EPPI

REVIEW

November 2003

A systematic review and meta-analysis of the effectiveness of ICT on literacy learning in English, 5-16

Review conducted by the English Review Group

AUTHORS

Carole Torgerson, University of York
Die Zhu, University of York

REVIEW TEAM

Richard Andrews, University of York
Sue Beverton, University of Durham
Andrew Burn, Institute of Education, University of London
Jenny Leach, The Open University
Terry Locke, University of Waikato, New Zealand
Graham Low, University of York
Carole Torgerson, University of York
Die Zhu, University of York

International correspondents

Wendy Morgan, Queensland University of Technology, Australia
Eileen Shakespeare, Harvard Graduate School of Education, USA

Database management and administrative support

Alison Robinson, University of York

Literature searching

Julie Glanville, National Health Service Centre for Reviews and Dissemination, University of York

ADVISORY GROUP

James Durran, Parkside Community College, Cambridge
Peter Hatcher, University of York
Nick McGuinn, University of York
Gloria Reid, East Riding of Yorkshire Advisory Service
Nancy Rowland, National Health Service Centre for Reviews and
        Dissemination, University of York
Maggie Snowling, University of York

ACKNOWLEDGEMENTS

LIST OF ABBREVIATIONS

BECTa	British Educational Communications and Technology Agency
BEI	British Education Index
DfES	Department for Education and Skills (previously DfEE: Department for Education and Employment) (England and Wales)
CAI/CAL	Computer-Assisted Instruction/Computer-Assisted Learning
CT	Controlled Trial
EPPI-Centre	Evidence for Policy and Practice Information and Co-ordinating Centre
ERIC	Educational Resources Information Center
ICT	Information and Communication Technology
RCT	Randomised Controlled Trial
SIGLE	Source for Information on Grey Literature in Europe
SSCI	Social Science Citation Index

Note on terminology

The terminology used in the review to describe learners' characteristics is the original terminology used by the authors of the included studies (e.g. 'learning disabled', etc.). Such terminology has been included in quotation marks to indicate direct quotation from the original studies.

This report should be cited as: Torgerson C, Zhu D (2003) A systematic review and meta-analysis of the effectiveness of ICT on literacy learning in English, 5-16. In: *Research Evidence in Education Library*. London: EPPI-Centre, Social Science Research Unit, Institute of Education.

TABLE OF CONTENTS

SUMMARY

Background

The English Review Group completed an overarching systematic review of the *impact* of Information and Communication Technology (ICT) on literacy learning in English in 2002 (Andrews *et al.*, 2002). In this review, a 'map' described all the included research in the field. An in-depth sub-review reported on the impact of networked ICT on literacy learning (Andrews *et al.*, 2002). This present review is one of a further four in-depth sub-reviews that address aspects of the overarching question – what is the impact of Information and Communication Technology on literacy learning in English? The broad background to the descriptive map and the in-depth sub reviews is that there is a growing concern internationally that the investment in ICT in schools is not impacting on literacy development. This concern arises from a belief held by many – including governments as well as schools – that ICT *is* beneficial to learning and specifically literacy learning. The question is a specific one and has to be seen within a wider political, social and technological context in which the symbiosis between new technologies and new literacies (and thus literacy learning) is acknowledged.

The set of four in-depth sub-reviews follows an initial in-depth sub review on the impact of *networked* ICT on literacy learning (Andrews *et al.*, 2002). This review is one of those four sub-reviews and addresses a question about the *effectiveness* of ICT on literacy learning.

Policy and practice background
The use of ICT in schools to support literacy learning is pervasive. Since the mid-1980s, successive governments have invested large amounts of resources to develop ICT in schools. However, little robust evidence based on effectiveness research has been used to underpin this use of ICT.

Research background
Andrews *et al.* (2002) identified five systematic reviews in the field of ICT and literacy. All five reviews synthesised research in various aspects of literacy, such as spelling or writing (Bangert-Drowns, 1993; Blok *et al.*, 2001; Fulk and Stormont-Spurgin, 1995; MacArthur *et al.*, 2001; and Torgerson and Elbourne, 2002). In some of the reviews, the included studies focused on participants with specific learner characteristics, such as pupils experiencing learning disabilities. Most of the reviews included papers of all study types, whilst others were restricted to experimental research (randomised, controlled trials and controlled trials or RCTs and CTs). Not all the systematic reviews included detailed assessment of the quality of the included studies. From these reviews, the evidence to date, on the effectiveness of ICT on literacy learning, is equivocal.

In summary, whilst there have been some systematic reviews relevant to the policy question of whether ICT is effective in improving literacy learning, the extant reviews are either insufficiently rigorous in that they include non-randomised or poor quality trials; or, they focus on only one aspect of literacy. There is, therefore, a need for a systematic review of recent ICT effectiveness research on all aspects of literacy.

Aims

The overall aim of the two-year project is to determine the impact of ICT on literacy learning in English for 5-16 year olds.

The main aim of this in-depth sub-review is to investigate whether or not ICT is effective in improving young people's literacy learning in English. Subsidiary aims are to assess the effectiveness of ICT on different literacy outcomes and, within those outcomes, to assess whether effectiveness varies according to different interventions.

Review questions

The overall research question for the two-year project is:

What is the impact of ICT on literacy learning in English, 5 – 16?

The research question for this effectiveness sub-review is:

What is the evidence for the effectiveness of ICT on literacy learning in English, 5-16?

This research question was developed because, despite huge investment by this and previous governments in the use of ICT in schools generally in the UK and with a view to improving literacy learning in particular, to date no generic systematic review has been undertaken to examine the effectiveness or otherwise of ICT on literacy learning in English. Specifically, no systematic review of effectiveness has reviewed studies in all aspects of literacy learning, with diverse learner characteristics, focused exclusively on the most appropriate study design for judging effectiveness: the randomised controlled trial (RCT). This study design is the most appropriate for judging effectiveness because it is the only experimental design that can control for all known and unknown extraneous variables, and for regression to the mean effects commonly observed in uncontrolled study designs.

Structure of review

The structure of this review is unusual in that it includes a *two-stage* 'mapping' process, followed by an in-depth review.

In the **descriptive map of the overarching review**, the process of identifying, including and characterising the studies for the systematic review of the *impact* of the ICT on literacy learning is described. This map is an updated version of the original map described in Andrews *et al.*, 2002. In total, a series of five sub-reviews have been undertaken to address aspects of the original research question. In the present review, the **effectiveness map** describes the process of identifying, including and characterising the studies for one of the five sub-reviews. This review is a systematic review and meta-analysis of the *effectiveness* of ICT on literacy learning. In the **in-depth effectiveness review**, the inclusion criteria have been refined to identify a sub-section of RCTs that can be used to address the question: 'What is the effectiveness of ICT on literacy learning in English, 5-16?'

Methods

Defining relevant studies for descriptive map of overarching review: inclusion and exclusion criteria

The earlier systematic review (Andrews *et al.,* 2002) mapped the research on the impact of ICT on literacy learning in English, 5-16. The relevant research was searched for, located, sent for and mapped for the years 1990-2001. In addition to updating the searches for the period 2001-2002, and screening for inclusion of any potentially relevant studies for the period 2001-2002, all the included studies in the original map were re-keyworded using revised generic and review-specific keywording sheets. The English Review Group working document (Appendix 2.1) for the inclusion and exclusion of potentially relevant studies was updated to reflect changes made to the keywording sheets, both generic and review-specific. See Appendix 2.1 for the inclusion/exclusion criteria for the descriptive map of the overarching review.

Defining relevant studies for effectiveness map: inclusion and exclusion criteria

As the focus of the sub-review was 'effectiveness', papers using rigorous methods to assess effectiveness were required; this implies the identification of relevant randomised controlled trials (RCTs).

Defining relevant studies for in-depth review: inclusion and exclusion criteria

For this review, studies were only included if they had randomly allocated pupils to an ICT or no ICT treatment for the teaching of literacy. Both individually randomised trials and cluster randomised trials were included, but cluster trials were only included if each arm contained more than four clusters, and if the unit of analysis was at the cluster level (not the individual level), i.e. if there was no unit of analysis error. Because this review is an effectiveness review, in order to establish effectiveness, it was necessary to look at the effect sizes (with confidence intervals). If the authors did not present effect sizes, or if the reviewers were unable to calculate the effect sizes, an RCT was excluded. Essentially this means that the study had to report either means of post-tests or mean gain scores; numbers of participants in the intervention and control groups and the standard deviations of the mean scores; or the means and numbers of participants in each group and either a t-value or precise p value in order that the reviewers could calculate the standard deviations. RCTs were included if they presented sufficient data. It was decided not to reanalyse poorly analysed cluster trials, and not to approach authors for further data.

Identification of potential studies for descriptive map of overarching review: search strategy

The potential studies for this review were identified from the original systematic review (Andrews *et al*., 2002) and through an updating of the original electronic searches and handsearches (Appendix 2.2), for the period 2001-2002.

Identification of potential studies for the effectiveness map: search strategy

The earlier systematic review (Andrews *et al*., 2002) mapped the research on the impact of ICT on literacy learning in English, 5-16. All included studies were keyworded according to study type. A research question looking at the effectiveness of ICT on literacy learning would therefore include studies keyworded as 'RCTs'. After updating searches to locate any further relevant

studies that were undertaken after 2001 and re-keywording using the EPPI-Centre core keywording strategy (EPPI-Centre, 2002a), the keyword 'RCT' was used to identify any RCTs from the updated database.

Identification of potential studies for the in-depth review: search strategy

All RCTs identified in the effectiveness map were re-screened for inclusion in the in-depth effectiveness review, using pre-established inclusion and exclusion criteria.

Screening studies for descriptive map of overarching review: inclusion and exclusion criteria

The updated database for 2002-2003 that included potentially relevant studies published after October 2001, was screened by a member of the Review Team (CT), using titles and abstracts and the updated working document with inclusion and exclusion criteria (Appendix 2.1).

Screening studies for the effectiveness map: inclusion and exclusion criteria

All studies keyworded as RCTs were re-screened to check that they were individual or cluster RCTs and fulfilled the inclusion criteria for the effectiveness map. They were then included in the map.

Screening studies for effectiveness in-depth review: inclusion and exclusion criteria

All identified RCTs were screened for inclusion in the in-depth effectiveness review, using the pre-established inclusion/exclusion criteria.

Characterising included studies for the descriptive map of the overarching review: EPPI-Centre and review-specific keywording

All the studies included in the original database from the review of 2001 were re-keyworded by members of the Review Team, using the new guidelines from the EPPI-Centre (EPPI-Centre, 2002a). The studies retrieved for the updated database were keyworded by a member of the Review Team (CT), with assistance from other members of the Review Team and the EPPI-Centre where there was any doubt about keywording. The database was fully annotated with the keywords (AR). For pragmatic reasons, the database for 2002 was closed on November 30th 2002. Any studies received after that time will be included in the next update.

Characterising included studies for the effectiveness map: EPPI-Centre and review-specific keywording

The included RCTs were therefore characterised using the EPPI-Centre and review-specific keywords (appendices 2.3 and 2.4) as part of the descriptive map of the overarching review.

Identifying and describing studies for the descriptive map of the overarching review: quality assurance process

For the purposes of quality assurance, two members of the Review Team (RA and SB) and one member of the EPPI-Centre (DE) screened a random sample of 10 percent of the studies (screened by CT) in the updated database. Screening was undertaken independently, using the inclusion/exclusion criteria working document. After double-screening, the inter-rater reliability scores between CT

and RA, between CT and SB, and between CT and DE were calculated using the Cohen's Kappa.

Identifying and describing studies for the effectiveness map: quality assurance process

Two reviewers (CT and DZ) independently re-screened the studies retrieved from the database and then compared results. In cases where there was disagreement, a member of the EPPI-Centre was asked to advise (DE).

In-depth effectiveness review

Screening

Two reviewers independently screened all included RCTs and coded them for inclusion or exclusion using the four exclusion criteria (CT and DZ).

Data-extraction and quality assessment of included RCTs

Data-extraction was undertaken by two reviewers. The included RCTs were data- extracted and quality appraised using the EPPI-Centre Guidelines (EPPI-Centre, 2002b). Any disagreements between the reviewers were discussed and resolved. In addition, because this is an effectiveness review and meta-analyses of effect sizes were calculated in order to judge the effectiveness of various interventions, outcomes data were extracted from all the RCTs. This was undertaken by two reviewers. Any disagreements were discussed and resolved. Quality assurance of data-extraction and quality assessment of the included RCTs was provided by the data-extraction undertaken by DE and KS from the EPPI-Centre.

Weight of evidence judgements about included RCTs

The methodological quality of each trial (A) was reviewed in terms of how well it was executed. In addition, each trial was assessed for how much weight of evidence it provided for the specific review in terms of (B) the appropriateness of research design for the review question, and (C) the relevance of the study for the review question. Finally, on the basis of judgments about (A), (B) and (C) an overall weight (D) was ascribed to each randomised trial. The weight of evidence assessments were taken into consideration in both the narrative syntheses and the meta-analyses. Only studies assessed as 'medium' or 'high' on overall weight of evidence were included in the syntheses.

Narrative synthesis of included RCTs

A narrative synthesis of the included trials was undertaken. The conceptual framework which formed the basis of the synthesis focused firstly on different ICT interventions and secondly on different literacy outcomes. This resulted in two approaches to synthesizing the evidence:

(1) Interventions: an analysis of the effectiveness of different types of ICT interventions on a range of literacy outcomes
(2) Outcomes: an analysis of the effectiveness of different types of ICT on specific literacy outcomes

Statistical synthesis of outcomes (meta-analysis)

A meta-analysis essentially averages the results from a number of studies together using a statistical method that gives the greatest weight to the studies with the smallest standard errors, which usually means the largest studies. We pooled some of the studies in a series of meta-analyses that investigated effectiveness in different aspects of ICT and literacy.

Publication bias

One source of bias for systematic reviews is publication bias. If studies showing a positive (beneficial) effect are more likely to be published than negative or inconclusive studies, this will give a biased estimate of effect. One method of determining the existence of publication bias is to draw a funnel plot. This plots the effect size of a study (on the x-axis) against its sample size (on the y-axis). Very small studies will have a high probability of showing an inconclusive effect even if the intervention is effective, just as they will have a raised probability of showing a positive effect if the intervention is ineffective. If there is no publication bias, small studies should be scattered along the x-axis, with the larger trials being situated closer to the true estimate of effect (as they are less subject to variability). A funnel plot was drawn to investigate whether or not there is any publication bias in research in the effectiveness of ICT on literacy learning.

Results

Identification of studies: descriptive map of overarching review

A total of 2,319 potentially relevant reports were identified for the current review. Of these 2,319 reports, 1,891 (just over 81%) were excluded by screening titles and/or abstracts and 428 were sent for. Of these, 34 (fewer than 8%) were not received within the timeframe of the review or were unavailable. A reading of the full report resulted in the exclusion of a further 182 reports, leaving a total of 212 that met the criteria for inclusion in the mapping study.

Identification of studies: effectiveness map

A total of 45 RCTs were identified from the updated database, using the keyword 'RCT'. Three of these failed to meet inclusion criteria, leaving a total of 42 trials included in the effectiveness map.

Most of the studies in the map were identified through the electronic searches on PsycInfo and ERIC. Most of the RCTs were undertaken in the US, with only three being undertaken in the UK.

Identification of studies: in-depth review

Forty-two RCTs were included in the map. Thirty of these were excluded from the in-depth review for the following reasons: no appropriate non-ICT control (19 RCTs); no literacy outcome measures (two RCTs); no data or insufficient data (six RCTs); cluster randomised trials with too few clusters or inappropriate analysis of cluster trial (three RCTs). This left 12 RCTs in the in-depth review. All the studies included in the in-depth review were retrieved from searches on two electronic databases: PsycInfo and ERIC.

In-depth effectiveness review

Publication bias

We plotted the effect size of the identified trials against their sample size. If there is no publication bias, then the included trials should form an 'inverted' funnel with the largest trial at the top. The largest trial reported a negative effect size; however, the studies with the largest effect sizes were positive. There is a suggestion, therefore, that some of the 'missing' trials would have had negative effect sizes. The absence of these trials will tend to make any estimates of effect biased towards the positive.

Synthesis

A range of five different kinds of ICT interventions emerged from the twelve included RCTs in the review: (1) computer-assisted instruction (CAI), (2) networked computer system (classroom intranet), (3) word-processing software packages, (4) computer-mediated texts (electronic text) and (5) speech synthesis systems. There were also three literacy outcomes: (1) reading, including reading comprehension and phonological awareness (pre-reading understandings), (2) writing and (3) spelling.

Six RCTs evaluated CAI interventions (Berninger *et al.*, 1998; Heise *et al.*, 1991; Jinkerson and Baggett, 1993; Lin *et al.*, 1991; McArthur *et al.*, 1990; Mitchell and Fox, 2001). The CAI interventions consisted of studies designed to increase spelling abilities, reading abilities or phonological awareness (pre-reading understandings). One RCT evaluated a networked computer system intervention (Golden *et al.*, 1990) and two RCTs evaluated word-processing interventions; three RCTs evaluated computer mediated texts interventions and one RCT evaluated a speech synthesis intervention.

In synthesis (1), for five different ICT interventions, overall we included 20 comparisons from the 12 RCTs: 13 were positive and seven were negative. Of the positive ones, three were statistically significant, whilst of the seven negative trials, one was statistically significant. These data would suggest that there is little evidence to support the widespread use of ICT in literacy learning in English. This also supports the findings from previous systematic reviews that have used data from rigorous study designs. It also supports the most recent observational data from the Impact2 study. These findings support the view that ICT use for literacy learning should be restricted to pupils participating in rigorous, randomised trials of such technology.

In synthesis (2), we undertook three principal meta-analyses: one for each of the three literacy outcomes measures in which we were interested. In two, there was no evidence of benefit or harm; that is, in spelling and reading the small effect sizes were not statistically significant). In writing, there was weak evidence for a positive effect, but it was weak because only 42 children altogether were included in this meta-analysis.

Quality assurance results: descriptive map of overarching review

Screening

The inter-rater reliability score between CT and RA was 0.65 (good); the inter-rater reliability score between CT and SB was 0.39 (fair); and the inter-rater reliability score between CT and DE was 0.36 (fair). CT and RA were initially less inclusive, possibly because of greater experience of screening educational databases. SB and DE were consistently more cautious in excluding papers in the initial screening, including papers where there was any doubt.

Keywording: EPPI-Centre generic keywording sheet (Appendix 2.3)

Inter-rater agreement was very high. Out of a total possible 180 'keywords', disagreement occurred in only 30 keywords (i.e. 16.7%).

Keywording: English Review Group ICT and literacy keywording sheet (Appendix 2.4)

Agreement was again very good. Out of a total possible 794 keywords, disagreement occurred in 88 cases (i.e. 11%).

Quality assurance results: effectiveness map
Both reviewers agreed on the exclusion of three RCTs from the map and the inclusion of 42 RCTs. They also agreed about whether these RCTs were individually randomised trials or cluster randomised trials.

Quality assurance results: in-depth effectiveness review
Both reviewers included the same 12 RCTs and excluded the same 30 RCTs. In addition, there was complete agreement on exclusion codes. One reviewer (CT) excluded on the basis of the first exclusion code in the hierarchy to apply to a trial, while the other reviewer (DZ) excluded on the basis of all codes that applied to any trial.

There are 12 RCTs in the in-depth review for this research question. All 12 trials were independently double data-extracted by Carole Torgerson, Graham Low and Die Zhu (all three from the University of York), and by Diana Elbourne and Katy Sutcliffe (both from the EPPI-Centre). The data-extractions were compared and all disagreements resolved. The English Review Group data-extraction for each of the 12 RCTs was then uploaded

Conclusions: in-depth review

We identified 12 relatively small RCTs for the in-depth review. Some were so small that they could only really be considered to be pilot studies. This group of tiny trials represent the sum of the most rigorous effectiveness evidence available to date upon which to justify or refute the policy of spending millions of pounds on ICT equipment, software and teacher training. Given that the trials showed little evidence of benefit large, rigorously design, randomised trials are urgently required.

Strengths and limitations
We focused on a robust research design (RCT) appropriate for an effectiveness review. We applied rigorous inclusion and exclusion criteria for including studies in the in-depth review. All the included RCTs were highly relevant to the review and were assessed as being of high or medium overall weight of evidence. We did not include studies of other experimental designs; we did not attempt to combine the results of RCTs with trials of other designs. There was high quality assurance for the review: independent double-screening, data-extraction and quality assessment at each stage.

We did not search for any studies published before 1990. The reason for this is that we felt that ICT of the 1980s and before was relatively unsophisticated compared with current ICT provision. Therefore, trying to inform current ICT policy from studies that used 1980s technology could be misleading. We may have missed some studies. Nevertheless, we accept the possibility that our results could have been affected by publication bias. Publication bias is a very real problem for any systematic review. The fact that we have found and included some negative studies of ICT and literacy is somewhat re-assuring as publication bias tends mainly to affect negative studies. Nevertheless, one interpretation of our data could be that our results are over-optimistic as it is likely that the studies that remain unpublished are more likely to be negative studies than positive ones. If this is true, then the overall effects of ICT could be harmful. All the studies included in the in-depth review were undertaken in the US so they may be of limited generalisability to the UK. All of the participants in the studies were either very young children in the stages of beginning literacy, or slightly

older children who were experiencing difficulties or disabilities in learning in literacy.

Implications for policy, practice and research

Policy-makers should refrain from any further investment in ICT and literacy until at least one large and rigorously designed randomised trial has shown it to be effective in increasing literacy outcomes.

Teachers should be aware that there is no evidence that non-ICT methods of instruction and non-ICT resources are inferior to the use of ICT to promote literacy learning.

A series of large, rigorously designed RCTs to evaluate ICT and literacy learning across all age ranges is urgently required.

1. BACKGROUND

1.1 Aims and rationale for the review

The impact of Information and Communication Technology (ICT) on literacy learning in English is a topical and important issue. There is a need for a systematic review of research in this field, not least because governments worldwide are investing heavily in the provision of hardware and software to educational institutions as well as in the training of teachers and students of all ages in the application of ICT in literacy learning.

Between March 2001 and June 2002, the English Review Group carried out the first part of a systematic review in attempting to answer the overall question 'What is the impact of ICT on literacy learning in English, 5-16?' Having mapped the research literature, the first in-depth review focused on *networked* ICT (i.e. email and the internet). The second part – which is the focus of the present report – looks at another in-depth sub-review that investigates an aspect of the impact of ICT on literacy learning: effectiveness (by identifying and synthesizing all the randomised experimental research). Other sub-reviews in ICT and 'moving image' research, 'literature-based literacies' and English as a second language have also been undertaken, by other members of the English Review Group Review Team.

The main aim of the present systematic review was to investigate whether or not ICT is effective in improving young people's literacy learning in English. Subsidiary aims were to assess the effectiveness of ICT on the different literacy outcomes of reading (including reading comprehension and phonological awareness), writing and spelling and, within those outcomes, to assess whether effectiveness varies according to different interventions.

1.2 Definitional and conceptual issues

ICT includes stand-alone computers, networked technologies with a multimodal interface, mobile phones with the capacity for a range of types of communication, and other technologies, which allow multimodal and interactive communication.

Literacy can be defined narrowly, as the ability to understand and create written language. It is, however, frequently defined in two broader senses, and both are included in the present study. Firstly, the scope can be expanded so that language becomes written language and graphical or pictorial representation. Secondly, the skill can be treated as social, rather than psychological; in this view, literacy is the ability to operate a series of social or cultural representations. Since sets of expectations or norms differ depending on the situation, the social view of literacy entails a number of different 'literacies'.

Literacy as a 'psychological skill': refers to aspects or representations that focus principally on internal dimensions: cognitive advances, mental processing, literacy as expressed via thought, internal dialogue or individual expression. The underlying conception of literacy is one that sees it as the development of individual skills and expectations.

Literacy outcomes

Reading: the act of bringing meaning to print.

Reading comprehension: the interaction between the reader and a text in which meaning is created.

Phonological awareness: understandings related to the sounds of words, including knowledge of rhyme, the ability to segment words and blend a sequence of sounds to produce a word (pre-reading understandings).

Writing: the structure and expression of compositions.

Spelling: orthographic representation of phonemes, morphemes and words; that is, the correct sequence of letters for the smallest units of sound and meaning and of words.

Effect size: a standardised measure that allows studies using different outcome measures to be compared using the same metric (i.e. the mean difference between groups divided by a pooled standard deviation).

