of this paper I concentrated on assessing the evidence for the effectiveness of new technology in a wide variety of contexts. Here, I focused on research findings, and most typically on those reported in meta-analytic studies.

However, once I got beyond the comparison studies I found that there was a good deal of literature that assessed the effectiveness of new technology without collecting much quantitative data. There were especially interesting case studies in the field of special needs and in work with very young children (eg, Florian & Hegarty, 2004; Siraj-Blatchford, 2004). Indeed, in my judgement, it is in these areas in the Western world where the most spectacular advances are being made. Here, we can find studies of children using digital cameras, video projectors, electronic whiteboards, virtual environments, mobile technologies and various wearable and other types of control switches. These studies show dramatically how new technology can and will infiltrate the home and the educational system. Children are much more relaxed than adults in using these new technologies.

In writing this paper, I have concentrated mainly on 'success stories'. Stories of failures are rare to find in the published literature (but see Raven, 2005; Shackel, 2004; and Vol. 36 No 4 of the *British Journal of Educational Technology*   ). And, where success has been limited, I have taken the view that, as no one can stop the tide of new technology, we need to learn what to do to remedy the situation. However, I have probably said less than I should about what many see as the 'downside' of new technology—the technological determinism, the commercialisation of education, the trivialisation of assessment, the unwarranted intrusions into websites, the frustrations that arise when things do not work and the need for countries to be rich in order to benefit.

It is clear that introducing a new technology into any learning situation in any country requires a great deal of thought and planning, and a good deal of developmental testing. It requires multidisciplinary approaches involving teachers, researchers, technologists, developers and pupils. And it requires specific training for all of these groups, and possibly changes in attitudes as well as approach. Berge and Clark (2005), Carr-Chelman (2005), Guri-Rosenblit (2005) and O'Neil and Perez (2003) provide useful, more detailed, discussions of these issues.

References

Arditi, A. (2004). Adjustable typography: an approach to enhancing low vision text accessibility. *Ergonomics*, *47*, 5, 468–482.

Armstrong, V., Barnes, S., Sutherland, R., Curran, J., Mills, S. & Thompson, T. (2005). Collaborative research methodology for investigating learning: the use of interactive whiteboard technology. *Educational Review*, 57, 4, 457–469.

Attewell, J. & Savill-Smith, C. (Eds) (2005a). *Learning with mobile devices: research and development*. London: Learning and Skills Development Agency.

Attewell, J. & Savill-Smith, C. (2005b). Mobile learning and social inclusion: focusing on learners and learning. In J. Attewell & C. Savill-Smith (Eds), *Learning with mobile devices: research and development* (pp. 3–12). London: Learning and Skills Development Agency.

Azevedo, R. (Ed.) (2005). Special issue: computers as metacognitive tools for enhancing learning. *Educational Psychologist*, 40, 4, 193–271.

Barak, M. (2005). From order to disorder: the role of computer-based electronics projects on fostering of higher-order cognitive skills. *Computers & Education*, 45, 2, 231–243.

Barr, H. (1994). Social studies by electronic mail. *The Social Studies*, Nov-Dec, 281–285.

Batchelder, J. S. & Rachal, R. R. (2000). Efficacy of a computer-assisted instruction program in a prison setting: an experimental study. *Adult Education Quarterly*, 50, 2, 120–133.

Bay, S. & Ziefle, M. (2005). Children using cellular phones: the effects of shortcomings in user interface design. *Human Factors*, 47, 1, 158–168.

Berge, Z. L. & Clark, T. A. (Eds) (2005). *Virtual schools: planning for success*. New York: Teachers College Press.

Bishop, D., Adams, C., Lehtonen, A. & Rosen, S. (2005). Effectiveness of computerised spelling training in children with language impairments: a comparison of modified and unmodified speech input. *Journal of Research in Reading*, 28, 2, 144–157.

Bishop, J. (2003). The internet for educating individuals with social impairments. *Journal of Computer Assisted Learning*, 19, 4, 546–566.

Bonham, S. W., Deardorff, D. L. & Beichner, R. J. (2003). Comparison of student performance using web and paper-based homework in college-level physics. *Journal of Research in Science Teaching*, 40, 10, 1050–1071.

Bradford, J. (2005). *Designing web pages for dyslexic readers*. Retrieved January 9, 2005, from http://www.dyslexia-parent.com/mag35/html

Brandt, E., Scaramuzzi, A. & Finkelstein, A. (2005). Self-produced video to augment peer-to-peer learning. In J. Attewell & C. Savill-Smith (Eds), *Learning with mobile devices: research and development* (pp. 27–34). London: Learning and Skills Development Agency.