By '**English**' we mean, for the purposes of this review, English as a first or second (or additional) language learnt as a medium of instruction in school or spoken and written at home (and, for example, encountered on the internet) – not as a 'foreign' language in, for example, a Modern Foreign Languages department. In terms of commonly used abbreviations, we include ESL (English as a second language) and EAL (English as an additional language), but exclude EFL (English as a foreign language).

1.3 Policy and practice background

The use of ICT to increase literacy learning
The use of ICT in schools to support literacy learning is pervasive. Successive governments have, since the mid-1980s, invested large amounts of resources to develop ICT in schools, including more than £1 billion in the last five years in the UK. However, little robust evidence has been used to underpin this use of ICT.

Recent UK government policy on ICT is supported by five research reports from the British Educational Communications and Technology Agency (BECTa, 1998; BECTa, 1998-9; BECTa, 2001a; BECTa, 2001b; BECTa, 2002). All five reports asserted that Government investment in ICT is justified in terms of its impact on pupil achievement.

In the most recent report (BECTa, 2002) the aim was to investigate the associations between 'high' and 'low' use of ICT (networked technologies) and the educational attainment of pupils at key stages. There was a positive relationship for 'high' ICT and pupil attainment in twelve out of thirteen associations (various subjects at different key stages) but in most cases this association was not statistically significant (seven out of twelve associations) and those associations that were statistically significant typically observed only very small effects. A critical examination of the methods and data presented in the BECTa reports does not consistently support the conclusions drawn by the government policy documents. Indeed, some of the data can be interpreted as showing that ICT is ineffective or harmful. In addition, the evidence presented in

the ImpaCT report (BECTa, 2002) was based on observational data. It would not have been possible to establish a causal relationship between the level of ICT use and the educational attainment of the pupils because the observed effects could have been due to other known or unknown variables.

This absence of evidence for benefit in the UK was supported by a more recent evaluation of the introduction of computers in to Israeli schools (Angrist and Lavy, 2002). This study not only found an absence of benefit in Hebrew literacy but also noted a statistically significant decline in standards of mathematics. The Israeli authors, unsurprisingly, concluded that the large financial investment would have been better spent on other educational inputs.

Whilst the BECTa and Israeli data were consistent in showing either no evidence of benefit or potential harm of ICT, they were not from randomised trials and were therefore susceptible to a range of biases that could make their results unreliable. To assess reliably the effects of ICT on literacy or any educational outcome requires an analysis of randomised controlled trials.

1.4 Research background

A study from the first year of the current project (Andrews *et al.*, 2002) – a mapping exercise on the impact of ICT on literacy learning and an in-depth review of the impact of *networked* ICT on literacy for 5-16 year olds – identified 188 papers published since 1990 that examine the impact of ICT. Most of these originated from the US, though a significant minority arose from research in the UK, Canada, Australia and New Zealand. Of the total, 67 percent were set in primary/elementary schools (especially in the 7-11 age range), with about 44 percent set in secondary/high schools with some studies conducted in both types of setting. About two-thirds of the studies assumed a psychological representation of literacy; that is, they assumed that literacy development was an individual matter concerned with writing and reading processes. One-third adopted a more sociological conception of the practice; that is, one that assumes that literacy development is a matter of the academic and social communities in which you learn. Of the 188 studies, 57 percent were focused on writing, graphical or pictorial production, whereas 46 percent had an interest in reading.

Empirical research
Andrews *et al.* (2002) identified five systematic reviews in the field of ICT and literacy (Bangert-Drowns, 1993; Blok *et al.*, 2001; Fulk and Stormont-Spurgin, 1995; MacArthur *et al.*, 2001; and Torgerson and Elbourne, 2002). These reviews all used a systematic strategy to identify their included studies. All five reviews synthesised research in various aspects of literacy: spelling (Fulk and Stormont-Spurgin, 1995; Torgerson and Elbourne, 2002), writing (Bangert-Drowns, 1993), or verbal and vocabulary development (Blok *et al.*, 2001). In some of the reviews, the included studies focused on participants with specific learner characteristics; for example, pupils experiencing learning disabilities (Fulk and Stormont-Spurgin, 1995; MacArthur *et al.*, 2001). Most of the reviews included papers of all study types (Fulk and Stormont-Spurgin, 1995; MacArthur *et al.*, 2001), whilst others were restricted to experimental research: that is, randomised controlled trials or RCTs and CTs (Blok *et al.*, 2001, Bangert-Drowns, 1993; Torgerson and Elbourne, 2002). Not all the systematic reviews included detailed assessment of the quality of the included studies (Fulk and Stormont-Spurgin, 1995).

Fulk and Stormont-Spurgin (1995) reviewed published research on spelling interventions for pupils with learning disabilities. They reviewed the effectiveness of four techniques for improving spelling, one of which was computer-assisted instruction (CAI), comprising nine studies. The authors of the review concluded that eight out of the nine studies in CAI reported positive effects for CAI. However, only two out of these nine included studies used an experimental design with random or non-random allocation to intervention (CAI) or control (traditional paper-and-pencil methods). The positive effects reported in the seven one-group studies could have been explained in ways other than by any casual relationship with ICT. These other explanations include the statistical phenomenon of regression to the mean, where 'extreme' values either improve or decline, depending on which extreme of a distribution they lie; the Hawthorne effect, where merely the act of observation provokes a beneficial response; or temporal effects, whereby children tend to improve their spelling abilities, irrespective of any intervention over the course of time.

In contrast, a more recent systematic review and meta-analysis of only randomised controlled trials evaluating the effectiveness of ICT interventions in the teaching of spelling (Torgerson and Elbourne, 2002) suggested at best only a modest effect in favour of computer interventions on spelling. This benefit was not statistically significant.

Blok *et al.* (2001) investigated whether or not computers enabled young children to learn vocabulary more effectively than traditional teacher-led approaches. This 'effectiveness' review restricted inclusion by study type and therefore only studies with an experimental design were reviewed. In addition, the authors implemented fairly rigorous inclusion and exclusion criteria. Five studies were included, only one of which demonstrated a positive effect for the computer condition. The review included a discussion of the quality of the five studies and concluded that there was little difference in effectiveness in vocabulary acquisition by computer or by teacher.

MacArthur *et al.* (2001) reviewed published research on the use of ICT to teach or support literacy in populations of students 'with mild disabilities'. They reviewed research in technology and three literacy areas: word identification, reading comprehension and writing. This review included only studies with either an experimental design or studies where quantified learning outcomes were reported. The authors concluded that 'cautious optimism' was justified about the technology potential to improve the literacy skills of students with learning disabilities. However, they also concluded that the methodological quality of the included studies was mixed and they outlined a number of methodological problems with some of the included studies, for example ill-defined or weak control group treatments, insufficient information about the characteristics of the sample and small sample sizes.

Bangert-Drowns (1993) conducted a meta-analysis of 32 studies, using an experimental method (with random or non-random assignment to treatment group) to evaluate the effectiveness of using the word-processor to write assignments. Each included study compared two groups of students who received identical instruction in writing apart from the medium used for the writing process (word-processor or by hand). Each study also measured treatment outcomes quantitatively. However, it is not possible to distinguish the randomised controlled trials from the controlled trials in the analysis and sizes of effect could not be calculated for all the trials. The included studies were published between 1983 and 1990, and only about half of them were conducted with populations of students between the ages of 5 and 16. Seventeen studies

were conducted in college settings. The author concluded that the word processing groups (especially the weaker writers) improved the quality of their writing more than the control groups.

The evidence to date on the effectiveness of ICT on literacy learning is, therefore, equivocal. In summary, whilst there have been some systematic reviews relevant to the policy question of whether ICT is effective in improving literacy outcomes, the extant reviews were either insufficiently rigorous in that they included non-randomised or poor quality trials, or they focused on one aspect of literacy. There was, therefore, a need for a systematic review of recent ICT effectiveness evidence on all aspects of literacy.

1.5 Authors, funders and other users of the review

Richard Andrews is the Co-Ordinator of the English Review Group. His immediate team consists of Carole Torgerson (Research Fellow at the University of York) and Alison Robinson (Research Secretary for the Review Group), Sue Beverton (University of Durham), Jenny Leach (Open University), Andrew Burn (Institute of Education), Graham Low (University of York, Language Teaching Centre), Terry Locke (University of Waikato, New Zealand) and Die Zhu (University of York), who each took responsibility for sub-reviews; they also read interim drafts, attended training and acted as a project *team* in the creation of the review. During the mapping exercise, Torgerson managed/administered the process, with team members contributing. During the writing-up of the review (undertaken on two levels: the writing-up of the overall descriptive map of the overarching review, co-ordinated by Torgerson, Robinson and Andrews, and the composition of chapters for the RoutledgeFalmer book, co-ordinated by Andrews[1]), team members played a more individual role, while maintaining the collective critical eye on the development of the material.

Reference was made to our international colleagues, Wendy Morgan and Eileen Shakespeare. Nancy Rowland advised from a NHS CRD perspective; Diana Elbourne and Katy Sutcliffe from the EPPI-Centre, acted as independent reviewers for sets of the abstracts and sample papers at the mapping, keywording and the data-extraction stages.

The above are all members of the English Review Group, which also consists of Nick McGuinn (University of York), Maggie Snowling and Peter Hatcher (both at the Department of Psychology, University of York), James Durran (Parkside Community College, Cambridge) and Gloria Reid (City of Kingston-upon-Hull Education Services). More achieved drafts of the emerging review – and any other questions that arose in the process of reviewing and writing – were presented to this Advisory Group, both at and between formal English Review Group meetings. The Advisory Group contains members representing 'user groups': for example, Gloria Reid for primary schooling and the education advisory services, James Durran from secondary schooling, and Nancy Rowland as parent governor of both a primary and secondary school[2].

---

1 RoutledgeFalmer have commissioned a book from the Review Group, edited by Andrews with contributions by Beverton, Burn, Die, Elbourne, Leach, Locke, Low, Rees and Torgerson. The book, provisionally entitled *The Impact on ICT on Literacy Education*, was submitted in July 2003 and will be published in 2004.
2 Almost all members of the Advisory Group are parents of school-age children.

In our first in-depth review, users were involved in determining the topic to review, commenting on the protocol, commenting on drafts of the report, disseminating the results of the review (most notably at the launch of the first reports in June 2002) and in writing user summaries. In this present in-depth review such involvement has continued. In addition:

- Users on the advisory group have commented, and will continue to do so, on the emerging sub-review.
- They will take a more proactive role in disseminating the results of the review.
- Discussion of the draft conclusions and of the methodology of the review took place with senior figures at the Teacher Training Agency in a meeting in York in June 2003.
- We will hold a meeting early in 2004 with teachers, parent governors, LEA advisers and others to disseminate the findings of the review and to receive critical feedback.
- Students in initial teacher education will be invited to our dissemination meeting to provide critical feedback

User summaries will be commissioned once the review is completed. These will be from a policy-maker, parent governor, teacher and students, as in the first review. These summaries will be published on REEL, disseminated at conferences and through the communication networks of the different constituencies (e.g. governors' newsletters).

1.6 Review question

The research question for this sub review (for both the 'effectiveness' map and in-depth review) was as follows:

What is the evidence for the effectiveness of ICT on literacy learning in English, 5-16?

This research question was developed because, despite huge investment by this and previous governments in the use of ICT in schools generally in the UK, and with a view to improving literacy learning in particular, to date no generic systematic review to examine the effectiveness or otherwise of ICT on literacy learning in English has been undertaken. Specifically, no systematic review of effectiveness has reviewed studies in all aspects of literacy learning, with diverse learner characteristics but focused exclusively on the most appropriate study design for judging effectiveness – the randomised controlled trial (RCT). This study design is the most appropriate for judging effectiveness because it is the only experimental design that can control for all known and unknown extraneous variables, and for regression to the mean effects commonly observed in uncontrolled study designs.

The review is delimited by the following:

Initially, we confined our searches to English in the curriculum from ages 5 to 16.

In order to delimit the scope of the review further, and because of the rapidly changing nature of ICT, we focused on research published since 1990, the beginning of the decade in which the Internet became widely used and in which schools began to use it in significant numbers.

1.7 Structure of the review

The structure of this review is unusual in that it includes a *two-stage* 'mapping' process, followed by an in-depth review.

In the **descriptive map of the overarching review**, the process of identifying, including and characterising the studies for the systematic review of the *impact* of the ICT on literacy learning is described. In the **effectiveness map**, the process of identifying, including and characterising the studies for the systematic review of the *effectiveness* of ICT on literacy learning is described. For the **in-depth effectiveness review**, the inclusion criteria were refined to identify a sub-section of RCTs to address the effectiveness question.

2. METHODS USED IN THE REVIEW

2.1 User-involvement

User-involvement took place throughout the process of systematic reviewing in the following ways. First, the English Review Group's Advisory Group determined the topic for the review; second, it commented on the draft protocol; third, it commented on the map of studies, advising which particular sub-areas of ICT and literacy were most appropriate for in-depth review; and fourth, it commented in the draft, in-depth review report.

A group of students, teachers, LEA advisory teachers, parents, researchers and governors will be invited to a colloquium to discuss the final draft of the report as part of a dissemination strategy.

A dissemination strategy for the project as a whole was developed in consultation with the parent governor/Director of Dissemination for NHS CRD.

2.2 Identifying and describing studies

2.2.1 Defining relevant studies for the descriptive map of the overarching review: inclusion and exclusion criteria

In order to be included in the mapping section, studies had to meet the following inclusion criteria:

- They had to be one of the following study types: an exploration of relationships, an evaluation (naturally occurring or researcher manipulated) or a systematic review.
- They had to have as their main focus ICT applications to literacy development.
- They had to focus on literacy learning and teaching in schools and/or homes.
- They had to be about the impact of ICT on literacy development.
- They had to be published in English, in the period 1990 to 2002.
- They had to look at literacy and ICT in English-speaking countries.
- They had to be a completed study.
- They had to be studies whose participants/study population includes children of the ages 5 to 16, and young people.
- They could not be opinion pieces or studies of other excluded study types.

The English Review Group working document for the inclusion and exclusion of potentially relevant studies (see Appendix 2.1) was updated to reflect the changes made to the keywording sheets, both generic and review-specific (see Appendices 2.3 and 2.4) since the 2000-2002 review. In terms of the generic keywording sheet, the main differences for 2002-2003 are the changes made to question 10 on study type. In terms of the review-specific keywording sheet, the main differences for 2002-2003 are the streamlining of the literacy, learning and ICT focus keywords (question 12), and the inclusion of a glossary sheet to clarify definitions for all the review-specific keywords (see Appendix 2.5).

2.2.2 Defining relevant studies for the 'effectiveness map': inclusion and exclusion criteria

As the focus of the review was 'effectiveness', studies using rigorous study designs to assess effectiveness were required: this implies the identification of relevant randomised controlled trials (RCTs). The RCT is an experimental design that provides a way of reducing the risk of selection biases at entry to a study. In an RCT, participants are randomly allocated to the interventions being evaluated. Typically, a participant will be allocated to the new intervention (so-called experimental group) or allocated to whatever is the usual practice (the control group). There are many variants to this design; for example, allocating the participants to receive the new intervention either straight away or later (a waiting list design), or to receive both the new and the old intervention but in different randomised sequences (reversal or cross-over design), or allocating groups or clusters (usually intact classes or schools in the educational field). However, the essence of this design and all its variants is the *random* allocation. If participants are allocated on any other basis, one cannot be sure whether (except for chance differences) the experimental and control groups were similar before receiving (or not receiving) the intervention, and therefore it becomes impossible to disentangle the effects of the intervention from the characteristics of the people being allocated to the intervention. Techniques can be used to attempt to control for the potential confounding from known variables, but they cannot adjust for unknown variables. Thus, non-randomised designs cannot be certain to generate groups which do not differ (except by chance) in either known or unknown factors, and hence these designs always have the potential that selection biases may make comparisons between the two groups about the effect of the intervention uncertain. As well as controlling for confounding due to selection bias, randomisation also controls for the statistical phenomenon of regression to the mean. Regression to the mean occurs when extreme test results occur partly by chance. Extreme results, such as low test-scores, will tend to 'regress to the mean' on re-testing irrespective of any intervention. Because randomisation ensures that equal proportions of children with 'extreme' test results are present in each group, regression to the mean will affect all treatment groups equally and the change in test scores due to this phenomenon will be cancelled out. Therefore it is important that, for this review, studies were only included if they randomly allocated pupils to an ICT or no ICT intervention for the teaching of literacy.

The superiority of the RCT over other research designs for assessing effectiveness has been recognised in the field of social policy innovations for a considerable time (Cook and Campbell, 1979; Cook, 2002). Although the RCT addresses the issue of selection bias, it is also statistically a more efficient method than other quasi-experiments. An analysis of 74 meta-analyses of psychological, educational and behavioural interventions revealed that, although in these fields the average effect sizes did not differ between 'true' and 'quasi' experiments, the standard deviation was much larger for the non-randomised experiments (Cook, 2002; Lipsey and Wilson, 1993, p.1192). In other words, the randomised experiments were more efficient than controlled trials in their probing of causal hypotheses (Cook, 2002). In addition, one-group pre-test and post-test designs for assessing the effectiveness of interventions overestimate the size of the effects by up to 61 percent compared with evaluations using designs that employ a control or comparison group (Lipsey and Wilson, 1993, p.1193; p.1197).

Given the importance of the RCT, this systematic review sought to identify all RCTs that evaluate interventions using ICT to increase literacy learning in order to assess whether or not ICT is effective in improving literacy learning.

2.2.3 Identification of potential studies for the descriptive map of the overarching review: search strategy

The potential studies for this review were identified through an updating of the original electronic searches and handsearches. In August 2002, Julie Glanville (NHS CRD at the University of York) re-ran the electronic searches on PsycINFO, ERIC, BEI, SSCI, SIGLE, C2-SPECTR and Dissertation Abstracts using the original search strategies (see Appendix 2.2). In addition, members of the Review Team and Advisory Group who handsearched key journals in the field for the 2001-2002 review undertook handsearching of the same journals for the period July 2001-October 2002 in order to identify any other potentially relevant studies not retrieved through the updated electronic searches. All potentially relevant studies were sent for.

2.2.4 Identification of potential studies for the effectiveness map: search strategy

In their systematic review, Andrews *et al.* (2002) mapped the research on the impact of ICT on literacy learning in English, 5 to 16. The relevant research was searched for, located, sent for and mapped for the years 1990-2001. Research studies were identified, screened and keyworded with respect to the research question of the impact of ICT on literacy learning (5 to 16) in general. Studies were keyworded according to study type. A research question looking at the *effectiveness* of ICT on literacy learning would therefore include studies keyworded as 'RCTs'. After updating searches to locate any further relevant studies that were undertaken after 2001 and re-keywording using the EPPI-Centre core keywording strategy (EPPI-Centre, 2002a), the keyword 'RCT' was used to identify any RCTs from the updated database.

2.2.5 Screening studies for the descriptive map of the overarching review: applying inclusion and exclusion criteria

The updated database for 2002-2003 that included potentially relevant studies published after October 2001 was screened by a member of the Review Team (CT), using titles and abstracts and the updated working document with inclusion and exclusion criteria. Any potentially relevant studies were sent for through library interlending. Finally, the original database was merged with the updated database.

2.2.6 Screening studies for the effectiveness map: applying inclusion and exclusion criteria

All studies keyworded as RCTs were re-screened to check that they were individual or cluster RCTs and fulfilled the inclusion criteria for the systematic map. They were then included in the map.

2.2.7 Characterising included studies in the descriptive map of the overarching review: EPPI-Centre and review-specific keywording

All the studies included in the original database from the review of 2001 were re-keyworded by members of the Review Team using the new guidelines from the EPPI-Centre (EPPI-Centre, 2002a). The studies retrieved for the updated database were keyworded by a member of the Review Team (CT), with assistance from other members of the Review Team and the EPPI-Centre where there was any doubt about keywording. The database was fully annotated with the keywords (AR). For pragmatic reasons, the database for 2002 was closed on November 30th 2002. Any studies received after that time will be included in the next update.

2.2.8 Characterising included studies in the effectiveness review: EPPI-Centre and review-specific keywording

The included RCTs were characterised using the EPPI-Centre (Appendix 2.3) and review-specific (Appendix 2.4) keywords. Using these keywords, the effectiveness map was drawn. It focused on origin of RCT, country of study, learner characteristics, literacy focus and ICT intervention.

2.2.9 Identifying and describing studies in the descriptive map of the overarching review: quality assurance process

For the purposes of quality assurance, two members of the Review Team (RA and SB) and one member of the EEPI-Centre (DE) screened a random sample of 10 percent of the studies in the updated database. Screening was undertaken independently, using the inclusion/exclusion criteria working document (Appendix 2.1). After double-screening, the inter-rater reliability scores between CT and RA; CT and SB; and CT and DE were calculated using the Cohen's Kappa. For the purposes of quality appraisal, a random sample of 18 papers was double re-keyworded by two members of the EPPI-Centre (DE and KS).

2.2.10 Identifying and describing studies in the effectiveness map: quality assurance process

Two reviewers (CT and DZ) independently re-screened the studies retrieved from the database and then compared results. In cases where there was disagreement, a member of the EPPI-Centre was asked to advise (DE).

2.3 In-depth review

2.3.1 Moving from broad characterisation (effectiveness mapping) to effectiveness in-depth review

Although the research question was identical for both the effectiveness map and the in-depth review, the inclusion criteria were more rigorous for the in-depth review. For a paper to be included in the in-depth review, it had to be to be a study looking at the effect of ICT on the teaching of literacy to children in a school setting. Control treatments could take any form, such as routine classroom

teaching, or other non-computer teaching. However, in order to investigate the effectiveness of ICT on literacy learning, included studies had to have an appropriate non-ICT control group that isolated the medium of instruction as the independent variable. Studies that did not explicitly have a control group that was not exposed to ICT were excluded. Included RCTs had to have a literacy intervention (students were exposed to an intervention that aimed to increase reading, writing or spelling abilities), and at least one quantified literacy outcome measure (reading, writing, spelling). If RCTs did not have both a literacy intervention (reading, writing, spelling) and at least one literacy outcome measure they were excluded.

For this review, studies were therefore only included if they randomly allocated pupils to an ICT or no ICT treatment for the teaching of literacy. Both individually randomised trials and cluster randomised trials were included, but cluster trials were only included if each arm contained more than four clusters (Ukoumunne *et al.*, 1998), and if the unit of analysis was at the cluster level (not the individual level); that is, if there was no unit of analysis error. Because this review is an effectiveness review it was necessary to look at the effect sizes (with confidence intervals) in the primary studies. If the authors did not present effect sizes, or if the reviewers were unable to calculate the effect sizes, a RCT was excluded. Essentially this means that the study had to report either means of post-tests or mean gain scores, numbers of participants in the intervention and control groups and the standard deviations of the mean scores, or the means and numbers of participants in each group and either a t-value or precise p value in order that the reviewers could calculate the standard deviations. RCTs were included if they presented sufficient data. It was decided not to reanalyse poorly analysed cluster trials and not to approach authors of RCTs for further data.

Summary of inclusion and exclusion criteria are given below.

Inclusion criteria
- Must be a randomised controlled trial (individual or cluster with sufficient clusters)
- Must have an appropriate non-ICT control group
- Must include a literacy based intervention (reading, writing or spelling)
- Must include at least one quantified literacy outcome measure (reading, writing, or spelling test or curriculum-based assessment)
- Must include sufficient data in order that reviewers can calculate effect sizes (either means of post-tests or mean gain scores with numbers and standard deviations in both intervention and control groups or means and numbers and either a precise p value or t value)

Exclusion criteria
- No appropriate non-ICT control (exclusion 1)
- No literacy outcome measure (exclusion 2)
- No data or insufficient data (exclusion 3)
- Too few clusters in cluster randomised trial (exclusion 4)

2.3.2 Detailed description of studies in the effectiveness in-depth review: EPPI-Centre and review-specific data-extraction

Data-extraction was undertaken by two reviewers. The included RCTs were data-extracted and quality appraised using the EPPI-Centre Guidelines (EPPI-

Centre, 2002b). Any disagreements between the reviewers were discussed and resolved. In addition, because this is an effectiveness review and meta-analyses of effect sizes were calculated in order to judge the effectiveness of various interventions, outcomes data were extracted from all the RCTs. This was undertaken by two reviewers. Any disagreements were discussed and resolved. Any included RCTs that were data-extracted for the 2001-2002 review on networked technologies (Andrews *et al.*, 2002) were re-data-extracted according to the new guidelines for this review.

2.3.3 Assessing quality of studies and weight of evidence for the review question

EPPI-Centre Guidelines as set out in section 7 of the revised data-extraction tool (September 2002) were used to gauge the weight of evidence an individual study brought to the review. The methodological quality of each trial (A) was reviewed in terms of how well it was executed. In addition, each trial was assessed for how much weight of evidence it provided for the specific review, in terms of (B) the appropriateness of research design for the review question, and (C) the relevance of the study for the review question. Finally, on the basis of judgments about (A), (B) and (C), and an overall weight (D) was ascribed to each randomised trial. The weight of evidence assessments were taken into consideration in both the narrative syntheses and the meta-analyses. Only studies assessed as 'medium' or 'high' on overall weight of evidence were included in the syntheses.

2.3.4 Synthesis of evidence

A narrative synthesis of the included trials was undertaken. The conceptual framework which formed the basis of the synthesis focused firstly on different ICT interventions and secondly on different literacy outcomes. This resulted in two approaches to synthesizing the evidence:

(1) Interventions: an analysis of the effectiveness of different types of ICT interventions on a range of literacy outcomes
(2) Outcomes: an analysis of the effectiveness of different types of ICT on specific literacy outcomes

In the first synthesis, the effectiveness of the different types of ICT interventions was established by a standard measure of effect for the range of literacy outcomes in the included trials (effect size). An effect size is a standardized measure that allows studies using different outcome measures to be compared using the same metric (i.e. the mean difference between groups divided by a pooled standard deviation). In order to present these effect sizes, the most appropriate literacy outcome measures at immediate post-test were selected. These outcomes were chosen by the author of the review (CT), with advice from other reviewers involved in the data-extraction and quality assessment of the included trials (DZ, DE and KS). If a 'total' reading, writing or spelling test was used in addition to a variety of subtests, the 'total' test was selected. If a number of 'total' tests were used, the outcome selected was the one felt to have the most important educational significance. The most appropriate outcome measures for reading were reading comprehension and accuracy. For writing, the most appropriate measures were holistic scoring (quality of writing) and word-count (quantity of writing). For spelling, the outcome measure selected was spelling accuracy on a selection of words taught in the intervention. For phonological awareness, the outcome measure selected was total score on phonological

awareness test. Where there were two outcomes of equal importance, both effect sizes were calculated for the syntheses.

In the second synthesis, the effectiveness of different types of ICT on three specific literacy outcomes (reading, writing, spelling) was established through a narrative synthesis and a series of meta-analyses where appropriate.

Statistical synthesis of outcomes (meta-analysis)
A meta-analysis essentially adds a number of studies together using a statistical method that gives the greatest weight to the studies with the smallest standard errors, which usually means the largest studies. We pooled some of the studies in a series of meta-analyses that investigated effectiveness in different aspects of ICT and literacy.

The formulae for the meta-analysis statistics can all be found in Deeks *et al.* (2001) (see Appendix 2.6).

Weight of evidence
The EPPI Guidelines were used to establish the relative 'weight of evidence' that was ascribed to each included trial. This information was taken into account in both the narrative syntheses and the meta-analyses.

Publication bias
One source of bias for systematic reviews is through publication bias. If studies showing a positive (beneficial) effect are more likely to be published than negative or inconclusive studies, this will give a biased estimate of effect. One method of determining the existence of publication bias is to draw a funnel plot. This plots the effect size of a study (on the x-axis) against its sample size (on the y-axis). Very small studies will have a high probability of showing an inconclusive effect even if the intervention is effective, just as they will have a raised probability of showing a positive effect if the intervention is ineffective. If there is no publication bias, small studies should be scattered along the x-axis, with the larger trials being situated closer to the true estimate of effect (as they are less subject to variability). A funnel plot was drawn to investigate whether or not there was any publication bias in research in the effectiveness of ICT on literacy learning.

2.3.5 Effectiveness in-depth review: quality assurance process

Two reviewers independently screened all included RCTs and coded them for inclusion or exclusion using the four exclusion criteria (CT and DZ).

Quality assurance of data-extraction and quality assessment of the included RCTs were provided by the data-extraction undertaken by DE and KS from the EPPI-Centre. In addition, DE and KS read and commented on emerging drafts of the review.

3. IDENTIFYING AND DESCRIBING STUDIES: RESULTS

3.1 Studies included in descriptive map of overarching review from searching and screening

Table 3.1 illustrates the process of identifying, obtaining and describing reports for the current review. A revised version of the mapping study retrieval process reported in Andrews *et al.* (2002) is shown in column one. The revisions were the result of further de-duplication of the database (four papers deleted), annotation of reports received outside the review's original timeframe (n = 8), and re-keywording of included reports in accordance with EPPI's Revised Guidelines (EPPI-Centre, 2002a), which led to further exclusions (n = 8). In addition, five papers originally excluded at the second stage were included in the current review following re-keywording. Column two shows the mapping study retrieval process for those additional reports identified by an update of the electronic and handsearches. The final column merges the original mapping study retrieval process with the update to show the process of retrieval of the reports in the mapping study for the current review.

A total of 2,319 potentially relevant reports were identified for the current review. Of these 2,319 reports, 1,891 (just over 81%) were excluded by screening titles and/or abstracts and 428 were sent for. Of these, 34 (fewer than 8%) were not received within the timeframe of the review or were unavailable. A reading of the full paper resulted in the exclusion of a further 182 reports, leaving a total of 212 reports that met the criteria for inclusion in the mapping study. Each report contains only one study, with one exception: Matthew (1997), which contains two studies, a controlled trial and a randomised controlled trial. Only one study is reported in two reports: Matthew (1996) and Matthew (1997), both of which report the same randomised controlled trial. Therefore 212 reports containing 212 studies were included in the descriptive map. This information is presented in Figure 3.1.

Table 3.1: The process of retrieval of the reports in the mapping study

	Andrews *et al.*, 2002 (revised)	Review update	Current review
Total number of 'hits'	1,867	452	2,319
Met mapping study inclusion criteria on the basis of the title or abstract	358	70	428
Not received or unavailable	22	12	34
Full reports available	336	58	394
Full reports that did not meet mapping study inclusion criteria	159	23	182
Met mapping study inclusion criteria and keyworded	177	35	212

Figure 3.1: Filtering of papers from searching to map to synthesis – generic review
*Criteria for exclusion are not mutually exclusive

1. Identification of potential studies

Papers identified through electronic and handsearching
N = 2,319

One-stage screening
N = 57

Two-stage screening
N = 2,262

Papers excluded
N = 1,891

Criterion 1*:
N = 1,067

Criterion 2*:
N = 106

Criterion 3*:
N = 97

Criterion 4*:
N = 579

Criterion 5*:
N = 134

2. Application of inclusion/ exclusion criteria

Potential includes
N = 428

Papers not obtained
N = 34

Full document screened
N = 394

Papers excluded
N = 182

Criterion 1*:
N = 24

Criterion 2*:
N = 31

Criterion 3*:
N = 12

Criterion 4*:
N = 102

Criterion 5*:
N = 15

3. Characterisation

Systematic map
studies included
N = 212

In map but excluded from in-depth reviews
N = 133

4. In-depth reviews

In-depth reviews
studies included:
Effectiveness N = 45*
Moving Image N = 12
Literature N = 12
ESL/EAL N = 10

*This refers to the number of studies in the generic review keyworded 'RCT' and therefore included in the effectiveness map. The effectiveness review covers 12 of the 45; see section 3.4 and Figure 4.1.

Table 3.2 presents the origin, by database or other method of retrieval, of all the 212 reports (containing 212 studies) included in the mapping study. It also shows the process of retrieval for each database.

The great majority of the reports found to meet the mapping study's inclusion criteria (185: 88%) were found with the database searches. Handsearching found an additional 22 (11%). The checking of citations (systematic review bibliographies and citations in the text of full reports) and reviewers' searches of their own shelves identified a further four and one relevant report respectively. No reports were identified solely through C2-SPECTR or web page searches.

Table 3.2: Origin of reports in the mapping study

	Found	**Included**
PsycINFO	849	97
ERIC	880	62
BEI	295	20
SSCI	59	2
Cochrane	26	0
SIGLE	48	2
C2-SPECTR	49	0
DisAbs	56	2
Handsearch	43	22
Citation	8	4
Website	3	0
Contact	3	1
Total	*2,319*	*212*

Note: Reports could originally have more than one origin but a hierarchy of databases and other sources was created resulting in each category being made mutually exclusive.

3.2 Characteristics of the included studies: the impact of ICT on literacy learning in English for 5-16 year olds

The remaining tables in this section present analyses of the included and keyworded studies contained in the 212 reports. All the percentages are based on these 212 reports.

Table 3.3 shows the number and proportion of studies according to the country in which they were conducted. Most (63%) were conducted in the US. A total of 39 (18%) were from the UK. In three cases (2%), it was not possible to determine where a study had taken place. These figures may reflect bias within the bibliographic sources searched towards reports published within the North America, Australasia and the UK.

Table 3.3: Study country

	Number
USA	134
UK	39
Australia	17
Canada	15
New Zealand	2
Sweden	1
Netherlands	1
Not stated	3

Note: All studies were conducted in one country only.

Table 3.4 describes the educational setting for the studies. A study could be conducted in more than one setting. Primary education was the most frequently studied; 66 percent of reports look at this kind of setting, compared with 34 percent that look at secondary settings. A total of 32 studies were conducted in both primary and secondary settings. Thirty studies were conducted in other settings, including independent schools, special schools and the home.

Table 3.4: Educational setting

	Number
Primary education	140
Secondary education	74
Other	30

Note: A single study could be conducted in more than one type of educational setting.

Table 3.5 presents the number of studies that conceptualised literacy in psychological and/or social/cultural/critical terms and the number that focused on reading and/or writing. Of the studies identified, about two-thirds (62%) assume a psychological representation of literacy. A third (34%) adopt a more sociological conception of the practice. Two-thirds (62%) focus on writing, graphical or pictorial production, whereas half (50%) have an interest in reading. Studies could have more than one focus with respect to both of these dimensions of literacy. For both dimensions, there were a number of studies where reviewers were unable to categorise the aspect of literacy under study.

Table 3.5: Principal aspect(s) of literacy

	Number
Conceptualisation of literacy	
Psychological aspects or representations	131
Social representations and/or cultural/critical representations	73
Unclear	21
Reading/writing	
Writing print and graphical or pictorial representation	131

	Number
Reading print and graphical or pictorial representation	106
Unclear	5

Note: Studies could theoretically focus on two to four of these aspects of literacy.

Table 3.6 shows the overall distribution of reports according to study type. Most (179) of the 212 reports meeting the inclusion criteria for the mapping study were evaluations; 169 of these were where the intervention was researcher-manipulated and 10 were where the intervention was naturally occurring. Of the 169 evaluations with researcher-manipulated interventions, 45 were RCTs, 84 were trials and 41 were other types of evaluation. One report contained both an RCT and a non-randomised controlled trial.

Table 3.6: Study type

	Number
Evaluation: researcher-manipulated	170
RCT	45
Trial	85
Other	41
Evaluation: naturally occurring	10
Exploration of relationships	28
Description	3
Review	6
Systematic review	5
Other review	1

Note: Studies could be defined as more than one type.

The type of ICT focused on by the identified studies is illustrated by Table 3.7. This shows the relative popularity of 'stand-alone' ICT as a topic of study in comparison with networked ICT systems. The use of email was studied more frequently than internet use.

Table 3.7: Type of ICT

	Number
Computer – stand alone (software)	191
Computer – networked (email and/or internet)	24
Computer – networked (email)	20
Computer – networked (internet)	11

Note: Studies could focus on more than one aspect of ICT.

Table 3.8 illustrates the process of identification by keyword of reports for inclusion in the four specific, in-depth sub-reviews introduced in the Background section of the Summary chapter at the beginning of this review. Each report was subject to the inclusion/exclusion criteria of the specific in-depth review for which they were identified. This process is described in the individual sub-review reports.

Table 3.8: Identification of reports for inclusion in the specific in-depth reviews

Keyword	Total reports
RCT	45
Moving image	12
Literature	12
ESL/EAL	10

Note: Reports could be included in more than one in-depth review.

3.3 Identifying and describing studies in the descriptive map of the overarching review: quality assurance results

Screening
The inter-rater reliability score between CT and RA was 0.65 (good); the inter-rater reliability score between CT and SB was 0.39 (fair); and the inter-rater reliability score between CT and DE was 0.36 (fair). CT and RA were initially less inclusive, possibly because of greater experience of screening educational databases. SB and DE were consistently more cautious in excluding papers in the initial screening, including papers where there was any doubt.

Keywording: EPPI-Centre generic keywording sheet
Inter-rater agreement was very high. Out of a total possible 180 'keywords', disagreement occurred in only 30 keywords (i.e. 16.7%). Most of these disagreements (19) were in the area of study topic (keyword 6) where the EPPI-Centre members were consistently more inclusive. Initially, the EPPI-Centre members included more than one study topic for some studies, for example 'curriculum' and 'teaching and learning'. Review Team members coded all 18 papers as 'curriculum'. The two EPPI-Centre members coded these 18 papers as 'curriculum' but in all cases also coded them as 'assessment' and/or 'teaching and learning'. The other 11 disagreements were mainly omissions, and disagreement on educational institution and age.

Keywording: English Review Group ICT and literacy keywording sheet
Agreement was again very good. Out of a total possible 794 keywords, disagreement occurred in 88 cases (i.e. 11%). Most of the disagreements were additions by members of the EPPI-Centre in keywords 14 and 17 (again due to them being more inclusive), and omissions by the members of the EPPI-Centre in keyword 16 where members of the Review Team tended to apply a keyword to both a *and* b. In addition, there were a few disagreements on study type. It was anticipated that these disagreements would be resolved at data-extraction stage. The results of this quality assurance exercise highlight the importance of including a glossary for review-specific keywords.

3.4 Studies included in the effectiveness map from searching and screening

A total of 45 RCTs were identified from the updated database, using the keyword 'RCT'. Three of these subsequently failed to meet inclusion criteria for the map. One of the 45 trials (Fuchs *et al.*, 1991) was excluded from the systematic map because it randomised teachers rather than learners to an intervention. The intervention was not an ICT intervention in literacy for the pupils, but rather ICT methods for teachers to use in their assessments of the pupils' progress (some of which happened to be in literacy). A second RCT was excluded because it was not adequately randomised (Varner-Quick, 1994). After randomising 120 second-grade pupils to intervention or control, an unspecified number were excluded at fourth grade (all repeaters, transfers and subjects that did not participate in the programme since its inception) in order to create a 'random sample' of students to include in the data-analysis. Therefore, the randomisation procedure was violated. Because of this problem, this study could no longer be considered an RCT. It will be re-keyworded in the update as a controlled trial. Two of the 45 papers described the same RCT (Matthew, 1996 and Matthew, 1997). Both of these papers were therefore considered together. This left a total of 42 trials included in the systematic map.

3.5 Characteristics of the included studies in the effectiveness map

The effectiveness map was based on the keywording (EPPI generic keywording and review-specific keywording) of the 42 RCTs.

Most of the studies in the map were identified through the electronic searches on PsycInfo and ERIC (Table 3.9). A hierarchy of importing relevant studies in to the database was established, starting with PsycInfo, then continuing with ERIC and so on. Therefore, if a study was found on ERIC but had already been found on PsycInfo, it would be coded on the database as having been retrieved from PsycInfo.

Table 3.9: Origin of 42 RCTs

Electronic database	Number of studies
PsycINFO	27
ERIC	12
BEI	2
Handsearch	1

Most of the RCTs were undertaken in the US, with only three undertaken in the UK (Table 3.10).

Table 3.10: Countries where 42 RCTs were undertaken

Country	Number of trials
USA	33
Canada	5
UK	3
Australia	1

The characteristics of the learners participating in the RCTs and the educational institutions where the RCTs were carried out were as follows:

Table 3.11: Ages of trial participants (in 42 RCTs)

Age range of children	Number of trials
5-10	33
11-16	17
5-10 and 11-16	8

In Table 3.11, the categories 5-10 and 11-16 are not mutually exclusive (hence the category 5-10 and 11-16, which indicates the overlap in eight trials).

Table 3.12: Gender of participants in the 42 trials

Gender	Number of trials
Mixed sex	26
Not stated	16

Table 3.13: Educational setting of 42 identified trials

Type of school	Number of trials
Primary school	32
Secondary school	16
Nursery school	1
Other*	1

* 6-8 grade public elementary school
In Table 3.13, the categories are not mutually exclusive.

The focus of each included trial, the type of ICT intervention, and the principal aspects of literacy of each trial are presented in tables 3.14 to 3.16.

Table 3.14: Focus (keywords)

Keywords	Number of trials
Reading	24
Spelling	4
Writing	15

In Table 3.14, the categories are not mutually exclusive.

Table 3.15: Type of intervention

Type of ICT	Number of trials
Computer – stand-alone	39
Computer – networked	3

Table 3.16: Principal aspects of literacy

Aspects of trials	Number of trials
Psychological aspects or representations	38
Social representations and/or cultural/critical representations	4

Aspects of trials	Number of trials
Writing print and graphical or pictorial representations*	19
Reading print and graphical or pictorial representations*	25

* These categories are not mutually exclusive.

Although all 42 trials in the effectiveness map were randomised controlled trials, and therefore appropriate for addressing questions of effectiveness, many of them addressed questions of relative effectiveness of one kind of software package compared with another. Additionally, a number of these 42 trials were not rigorous in their design or reporting; that is, they did not provide any data or they provided insufficient data (effect sizes could not be calculated), they were cluster trials with too few clusters or inappropriate analysis. Finally, a number of these trials did not report any literacy outcome measures.

3.6 Identifying and describing studies in the effectiveness map: quality assurance results

Both reviewers agreed on the exclusion of three RCTs from the map and the inclusion of 42 RCTs. They also agreed about whether these RCTs were individually randomised trials or cluster randomised trials.

4. EFFECTIVENESS IN-DEPTH REVIEW: RESULTS

4.1 Selecting studies for the effectiveness in-depth review

Studies were included in the effectiveness in-depth review if they matched the content-based and methodological criteria as outlined above.

Table 4.1 presents the results of this procedure. Forty-two RCTs were included in the map. Thirty of these were excluded from the in-depth review for the following reasons: no appropriate non-ICT control (19 RCTs - Exclusion 1); no literacy outcome measures (two RCTs - Exclusion 2); no data or insufficient data (six RCTs - Exclusion 3); cluster randomised trials with too few clusters or inappropriate analysis of cluster trial (three RCTs - Exclusion 4). This left 12 RCTs in the in-depth review. A hierarchy for excluding studies was established, starting with Exclusion 1, continuing with Exclusion 2, and so on. Therefore, if a study was excluded on the basis of Exclusion 3 (no or insufficient data), this means that there was an appropriate non-ICT control and there were literacy outcome measures in this trial. A number of trials were excluded on more than one criterion, but this has not been shown in the table. This information is also presented in Table 4.1and Figure 4.1.

Table 4.1: The 42 studies keyworded as RCTs indicating numbers included and excluded

	Number of RCTs
Total number of keyworded RCTs in map	42
Exclusion 1	19
Exclusion 2	2
Exclusion 3	6
Exclusion 4	3
Total number of excluded RCTs	30
Total number of RCTs included in in-depth review	12 RCTs

Figure 4.1: Filtering of papers from map to synthesis – effectiveness review


```
┌─────────────────┐        ┌──────────────┐
│ Studies         │        │   Papers     │
│ identified      │───────▶│  excluded    │
│ in              │        │   N = 3      │
│ generic map     │        └──────────────┘
│ N = 45          │
└─────────────────┘
        │                                    ┌──────────────┐
        ▼                                    │ Criterion 1  │
┌─────────────────┐        ┌──────────────┐  │   N = 19     │
│ Studies         │        │   Papers     │  └──────────────┘
│ identified for  │───────▶│  excluded    │  ┌──────────────┐
│ review map      │        │   N = 30     │─▶│ Criterion 2  │
│ N = 42          │        └──────────────┘  │   N = 2      │
└─────────────────┘                          └──────────────┘
        │                                    ┌──────────────┐
        ▼                                    │ Criterion 3  │
┌─────────────────┐                          │   N = 6      │
│ In-depth review │                          └──────────────┘
│ Studies included│                          ┌──────────────┐
│                 │                          │ Criterion 4  │
│    N = 12       │                          │   N = 3      │
└─────────────────┘                          └──────────────┘
```

Key to exclusion criteria:

Criterion 1 = No appropriate non-ICT control

Criterion 2 = No literacy outcome measures

Criterion 3 = No data or insufficient data

Criterion 4 = Cluster randomised trials with too few clusters or inappropriate analysis
            of cluster trial

Table 4.2 shows the reasons for exclusion for all 30 excluded trials. Most were excluded because they did not have an appropriate non-ICT control. (Also see Figure 4.1).

Table 4.2: Excluded studies and primary reasons for their exclusions

Exclusion 1	Exclusion 2	Exclusion 3	Exclusion 4
Barker, 1994	Adam and Wild, 1997	Braden *et al.*, 1991	Allen and Thompson, 1995
Barron *et al.*, 1992	Dwyer and Sullivan, 1993	Cato *et al.*, 1994	Silver and Repa, 1993
Bonk and Reynolds, 1992		Grejda and Hannafin, 1992	Spaulding and Lake, 1992
Calvert *et al.*, 1990		Harris and Bond, 1992	
Cardinale and Fish, 1994		Roberts and Samuels, 1993	
Feldmann and Fish, 1991		Topping, 1997	
Foster *et al.*, 1994			
Johnston 1996,			
Laframboise, 1991			
Leong, 1992			
Leong, 1995			
Leong, 1996			
Lewin, 2000			
Olson *et al.*, 1997			
Palumbo and Prater, 1992			
Rosenbluth and Reed, 1992			
Utay and Utay, 1997			
Wepner, 1992			
Wise and Olson, 1995			

The 19 RCTs excluded because they did not have an appropriate non-ICT control (Exclusion 1) compared two or more forms of ICT software, and therefore could not be used in the in-depth review to establish effectiveness of ICT compared with traditional paper-and-pencil methods of literacy learning. The two RCTs excluded because they did not have any literacy outcome measures (Exclusion 2) could not be used in the in-depth review because quantified evidence of effectiveness of ICT on literacy could not be established without at least one literacy outcome measure. Similarly, the six RCTs excluded because they contained no data or insufficient data (Exclusion 3) could not be used in the in-depth review to establish effectiveness because it was not possible to calculate effect sizes. Finally, the three RCTs that were excluded because they were cluster trials with too few clusters or cluster trials that were inappropriately analysed (Exclusion 4) could not be used in the in-depth review because of methodological shortcomings of these cluster trials.

4.2 Further details of studies included in the in-depth review

All 12 studies included in the in-depth review were retrieved from searches on two electronic databases: PsycInfo and ERIC.

Table 4.3: Database origin of 12 included studies

Database	Included studies
PsycINFO	6
ERIC	6
BEI	0
Handsearch	0

All the studies included in the in-depth review were carried out in the US.

Table 4.4: Country of origin 12 of included studies

Country	Included studies
USA	12
Canada	0
UK	0
Australia	0

The characteristics of the learners in the studies in the in-depth review are presented below.

Table 4.5: Age of study participants in 12 RCTs

Age of study participants	Included studies
5-10	10
11-16	5
5-10 and 11-16	3

The categories 5-10 and 11-16 in Table 4.6 are not mutually exclusive (hence the category that indicates the overlap).

Table 4.6: Gender mix in 12 RCTs

Gender	Included studies
Mixed sex	10
Not stated	2

Table 4.7: Educational setting of 12 included RCTs

Type of school	Included studies
Primary school	10
Secondary school	4
Nursery school	0
Other*	1

* 6-8 grade public elementary school. Categories in Table 4.7are not mutually exclusive.

The focus of each included trial, the type of ICT intervention, and the principal aspects of literacy of each trial are presented in Tables 4.8 to Table 4.10.

Table 4.8: Focus (keywords)

	Included studies
Reading	7
Spelling	3
Writing	2

Table 4.9: Type of intervention

	Included studies
Computer – stand-alone	11
Computer – networked	1

Table 4.10: Principal aspects of literacy

	Included studies
Psychological aspects or representations	12
Social representations and/or cultural/critical representations	0
Writing print and graphical or pictorial representations*	5
Reading print and graphical or pictorial representations*	8

*Categories are not mutually exclusive.

The participants in the 12 included trials ranged in age from 5 to 13 (kindergarten to Grade 8). In seven out of the 12 RCTs, either all or half of the actual sample children were pupils who experienced 'learning disabilities', or 'specific learning disabilities'.

The 12 included RCTs were tabulated according to their literacy and ICT focus keywords. Table 4.11 presents the results, in alphabetical order.