British Educational Communications and Technology Agency (Becta) (2005). *The Becta review: evidence on the progress of ICT in education*. Coventry: Becta.

Carr-Chelman, A. A. (Ed.) (2005). *Global perspectives on e-learning: rhetoric and reality*. Thousand Oaks, CA: Sage.

Chan, L. M. Y., Jones, A. C., Scanlon, E. & Joiner, R. (2006). The use of ICT to support the development of practical music skills through acquiring keyboard skills: a classroom based study. *Computers & Education*, 46, 4, 391–406.

Chang, C. Y. (2001). A problem-solving based computer-assisted tutorial for the earth sciences. Journal of Computer-Assisted. *Learning*, 17, 3, 263–274.

Chou, S-W. & Liu, C-H. (2005). Learning effectiveness in a web-based virtual learning environment: a learner control perspective. *Journal of Computer Assisted Learning*, 21, 1, 65–76.

Christmann, E., Badgett, J. & Lucking (1997). Microcomputer-based computer-assisted instruction within differing subject areas: a statistical deduction. *Journal of Educational Computing Research*, 16, 3, 281–296.

Clemens, A., Moore, T. & Nelson, B. (2001). *Math intervention "Smart" project*. Retreived August 1, 2005, from http://www.smarterkids.org/research/paper10.asp

Czaja, S. J. & Lee, C. C. (2003). Designing computer systems for older adults. In J. Jackso & A. Sears (Eds), *Handbook of human-computer interaction* (pp. 413–428). New York: Erlbaum.

Davies, A., Ramsay, J., Lindfield, H. & Couperthwaite, J. (2005). A blended approach to learning: adding value and lessons learnt from students' use of computer-based materials for neurological analysis. *British Journal of Educational Technology*, 36, 5, 839–849.

De Freitas, S. & Roberts, G. P. (2003). Does distance e-learning work? A comparison between distance and face-to-face learners using e-learning materials. *Association for Learning & Technology Journal*, *11*, 3, 69–87.

Draper, S. W. & Brown, M. I. (2004). Increasing interactivity in lectures using an electronic voting system. *Journal of Computer Assisted Learning*, *20*, 81–94.

Fabos, B. & Young, M. D. (1999). Telecommunication in the classroom: rhetoric versus reality. *Review of Educational Research*, *68*, 3, 322–349.

Fletcher-Flinn, C. M. & Gravatt, B. (1995). The efficacy of computer-based instruction (CAI): a meta-analysis. *Journal of Educational Computing Research*, *12*, 3, 219–242.

Florian, L. & Hegarty, J. (Eds) (2004). *ICT and special educational needs.* Maidenhead: Open University Press.

Gall, M. & Breeze, N. (2005). Music composition lessons: the multi-modal affordances of new technology. *Education Review*, *57*, 4, 415–433.

Glover, D., Miller, D., Averis, D. & Door, V. (2005). The interactive whiteboard: a literature review. *Technology, Pedagogy & Education*, *14*, 2, 55–170.

Goldberg, A., Russell, M. & Cook, A. (2003). The effect of computers on student writing: a meta-analysis of studies from 1992–2002. *Journal of Technology, Learning, and Assessment*, *2*, 1. Retrieved February 1, 2006, from http://www.jtla.org

Gregor, P., Dickinson, A., Macaffer, A. & Andreasen, P. (2003). SeeWord—a personal word processing environment for dyslexic computer users. *British Journal of Educational Technology*, *34*, 3, 341–355.

Griffiths, D. & Blat, P. (2004). ETui: scaffolding children's reflection with behaviour based robots. In J. Siraj-Blatchford (Ed.), *Developing new technologies for young children* (pp. 37–54). Stoke on Trent: Trentham Books.

Gubernick, L. & Ebeling, A. (1997). I got my degree through e-mail. *Forbes Magazine, June 16th*, 84–86, 88, 90, 92.

Guri-Rosenblit, S. (2005). Eight paradoxes in the implementation process of e-learning in higher education. *Higher Education Policy*, *18*, 5–9.

Hargreaves, D. H. (2004). *Learning for life: the foundations of life-long learning.* Bristol: The Policy Press.

Harrison, C., Lunzer, E. A., Tymms, P., Taylor Fitz-Gibbon, C. & 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.

Hartley, J., Howe, M. J. A. & McKeachie, W. J. (2001). Writing through time: longitudinal studies of the effects of new technology on writing. *British Journal of Educational Technology*, *32*, 2, 141–151.