Table 4.11: Studies included in the in-depth review with ICT focus (intervention) and literacy topic focus (literacy outcome)

Author, date	**ICT intervention**	**Literacy outcome**
Berninger *et al.*, 1998	CAI	Spelling
Golden *et al.*, 1990	Networked computer system	Reading (comprehension)
Heise *et al*., 1991	CAI	Reading
Jinkerson and Baggett, 1993	CAI	Spelling
Jones, 1994	Word-processing	Writing
Lin *et al.*, 1991	CAI	Reading
MacArthur *et al.*, 1990	CAI	Spelling
Matthew, 1996	Computer-mediated	Reading (comprehension)

Author, date	ICT intervention	Literacy outcome
(Matthew, 1997)	texts	
Mitchell and Fox, 2001	CAI	Reading (phonological awareness)
Reinking and Rickman, 1990	Computer-mediated texts	Reading (comprehension)
Swanson and Trahan, 1992	Computer-mediated texts	Reading (comprehension)
Zhang *et al.*, 1995	Speech synthesis Word-processing	Writing

The judgements on weight of evidence of all 12 trials are tabulated in Table 4.12.

Table 4.12: Weight of evidence

Study	A	B	C	D
Berninger *et al.*, 1998	High	High	High	High
Golden *et al.*, 1990	Medium	High	Medium	Medium
Heise *et al.*, 1991	Medium	High	High	Medium
Jinkerson and Baggett, 1993	Medium	High	High	Medium
Jones, 1994	Medium	High	High	Medium
Lin *et al.*, 1991	Medium	High	Medium	Medium
MacArthur *et al.*, 1990	High	High	High	High
Matthew, 1996 (Matthew, 1997)	High	High	High	High
Mitchell and Fox, 2001	High	High	Medium	Medium
Reinking and Rickman, 1990	Medium	High	High	Medium
Swanson and Trahan, 1992	High	High	High	High
Zhang *et al.*, 1995	Medium	High	High	Medium

Weight of evidence A: Soundness of method of each individual RCT according to general and study type specific criteria

Five of the trials were assessed as being 'high' and seven trials were assessed as being 'medium' in terms of the trustworthiness of each individual trial's findings and in terms of answering the trial's study question. Regarding internal validity, it is not surprising that all 12 trials were 'high' or 'medium' in this category. The inclusion criteria for the in-depth review were extremely rigorous and would have excluded RCTs with poor design, conduct or reporting.

Weight of evidence B: Appropriateness of study type to answer the review question

All twelve trials were assessed as being 'high'. This means that, for the purposes of this specific systematic review, all 12 trials were highly appropriate for answering the review question. The randomised controlled trial is the most appropriate design for addressing questions of effectiveness. Since a trial had to be an individually randomised trial or a cluster trial containing at least four clusters in each arm to be included in the in-depth review, it is not surprising that all 12 trials were assessed as being 'high' in this category.

Weight of evidence C: Relevance of the topic focus of the individual study to the review question
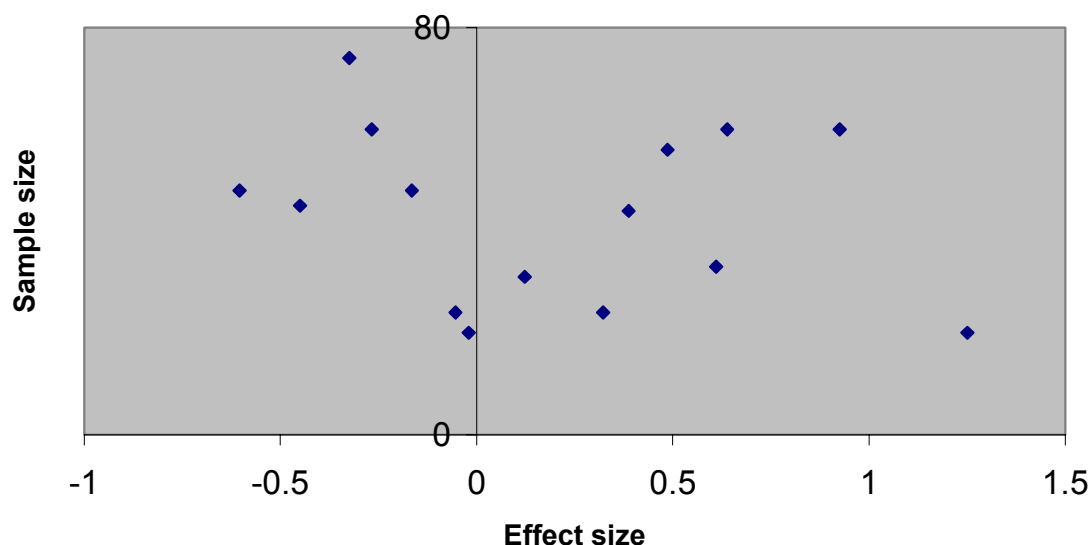
Nine trials were assessed as 'high' and three trials were assessed as 'medium' in terms of relevance to the review question.
Weight of evidence D: Overall weight of evidence
Four trials were assessed as being of 'high' overall weight of evidence and eight trials were assessed as being of 'medium' overall weight of evidence. For the narrative syntheses, all 12 trials were discussed.

Publication bias: a funnel plot of the included RCTs'

Figure 4.2: Funnel plot of included trials

In Figure 4.2, we plot the effect size of the identified trials against their sample size. If there is no publication bias, then the included trials should form an 'inverted' funnel with the largest trials at the top. In Figure 4.2, the largest trial reports a negative effect size; however, the studies with the largest effect sizes tend to be positive. There is a possibility, therefore, that a small number of 'missing' trials may have negative effect sizes. The absence of these trials will tend to make any estimates of effect biased towards the positive. The evidence for publication bias is not large.

4.3 Synthesis of evidence

Table 4.13 shows the range of five different kinds of ICT interventions that emerged from the 12 included RCTs in the review: computer-assisted Instruction (CAI), networked computer system (classroom intranet), word processing software packages, computer-mediated texts (electronic text) and speech synthesis systems. There were also three literacy outcomes: reading, including reading comprehension and phonological awareness (pre-reading understandings), writing and spelling. The table also shows how many RCTs were present in each ICT intervention/ literacy outcome category.

Table 4.13: Range of ICT interventions and literacy outcomes

ICT intervention	Literacy outcomes (number of studies)
CAI	Spelling (3) Reading (2) Phonological awareness (1)

ICT intervention	Literacy outcomes (number of studies)
Networked computer systems	Reading (comprehension) (1)
Word-processing	Writing (2)
Computer-mediated texts	Reading (comprehension) (3)
Speech synthesis	Writing (1)

Synthesis 1 interventions: an analysis of the effectiveness of different types of ICT interventions on a range of literacy outcomes

There were six RCTs that evaluated CAI interventions: Berninger *et al.*, 1998; Heise *et al.*, 1991; Jinkerson and Baggett, 1993; ; Lin *et al.*, 1991; McArthur *et al.*, 1990 and Mitchell and Fox, 2001. The CAI interventions consisted of studies designed to increase spelling, reading abilities or phonological awareness (pre-reading understandings).

There was one networked computer system intervention (Golden *et al.*, 1990) and two word-processing interventions, three computer-mediated texts interventions and one speech-synthesis intervention.

Three of the RCTs contained two strata (Berninger *et al.*, 1998; Lin *et al.*, 1991; Swanson and Trahan, 1992) because the pupils were divided into two groups with different learner characteristics (for example 'average' or 'learning disabled' readers) before being randomly allocated to the intervention or control groups. In all three cases, the pupils with different learner characteristics were analysed separately by the authors. They were therefore treated separately in the review.

One of the RCTs (Zhang *et al.*, 1995) compared traditional word-processing software with both a control group and with an innovatory word-processing package with speech synthesis. The results of the two comparisons were reported separately: traditional word-processing package *v.* control (MS v. CT); Robo-Writer speech synthesis system *v.* control (RW *v.* CT), although only one of the comparisons was included in a meta-analysis, because the same control group was used in both comparisons.

The effect sizes for literacy outcomes in each of the RCTs are presented in Table 4.14. In four of the RCTs, for the purposes of this synthesis, the effect sizes on two literacy outcome measures were calculated because the outcomes were deemed to be equally appropriate for measuring the effectiveness of a particular ICT intervention. For example, in Jones (1994), holistic scoring (writing quality) and word-count (writing quantity) were both reported.

The syntheses reported are based on appropriate subsets of the 20 effect sizes for the five different ICT interventions.

Table 4.14 shows the effectiveness results, with 95% confidence intervals of all the studies.

Table 4.14: Effectiveness of different interventions (CAI, networked computer systems, word-processing, computer-mediated texts and speech synthesis) on literacy outcomes

Study	Literacy outcome	Weight of evidence	Effect size and 95% confidence interval

Study	Literacy outcome	Weight of evidence	Effect size and 95% confidence interval
CAI intervention			
Berninger *et al.* (1 spelling disabilities) 1998	Spelling	High	-0.054 (-0.854 to 0.745)
Berninger *et al.* (2 spelling and handwriting disabilities) 1998	Spelling	High	0.322 (-0.484 to 1.128)
Jinkerson and Baggett, 1993	Spelling	Medium	-0.02 (-0.897 to 0.856)
McArthur *et al.*, 1990	Spelling	High	0.387 (-0.21 to 0.983)
Heise *et al.*, 1991	Reading	Medium	0.487 (-0.044 to 1.019)
Lin *et al.*, 1991 (1 'non handicapped')	Reading	Medium	-0.165 (-0.732 to 0.401)
Lin *et al.*, 1991 (2 'handicapped')	Reading	Medium	-0.45 (-1.051 to 0.136)
Mitchell and Fox, 2001	Phonological awareness	Medium	-0.604 (-0.02 to –1.184)
Networked computer systems			
Golden *et al.*, 1990	Reading 1 Reading 2	Medium	0.123 (-0.594 to 0.841) 0.61 (-0.12 to 1.349)
Word-processing			
Jones, 1994	Writing 1 Writing 2	Medium	1.251 (0.274 to 2.229) 0.47 (-0.415 to 1.368)
Zhang *et al.*, 1995 (MS v. CT)	Writing	Medium	0.610 (-0.248 to 1.469)
Computer-mediated texts			
Matthew, 1996	Reading 1 Reading 2	High	-0.324 (-0.783 to 0.134) 0.545 (0.081 to 1.010)
Reinking and Rickman, 1990	Vocabulary Reading	Medium	0.925 (0.391 to 1.46) 0.168 (-0.338 to 0.675)
Swanson and Trahan, 1992 (1 'learning disabled' readers)	Reading	High	-0.267 (-0.986 to 0.451)
Swanson and Trahan, 1992 (2 average readers)	Reading	High	0.639 -0.097 to 1.375)
Speech synthesis			
Zhang *et al.,* 1995 (RW v. CT)	Writing	Medium	2.740 (1.516 to 3.964)

Overall results

We included 20 comparisons among the 12 trials. Of these 20 effect sizes listed in Table 4.14, 13 were positive and seven were negative. Of the positive effect sizes, four were statistically significant, whilst one of the seven negative trials was statistically significant. One RCT was equivocal, reporting two main outcomes going in opposite directions (Matthew, 1996).

CAI

For CAI, the overall data were suggestive of potential harm on literacy outcomes. Thus, for one of the eight strata, in six trials there was a statistically significant harmful effect of CAI on literacy outcomes, whilst a further three noted a non-statistically significant harmful effect. Of the remaining three which all showed a benefit of CAI, none was statistically significant.

Networked computer systems

The one study (Golden) that looked at networked computer systems noted a positive effect size in its two main outcomes. Neither of these effect sizes was statistically significant and, in one, the point estimate was only a small positive effect. However, the confidence intervals around the estimates were wide, potentially not ruling out a large benefit or moderate harmful effect.

Word-processing

The effect of word-processing on writing was evaluated in two trials (Jones, 1994; Zhang *et al.*, 1995). Jones (1994) presented two main outcomes: in one outcome (writing quality), there was a large positive benefit, which was statistically significant; for the second outcome (writing quantity), there was a modest benefit, which was not statistically significant. In the other study (Zhang *et al.*, 1995), the positive effect for the word-processing condition was not statistically significant.

Computer-mediated texts

In the three trials (two of which had two relevant outcomes and one had two strata), the evidence for the use of computer-mediated texts was somewhat equivocal. Whilst there was one outcome for one trial showing a strong, statistically significant benefit of computer-mediated text on vocabulary and another showing a modest benefit (which was statistically significant) on reading, two strata in another trial had effect sizes in opposite directions, although neither was significant.

Speech synthesis

Only one RCT evaluated the use of a speech synthesis system for composing on the computer (Zhang *et al.*, 1995). The study shows a large positive effect for the intervention that was statistically significant.

Synthesis 2 outcomes: an analysis of the effectiveness of different types of ICT on specific literacy outcomes

Because there was more than one randomised trial measuring specific literacy outcomes and the trials within these subgroups appeared to be relatively homogeneous, we undertook a series of pooled analyses (i.e. meta-analyses).

CAI and spelling

We identified three relevant trials of CAI on spelling published since 1990: Berninger *et al.* (1998), Jinkerson and Baggett (1993) and MacArthur *et al.* (1990; also see Table 4.15).

Two strata were reported in Berninger *et al.* (1998). The aim of this trial was to investigate whether the computer or the pencil was more effective in helping pupils to learn to spell words. Forty-eight children (24 in stratum 1 with spelling disabilities and 24 in stratum 2 with spelling and handwriting disabilities) were randomly allocated to computer or paper and pencil response mode. The methods for teaching and learning 48 easy, moderate and difficult words were identical in both conditions, except the children in the computer condition identified the letters on the computer keyboard, pressed the keys and then were able to see the letters on the monitor; the children in the paper and pencil condition wrote the words as they learnt them. At post-test, there were no significant differences for response mode.

The aim of the trial by MacArthur *et al.* (1990) was to compare computer-assisted instruction in spelling practice with traditional paper-and-pencil instruction in spelling practice. Forty-four fifth and sixth grade students with learning disabilities were randomly allocated to CAI (with immediate corrective feedback) or PPI (where the feedback was provided by self-checking). The instructional techniques for each condition utilised features typical of CAI and PPI. There was a non-significant positive effect for the computer condition.

The aim of the trial by Jinkerson and Baggett (1993) was to investigate whether or not the use of a spell-checker would help students to identify and correct mis-spelt words in a story more effectively than students who identified and corrected by hand. Twenty pupils aged 9 to 11 were randomly allocated to a computer or a hand group. The same pre-written story was given to both groups to proofread for spelling errors. There were no significant differences between the groups at post-test.

The information from these three trials (four strata) is summarised in Table 4.15. Pooling these in a meta-analysis showed a small, but non-significant, benefit of CAI on spelling outcomes (Figure 4.3).

Table 4.15: Trials to test computer-assisted instruction (CAI) and spelling

Sub-group	Trial/stratum	Outcome	Group 1 N | M | SD	Group 2 N | M | SD	Hedges' g (corrected)	CI lower | upper
CAI and spelling	MacArthur *et al.*, 1990: 'Computer assisted instruction with learning disabled students: achievement, engagement, and other factors that influence achievement'.	Spelling Retention Test	22 | 8.450 | 5.460	22 | 6.360 | 5.150	0.387	-0.210 | 0.983
CAI and spelling	Jinkerson and Baggett, 1993: 'Spell checkers: aids in identifying and correcting spelling errors'.	Oral spelling post-test	10 | 14.400 | 4.270	10 | 14.500 | 5.100	-0.020	-0.897 | 0.856
CAI and spelling	Berninger *et al.*, 1998: 'Teaching spelling to children with specific learning disabilities: The mind's ear or eye beat the computer or pencil'.	Spelling disabilities	12 | 5.310 | 1.240	12 | 5.380 | 1.240	-0.055	-0.855 | 0.746
CAI and spelling	Berninger *et al.*, 1998: 'Teaching spelling to	Spelling and	12 | 5.130 | 1.890	12 | 4.420 | 2.340	0.322	-0.484 | 1.129

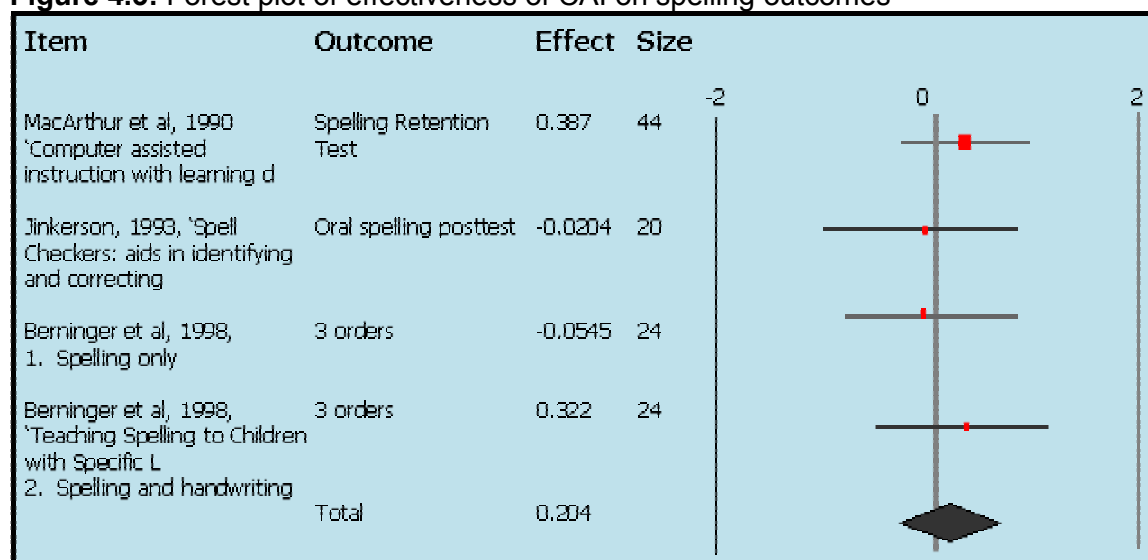| Sub-group	Trial/stratum	Outcome	Group 1 N | M | SD	Group 2 N | M | SD	Hedges' g (corrected)	CI lower | upper
	children with specific learning disabilities: The mind's ear or eye beat the computer or pencil'.	handwriting disabilities				
		Total			0.204	-0.168 | 0.576

Heterogeneity statistic Q = 1.1
Test statistic (combined effect) z = 1.07 p = 0.141
Meta-analysis method: Inverse Variance (fixed effects model)

The pooled effect size was 0.204 (C.I. –0.168 to 0.576). The heterogeneity 'Q' statistic was 1.1 (low). This shows that there was no statistical evidence for the studies being heterogeneous. We were therefore justified in pooling them in a meta-analysis. In Figure 4.3, we plot the effect sizes and 95 percent confidence intervals of the individual trials. As Figure 4.3 shows, the individual trials had large confidence intervals all passing through zero, which means that we could not rule in or rule out a relatively large effect.

Figure 4.3: Forest plot of effectiveness of CAI on spelling outcomes

The overall weight of evidence scores (D) for the RCTs in this meta-analysis were as follows: MacArthur *et al.* (1990), 'high'; Jinkerson and Baggett (1993), 'medium'; Berninger *et al.* (1998) (1), 'high'; Berninger *et al.*, (1998) (2), 'high'. Removing the RCT weighted as 'medium' (Jinkerson and Baggett, 1993) did not significantly alter these results. There was still a small positive effect for the intervention (0.274), which was not statistically significant (-0.15 to 0.700).

CAI and reading
Two trials (three strata) evaluated CAI and reading interventions (Lin *et al.*, 1991 and Heise *et al.*, 1991).

The aim of the trial by Heise was to investigate the role that CAI may play in the development of reading. Fifty-three third grade and sixth to eighth grade 'remedial' students were randomly allocated to computer-administered instruction or teacher-directed instruction, using a matched pair design. The CAI group used a software package designed to teach new words, definitions and their usage. The conventional instruction group used teacher-directed instruction similar to the

presentation on the software package. On a measure of total reading, there was a positive effect for the intervention, but this was not statistically significant.

The aim of the trial by Lin *et al.* (1991) was to assess the effectiveness of CAI on the word-recognition skills of 'mildly mentally handicapped' (stratum 2) and 'non-handicapped' learners (stratum 1). Ninety-three 'mildly mentally handicapped' and 'non-handicapped' students from various grades were randomly assigned to CAI or paper and pencil as the instructional medium for teaching word-recognition skills. The outcome measurements were accuracy scores and response times. At post-test, there were no significant differences between the groups for accuracy scores.

It was not possible to combine the two trials that evaluated the effectiveness of CAI interventions on reading because there was insufficient homogeneity between the two groups of learners in the two RCTs. In one of the RCTs (Lin *et al.*, 1991), the authors described the learners as 'bilingual' (Chinese American and Caucasian American). In the other RCT (Heise *et al.*, 1991) the author described the learners' ethnicities but it was not clear whether the intervention was aimed at improving English as a first or second language. This was an a priori decision, made before the reviewers looked at the results.

Word-processing and writing

We identified two RCTs that investigated the effect of word-processing on writing (Jones, 1994; Zhang *et al.*, 1995). The aim of the trial by Jones was to determine whether the use of a word-processor would result in a larger quantity of writing and a higher quality of writing when students composed with paper and pencil. Twenty second-grade students were randomly assigned to treatment or control condition. During the intervention period, the treatment group composed seven written assignments using a word-processing program, whilst the control group used paper and pencil. At post-test, both groups composed using paper and pencil. The overall quality of the treatment group's writing exceeded that of the control group, but there was no significant difference in mean word-count scores (quantity of writing).

The aim of the trial by Zhang *et al.* (1995) was to assess the impact of specifically designed software tools on the quality of writing of children performing at least one year behind their grade level. Thirty-three students with 'learning disabilities' in grades 2-5 were randomly assigned to one of three groups (using a matched triad design). The MS group used a traditional word-processing package; the RW group used an innovatory speech synthesis package; and the CT group used traditional paper and pencil. The pupils composed stories in their allocated treatment condition.

In the meta-analysis, the holistic measure was used for the trial by Jones (rather than the quantity of writing measure), because this was the measure used in the trial by Zhang.

Table 4.16: The effect of word-processing on writing

Sub-group	Item	Outcome	Group 1 N | M | SD	Group 2 N | M | SD	Hedges' g (corrected)	CI lower | upper
Word-processing and writing	Jones, 1994: 'The effect of a word processor on the written composition of second-grade pupils'.	Holistic	10 | 7.100 | 1.940	10 | 4.770 | 1.610	1.252	0.274 | 2.229

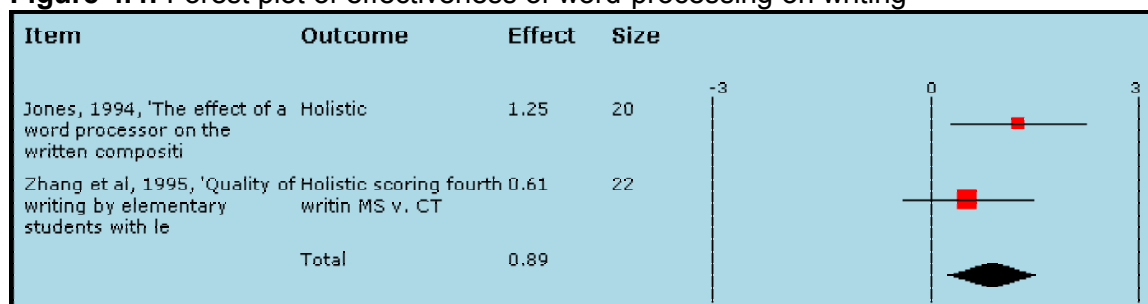| Sub-group	Item	Outcome	Group 1 N | M | SD	Group 2 N | M | SD	Hedges' g (corrected)	CI lower | upper
Word-processing and writing	Zhang *et al.*, 1995: 'Quality of writing by elementary students with learning disabilities'.	Holistic scoring fourth writing MS *v.* CT	11 | 4.020 | 1.040	11 | 3.460 | 0.690	0.610	-0.249 | 1.470
		Total			*0.890*	*0.245 | 1.535*

Heterogeneity statistic Q = 0.933
Test statistic (combined effect) z = 2.7 p = 0.00344
Meta-analysis method: inverse variance (fixed effects model)

There was a pooled effect size of 0.890 (C.I. 0.245 to 1.535). This was quite a large positive effect for the word-processing intervention and was statistically significant. Both of these RCTs had an overall weighting (D) of 'medium'. The heterogeneity 'Q'statistic was 0.933 (very low). This shows that, statistically, the studies were similar and therefore we were justified in performing a meta-analysis.