Ho, C. M. L. (2000). Developing intercultural awareness and writing skills through email exchange. *The Internet TSL Journal*, *VI*, 12 (December). Retrieved September 29, 2005, from http://iteslj.org/Articles/Ho-Email.html

Huffaker, D. A. & Calvert, S. L. (2004). *Gender, identity and language use in teenage blogs.* Retrieved 19 April 2006, from http://jcmc.indiana.edu/vol10/issue2/huffaker.html.

Ireson, J. & Hallam, S. (2001). *Ability grouping in education.* London: Paul Chapman.

Jackson, P. W. (1968). *Life in classrooms.* New York: Holt, Rinehart & Winston.

Jennings, K. (2005). Hyperscore: a case-study in computer mediated music composition. *Education & Information Technologies*, *10*, 3, 225–238.

Kent, N. & Facer, K. (2004). Different worlds? A comparison of young people's home and school use of ICT. *Journal of Computer Assisted Learning*, *20*, 440–455.

Keogh, T., Barnes, P., Joiner, R. & Littleton, K. (2000). Gender, pair composition and computer versus paper presentations of an English language task. *Educational Psychology*, *20*, 1, 33–43.

Kirriemuir, J. & McFarlane, A. (2004). *Literature review in games and learning.* Report No. 8. Bristol: NESTA Futurelab.

Kirschner, P. A. (Ed.) (2005). Technology-based collaborative learning: a European perspective. *Educational Technology*, *XLV*, 5, 5–48.

Knapper, C. & Cropley, A. J. (2000). *Lifelong learning in higher education* (3rd ed.). London: Kogan Page.

Kuiper, E., Volman, M. & Terwel, J. (2005). The web as an information resource in K-12 education: strategies for supporting students in searching and processing information. *Review of Research in Education*, *75*, 3, 285–328.

Kurhila, J. & Laine, T. (2000). Individualized special education with cognitive skill assessment. *British Journal of Educational Technology*, *31*, 2, 163–170.

Landauer, T., Egan, D., Remde, J., Lesk, M., Lochbaum, C. & Ketchum, D. (1993). Enhancing the usability of text through computer delivery and formative evaluation: the *SuperBook* project. In C. McNight, A. Dillon & J. Richardson (Eds), *Hypertext: a psychological perspective*. Hemel Hempstead: Ellis Horwood.

Lazonder, A. W. (2005). Do two heads search better than one? Effects of student collaboration on web search behaviour and search outcomes. *British Journal of Educational Technology*, *36*, 3, 465–475.

Leng, P., Shave, M., Schauer, H., Muehlbacher, J. R. & Aiken, R. (1999). An experiment in multi-national collaborative learning and group work using the internet. *Education & Information Technologies*, *4*, 33–47.

Ligorio, M. B. & Veermans, M. V. (Eds) (2005). Special issue: collaborative learning environments. *Computers & Education*, *45*, 3, 271–382.

Lipsey, M. W. & Wilson, D. B. (1993). The efficacy of psychological, educational, and behavioral treatment: confirmation from meta-analysis. *American Journal of Psychology*, *48*, 12, 1181–1209.

Livingstone, S., Bober, M. & Helsper, E. (2005). Active participation or just more information? Young people's take up of opportunities to act and interact on the internet. *Information Communication & Society*, *8*, 3, 287–314.

Lou, Y., Abrami, P. & D'Apollonia, S. (2001). Small group and individual learning with technology: a meta-analysis. *Review of Educational Research*, *71*, 3, 449–521.

Mathes, P. G., Torgesen, J. K. & Allor, J. H. (2001). The effects of peer-assisted literacy strategies for first-grade readers with and without additional computer-assisted instruction in phonological awareness. *American Educational Research Journal*, *38*, 2, 371–410.

McVay, G. J., Snyder, K. D. & Graetz, K. A. (2005). Evolution of a laptop university: a case study. *British Journal of Educational Technology*, *36*, 3, 513–524.

Merchant, G. (2001). Teenagers in cyberspace: an investigation of language use and language change in internet chatrooms. *Journal of Research in Reading*, *24*, 3, 293–306.

Mifsud, L. (2005). Learning 2go:making reality of the scenarios. In J. Attewell & C. Savill-Smith (Eds), *Learning with mobile devices: research and development* (pp. 99–104). London: Learning and Skills Development Agency.

Mitchell, A. (2005). Exploring the potential of a games-oriented implementation for m-portal. In J. Attewell & C. Savill-Smith (Eds), *Learning with mobile devices:research and development* (pp. 105–116). London: Learning and Skills Development Agency.

Mitchell, W. L. (1999). *Moving the museum on to the internet: the use of virtual environments in education about ancient Egypt*. Retrieved 19 April 2006, from http://www.doc.mmu.ac/RESEARCH/virtual-museum/Pubs/brad97/book.html.