Figure 4.4: Forest plot of effectiveness of word-processing on writing

In Figure 4.4, the two trials are plotted. As Figure 4.4 shows, both trials had relatively large confidence intervals, due to relatively small sample sizes. Nevertheless, one of the trials had a statistically significant benefit; whilst the other had a benefit, which was not statistically significant.

Computer-mediated texts and comprehension
Three RCTs (one with two strata) evaluating the effectiveness of computer-mediated texts interventions on reading comprehension outcomes were included in the in-depth review: Matthew, 1996; Swanson and Trahan study (1) and study (2), 1992; Reinking and Rickman, 1990. The aim of the trial by Matthew (1996) was to compare the reading comprehension of third-grade children who read interactive storybooks with children who read traditional print storybooks. Seventy-four pupils were randomly allocated to intervention or control, using a matched pair design. Students in the experimental group read CD-ROM storybooks on the computer. Students in the control group read the same books in a traditional print format. Two outcome measures were used to measure reading comprehension: 10 open-ended questions and story re-telling. There were no statistically significant differences in reading comprehension as assessed by open-ended questions. There was a positive and statistically significant effect of the intervention as assessed by story re-telling.

The aim of the trial by Reinking and Rickman (1990) was to investigate whether or not sixth-grade readers' vocabulary learning and comprehension would be improved through the use of computer-mediated texts. Sixty students were

randomly assigned to one of four conditions: control (dictionary or glossary condition with passages presented on typed pages and accompanied by either dictionary or typed glossary page) and computer-mediated intervention (select definitions or all definitions condition, whereby pupils could request the definitions of words on screen or they had to view the meanings of target words before proceeding to the next section of text). For the purposes of this review, the two print control groups and the two computer intervention groups were combined in order to calculate the effect size. There was a small positive effect for the intervention, but this was not statistically significant.

The aim of the trial undertaken by Swanson and Trahan (1992) was to determine the degree to which computer-mediated texts influenced 'learning disabled' children's reading comprehension. One hundred and twenty fourth, fifth and sixth grade pupils were randomly assigned to one of four conditions: control with all pre- and post-test measures but no reading comprehension intervention, other than normal classroom instruction; paper off-line, using traditional and cloze comprehension passages in printed form; computer presentation, with no re-reading (traditional and cloze story passages in computer-mediated form); and computer re-reading whereby readers were directed to re-read all or portions of the passages before answering comprehension items or cloze items.

For this effectiveness review, the paper offline condition was compared with the computer no re-read condition. In study 1 ('learning disabled' readers), there was a small positive effect for the control condition that was not statistically significant. In study 2 ('average' readers), there was quite a large positive effect for the treatment condition, but this was not statistically significant.

Two separate meta-analyses were undertaken for the trials investigating computer-mediated texts and reading comprehension (tables 4.15 and 4.16). This is because Matthew (1996) used two outcomes for reading comprehension (open-ended questions and story re-telling) that the reviewers judged to be equally appropriate for measuring reading comprehension.

Table 4.17: The effectiveness of computer-mediated texts intervention on reading - 1

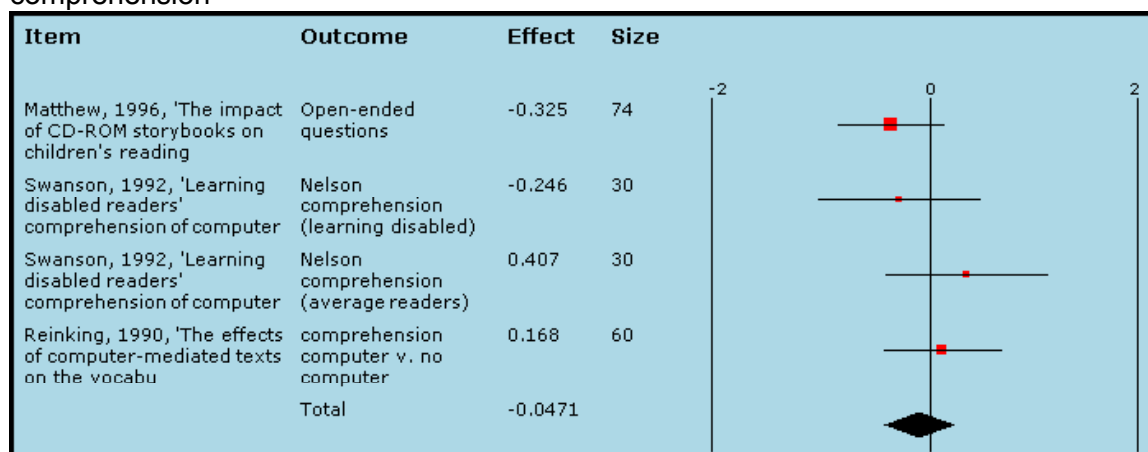| Sub-group	Item	Outcome	Group 1 N | M | SD	Group 2 N | M | SD	Hedges' g (corrected)	CI lower | upper
Computer-mediated texts and reading (1)	Matthew (1996) The impact of CD-ROM storybooks on children's reading comprehension and reading attitude	Open-ended questions	37 | 46.080 | 5.010	37 | 47.680 | 4.740	-0.325	-0.784 | 0.134
Computer-mediated texts and reading (1)	Swanson and Trahan (1992) Learning disabled readers' comprehension of computer mediated text: the influence of working memory, metacognition and attribution	Nelson comp-rehension (learning disabled)	15 | 12.300 | 5.020	15 | 13.550 | 4.850	-0.246	-0.965 | 0.472

Sub-group	Item	Outcome	Group 1 N | M | SD	Group 2 N | M | SD	Hedges' g (corrected)	CI lower | upper
Computer-mediated texts and reading (1)	Swanson and Trahan (1992) Learning disabled readers' comprehension of computer mediated text: the influence of working memory, metacognition and attribution	Nelson comp-rehension (average readers)	15 | 18.070 | 4.820	15 | 15.770 | 6.090	0.407	-0.317 | 1.132
Computer mediated texts and reading (1)	Reinking and Rickman (1990) The effects of computer-mediated texts on the vocabulary learning and comprehension of intermediate-grade readers	Comp-rehension computer *v.* no computer	30 | 3.650 | 2.800	30 | 3.160 | 2.946	0.168	-0.339 | 0.675
		Total			***-0.047***	***-0.330 | 0.236***

Heterogeneity statistic Q = 3.91
Test statistic (combined effect) z = -0.326 p = 0.628
Meta-analysis method: inverse variance (fixed effects model)

Figure 4.5: Forest plot of effectiveness of computer-mediated texts on reading comprehension

There was a non-statistically significant positive effect for the control. The effect size was –0.047 (C.I. –0.33 to 0.236). Removing the one RCT assessed as 'medium' weight of evidence (Reinking) did not substantially alter the outcome of the meta-analysis. There was still a small positive effect favouring the control condition which was not statistically significant (effect size –0.145 C.I –0.486 to 0.197). Again, with a low 'Q' statistic, there was no evidence of heterogeneity. We were therefore justified in performing a meta-analysis. Figure 4.5 shows that the confidence intervals around each effect size are wide.
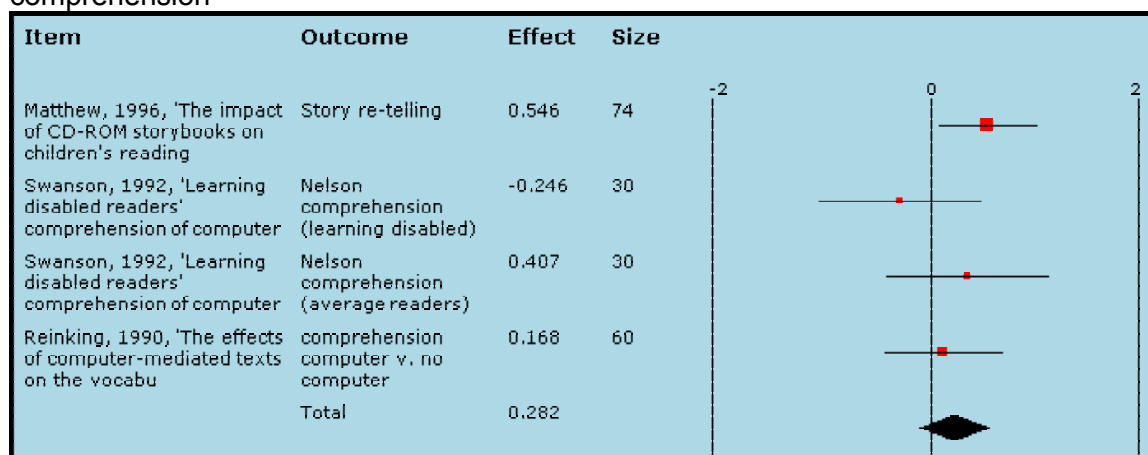
Table 4.18: The effectiveness of computer-mediated texts intervention on reading - 2

Sub-group	Item	Outcome	Group 1 N | M | SD	Group 2 N | M | SD	Hedges' g (corrected)	CI lower | upper
Computer-mediated texts and reading (2)	Matthew (1996) The impact of CD-ROM storybooks on children's reading comprehension and reading attitude	Story re-telling	37 | 24.990 | 2.960	37 | 23.170 | 3.610	0.546	0.081 | 1.010
Computer-mediated texts and reading (2)	Swanson and Trahan (1992) Learning disabled readers' comprehension of computer mediated text: the influence of working memory, metacognition and attribution	Nelson comprehension (learning disabled)	15 | 12.300 | 5.020	15 | 13.550 | 4.850	-0.246	-0.965 | 0.472
Computer-mediated texts and reading (2)	Swanson and Trahan (1992) Learning disabled readers' comprehension of computer mediated text: the influence of working memory, metacognition and attribution	Nelson comprehension (average readers)	15 | 18.070 | 4.820	15 | 15.770 | 6.090	0.407	-0.317 | 1.132
Computer-mediated texts and reading (2)	Reinking and Rickman (1990) The effects of computer-mediated texts on the vocabulary learning and comprehension of intermediate-grade readers	Comprehension computer *v.* no computer	30 | 3.650 | 2.800	30 | 3.160 | 2.946	0.168	-0.339 | 0.675
		Total			***0.282***	***-0.003 | 0.566***

Heterogeneity statistic Q = 3.62
Test statistic (combined effect) z = 1.94 p = 0.0261
Meta-analysis method: inverse variance (fixed effects model)

Figure 4.6: Forest plot of effectiveness of computer-mediated texts on reading comprehension

Item	Outcome	Effect	Size	
Matthew, 1996, 'The impact of CD-ROM storybooks on children's reading	Story re-telling	0.546	74	
Swanson, 1992, 'Learning disabled readers' comprehension of computer	Nelson comprehension (learning disabled)	-0.246	30	
Swanson, 1992, 'Learning disabled readers' comprehension of computer	Nelson comprehension (average readers)	0.407	30	
Reinking, 1990, 'The effects of computer-mediated texts on the vocabu	comprehension computer v. no computer	0.168	60	
	Total	0.282		

There was a small positive effect for the computer-mediated texts group which was of borderline statistical significance (effect size 0.282 C.I. –0.003 to 0.566). Removing the effect size of the Reinking study (1990) from the meta-analysis did not substantially alter the results of the meta-analysis. There was still a small positive effect for the computer-mediated texts group which was of borderline statistical significance (effect size 0.334 C.I. –0.010 to 0.677). Again the 'Q' statistic was low. There was therefore no evidence of heterogeneity and we were justified in performing the meta-analysis. Figure 4.6 shows the individual trials in a forest plot; one had a statistically significant effect (Mathew, 1996).

4.4 In-depth review: quality assurance results

Both reviewers included the same 12 RCTs and excluded the same 30 RCTs. In addition, there was complete agreement on exclusion codes. One reviewer (CT) excluded on the basis of the first exclusion code in the hierarchy to apply to a trial, while the other reviewer (DZ) excluded on the basis of all codes that applied to any trial.

There are 12 RCTs in the in-depth review for this research question. All 12 trials were independently double data-extracted by Carole Torgerson, Graham Low and Die Zhu (all three from the University of York), and Diana Elbourne and Katy Sutcliffe (both from the EPPI-Centre). The data-extractions were compared and all disagreements resolved. The English Review Group data-extraction for each of the 12 RCTs was then uploaded.

5. EFFECTIVENESS REVIEW: FINDINGS AND IMPLICATIONS

In this review, we have reported the results of a systematic search for, and synthesis, of all the randomised controlled trials in ICT and literacy. The results of the review are not clearly supportive of the benefit of ICT on literacy outcomes. On the other hand, the evidence is not strongly supportive of a harmful effect on literacy development. Therefore, the results seem to be equivocal.

The implication of this is that the case for large investment in ICT by schools to improve literacy has yet to be made. Ideally, therefore, large robust trials that could confirm any benefit of ICT on literacy need to be done, otherwise the continued high investment in ICT could be wasted.

5.1 Summary of principal findings

5.1.1 Identification of studies

Studies were retrieved from the three electronic databases. PsycInfo and ERIC were the richest sources for retrieving RCTs for this review.

5.1.2 Mapping of all included studies

Forty-two RCTs were identified for the effectiveness map.

5.1.3 Nature of studies selected for effectiveness in-depth review

The 12 included RCTs were assessed as being of 'medium' or 'high' quality in terms of internal quality: 'high' quality in terms of relevance to the review; 'medium' or 'high' in terms of the relevance of the topic focus; and 'medium' or' high' for overall weight of evidence.

All 12 studies were undertaken in the USA with children aged between 5 and 14. Seven of the RCTs included samples where *all* or *half* of the participants experienced learning disabilities or difficulties or specific learning disabilities. All 12 studies focused on the psychological aspects or representations of literacy.

5.1.4 Synthesis of findings from studies in effectiveness in-depth review

We identified 12 relatively small RCTs for the effectiveness in-depth review. Some were so small that they could only really be considered to be pilot studies. These tiny trials are the sum of the most rigorous evidence available to date upon which to justify or refute the policy of spending millions of pounds on ICT equipment, software and teacher training.

In Synthesis 1, for five different ICT interventions overall, we included 20 comparisons from the 12 RCTs, of which 13 were positive and seven were

negative. Of the positive ones, three were statistically significant; of the seven negative trials, one was statistically significant. These data would suggest that there is little evidence to support the widespread use of ICT in literacy learning in English. This also supports the findings from previous systematic reviews that have used data from rigorous study designs. It also supports the most recent observational data from the Impact2 study. These findings support the view that ICT use for literacy learning should be restricted to pupils participating in rigorous randomised trials of such technology.

In Synthesis 2, we undertook three principal meta-analyses: one for the effect of CAI on spelling; one for the effect of word-processing on writing; and one for the effect of computer-mediated texts on reading. In two, there was no evidence of benefit or harm (in spelling and reading the small effect sizes were not statistically significant). In writing, there was weak evidence for a positive effect, but it was weak because only 42 children altogether were included in this meta-analysis.

5.2 Strengths and limitations of this systematic review

Strengths
We focused on a robust research design (RCT) appropriate for an effectiveness review. We applied rigorous inclusion and exclusion criteria for including studies in the in-depth review. All the included RCTs were highly relevant to the review, and were assessed as being of high or medium overall weight of evidence.

We did not include studies of other experimental designs; we did not attempt to combine the results of RCTs with trials of other designs.

There was high quality assurance for the review: independent double-screening, data-extraction and quality assessment at each stage.

Limitations
As with all systematic reviews, there are some weaknesses to the review. One criticism that could be made is that we did not search for any studies published before 1990. The reason for this is that we felt that ICT of the 1980s and before was relatively unsophisticated compared with current ICT provision. Therefore, trying to inform current ICT policy from studies that used technology from the 1980s could be misleading.

Standardised effect sizes make assumptions that the different studies are measuring similar enough outcomes for it to be sensible to try to put them into a form where they can be synthesised. In all the included meta-analyses, the outcomes were very similar. We therefore felt justified in synthesising them in a series of meta-analyses. For example, all the spelling studies used spelling tests of words taught in the intervention as post-test measures; the writing studies both used holistic scoring measures of outcome. There was some diversity in the interventions used in the individual studies. For example, in the spelling meta-analysis, all studies used the computer in the intervention but the teaching strategies were slightly different. Similarly, the characteristics of the participants in different studies in the meta-analyses differed. Some of the participants were younger primary school children, whereas others were older primary school children experiencing learning difficulties. However, it was not felt that these differences were sufficient to preclude the use of meta-analyses in synthesizing the studies.

Another weakness is that we may have missed some studies. This is almost inevitable in any review. Nevertheless, it is only a problem to the overall review if the studies we have missed are systematically different from those we have included. Nevertheless, we accept the possibility that our results could have been affected by publication bias. Publication bias is a very real problem for any systematic review. The fact that we have found and included some negative studies of ICT and literacy is somewhat reassuring, as publication bias tends mainly to affect negative studies. Nevertheless, one interpretation of our data could be that our results are over-optimistic as it is likely that the studies that remain unpublished are more likely to be negative studies than positive ones. If this is true, then the overall effects of ICT could be harmful.

All the studies included in the in-depth review were undertaken in the US so they may be of limited generalisability to the UK. All the participants in the studies were either very young children in the stages of beginning literacy, or slightly older children who were experiencing difficulties or disabilities in learning in literacy.

5.3 Implications

5.3.1 Policy

Policy-makers should refrain from any further investment in ICT and literacy until at least one large and rigorously designed randomised trial has shown it to be effective in increasing literacy outcomes.

5.3.2 Practice

Teachers should be aware that there is no evidence that non-ICT methods of instruction and non-ICT resources are inferior to the use of ICT to promote literacy learning.

5.3.3 Research

A series of large, rigorously designed RCTs to evaluate ICT and literacy learning across all age ranges is urgently required.

6. REFERENCES

6.1 Studies included in effectiveness map and synthesis (in-depth effectiveness review)

Studies selected for in-depth review are marked with asterisks

Adam N, Wild M (1997) Applying CD-ROM interactive storybooks to learning to read. *Journal of Computer Assisted Learning* **13:** 119-132.

Allen G, Thompson A (1995) Analysis of the effect of networking on computer-assisted collaborative writing in a fifth grade classroom. *Journal of Educational Computing Research* **12:** 65-75.

Barker TA (1994) *An Evaluation of Computer-Assisted Instruction in Phonological Awareness with Below Average Readers*. Tallahassee, FL, USA: Florida State University.

Barron RW, Golden JO, Seldon DM, Tait CF, Marmurek HHC, Haines LP (1992) Teaching prereading skills with a talking computer: letter-sound knowledge and print feedback facilitate nonreaders' phonological awareness training. *Reading and Writing: an Interdisciplinary Journal* **4:** 179-204.

*Berninger V, Abbott R, Rogan L, Reed E, Abbott S, Brooks A, Vaughan K, Graham S (1998) Teaching spelling to children with specific learning disabilities: the mind's ear and eye beat the computer or pencil. *Learning Disability Quarterly* **21:** 106-122.

Bonk CJ, Reynolds TH (1992) Early adolescent composing within a generative-evaluative computerized prompting framework. *Computers in Human Behavior* **8:** 39-62.

Braden JP, Shaw SR, Grecko L (1991) An evaluation of a computer-assisted instructional program for elementary hearing-impaired students. *Volta Review* **93:** 247-252.

Calvert SL, Watson JA, Brinkley V, Penny J (1990) Computer presentational features for poor readers' recall of information. *Journal of Educational Computing Research* **6:** 287-298.

Cardinale P, Fish JM (1994) Treating children's writing apprehension with word processing. *Journal of Personality and Clinical Studies* **10:** 1-15.

Cato V, English F, Trushell J (1994) Reading screens: mapping the labyrinth. In: Wray D (ed.) *Literacy and Computers: Insights from Research*. Royston, Herts: United Kingdom Reading Association, pages 31-40.

Dwyer HJ, Sullivan HJ (1993) Student preferences for teacher and computer composition marking. *Journal of Educational Research* **86:** 137-141.

Feldmann SC, Fish MC (1991) Use of computer-mediated reading supports to enhance reading comprehension of high school students. *Journal of Educational Computing Research* **7:** 25-36.

Foster KC, Erickson GC, Foster DF, Brinkman D, Torgesen JK (1994) Computer administered instruction in phonological awareness: evaluation of the DaisyQuest Program. *Journal of Research and Development in Education* **27:** 126-37.

Fuchs LS, Fuchs D, Hamlett CL, Allinder RM (1991) Effects of expert system advice within curriculum-based measurement in teacher planning and student achievement in spelling. *School Psychology Review* **20:** 49-66.

*Golden N, Gersten R, Woodward J (1990) Effectiveness of guided practice during remedial reading instruction: an application of computer-managed instruction. *Elementary School Journal* **90:** 291-304.

Grejda GF, Hannafin MJ (1992) Effects of word processing on sixth graders' holistic writing and revisions. *Journal of Educational Research* **85:** 144-149.

Harris EA, Bond CL (1992) A holistic approach to guided writing: using the WICAT Program supplemented with peer critique. *Journal of Computing in Childhood Education* **3:** 193-201.

*Heise BL, Papalewis R, Tanner DE (1991) Building base vocabulary with computer-assisted instruction. *Teacher Education Quarterly* **18:** 55-63.

*Jinkerson L, Baggett P (1993) Spell checkers: aids in identifying and correcting spelling errors. *Journal of Computing in Childhood Education* **4:** 291-306.

Johnston CB (1996) Interactive storybook software: effects on verbal development in kindergarten children. *Early Child Development and Care* **132:** 33-44.

*Jones I (1994) The effect of a word processor on the written composition of pupils. *Computers in the Schools* **11:** 43-54.

Laframboise KL (1991) The facilitative effects of word processing on sentence-combining tasks with at-risk fourth graders. *Journal of Research and Development in Education* **24:** 1-8.

Leong CK (1992) Enhancing reading comprehension with text-to-speech (DECtalk) computer system. *Reading and Writing* **4:** 205-217.

Leong CK (1995) Effects of online reading and simultaneous DECtalk auding in helping below-average and poor readers comprehend and summarize text. *Learning Disability Quarterly* **18:** 101-116.

Leong CK (1996) Using microcomputer technology to promote students' 'higher-order' reading. In: Gorayska BEM, Jacob L (eds) *Cognitive Technology: In Search of a Humane Interface. Advances in Psychology, Vol. 113*. New York, NY, USA: Elsevier Science, pages 257-281.

Lewin C (2000) Exploring the effects of talking book software in UK primary classrooms. *Journal of Research in Reading* **23:** 149-157.

*Lin A, Podell DM, Rein N (1991) The effects of CAI on word recognition in mildly mentally handicapped and nonhandicapped learners. *Journal of Special Education Technology* **11:** 16-25.

*MacArthur CA, Haynes JA, Malouf DB, Harris K, Owings M (1990) Computer assisted instruction with learning disabled students: achievement, engagement, and other factors that influence achievement. *Journal of Educational Computing Research* **6:** 311-328.

*Matthew KI (1996) The impact of CD-ROM storybooks on children's reading comprehension and reading attitude. *Journal of Educational Multimedia and Hypermedia* **5:** 379-94.

Matthew KI (1997) A comparison of the influence of interactive CD-ROM storybooks and traditional print storybooks on reading comprehension. *Journal of Research in Computing in Education* **29:** 263-75.

*Mitchell MJ, Fox BJ (2001) The effects of computer software for developing phonological awareness in low-progress readers. *Reading Research and Instruction* **40:** 315-332.

Olson RK, Wise B, Ring J, Johnson M (1997) Computer-based remedial training in phoneme awareness and phonological decoding: effects on the posttraining development of word recognition. *Scientific Studies of Reading* **1:** 235-253.

Palumbo DB, Prater DL (1992) A comparison of computer-based prewriting strategies for basic ninth-grade writers. *Computers in Human Behavior* **8:** 63-70.

*Reinking D, Rickman SS (1990) The effects of computer-mediated texts on the vocabulary learning and comprehension of intermediate-grade readers. *Journal of Reading Behavior* **22:** 395-411.

Roberts GI, Samuels MT (1993) Handwriting remediation: a comparison of computer-based and traditional approaches. *Journal of Educational Research* **87:** 118-25.

Rosenbluth GS, Reed WM (1992) The effects of writing-process-based instruction and word processing on remedial and accelerated 11th graders. *Computers in Human Behavior* **8:** 71-95.

Silver NW, Repa JT (1993) The effect of word processing on the quality of writing and self-esteem of secondary school English-as-second-language students: writing without censure. *Journal of Educational Computing Research* **9:** 265-283.

Spaulding CL, Lake D (1992) Interactive effects of computer network and student characteristics on students' writing and collaborating. *High School Journal* **76:** 67-77.

*Swanson HL, Trahan MF (1992) Learning disabled readers' comprehension of computer mediated text: the influence of working memory, metacognition and attribution. *Learning Disabilities Research and Practice* **7:** 74-86.

Topping KJ (1997) Family electronic literacy: Part 1 - home-school links through audiotaped books. *Reading* **31:** 7-11.

Utay C, Utay J (1997) Peer-assisted learning: The effects of cooperative learning and cross-age peer tutoring with word processing on writing skills of students with learning disabilities. *Journal of Computing in Childhood Education* **8:** 165-185.

Varner-Quick WS (1994) The effects of computer-assisted instruction on reading abilities: a comparison of fourth grade reading programs with and without computer technology. Unpublished thesis. Pullman, WA, USA: Wayne State University.

Wepner SB (1992) 'Real-life' reading software and 'at-risk' secondary students. *Reading Horizons* **32:** 279-288.

Wise BW, Olson RK (1995) Computer-based phonological awareness and reading instruction. *Annals of Dyslexia* **45:** 99-122.

*Zhang Y, Brooks DW, Frields T, Redelfs M (1995) Quality of writing by elementary students with learning disabilities. *Multimedia Today* **3:** 30-39.

6.2 Studies included in descriptive map of overarching review

Abbott C (2001) Some young male website owners: the technological aesthete, the community builder and the professional activist. *Education, Communication and Information* **1:** 197-212.

Adam N, Wild M (1997) Applying CD-ROM interactive storybooks to learning to read. *Journal of Computer Assisted Learning* **13:** 119-132.

Allen G, Thompson A (1995) Analysis of the effect of networking on computer-assisted collaborative writing in a fifth grade classroom. *Journal of Educational Computing Research* **12:** 65-75.

Allred RA (1993) Integrating proven spelling content and methods with emerging literacy programs. *Reading Psychology* **14:** 15-31.

Angeli C, Cunningham DJ (1998) Bubble dialogue: tools for supporting literacy and mind. In: Bonk CJ, King KS (eds) *Electronic Collaborators: Learner Centered Technologies for Literacy, Apprenticeship, and Discourse.* Mahwah, NJ, USA: Lawrence Erlbaum Associates Inc., pages 81-101.

Bahr CM, Nelson NW, Van Meter AM (1996) The effects of text-based and graphics-based software tools on planning and organizing of stories. *Journal of Learning Disabilities* **29:** 355-370.

Baker EA (2001) The nature of literacy in a technology-rich, fourth-grade classroom. *Reading Research and Instruction* **40:** 159-184.

Bangert-Drowns RL (1993) The word processor as an instructional tool: a meta-analysis of word processing in writing instruction. *Review of Educational Research* **63:** 69-93.

Barker TA (1994) *An Evaluation of Computer-Assisted Instruction in Phonological Awareness with Below Average Readers*. Tallahassee, FL, USA: Florida State University.

Barrera MT, Rule AC, Diemart A (2001) The effect of writing with computers versus handwriting on the writing achievement of first-graders. *Information Technology in Childhood Education Annual* **13:** 215-228.

Barron RW, Golden JO, Seldon DM, Tait CF, Marmurek HHC, Haines LP (1992) Teaching prereading skills with a talking computer: letter-sound knowledge and print feedback facilitate nonreaders' phonological awareness training. *Reading and Writing: An Interdisciplinary Journal* **4:** 179-204.

Bentivolio K (2001) Improving a student's reading comprehension skills by teaching computer aided design. Educational Resources Information Centre (ERIC) document number ED455507.

Berninger V, Abbott R, Rogan L, Reed E, Abbott S, Brooks A, Vaughan K, Graham S (1998) Teaching spelling to children with specific learning disabilities: The mind's ear and eye beat the computer or pencil. *Learning Disability Quarterly* **21:** 106-122.

Bigum C, Lankshear C, Morgan W, Snyder I (1997) *Digital Rhetorics: Literacies and Technologies in Education - Current Practices and Future Directions*. Brisbane, Australia: Queensland University.

Blasewitz MR, Taylor RT (1999) Attacking literacy with technology in an urban setting. *Middle School Journal* **30:** 33-39.

Blok H, Van Daalen-Kapteijns MM, Otter ME, Overmaat M (2001) Using computers to learn words in the elementary grades: an evaluation framework and a review of effect studies. *Computer Assisted Language Learning* **14:** 99-128.

Bonk CJ, Reynolds TH (1992) Early adolescent composing within a generative-evaluative computerized prompting framework. *Computers in Human Behavior* **8:** 39-62.

Boone R, Higgins K (1993) Hypermedia Basal readers: three years of school-based research. *Journal of Special Education Technology* **12:** 86-106.

Boone R, Higgins K, Notari A, Stump CS (1996) Hypermedia pre-reading lessons: learner-centered software for kindergarten. *Journal of Computing in Childhood Education* **7:** 39-70.

Borgh K, Dickson WP (1992) The effects on children's writing of adding speech synthesis to a word processor. *Journal of Research in Computing in Education* **24:** 533-544.

Braden JP, Shaw SR, Grecko L (1991) An evaluation of a computer-assisted instructional program for elementary hearing-impaired students. *Volta Review* **93:** 247-252.

Breese C, Jackson A, Prince T (1995) Promise in impermanence: children writing with unlimited access to word processors. *Early Child Development and Care* **118:** 67-91.

Brush TA, Armstrong J, Barbrow D, Ulintz L (1999) Design and delivery of integrated learning systems: their impact on student achievement and attitudes. *Journal of Educational Computing Research* **21:** 475-486.

Burn A (2000) Repackaging the Slasher Movie: digital unwriting of film in the classroom. *English in Australia* **127-128:** 24-34.

Burn A, Brindley S, Durran J, Kelsall C, Sweetlove J (2001) 'The rush of images': a research report into digital editing and the moving image. *English in Education* **35:** 34-47.

Burn A, Reed K (1999) Digi-teens: media literacies and digital technologies in the secondary classroom. *English in Education* **33:** 5-20.

Burn A, Parker D (2001) Making your mark: digital inscription, animation, and a new visual semiotic. *Education, Communication and Information* **1:** 155-179.

Butzin SM (2001) Using instructional technology in transformed learning environments: an evaluation of Project CHILD. *Journal of Research on Technology in Education* **33:** 367-373.

Calvert SL, Watson JA, Brinkley V, Penny J (1990) Computer presentational features for poor readers' recall of information. *Journal of Educational Computing Research* **6:** 287-298.

Cardinale P, Fish JM (1994) Treating children's writing apprehension with word processing. *Journal of Personality and Clinical Studies* **10:** 1-15.

Carlson PA, Miller TM (1996) *Beyond Word Processing: Using an Interactive Learning Environment to Teach Writing.* Texas, USA: Brooks Airforce Base.

Casey JM (2001) A path to literacy: empowering students in your classroom. ERIC document number ED458540.

Cato V, English F, Trushell J (1994) Reading screens: mapping the labyrinth. In: Wray D (ed.) *Literacy and Computers: Insights from Research*. Royston, Herts: United Kingdom Reading Association, pages 31-40.

Chambers B, Abrami PC, McWhaw K, Therrien MC (2001) Developing a computer-assisted tutoring program to help children at risk to learn to read. *Educational Research and Evaluation (An International Journal on Theory and Practice)* **7:** 223-239.

Chambless JR, Chambless MS (1994) The impact of instructional technology on reading/writing skills of 2nd grade students. *Reading Improvement* **31:** 151-155.

Chang LL, Osguthorpe RT (1990) The effects of computerized picture-word processing on kindergartners' language development. *Journal of Research in Childhood Education* **5:** 73-84.

Chu M-LL (1995) Reader response to interactive computer books: examining literary responses in a non-traditional reading setting. *Reading Research and Instruction* **34:** 352-366.

Clouse RW (1991) Teaching and learning with computers: a classroom analysis. *Journal of Educational Technology Systems* **20:** 281-302.

Collins J (1993) Beyond the word processor: computer-mediated communication with pupils and teachers. *Computer Education* **73:** 13-17.

Cramer S, Smith A (2002) Technology's impact on student writing at the middle school level. *Journal of Instructional Psychology* **29:** 3-14.

Cunningham AE, Stanovich KE (1990) Early spelling acquisition: writing beats the computer. *Journal of Educational Psychology* **82:** 159-162.

Daiute C, Morse F (1994) Access to knowledge and expression: multimedia writing tools for students with diverse needs and strengths. *Journal of Special Education Technology* **12:** 221-256.

Davidson J, Elcock J, Noyes P (1996) A preliminary study of the effect of computer-assisted practice on reading attainment. *Journal of Research in Reading* **19:** 102-110.

Dawson L, Venn ML, Gunter PL (2000) The effects of teacher versus computer reading models. *Behavioral Disorders* **25:** 105-113.

Deadman G (1997) An analysis of pupils' reflective writing within a hypermedia framework. *Journal of Computer Assisted Learning* **13:** 16-25.

DeCosta SB (1992) Sociological findings in young children's word-processed writings. *Computers in Human Behavior* **8:** 17-25.

Divine KP, Whanger RE (1990) Use of a computer learning laboratory with at-risk high school students. *Educational Technology* **30:** 46-48.

Douglas G (2001) A comparison between reading from paper and computer screen by children with a visual impairment. *British Journal of Visual Impairment* **19:** 29-34.

Dwyer HJ, Sullivan HJ (1993) Student preferences for teacher and computer composition marking. *Journal of Educational Research* **86:** 137-141.

Dybdahl CS, Shaw DG, Blahous E (1997) The impact of the computer on writing: no simple answers. *Computers in the Schools* **13:** 41-53.

Elkind J, Cohen K, Murray C (1993) Using computer-based readers to improve reading comprehension of students with dyslexia. *Annals of Dyslexia* **43:** 238-259.

Erdner RA, Guy RF, Bush A (1998) The impact of a year of computer assisted instruction on the development of first grade learning skills. *Journal of Educational Computing Research* **18:** 369-386.

Erickson B, Allen A, Mountain L (1992) Telecommunications promotes summer reading and writing: a pilot project report. *Journal of Computing in Childhood Education* **3:** 295-302.

Erickson KA, Koppenhaver DA, Yoder DE, Nance J (1997) Integrated communication and literacy instruction for a child with multiple disabilities. *Focus on Autism and Other Developmental Disabilities* **12:** 142-150.

Ewing J (2000) Enhancement of online and offline student learning. *Education Media International* **37:** 205-217.

Farmer ME, Klein R, Bryson SE (1992) Computer-assisted reading; effects of whole-word feedback on fluency and comprehension in readers with severe disabilities. *Remedial and Special Education* **13:** 50-60.

Fawcett AJ, Nicolson RI, Morris S (1993) Computer-based spelling remediation for dyslexic children. *Journal of Computer Assisted Learning* **9:** 171-183.

Feldmann SC, Fish MC (1991) Use of computer-mediated reading supports to enhance reading comprehension of high school students. *Journal of Educational Computing Research* **7:** 25-36.

Fletcher DC (2001) Second graders decide when to use electronic editing tools. *Information Technology in Childhood Education Annual* **1:** 155-174.

Foster KC, Erickson GC, Foster DF, Brinkman D, Torgesen JK (1994) Computer administered instruction in phonological awareness: evaluation of the DaisyQuest Program. *Journal of Research and Development in Education* **27:** 126-137.

Fuchs LS, Fuchs D, Hamlett CL, Allinder RM (1991) Effects of expert system advice within curriculum-based measurement in teacher planning and student achievement in spelling. *School Psychology Review* **20:** 49-66.

Fulk BM, Stormont-Spurgin M (1995) Spelling interventions for students with disabilities: a review. *Journal of Special Education* **28:** 488-513.

Garner R, Tan S, Zhao Y (2000) Why write? *Computers in Human Behavior* **16:** 339-347.

Golden N, Gersten R, Woodward J (1990) Effectiveness of guided practice during remedial reading instruction: an application of computer-managed instruction. *Elementary School Journal* **90:** 291-304.

Greenleaf C (1994) Technological indeterminacy: the role of classroom writing practices and pedagogy in shaping student use of the computer. *Written Communication* **11:** 85-130.

Greenlee Moore ME, Smith LL (1996) Interactive computer software: the effects on young children's reading achievement. *Reading Psychology* **17:** 43-64.

Grejda GF, Hannafin MJ (1992) Effects of word processing on sixth graders' holistic writing and revisions. *Journal of Educational Research* **85:** 144-149.

Harris EA, Bond CL (1992) A holistic approach to guided writing: using the WICAT Program supplemented with peer critique. *Journal of Computing in Childhood Education* **3:** 193-201.

Harris L, Doyle ES, Haaf R (1996) Language treatment approach for users of AAC: experimental single-subject investigation. *AAC: Augmentative and Alternative Communication* **12:** 230-243.

Hartas C, Moseley D (1993) 'Say that again, please': a scheme to boost reading skills using a computer with digitised speech. *Support for Learning* **8:** 16-21.

Hasselbring TS, Goin L, Taylor R, Bottge B, Daley P (1997) The computer doesn't embarrass me. *Educational Leadership* **55:** 30-33.

Heise BL, Papalewis R, Tanner DE (1991) Building base vocabulary with computer-assisted instruction. *Teacher Education Quarterly* **18:** 55-63.

Higgins C (2002) Using film text to support reluctant writers. *English in Education* **36:** 25-37.

Hine MS, Goldman SR, Cosden MA (1990) Error monitoring by learning handicappped students engaged in collaborative microcomputer-based writing. *Journal of Special Education* **23:** 407-422.

Horney MA, Anderson Inman L (1994) Students and hypertext: developing a new literacy for a new reading context. In: Wray D (ed.) *Literacy and Computers: Insights from Research.* Royston, Herts: United Kingdom Reading Association.

Horney MA, Anderson Inman L (1999) Supported text in electronic reading environments. *Reading and Writing Quarterly: Overcoming Learning Difficulties* **15:** 127-168.

Howell RD, Erikson K, Stanger C, Wheaton JE (2000) Evaluation of a computer-based program on the reading performance of first grade students with potential for reading failure. *Journal of Special Education Technology* **15:** 5-14.

Ignatz M (2000) The effectiveness of the Read, Write and Type! Program in increasing the phonological awareness of first grade students. ERIC document number ED453814.

The Institute for Academic Excellence Inc (1999) *Idaho Statewide Implementation of Reading Renaissance: Summary of First Year's Results Monograph*. Madison, WI, USA: Renaissance Learning.

Jinkerson L, Baggett P (1993) Spell checkers: aids in identifying and correcting spelling errors. *Journal of Computing in Childhood Education* **4:** 291-306.

Johnston CB (1996) Interactive storybook software: effects on verbal development in kindergarten children. *Early Child Development and Care* **132:** 33-44.

Jones I (1994) The effect of a word processor on the written composition of pupils. *Computers in the Schools* **11:** 43-54.

Jones I (1998) The effect of computer-generated spoken feedback on kindergarten students' written narratives. *Journal of Computing in Childhood Education* **9:** 43-56.

Jones I, Pellegrini AD (1996) The effects of social relationships, writing media, and microgenetic development on first-grade students' written narratives. *American Educational Research Journal* **33:** 691-718.

Joram E, Woodruff E, Bryson M, Lindsay P (1992) The effects of revising with a word processor on written composition. *Research in the Teaching of English* **26:** 167-193.

Labbo LD (1996) A semiotic analysis of young children's symbol making in a classroom computer center. *Reading Research Quarterly* **31:** 356-385.

Laframboise KL (1991) The facilitative effects of word processing on sentence-combining tasks with at-risk fourth graders. *Journal of Research and Development in Education* **24:** 1-8.

Laine CJ, Follansbee R (1994) Using word-prediction technology to improve the writing of low-functioning hearing-impaired students. *Child Language Teaching and Therapy* **10:** 283-297.

Leahy P (1991) A multi-year formative evaluation of IBM's 'Writing to Read' Program. *Reading Improvement* **28:** 257-264.

Leong CK (1992) Enhancing reading comprehension with text-to-speech (DECtalk) computer system. *Reading and Writing* **4:** 205-217.

Leong CK (1995) Effects of on-line reading and simultaneous DECtalk auding in helping below-average and poor readers comprehend and summarize text. *Learning Disability Quarterly* **18:** 101-116.

Leong CK (1996) Using microcomputer technology to promote students' 'higher-order' reading. In: Gorayska B, Mey JL (eds) *Cognitive Technology: In Search of a Humane Interface.* New York, USA: Elsevier Science, pages 257-281.

Levary EF (1992) Starting out: (Part 1) computer activities and the development of transitions in student writing. *Educational Computing and Technology* **13:** 73-74.

Lewin C (1997) 'Test driving' CARS: addressing the issues in the evaluation of computer-assisted reading software. *Journal of Computing in Childhood Education* **8:** 111-132.

Lewin C (2000) Exploring the effects of talking book software in UK primary classrooms. *Journal of Research in Reading* **23:** 149-157.

Lewis RB, Graves AW, Ashton TM, Kieley CL (1998) Word processing tools for students with learning disabilities: a comparison of strategies to increase text entry speed. *Learning Disabilities Research and Practice* **13:** 95-108.

Lin A, Podell DM, Rein N (1991) The effects of CAI on word recognition in mildly mentally handicapped and non-handicapped learners. *Journal of Special Education Technology* **11:** 16-25.

Love K (1998) Old cyborgs, young cyborgs (and those in between). *English in Australia* **121:** 63-75.

MacArthur CA (1998) Word processing with speech synthesis and word prediction: effects on the dialogue journal writing of students with learning disabilities. *Learning Disability Quarterly* **21:** 151-166.

MacArthur CA (1998) From illegible to understandable: how word prediction and speech synthesis can help. *Teaching Exceptional Children* **30:** 66-71.

MacArthur CA (1999) Word prediction for students with severe spelling problems. *Learning Disability Quarterly* **22:** 158-172.

MacArthur CA, Ferretti RP, Okolo CM, Cavalier AR (2001) Technology applications for students with literacy problems: a critical review. *Elementary School Journal* **101:** 273-301.

MacArthur CA, Graham S, Haynes JB, DeLaPaz S (1996) Spelling checkers and students with learning disabilities: performance comparisons and impact on spelling. *Journal of Special Education* **30:** 35-57.

MacArthur CA, Graham S, Schwartz SS, Shafer WD (1995) Evaluation of a writing instruction model that integrated a process approach, strategy instruction, and word processing. *Learning Disability Quarterly* **18:** 278-291.

MacArthur CA, Haynes JA, Malouf DB, Harris KR, Owings M (1990) Computer assisted instruction with learning disabled students: achievement, engagement, and other factors that influence achievement. *Journal of Educational Computing Research* **6:** 311-328.

McAteer E, Demissie A (1992) Schoolchildren's revision tactics. *Instructional Science* **21:** 109-124.

McClay JK (2002) Hidden 'treasure': new genres, new media and the teaching of writing. *English in Education* **36:** 46-55.

McKeon CA, Burkey LC (1998) A literature based e-mail collaborative. In: Sturtevant EG, Dugan J, Linder P, Linek WM (eds) *Literacy and Community: The Twentieth Yearbook.* Carrollton, GA, USA: College Reading Association, pages 84-93.

McKeon CA, Sage MCG (2001) E-mail as a motivating literacy event for one struggling reader: Donna's case. *Reading Research and Instruction* **40:** 185-202.

McNamee GD (1995) A Vygotskian perspective on literacy development. *School Psychology International* **16:** 185-198.

McNaughton D, Hughes C, Ofiesh N (1997) Proofreading for students with learning disabilities: integrating computer and strategy use. *Learning Disabilities Research and Practice* **12:** 16-28.

Mackereth M, Anderson J (2000) Computers, video games, and literacy: what do girls think? *The Australian Journal of Language and Literacy* **23:** 184-195.

Mander R, Wilton KM, Townsend MAR, Thomson P (1995) Personal computers and process writing: a written language intervention for deaf children. *British Journal of Educational Psychology* **65:** 441-453.

Marston D, Deno SL, Kim D, Diment K, Rogers D (1995) Comparison of reading intervention approaches for students with mild disabilities. *Exceptional Children* **62:** 20-37.

Matthew K (1997) A comparison of the influence of interactive CD-ROM storybooks and traditional print storybooks on reading comprehension. *Journal of Research in Computing in Education* **29:** 263-275.

Matthew KI (1996) The impact of CD-ROM storybooks on children's reading comprehension and reading attitude. *Journal of Educational Multimedia and Hypermedia* **5:** 379-394.

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

Meskill C, Swan K (1996) Roles for multimedia in the response-based literature classroom. *Journal of Educational Computing Research* **15:** 217-239.

Meskill C, Swan K (1998) Response-based multimedia and the culture of the classroom: a pilot study of Kid's Space in four elementary classrooms. *Educational Computing Research* **18:** 339-367.

Meyers LF (1992) Teach me my language: teaching children with learning disabilities to link meaning with speech and text. *Writing Notebook: Creative Word Processing in the Classroom* **9:** 44-46.

Miller L, DeJean J, Miller R (2000) The literacy curriculum and use of an integrated learning system. *Journal of Research in Reading* **23:** 123-135.

Mitchell MJ, Fox BJ (2001) The effects of computer software for developing phonological awareness in low-progress readers. *Reading Research and Instruction* **40:** 315-332.

Moore MA, Karabenick SA (1992) The effects of computer communications on the reading and writing performance of fifth-grade students. *Computers in Human Behavior* **8:** 27-38.

Moore-Hart MA (1995) The effects of multicultural links on reading and writing performance and cultural awareness of fourth and fifth graders. *Computers in Human Behavior* **11:** 391-410.

Morgan W (1995) Safe harbours or open seas: English classrooms in an age of electronic text. *English in Australia* **111:** 9-16.

Morgan W (1997) From the margins to the centre: schools online. *English in Aotearoa* **32:** 4-11.

Morgan W (2001) Computers for literacy: making the difference? *Asia Pacific Journal of Teacher Education* **29:** 31-47.

Morocco CC, Dalton B, Tivnan T (1992) The impact of computer-supported writing instruction on fourth-grade students with and without learning disabilities. *Reading and Writing Quarterly: Overcoming Learning Difficulties* **8:** 87-113.

Moseley D, Higgins S (1999) *Ways Forward with ICT: Effective Pedagogy Using Information and Communications Technology for Literacy and Numeracy in Primary Schools.* UK: University of Newcastle.

Nelson MH (1994) Processing poetry to develop literacy. *Computing Teacher* **22:** 39-41.

Nettelbeck D (2000) Using information technology to enrich the learning experiences of secondary English students. *Literacy Learning: the Middle Years* **8.2:** 40-49.

Newell AF (1992) Increasing literacy levels by the use of linguistic prediction. *Child Language Teaching and Therapy* **8:** 138-187.

Nichols LM (1996) Pencil and paper versus word processing: a comparative study of creative writing in the elementary school. *Journal of Research in Computing in Education* **29:** 159-166.

Nicolson RI, Fawcett AJ, Pickering S (1991) A hypercard spelling support environment for dyslexic children. *Computers and Education* **16:** 203-209.

Nicolson RI, Fawcett AJ, Nicolson, MK (2000) Evaluation of a computer-based reading intervention in infant and junior schools. *Journal of Research in Reading* **23:** 194-209.

Nwogu K, Nwogu E (1992) Computers and ESL in the West Midlands. *Language Learning Journal* **6:** 74-76.

O' Brien DG, Springs R, Stith D (2001) Engaging at-risk high school students: Literacy learning in a high school literacy lab. In: Moje EB, O'Brien DG (eds) *Constructions of Literacy: Studies of Teaching and Learning in and out Of Secondary Schools.* Mahwah, NJ, USA: Lawrence Erlbaum Associates Inc., pages 105-123.

Olson RK, Wise B, Ring J, Johnson M (1997) Computer-based remedial training in phoneme awareness and phonological decoding: effects on the posttraining development of word recognition. *Scientific Studies of Reading* **1:** 235-253.

Olson RK, Wise BW (1992) Reading on the computer with orthographic and speech feedback: an overview of the Colorado remediation project. *Reading and Writing* **4:** 107-144.

Owston RD, Murphy S, Wideman HH (1991) On and off computer writing of eighth grade students experienced in word processing. *Computers in the Schools* **8:** 67-87.

Owston RD, Murphy S, Wideman HH (1992) The effects of word-processing on students writing quality and revision strategies. *Research in the Teaching of English* **26:** 249-276.

Owston RD, Wideman HH (1997) Word processors and children's writing in a high-computer-access setting. *Journal of Research in Computing in Education* **30:** 202-220.