Mitra, S. (2003). Minimally invasive education: a progress report on "the hole in the wall" experiments. *British Journal of Educational Technology*, *34*, 3, 367–371.

Mitra, S. & Rana, V. (2001). Children and the internet: experiments with minimally invasive education in India. *British Journal of Educational Technology*, *32*, 2, 221–232.

Morrell, R. W. (Ed.) (2002). *Older adults, health information, and the world wide web*. Mahwah, NJ: Erlbaum.

Mottarella, K., Fritzsche, B. & Parrish, T. (2004). Who learns more? Achievement scores following web-based versus classroom instruction in Psychology courses. *Psychology Learning and Teaching*, *4*, 1, 51–54.

Murphy, C. & Beggs, J. (2003). Primary pupils' and teachers' use of computers at home and at school. *British Journal of Educational Technology*, *34*, 1, 79–83.

O'Neil, H. F. & Perez, R. S. (Eds) (2003). *Technology applications in education.* Mahwah, NJ: Erlbaum.

Papert, S. (1980). *Mindstorms: children, computers and powerful ideas.* Brighton: Harvester Press.

Papert, S. (1993). *The children's machine: rethinking school in the age of the computer.* Hemel Hempstead: Harvester Wheatsheaf.

Parr, J. M. (2005). A review of the literature on computer-assisted learning, particularly integrated learning systems, and outcomes with respect to literacy and numeracy (Updated October 10, 2005). Retrieved November 11, 2005, from http://www.minedu.govt.nz/index.cfm?layout=document&documentid=5499&CFID

Parsons, S. & Mitchell, P. (2002). The potential of virtual reality in social skills training for people with autistic spectrum disorders. *Journal of Intellectual Disability Research, 46,* 5, 430–443.

Passig, D. & Eden, S. (2003). Cognitive intervention through virtual environments among deaf and hard-of-hearing children. *European Journal of Special Needs Education, 18,* 2, 173–182.

Pereira, J. & Murzyn, T. (2001). Integrating the "new" with the "traditional": an innovative educational model. *Journal of Palliative Medicine, 4,* 1, 31–37.

Portier, S. J. & van Buuren, H. A. (1995). An interactive learning environment (ILE) to study statistics: effects of prior knowledge on the use of embedded support devices. *European Journal of Psychology of Education, 10,* 2, 197–207.

Proctor, N. & Burton, P. (2005). Tate Modern multimedia tour pilots 2002–2003. In J. Attewell & C. Savill-Smith (Eds), *Learning with mobile devices: research and development* (pp. 127–130). London: Learning and Skills Development Agency.

Rainger, P. (2005). Usability and accessibility of personal digital assistants as assistive technologies in education. In J. Attewell & C. Savill-Smith (Eds), *Learning with mobile devices: research and development* (pp. 131–138). London: Learning and Skills Development Agency.

Raven, J. (2005). How not to integrate computers with group projects: an example from the field. *Technology, Pedagogy & Education, 14,* 2, 255–268.

Reynolds, N. (2005). The computer as scaffold, tool and data collector: children composing with computers. *Educational & Information Technologies, 10,* 3, 239–248.

Seale, J. K. (2001). The same but different: the use of the personal Home Page by adults with Down syndrome as a tool for self-presentation. *British Journal of Educational Technology, 32,* 3, 342–352.

Shackel, B. (2004). A user's experience. *British Journal of Educational Technology, 35,* 5, 645–656.

Sharples, M. (2000). The design of personal mobile technologies for lifelong learning. *Computers & Education, 34,* 177–193.

Shaw, R. & Lewis, V. (2005). The impact of computer-mediated and traditional academic task presentation on the performance and behaviour of children with ADHD. *Journal of Research in Special Education Needs, 5,* 2, 47–54.

Simpson, O. (2005). E-learning, democracy and social exclusion: Issues of access and retention in the United Kingdom. In A. A. Carr-Chellman (Ed.), *Global perspectives on e-learning: rhetoric and reality* (pp. 89–100). Thousand Oaks, CA: Sage.

Singleton, C. & Simmons, F. (2001). An evaluation of *Wordshark* in the classroom. *British Journal of Educational Technology, 32,* 3, 317–330.

Siraj-Blatchford, J. (Ed.) (2004). *Developing new technologies for young children.* Stoke on Trent: Trentham Books.

Standen, P. & Brown, D. (2004). Using virtual environments with pupils with learning difficulties. In L. Florian & J. Hegarty (Eds), *ICT and special educational needs* (pp. 96–108). Maidenhead: Open University Press.