Palumbo DB, Prater DL (1992) A comparison of computer-based prewriting strategies for basic ninth-grade writers. *Computers in Human Behavior* **8:** 63-70.

Parker D (1999) You've read the book, now make the film: moving image media, print literacy and narrative. *English in Education* **33:** 24-35.

Parker D (2002) Show us a story: an overview of recent research and resource development work at the British Film Institute. *English in Education* **36:** 38-45.

Parr JM (1997) Computer assisted learning with an integrated learning system: another front for raising literacy and numeracy amongst secondary students? *New Zealand Journal of Educational Studies* **32:** 37-51.

Peterson SE (1993) A comparison of student revisions when composing with pen and paper versus word-processing. *Computers in the Schools* **9:** 55-69.

Peyton JK (1991) Electronic communication for developing the literacy skills of elementary school students: The case of ENFI. *Teaching English to Deaf and Second Language Students* **9:** 4-9.

Pinkard N (1999) *Learning To Read in Culturally Responsive Computer Environments.* Ann Arbor, MI, USA: Center for the Improvement of Early Reading Achievement.

Pinkard N (2001) 'Rappin' Reader' and 'Say Say Oh Playmate': using children's childhood songs as literacy scaffolds in computer-based learning environments. *Journal of Educational Computing Research* **25:** 17-34.

Potter L, Small J (1998) Utilizing computers for reading improvement in a junior high: a case study. *International Journal of Instructional Media* **25:** 383-387.

Pritchard A (1997) The refinement of an 'ideas map' as a means of assessment and of enhancing children's understanding of texts. *Reading* **31:** 55-59.

Pullen MC (1993) *A Comparison of Writing Performance Using Conventional and Computer-based Writing Techniques*. Memphis, TN, USA: Memphis State University.

Reinking D, Rickman SS (1990) The effects of computer-mediated texts on the vocabulary learning and comprehension of intermediate-grade readers. *Journal of Reading Behavior* **22:** 395-411.

Reinking D, Watkins J (2000) A formative experiment investigating the use of multimedia book reviews to increase elementary students' independent reading. *Reading Research Quarterly* **35:** 384-419.

Repman J, Cothern NB, Cothern JS (1992) Novice writers and word processing in the one-computer classroom. *Journal of Computing in Childhood Education* **3:** 203-214.

Roberts GC, Mutter G (1991) A celebration of literacy: computer-assisted writing in the St James-Assiniboia School Division No 2. How it started and how it works. *Education Canada* **31:** 4-7.

Roberts GI, Samuels MT (1993) Handwriting remediation: a comparison of computer-based and traditional approaches. *Journal of Educational Research* **87:** 118-125.

Rogier LL, Owens JL, Patty DL (1999) Writing to read: a valuable program for first grade? *Reading Improvement* **36:** 24-34.

Rosenbluth GS, Reed WM (1992) The effects of writing process-based instruction and word processing on remedial and accelerated 11th graders. *Computers in Human Behavior* **8:** 71-95.

Ross JA, Hogaboam-Gray A, Hannay, L (2001) Collateral benefits of an interactive literacy program for grade 1 and 2 students. *Journal of Research in Computing in Education* **33:** 219-234.

Rowley K, Carlson P, Miller T (1998) A cognitive technology to teach composition skills: four studies with the R-WISE writing tutor. *Journal of Educational Computing Research* **18:** 259-296.

Russell G (1998) Elements and implications of a hypertext pedagogy. *Computers and Education* **31:** 185-193.

Seawel L, Smaldino SE, Steele JL, Lewis JY (1994) A descriptive study comparing computer-based word processing and handwriting on attitudes and performance of third and fourth grade students involved in a program based on a process approach to writing. *Journal of Computing in Childhood Education* **5:** 43-59.

Shaw EL, Nauman AK, Burson D (1994) Comparisons of spontaneous and word processed compositions in elementary classrooms: a three-year study. *Journal of Computing in Childhood Education* **5:** 319-327.

Silver NW, Repa JT (1993) The effect of word processing on the quality of writing and self-esteem of secondary school English-as-second-language students: Writing without censure. *Journal of Educational Computing Research* **9:** 265-283.

Sinatra R, Beaudry J, Pizzo J, Geisert G (1994) Using a computer-based semantic mapping, reading, and writing approach with at-risk fourth graders. *Journal of Computing in Childhood Education* **5:** 93-112.

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

Smith S (2001) Using computers to improve literacy learning among low-achieving year 7 boys. *English in Australia* **129-130:** 163 -170.

Snyder I (1994) Writing with word processors: the computer's influence on the classroom context. *Journal of Curriculum Studies* **26:** 143-162.

Snyder I (1995) Towards electronic writing classrooms: the challenge for teachers. *Journal of Information Technology for Teacher Education* **4:** 51-65.

Snyder I (1996) Integrating computers into the literacy curriculum: more difficult than we first imagined. *The Australian Journal of Language and Literacy* **19:** 330-344.

Spaulding CL, Lake D (1992) Interactive effects of computer network and student characteristics on students' writing and collaborating. *High School Journal* **76:** 67-77.

Steelman JD (1994) Revision strategies employed by middle level students using computers. *Journal of Educational Computing Research* **11:** 141-152.

Steg DR, Lazar I, Boyce C (1994) A cybernetic approach to early education. *Journal of Educational Computing Research* **10:** 1-27.

Stevens KB, Blackhurst AE, Slaton DB (1991) Teaching memorized spelling with a microcomputer: time delay and computer-assisted instruction. *Journal of Applied Behavior Analysis* **24:** 153-160.

Stoddard B, MacArthur CA (1993) A peer editor strategy: guiding learning-disabled students in response and revision. *Research in the Teaching of English* **27:** 76-103.

Stromer R, Mackay HA (1992) Spelling and emergent picture-printed word relations established with delayed identity matching to complex samples. *Journal of Applied Behavior Analysis* **25:** 893-904.

Stuhlmann JM, Taylor HG (1998) Analyzing the impact of telecommunications on learning outcomes in elementary classrooms. *Journal of Computing in Childhood Education* **9:** 79-92.

Sutherland MJ, Smith CD (1997) The benefits and difficulties of using portable word processors with older dyslexics. *Dyslexia* **3:** 15-26.

Swanson HL, Trahan MF (1992) Learning disabled readers' comprehension of computer mediated text: the influence of working memory, metacognition and attribution. *Learning Disabilities Research and Practice* **7:** 74-86.

Tjus T, Heimann M, Nelson KE (1998) Gains in literacy through the use of a specially developed multimedia computer strategy. *Autism* **2:** 139-156.

Topping KJ (1997) Family electronic literacy: Part 1 - Home-school links through audiotaped books. *Reading* **31:** 7-11.

Topping KJ, Sanders WL (2000) Teacher effectiveness and computer assessment of reading: relating value added and learning information system data. *School Effectiveness and School Improvement* **11:** 305-337.

Torgerson CJ, 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:** 129-143.

Trushell J, Burrell C, Maitland A (2001) Year 5 pupils reading an 'interactive storybook' on CD-ROM: losing the plot? *British Journal of Educational Technology* **32:** 389-401.

Turbill J (2001) A researcher goes to school: using technology in the kindergarten literacy curriculum. *Journal of Early Childhood Literacy* **1:** 255-279.

Underwood J (1996) Are integrated learning systems effective learning support tools? *Computers and Education* **26:** 1-3.

Underwood JDM (2000) A comparison of two types of computer support for reading development. *Journal of Research in Reading* **23:** 136-148.

Utay C, Utay J (1997) Peer-assisted learning: the effects of cooperative learning and cross-age peer tutoring with word processing on writing skills of students with learning disabilities. *Journal of Computing in Childhood Education* **8:** 165-185.

Van Haalen T, Bright GW (1993) Writing and revising by bilingual students in traditional and word processing environments. *Journal of Educational Computing Research* **9:** 313-328.

Varner-Quick WS (1994) *The effects of computer-assisted instruction on reading abilities: a comparison of fourth grade reading programs with and without computer technology*: Pullman, WA, USA: Wayne State University.

Vaughn S, Schumm JS, Gordon J (1992) Early spelling acquisition: does writing really beat the computer? *Learning Disability Quarterly* **15:** 223-228.

Vaughn S, Schumm JS, Gordon J (1993) Which motoric condition is most effective for teaching spelling to students with and without learning disabilities? *Journal of Learning Disabilities* **26:** 191-198.

Vincent J (2001) The role of visually rich technology in facilitating children's writing. *Journal of Computer Assisted Learning* **17:** 242-250.

Vollands SR, Topping K, Evans H (1996) *Experimental Evaluation of Computer Assisted Self-Assessment of Reading.* UK: Dundee University.

Vollands SR, Topping KJ, Evans RM (1999) Computerized self-assessment of reading comprehension with the Accelerated Reader: action research. *Reading and Writing Quarterly: Overcoming Learning Difficulties* **15:** 197-211.

Walker SA, Pilkington RM (2000) *Computer-mediated Communication in the Development of Writing Skills at Key Stage Three.* UK: University of Leeds.

Watts M, Lloyd C (2001) Evaluating a classroom multimedia programme in the teaching of literacy. *Educational Research and Evaluation* **7:** 35-52.

Weller LD, Carpenter S, Holmes CT (1998) Achievement gains of low-achieving students using computer-assisted vs. regular instruction. *Psychological Reports* **83:** 834.

Wepner SB (1992) 'Real-life' reading software and 'at-risk' secondary students. *Reading Horizons* **32:** 279-288.

Wild M (1997) Using CD-Rom storybooks to encourage reading development. *Set Special 1997: Language and Literacy* **6:** 1-4.

Wild M, Ing J (1994) An investigation into the use of a concept keyboard as a computer-related device to improve the structure of young children's writing. *Journal of Computing in Childhood Education* **5:** 299-309.

Williams HS, Williams PN (2000) Integrating reading and computers: an approach to improve ESL students' reading skills. *Reading Improvement* **37:** 98-100.

Wise BW, Olson RK (1992) How poor readers and spellers use interactive speech in a computerized spelling program. *Reading and Writing* **4:** 145-163.

Wise BW, Olson RK (1995) Computer-based phonological awareness and reading instruction. *Annals of Dyslexia* **45:** 99-122.

Wise BW, Olson RK, Ring J, Johnson M (1998) Interactive computer support for improving phonological skills. In: Metsala JL, Ehri, LC (eds) *Word Recognition in Beginning Literacy.* Mahwah, NJ, USA: Lawrence Erlbaum Associates Inc., pages 189-208.

Wise BW, Ring J, Olson RK (1999) Training phonological awareness with and without explicit attention to articulation. *Journal of Experimental Child Psychology* **72:** 271-304.

Wise BW, Ring J, Olson RK (2000) Individual differences in gains from computer-assisted remedial reading. *Journal of Experimental Child Psychology* **77:** 197-235.

Wishart E (1994) Using a TTNS electronic mailbox in a junior class: a case study. In: Wray D *Literacy and Computers: Insights from Research*. Royston, Herts: United Kingdom Reading Association, pages 23-30.

Wolfe EW, Bolton S, Feltovich B, Bangert AW (1996) A study of word processing experience and its effects on student essay writing. *Journal of Educational Computing Research* **14:** 269-284.

Zhang Y, Brooks DW, Frields T, Redelfs M (1995) Quality of writing by elementary students with learning disabilities. *Multimedia Today* **3:** 30-39.

6.3 Other references used in the text of the report

Andrews R, Burn A, Leach J, Locke T, Low G, Torgerson C (2002) A systematic review of the impact of networked ICT on 5-16 year olds' literacy in English. In: *Research Evidence in Education Library.* Issue 1. London: EPPI-Centre, Social Science Research Unit, Institute of Education.

Angrist J, Lavy V (2002) New evidence on classroom computers and pupil learning. *The Economic Journal* 12 (October) 735-765.

Bangert-Drowns RL (1993) The word processor as an instructional tool: a meta-analysis of word processing in writing instruction. *Review of Educational Research* **63:** 69-93.

Blok H, Van Daalen-Kapteijns MM, Otter ME, Overmaat M (2001) Using computers to learn words in the elementary grades: an evaluation framework and a review of effect studies. *Computer Assisted Language Learning* **14**: 99-128.

British Educational Communications and Technology Agency (BECTa) (1998), *The UK Evaluations Final Report*. Coventry, UK: BECTa.

British Educational Communications and Technology Agency (BECTa) (1998-99), *A Preliminary Report for the DfEE on the Relationship Between ICT and Primary School Standards.* Coventry, UK: BECTa.

British Educational Communications and Technology Agency (BECTa) (2001a) *Primary Schools of the Future - Achieving Today.* Coventry, UK: BECTa.

British Educational Communications and Technology Agency (BECTa) (2001b) *The Secondary School of the Future.* Coventry, UK: BECTa.

British Educational Communications and Technology Agency (BECTa) (2002) *The Impact of Information and Communication Technologies on Pupil Learning and Attainment.* Coventry, UK: BECTa.

Cook TD (2002) Reappraising the arguments against randomised experiments in education: an analysis of the culture of evaluation in American schools of education. Evanston, IL, USA: Northwestern University. Available online from www.sri.com/policy/designkt/found.html.

Cook TD, Campbell TD (1979) *Quasi-Experimentation: Design and Analysis Issues for Field Settings.* Boston, MA, USA: Houghton Mifflin.

Deeks JS, Altman DG, Bradburn MJ (2001) Statistical methods for examining heterogeneity and combining results from several studies in meta-analysis. In: Egger M, Davey Smith G, Altman DG (eds) *Systematic Reviews in Health Care.* London: BMJ Publishing Group.

EPPI-Centre (2002a) *Core Keywording Strategy: Data Collection for a Register of Educational Research. Version 0.9.5.* London: EPPI-Centre, Social Science Research Unit.

EPPI-Centre (2002b) *Review Guidelines for Extracting Data and Quality Assessing Primary Studies in Educational Research. Version 0.9.5.* London: EPPI-Centre, Social Science Research Unit.

Fulk BM, Stormont-Spurgin (1995) Spelling interventions for students with disabilities: a review. *The Journal of Special Education* **28:** 488-513.

Lipsey M, Wilson D (1993), The efficacy of psychological, educational and behavioural treatment confirmation from meta-analysis. *American Psychologist* **48:** 1181-1209.

MacArthur CA, Ferretti RP, Okolo CM and Cavalier AR (2001) Technology applications for students with literacy problems: a critical review. *The Elementary School journal* **101:** 273-301.

Torgerson CJ, 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:** 129-143.

Ukoumunne OC, Gulliford MC, Chinn S, Sterne JAC, Burney PGJ (1998) Evaluation of health care interventions at area and organizational level. In: Black N, Brazier J, Fitzpatrick R and Reeves B (eds) *Health Services Research Methods.* London: BMJ Publishing Group.

APPENDIX 2.1: Exclusion criteria

English Review Group working document

Systematic review on 'The impact of ICT on 5-16 year olds' literacy in English'
Screening studies for inclusion in 'mapping' section of review.
Exclusion criteria: to be included, a study must *not* fall into any one of the following categories.

IF A STUDY IS TO BE EXCLUDED, RECORD REASON BY USING APPROPRIATE EXCLUSION CODE (ONE, TWO, THREE, FOUR, OR FIVE)

EXCLUSION ON SCOPE

ONE   Not ICT or literacy

      ⟨ *Definition of ICT: ICT stands for 'information and communication technologies', networked technologies with a multimodal interface, i.e. networked and stand-alone computers, mobile phones with the capacity for a range of types of communication, and other technologies which allow multimodal and interactive communication.*

      ⟨ *Definition of literacy: Literacy can be defined narrowly, as the ability to understand and create written language. It is, however, frequently defined in two broader senses, and both are included in the present study. Firstly, the scope can be expanded so that written language becomes written language and graphical or pictorial representation. Secondly, the skill can be treated as social, rather than psychological; in this view literacy is the ability to operate a series of social or cultural representations. Since sets of expectations and norms differ depending on the situation, the social view of literacy entails a number of different 'literacies'.*

TWO   Not children aged 5–16, or main focus not children aged 5–16

THREE   Not about the impact of ICT on literacy learning and/or teaching, or vice versa

      ⟨ *Definition of the impact of ICT on literacy: Impact will be defined as the result on end-users (here children between 5 and 16) of an intervention aimed at improving the teaching or learning of literacy. It may also be the result of a non-intervention activity which could reasonably be expected to increase or decrease literacy. Either can be considered as 'literacy-related activities'. Entailment: A research study which focuses on teachers' or learners' perspectives, opinions or strategies, may be considered to deal with the impact of ICT on literacy as long as it refers to a specific literacy-related activity.*

EXCLUSION ON STUDY TYPE
FOUR   (a) Editorials, commentaries, book reviews
               (b) Policy documents
               (c) Prevalence or incidence of ICT in literacy learning
               (d) Non-systematic reviews
               (e) Non-evaluated interventions
               (f) Surveys examining a range of curricular activities
               (g) Resources
               (h) Bibliography
               (i) Theoretical paper
               (j) Methodology paper
               (k) Non-evaluated non-interventions∗

∗ A non-evaluated, non-intervention would typically describe a naturally occurring phenomenon, rather than evaluating it. So an ethnographic case-study of a classroom, or a learning site of some other kind, could fall into this category if it didn't attempt to evaluate processes or outcomes. Of

(l) Dissertation abstracts (unless RCTs)

EXCLUSION ON SETTING IN WHICH STUDY WAS CARRIED OUT

FIVE   Settings in which a language other than English is being used as a primary medium for literacy learning (i.e. include ESL and EAL, exclude EFL).

Acknowledgements: This document was developed from the EPPI-Centre Working document on Inclusion Criteria for Mapping. Training and support are acknowledged.

---

course, all description is a kind of evaluation (as it will be based on selection according to certain principles); but if those principles are not articulated, then it is hard to judge the work as research.

APPENDIX 2.2: Search strategy for electronic databases

ICT AND LITERACY – UPDATE SEARCHES

**Searcher: Julie Glanville, NHS Centre for Reviews and Dissemination
Completed 20 August 2002**

1. Databases

1a. ERIC

ERIC was searched on 16/8/2 using the BIDS Ovid interface. The database was searched for the period of updates May 2001 to June 2002 and 181 records were retrieved. The records were loaded into an Endnote library.

1. exp children/ or exp adolescents/
2. exp early adolescents/ or exp late adolescents/
3. exp preadolescents/ or exp secondary school students/
4. students/ or elementary school students/ or high risk students/
5. lower class students/ or middle class students/
6. middle school students/ or special needs students
7. exp special schools/ or disadvantaged youth
8. exp early childhood education/
9. exp elementary education/ or exp british infant schools/
10. exp elementary schools/ or exp middle schools/
11. exp public schools/ or exp secondary schools/ or exp state schools/
12. or/1-11
13. exp computers/ or computer centers/ or computer games/
14. computer graphics/ or exp computer interfaces/ or computer managed instruction/
15. computer mediated communication/ or exp computer networks/ or exp computer software/
16. exp computer uses in education/ or exp expert systems/
17. hypermedia/ or gateway systems/ or information systems/
18. information technology/ or exp man machine systems/
19. multimedia materials/ or natural language processing/
20. exp optical disks/
21. "screen design (computers)"/
22. telecommunications/ or virtual reality/ or workstations/
23. multimedia instruction/ or nonprint media/ or world wide web/ or internet/
24. or/13-23
25. 12 and 24
26. literacy/ or exp functional literacy/ or exp reading/ or "writing (composition)"/
27. literacy education/ or exp reading skills/ or reading ability/
28. reading failure/ or reading habits/ or reading improvement/
29. exp reading instruction/ or basic writing/ or children's writing/
30. creative writing/ or descriptive writing/ or exp handwriting/
31. exp sentences/ or spelling/ or exp writing ability/
32. writing exercises/ or writing improvement/ or writing instruction/
33. sentence structure/ or syntax/ or alphabetizing skills/
34. or/26-33
35. 25 and 34

36. *adult education/
37. *postsecondary education/ or exp *adults/
38. *adult learning/ or *adult literacy/
39. exp *adult programs/
40. *adult basic education/ or *workplace literacy/
41. or/36-40
42. 35 not 41
43. limit 42 to english language
44. (computer$ adj3 literacy).mp.
45. (computer$ adj3 literacies).mp.
46. (computer$ adj3 read).mp.
47. (computer$ adj3 reading).mp.
48. (computer$ adj3 spell).mp.
49. (computer$ adj3 spelling).mp.
50. (computer$ adj3 write).mp.
51. (computer$ adj3 writing).mp.
52. (computer$ adj3 learn).mp.
53. (computer$ adj3 learning).mp.
54. (cal adj3 (read or reading or spell or spelling or write or writing or learn or learning)).mp.
55. (cai adj3 (read or reading or spell or spelling or write or writing or learn or learning)).mp.
56. (call adj3 (read or reading or spell or spelling or write or writing or learn or learning)).mp.
57. (multimedia adj3 (read or reading or spell or spelling or write or writing or learn or learning)).mp.
58. (ict adj3 (read or reading or spell or spelling or write or writing or learn or learning)).mp.
59. (www adj3 (read or reading or spell or spelling or write or writing or learn or learning)).mp.
60. (software adj3 (read or reading or spell or spelling or write or writing or learn or learning)).mp.
61. or/44-60
62. 61 not (43 or 41)
63. limit 62 to english language
64. 50 and 12
65. 63 and 12
66. 65 or 42
67. 65 or 43
68. ("200105" or "200106" or "200107" or "200108" or "200109" or "200110" or "200111" or "200112" or "200201" or "200202" or "200203" or "200204" or "200205" or "200206").em.
69. 67 and 68

1b British Education Index
The BEI was searched on 19/8/2 using the BIDS Ovid interface. The database was searched for the updates first quarter 2001 to first quarter 2002 and 67 records were retrieved. The records were loaded into an Endnote library.

1. ict.mp.
2. (information adj technolog$).mp.
3. (communication adj technolog$).mp.
4. (cal or cai or computer$ or multimodal or multimedia).mp.
5. (networked adj technolog$).mp.
6. (mobile adj phone$).mp.
7. (digital adj media).mp.

8. (internet or cdrom or hypertext or www).mp.
9. (world adj wide adj web).mp.
10. (worldwide adj web).mp.
11. software.mp.
12. "computer uses in education".sh.
13. ("computer assisted learning" or "educational software").sh.
14. information systems/
15. "educational technology".sh.
16. exp "screens (displays)"/
17. "electronic books".sh.
18. "multimedia approach".sh.
19. "computer games".sh.
20. or/1-19
21. (literacy or literacies).mp.
22. "spelling teaching".sh.
23. reading comprehension/
24. reading skills/
25. reading teaching/
26. (learn adj4 english).mp.
27. (learn adj4 read).mp.
28. (learn adj4 reading).mp.
29. (learn adj4 writing).mp.
30. (learn adj4 write).mp.
31. (learn adj4 spell$).mp.
32. (learning adj4 english).mp.
33. (learning adj4 read).mp.
34. (learning adj4 reading).mp.
35. (learning adj4 write).mp.
36. (learning adj4 writing).mp.
37. (learning adj4 spell$).mp.
38. (teach$ adj4 english).mp.
39. (teach$ adj4 read).mp.
40. (teach$ adj4 reading).mp.
41. (teach$ adj4 writing).mp.
42. (teach$ adj4 write).mp.
43. (teach$ adj4 spell$).mp.
44. (develop$ adj4 english).mp.
45. (develop$ adj4 read).mp.
46. (develop$ adj4 reading).mp.
47. (develop$ adj4 writing).mp
48. (develop$ adj4 write).mp.
49. (develop$ adj4 spell$).mp.
50. (reading adj3 disab$).mp.
51. reading ability/
52. reading improvement/
53. spelling/
54. writing skills/
55. reading difficulties/
56. or/21-55
57. computer assisted reading/
58. computer assisted language learning/
59. 20 and 56
60. or/57-59
61. adult literacy/
62. adult basic education/
63. adult basic education.id.

64. higher education.id.
65. professional education.id.
66. or/61-65
67. 60 not 66
68. ("200101" or "200102" or "200103" or "200104" or "200201").up.
69. 67 and 68

1c PsycINFO

PsycINFO was searched on 19/8/02 using the WEBSPIRS interface. The database was searched for the updates 2001/4 week 1 to 2002/8 week 1 and 122 records were retrieved.

The records were loaded into an Endnote Library.