Stanton, D., O'Malley, C., Bayon, V., Hourcade, J-P., Sundblad, Y., Fast, C. *et al* (2004). The KidStory project: developing collaborative storytelling tools for children, with children. In J. Siraj-Blatchford (Ed.), *Developing new technologies for young children* (pp. 75–92). Stoke on Trent: Trentham Books.

Stoyanova, N. & Kommers, P. (2002). Concept mapping as a medium of shared cognition in computer-supported collaborative problem solving. *Journal of Interactive Learning Research, 13,* 1–2, 111–133.

Sweeney, S. & Crestani, F. (2005). Effective search results summary size and device screen size. Is there a relationship? *Information Processing and Management*, *42*, 4, 1056–1074.

Topping, K. (2005). Trends in peer learning. *Educational Psychology*, *25*, 6, 631–645.

Torgerson, C. J. & Elbourne, D. (2002). A systematic review and meta-analysis of the effectiveness of information and communication technology (ICT) on the teaching of spelling. *Journal of Research in Reading*, *25*, 2, 129–143.

Torgerson, C. J. & Zhu, D. (2004). Evidence for the effectiveness of ICT on literacy learning. In R. Andres (Ed.), *The impact of ICT on literacy education 99* (pp. 34–68). London: RoutledgeFalmer.

Underwood, J. (2000). A comparison of two types of computer support for reading development. *Journal of Research in Reading*, *23*, 2, 136–148.

Upton, D. & Cooper, C. D. (2003). Online health psychology: do students need it, use it, like it and want it? *Psychology Learning & Teaching*, *3*, 1, 27–35.

Van Daal, V. H. P. & Reitsma, P. (2000). Computer-assisted learning to read and spell: results from two pilot studies. *Journal of Research in Reading*, *23*, 2, 181–193.

Wall, K., Higgins, S. & Smith, H. (2005). The visual helps me understand the complicated things': pupil views of teaching and learning with interactive whiteboards. *British Journal of Educational Technology*, *36*, 5, 851–867.

Waycott, J. (2002). Reading with new tools: an evaluation of person digital assistants as tools for reading course materials. *ALT-J, Research in Learning Technology*, *10*, 2, 38–50.

Whatley, J. & Bell, F. (2003). Discussion across borders: benefits for collaborative learning. *Educational Media International*, *40*, 1–2, 139–152.

Wishart, J. (2004). Internet safety in emerging educational contexts. *Computers & Education*, *43*, 193–204.

Wood, C. (2005). Beginning readers' use of 'talking books' software can affect their reading strategies. *Journal of Research in Reading*, *28*, 2, 170–182.

Zellermayer, M., Salomon, G., Globerson, T. & Givon, H. (1991). Enhancing writing related metacognitions through a computerized writing partner. *American Educational Research Journal*, *28*, 373–391.

Zhang, W., Perris, K. & Yeung, L. (2005). Online tutorial support in open and distance learning: students' perspectives. *British Journal of Educational Technology*, *36*, 5, 821–837.

Appendix

Examples of data-based studies conducted with different aims in different educational contexts

	Direct instruction	Adjunct instruction	Metacognitive skills	Social skills	Widening horizons
Primary Schools	Clemens *et al* (2001) Torgerson and Elbourne (2002)	Singleton and Simmons (2001)	Griffiths and Brna (2004) Stanton *et al* (2004)	Mathes *et al* (2001)	Ho (2000) Mitchell (1999)
Secondary Schools	Chang (2001) Chou and Liu (2005)	Chan *et al* (2006) Harrison *et al* (2004)	Barak (2005) Zellermayer *et al* (1991)	Keogh *et al* (2000)	Barr (1994) Merchant (2001) Reynolds (2005)
Higher Education	McVay *et al* (2005) Mottarella *et al* (2004) Upton and Cooper (2003)	Bonham *et al* (2003) de Freitas and Roberts (2003) Pereira and Murzyn (2001)	Landauer *et al* (1993) Stoyanova and Kommers (2002)	Brandt *et al* (2005) Draper and Brown (2004)	Leng *et al* (1999) Waycott (2002) Whatley and Bell (2003)
Special Needs	Shaw and Lewis (2005)	Singleton and Simmons (2001) Standen and Brown (2004)	Kurhila and Laine (2000) Passig and Eden (2003)	Bishop (2003) Parsons and Mitchell (2002)	Seale (2001)
Home and Away	Batchelder and Rachal (2000)		Huffaker and Calvert (2004)	Kent and Facer (2004) Livingstone *et al* (2005)	Mitra (2003) Morrell (2002)