#1 explode 'Computers-' in DE (222 records)
#2 explode 'computer-applications' in de (1274 records)
#3 'computer-games' in de (45 records)
#4 explode 'computer-simulation' in de (751 records)
#5 explode 'computer-software' in de (382 records)
#6 'Electronic-Communication' in DE (231 records)
#7 explode 'information-systems' in de (913 records)
#8 'internet-' in de (771 records)
#9 'word-processing' in de (18 records)
#10 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 (2940 records)
#11 'literacy-' in de (323 records)
#12 'literacy-programs' in de (75 records)
#13 explode 'language-arts-education' in de (307 records)
#14 explode 'reading' in de (399 records)
#15 'reading-development' in de (144 records)
#16 explode 'reading-measures' in de (26 records)
#17 explode 'reading-skills' in de (329 records)
#18 'writing-skills' in de (179 records)
#19 #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 (1394 records)
#20 'computer-assisted-instruction' in de (365 records)
#21 #10 or #20 (2940 records)
#22 #19 and #21 (64 records)
#23 (ict near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (0 records)
#24 (information technolog* near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (5 records)
#25 (communication technolog* near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (3 records)
#26 (cal near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (0 records)
#27 (cai near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (2 records)
#28 (networked technolog* near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (0 records)
#29 (multimodal near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (3 records)
#30 (digital media near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (0 records)
#31 (internet near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (42 records)
#32 (cdrom near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (0 records)

#33 (hypertext near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (5 records)

#34 (wide web near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (13 records)

#35 (www near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (1 record)

#36 (worldwide web near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (0 records)

#37 (software near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (33 records)

#38 (computer* near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (163 records)

#39 (electronic near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab (23 records)

#40 #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or #31 or #32 or #33 or #34 or #35 or #36 or #37 or #38 or #39 (236 records)

#41 'adult-development' in de (253 records)

#42 'adult-education' in de (48 records)

#43 'adult-learning' in de (42 records)

#44 (ADULTHOOD in AG:PY) or (AGED in AG:PY) or (MIDDLE-AGE in AG:PY) or (THIRTIES in AG:PY) or (VERY-OLD in AG:PY) or (YOUNG-ADULTHOOD in AG:PY) (45840 records)

#45 #41 or #42 or #43 or #44 (45904 records)

#46 #22 or #40 (258 records)

#47 #46 not #45 (137 records)

#48 #47 and (la='english') (133 records)

#49 (20000809 in UD:PY) or (20000816 in UD:PY) or (20000823 in UD:PY) or (20000830 in UD:PY) or (20000906 in UD:PY) or (20000913 in UD:PY) or (20000920 in UD:PY) or (20000927 in UD:PY) or (20001101 in UD:PY) or (20001108 in UD:PY) or (20001115 in UD:PY) or (20001129 in UD:PY) or (20001206 in UD:PY) or (20001213 in UD:PY) or (20001220 in UD:PY) or (20001227 in UD:PY) or (20010103 in UD:PY) or (20010110 in UD:PY) or (20010117 in UD:PY) or (20010124 in UD:PY) or (20010131 in UD:PY) or (20010207 in UD:PY) or (20010214 in UD:PY) or (20010221 in UD:PY) or (20010228 in UD:PY) or (20010307 in UD:PY) or (20010314 in UD:PY) or (20010321 in UD:PY) or (20010328 in UD:PY) (5963 records)

#50 #48 not #49 (122 records)

1d. Cochrane Library

Issue 2002/2 of the Cochrane Library was searched. 338 records were identified. As it is not possible to limit to a range of update periods, the records were hand-sifted by the information officer to exclude large numbers of records about computer-based training of health professionals. The resulting records (11) were loaded into an Endnote Library.

1. COMPUTER* near LITERACY
2. COMPUTER* near LEARN*
3. COMPUTER* near SPELL*
4. cOMPUTER* near READ*
5. COMPUTER* near WRIT*
6. hYPERMEDIA near LITERACY
7. hypermedia near LEARN*
8. hypermedia near SPELL*
9. hypermedia near READ*
10. hypermedia near WRIT*
11. SYSTEM* near LITERACY

12. system* near LEARN*
13. system* near SPELL*
14. system* near READ*
15. system* near WRIT*tECHNOLOG* near LITERACY
16. tECHNOLOG* near LEARN*
17. tECHNOLOG* near SPELL*
18. tECHNOLOG* near READ*
19. tECHNOLOG* near WRIT*MULTIMEDIA near LITERACY
20. MULTIMEDIA near LEARN*
21. MULTIMEDIA near SPELL*
22. MULTIMEDIA near READ*
23. MULTIMEDIA near WRIT*DISK* near LITERACY
24. DISK* near LEARN*
25. DISK* near SPELL*
26. DISK* near READ*
27. DISK* near WRIT*TELECOMMUNICATION* near LITERACY
28. TELECOMMUNICATION* near LEARN*
29. TELECOMMUNICATION* near SPELL*
30. TELECOMMUNICATION* near READ*
31. TELECOMMUNICATION* near WRIT*VIRTUAL near LITERACY
32. VIRTUAL near LEARN*
33. VIRTUAL near SPELL*
34. VIRTUAL near READ*
35. VIRTUAL near WRIT*WORKSTATION* near LITERACY
36. WORKSTATION* near LEARN*
37. WORKSTATION* near SPELL*
38. WORKSTATION* near READ*
39. WORKSTATION* near WRIT*wide NEAR LITERACY
40. wide near LEARN*
41. wide near SPELL*
42. wide near READ*
43. wide near WRIT*WORLDWIDE near LITERACY
44. WORLDWIDE near LEARN*
45. WORLDWIDE near SPELL*
46. WORLDWIDE near READ*
47. WORLDWIDE near WRIT*WWW near LITERACY
48. WWW near LEARN*
49. WWW near SPELL*
50. WWW near READ*
51. WWW near WRIT*INTERNET near LITERACY
52. INTERNET near LEARN*
53. INTERNET near SPELL*
54. INTERNET near READ*
55. INTERNET near WRIT*ICT near LITERACY
56. ICT near LEARN*
57. ICT near SPELL*
58. ICT near READ*
59. ICT near WRIT*cal near LITERACY
60. cal near LEARN*
61. cal near SPELL*
62. cal near READ*
63. cal near WRIT*cai near LITERACY
64. cai near LEARN*
65. cai near SPELL*
66. cai near READ*
67. cai near WRIT*

68. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or67

1e. Canadian Business and Current Affairs (CBCA) Fulltext Education database
Not available to CRD; not searched for update by CRD.

1f. Dissertation abstracts
Dissertation abstracts was searched using the Dialog Service. The search covered the period July 2001 to July 2002. Forty-five records were identified and the free formats were downloaded. These records give title and indexing only and should be scanned. Any of interest can then be sent back to the Information Officer who will obtain bibliographic details and abstracts.

1	S COMPUTER?
2	S EXPERT()SYSTEM? ?
3	S HYPERMEDIA OR INFORMATION()SYSTEMS
4	S INFORMATION()TECHNOLOGY
5	S MULTIMEDIA OR NATURAL()LANGUAGE()PROCESSING
6	S OPTICAL()DISK? ?
7	S TELECOMMUNICATIONS OR VIRTUAL()REALITY OR WORKSTATION? ?
8	S WORLD()WIDE()WEB OR INTERNET OR WWW
9	S ICT OR CAL OR CAI
10	S LITERACY OR READING OR WRITING
11	S SENTENCES OR SPELLING OR SYNTAX
12	S ADULT? ? OR POSTSECONDARY OR UNIVERSITY OR HIGHER()EDUCATION
13	S S1:S9
14	S S10:S11
15	s s13(3n)s14
16	s S15 NOT S12
17	s S16/ENG
18	s UD='200107':UD='200207'
19	s S17 AND S18

1g. Social Science Citation Index
This database was searched using the Dialog service (file 7). This was used in preference to the Web of Science interface because it allows more focused searching. The database was searched for the period June 2001 to August 2002 week 3. Forty-two records were identified and the free formats were downloaded. These records give title and indexing only and should be scanned. Any of interest can then be sent back to the Information officer who will obtain bibliographic details and abstracts.

1	S CHILDREN OR ADOLESCENTS
2	S SECONDARY()SCHOOL? ?
3	S ELEMENTARY()SCHOOL? ?
4	S MIDDLE()SCHOOL? ?

5   S SPECIAL()SCHOOL? ?
6   S CHILDHOOD
7   S ELEMENTARY()EDUCATION OR INFANT()SCHOOL? ?
8   S PUBLIC()SCHOOL? ? OR STATE()SCHOOL? ?
9   S COMPUTER?
10   S EXPERT()SYSTEM? ?
11   S HYPERMEDIA OR INFORMATION()SYSTEMS
12   S INFORMATION()TECHNOLOGY
13   S MULTIMEDIA OR NATURAL()LANGUAGE()PROCESSING
14   S OPTICAL()DISK? ?
15   S TELECOMMUNICATIONS OR VIRTUAL()REALITY OR WORKSTATION? ?
16   S WORLD()WIDE()WEB OR INTERNET OR WWW
17   S LITERACY OR READING OR WRITING
18   S SENTENCES OR SPELLING OR SYNTAX
19   S ADULT? ? OR POSTSECONDARY OR UNIVERSITY OR HIGHER()EDUCATION
20   S ICT OR CAL OR CAI
21   S S1:S8
22   S S9:S16 OR S20
23   S S17:S18
24   S S22(3N)S23
25   S S24 NOT S19
26   S S25/ENG
27   S UD>200106
28   S S27 AND S26

1h. SIGLE

The SIGLE database was searched using the ARC WinSPIRS service. The database was searched from updates 2001/1 to 2002/6. Three records were retrieved and loaded into the Endnote library.

1. (ict near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab
2. (information technolog* near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab
3. (communication technolog* near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab
4. ((cal or cai or networked technolog*) near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab
5. ((multimodal or digital media or internet) near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab
6. ((cdrom or hypertext or wide web or www or worldwide web) near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab
7. ((software or computer* or electronic) near (literacy or read or reading or spell or spelling or write or writing)) in ti,ab
8. #1 or #2 or #3 or #4 or #5 or #6 or #7

2. Internet

A selection of key internet sites were searched. Given the largely unstructured nature of web pages, it is difficult to restrict searches to material added since a previous search. Where possible, pages visited previously were revisited and researchers will need to look through the printouts and downloaded files to identify new material.

2a. Voice of the Shuttle (http://vos.ucsb.edu/)
Web page for humanities research (accessed 20 August 2002).

Search terms: literacy

The resulting pages of links were printed out for scanning by researchers.

2b. British Educational Communications and Technology Agency (http://www.becta.org.uk)
Accessed 20 August 2002. Printed out web page on literacy information (http://www.becta.org.uk/start/literacy.html) and other 'research' oriented BECTA pages.

Followed links to Literacy Time website (http://vtc.ngfl.gov.uk/literacy/index.html). Printed out Research and Reports page (http://vtc.ngfl.gov.uk/literacy/features/research_reports.html).

2c. OFSTED (http://www.ofsted.gov.uk)
The A-Z of OFSTED Publications list was printed out (20 August 2002). (http://www.ofsted.gov.uk/public/index.htm). In addition the list of publications for 2002 was printed out separately.

2d. National Literacy Trust (http://www.literacytrust.org.uk)
This web site was searched on 20 August 2002. The web pages were saved as files nlt1.htm to nlt12.htm and will need to be scanned for new and relevant information.

Searched ICT subsections.
Searched Ongoing research database.
Searched Research Findings database, using subject heading assigned by NLT: "Information technology and literacy". Retrieved 1 record.
Searched literacy researchers list and printed out.
Printed out a wide range of bibliographies and links pages.

2e Teachers Evaluating Educational Multimedia (http://www.teem.org.uk)
Accessed the web site (20 August 2002). This website still focuses on case studies, teachers' evaluations of software and publishers' product information. No further information on research evidence was identified.

3. Handsearches

All journals were searched for the period July 2001 to October 2002.

Australian Journal of Language and Literacy
English in Australia
English in Aeoteroa
Literacy Learning
Education Media International
Dyslexia
Reading and Writing
Education, Communication and Information
English in Education
Research in the Teaching of English
Journal of Educational Computing Research
Changing English

APPENDIX 2.3: EPPI-Centre educational keywording sheet

V0.9.5 *Bibliographic details and/or unique identifier*…………………………

1. Identification of report	6. What is/are the topic focus/foci of the study?	8. What is/are the population focus/foci of the study?	10. Which type(s) of study does this report describe?

1. Identification of report
Citation
Contact
Handsearch
Unknown
Electronic database
 (Please specify.) …………………………

2. Status
Published
In press
Unpublished

3. Linked reports
Is this report linked to one or more other reports in such a way that they also report the same study?

Not linked
Linked
(Please provide bibliographical details and/or unique identifier.)
………………………………………………
………………………………………………
………………………………………………
………………………………………………

4. Language (Please specify.)

………………………………………………

5. In which country/countries was the study carried out? (Please specify.)

………………………………………………
………………………………………………
………………………………………………

6. What is/are the topic focus/foci of the study?
Assessment
Classroom management
Curriculum*
Equal opportunities
Methodology
Organisation and management
Policy
Teacher careers
Teaching and learning
Other (Please specify.)…………………

*6a Curriculum
Art
Business studies
Citizenship
Cross-curricular
Design and technology
Environment
General
Geography
Hidden
History
ICT
Literacy – first language
Literacy further languages
Literature
Maths
Music
PSE
Phys. Ed.
Religious Ed.
Science
Vocational
Other (Please specify.) ………………......

7.   Programme name (Please specify.)

………………………………………………..

8. What is/are the population focus/foci of the study?
Learners*
Senior management
Teaching staff
Non-teaching staff
Other education practitioners
Government
Local education authority officers
Parents
Governors
Other (Please specify.) ……………………

*8a Age of learners (years)
0-4
5-10
11-16
17-20
21 and over
*8b. Sex of learners
Female only
Male only
Mixed sex

9. What is/are the educational setting(s) of the study?
Community centre
Correctional institution
Government department
Higher education institution
Home
Independent school
Local education authority
Nursery school
Post-compulsory education institution
Primary school
Pupil referral unit
Residential school
Secondary school
Special needs school
Workplace
Other educational setting (Please specify.)…….

10. Which type(s) of study does this report describe?

A.   Description
B.   Exploration of relationships
C.   Evaluation
  a.   Naturally occurring
  b.   Researcher-manipulated
D.   Development of methodology
E.   Review
  a.   Systematic review
  b.   Other review

Please state here if keywords have not been applied from any particular category (1-10) and the reason why (e.g. no information provided in the text)

………………………………………………
………………………………………………
………………………………………………
………………………………………………
………………………………………………
………………………………………………
………………………………………………

APPENDIX 2.4: EPPI English Review Group keywording sheet

KEYWORDS FOR ENDNOTE NO ……………………

---

14. *Focus of the report* (Tick *all* that apply.)

literacy	learning	ICT
genre	assessment	CAI/CAL
literacies	dyslexiahypertext	
literature	learning difficulties	moving image
multimodality	learning disabilities	multimedia
reading	motivation	word processing
spelling	teaching	
writing	ESL/EAL	
	audience	
	comprehension	

15. *Type(s) of intervention or non-intervention* (Tick *all* that apply.)

computer – stand alone (software)
computer – networked (e-mail)
computer – networked (internet)
mobile phone
other technology _____
(Please specify.)

---

16. *What principal aspect(s) of literacy is the study focused on increasing?* (Tick *all* that apply.)

16a. psychological aspects
or representations
social representations and/or
cultural/critical representations

16b. writing print and graphical
or pictorial representation
reading print and graphical or
pictorial representations

**17. Which outcomes are reported?
(tick <u>all</u> that apply)**

test results - reading
- writing
- spelling
examination results
motivation/engagement
self-esteem/attitude
quality of writing
increased awareness of process
quality of reading
quality of response to multimedia

18. If study type in question 10 is C.b. (researcher-manipulated), is it

A. RCT
B. Trial
C. Other?

KEYWORDER ……………………………………………………. DATE …………………………

APPENDIX 2.5: Glossary for review-specific keywords

Literacy
The ability to read and write.

Genre
Basically, a type or category of text. In the Australian tradition, it means 'text-type'. In the North American sociological tradition, it means identifiable patterns of 'social action' grounded in texts.

Literacies
'Literacy' can be defined narrowly, as the ability to understand and create written language. It is, however, frequently defined in two broader senses, and both are included in the present review. Firstly, the scope can be expanded so that written language becomes written language and graphical or pictorial representation. Secondly, the skill can be treated as social, rather than psychological; in this view, literacy is the ability to operate a series of social or cultural representations. Both these expansions of the narrow term 'literacy' can be termed 'literacies'.

Literature
Fictional, dramatic or poetic texts.

Multimodality
The use of more than one mode of communication to convey 'information'. All texts, in a sense, are multimodal in that printed writing is both visual and verbal. Multimodality is usually reserved for the combination of word and image and/or sound conveyed via the computer screen.

Reading
The act of bringing meaning to print.

Spelling
Orthographic representation of phonemes, morphemes and words.

Writing
This term should be reserved for papers that study the impact of ICT on general writing skills and capabilities: for example, the structure and expression of compositions.

ICT
'ICT' is taken to include stand-alone computers, networked technologies with a multimodal interface, mobile phones with the capacity for a range of types of communication, and other technologies which allow multimodal and interactive communication.

CAI/CAL
'Computer-assisted instruction' and 'computer-assisted learning'. The former tends to be associated with self-supporting computer programs which replace the teacher, rather than complementing him/her.

Hypertext
Computer-readable text which allows for extensive cross-referencing, particularly 'vertically': that is, it is possible to conceive of and present text in vertical layers rather than conventionally, in a horizontal plane.

Moving image
Film, video, animation.

Multimedia
The use of more than one medium of communication to convey information. Whereas multimodality refers to the combination of more than one mode of communication (e.g. the verbal and visual), multimedia is a more technical term referring to a range of media which can convey such modes of communication.

Word-processing
The composition of verbal language on screen, usually on computer and in substantial form (as opposed to 'texting').

Learning
The transformation from one state of personal knowledge to another.

Assessment
The measurement of learning performance, either 'summative' (at the end of a process of learning) or 'formative' (during the process of learning).

Dyslexia
Difficulty with learning to read or spell, arising from problems with grapho-phonemic equivalence. Also known as 'specific learning difficulties'.

Learning difficulties
These are difficulties with learning encountered by any children or young people of any age, and are associated with a variety of barriers to learning that may be temporary and which may be overcome by teaching strategies, appropriate curricula, etc.

Learning disabilities
These are more profound and developed difficulties with learning encountered by children and young people of any age, and are associated with a variety of barriers to learning that are usually more permanent.

Motivation
The impulse and/or desire to learn.

Teaching
Teacher-centred strategies for encouraging, eliciting and developing learning in pupils and students.

ESL/EAL
'English as a second language' (as opposed to EFL, 'English as a foreign language') refers to the language as learnt and taught by people for whom English is not a first language or mother tongue, but is acquired (often with much teaching help) as a second language with distinct functions in society. 'English as an additional language' (EAL) is now the preferred term, as it implies that English may be learnt not only as a second language, but as a third or fourth language in a culture.

Audience
This term can refer to an audience of one, as in a single respondent or listener, up to an audience of inestimable size via the Internet.

Comprehension
Understood by psychologists as a key activity in learning to read, and complementing 'decoding' of printed text. Understood by English teachers as a now outmoded form of textual analysis and appreciation in which text is subjected to a series of questions to elicit understanding.

APPENDIX 2.6: Calculating Hedges' g

First, d is calculated from the means, standard deviations and sample sizes entered into outcome records.

$$d = \frac{\overline{X}_1 - \overline{X}_2}{s}$$

where:

$\overline{X}_1 = mean\ of\ intervention\ group$

$\overline{X}_2 = mean\ of\ comparison\ or\ control\ group$

$$s = \sqrt{\frac{(n_1 - 1)SD^2_1 + (n_2 - 1)SD^2_2}{n_1 + n_2 - 2}}$$

where:

$n_1 = sample\ size\ for\ group\ 1$

$n_2 = sample\ size\ for\ group\ 2$

$SD_1 = standard\ deviation\ group\ 1$

$SD_2 = standard\ deviation\ group\ 2$

d is then corrected for sample size using the formula:

$$g_c = g(1 - \frac{3}{4N - 9})$$

and its standard error is calculated:

$$SE = \sqrt{\frac{n_1 + n_2}{n_1 n_2} + \frac{(g_c)^2}{2(n_1 + n_2)}}$$

Where: $n_1 = sample\ size\ of\ group\ 1\ and$

$n_2 = sample\ size\ of\ group\ 2$

Formulae for combining studies using the inverse variance method

Each study is weighted according to the formula:

$$w_i = \frac{1}{SE(\Theta_i)^2}$$

where Θ_i is the effect size of the study and SE is its standard error

The combined effect, Θ_{iv} is calculated

$$\Theta_{iv} = \frac{\sum w_i \Theta_i}{\sum w_i}$$

and its standard error:

$$SE(\Theta_{IV}) = \frac{1}{\sqrt{\sum w_i}}$$

The heterogeneity statistic, Q, is calculated using the formula below. Since it is distributed as a chi-square, a p-value is obtained with k-1 degrees of freedom, where k is the number of effect sizes being combined.

$$Q = \sum w_i (\Theta_i - \Theta_{iv})^2$$

95% confidence intervals for individual and overall effects are calculated using the formula:

$$\Theta \pm (1.96 * SE(\Theta))$$

The test statistic (z) for overall effect is:

$$z = \frac{\Theta}{SE(\Theta)}$$

APPENDIX 4.1: Characteristics of included studies

Author, date and country	Study type	Aim	What was studied?	How was it studied?	Measure of effectiveness
Berninger *et al.* (1998) USA	Evaluation: researcher-manipulated, RCT	To determine whether the computer or the pencil is the more effective response mode in learning to spell words.	Sample: 48 second-grade children (mean age of101.77 months) with spelling (n = 24) or spelling and handwriting (n = 24) disabilities were randomly assigned to pencil or computer response mode. They were taught 48 words of varying orders of sound-spelling predictability, using a method that emphasised hearing the word in the mind's ear and seeing the word in the mind's eye and making connections between the phonological and orthographic representations at the whole word and subword levels. Each word in a set of 48 words was taught using methods that were identical in both treatment conditions except: Intervention: Children 'wrote' the words with a computer keyboard. Control: Children wrote the words with a pencil. Outcome measurements: Five measures of spelling were the WIAT spelling subtests; the WRAT-3 spelling subtest; a spelling inventory of 48 words scored in two ways: a total score summed across the eight orders and a separate score for the easy, moderate and difficult orders.	RCT (individual) Pre-, mid-, and post-test data	Spelling: No significant difference between the two groups in all five outcome measures. One large positive effect (for control) for Spelling Order Easy but not statistically significant so potential for Type II error. Spelling and handwriting: No significant differences between the two groups in four outcome measures. One large positive effect (borderline statistical significance) for one outcome measure – Spelling Order Moderate. One large (but not statistically significant) effect for Spelling Order Difficult. Again, possibility of Type II error.
Golden *et al.* (1990) USA	Evaluation: researcher-manipulated, RCT	To evaluate the effect of computer networking program in providing guided practice in teaching reading comprehension.	Sample: 31, middle-school (years 6, 7 and 8) students 'receiving remedial instruction in reading' randomly assigned to intervention or control Intervention: Students received guided practice – computer networking provided the teacher with information for determining the nature and extent of guided practice necessary. Control: Students completed a worksheet containing the same questions that were given to the guided practice group; the teacher	RCT (individual) Pre- and post-test data	QAR2 (metacognitive strategy): No significant differences at immediate post-test; large positive effect for intervention at maintenance (borderline statistical significance). Rule-based inferences test: No significant difference at immediate post-test; large positive and statistically significant effect for intervention.

Author, date and country	Study type	Aim	What was studied?	How was it studied?	Measure of effectiveness
			corrected and analysed the worksheets. Outcome measurements: QAR2 (metacognitive strategy) and rule-based inferences test.		
Heise *et al.* (1991) USA	Evaluation: researcher-manipulated, RCT	To investigate the role that CAI may play in the development of base vocabulary (reading) in students.	Sample: 56 third grade and sixth to eighth grade 'remedial' students were match paired by grade level, scores and gender. One student of each pair was randomly allocated to computer-administered instruction (CAI). Intervention: CAI used to present vocabulary (Word Attack software package designed to teach new words, definitions and their usage). Control: Teacher-directed instruction (conventional instruction) similar to the presentation on the software package. Outcome measurements: CTBS (total reading – vocabulary and comprehension) Ginn Vocabulary Extraction Test (base vocabulary knowledge)	RCT (individual) Pre- and post-test data	CTBS: No significant difference between the two samples Ginn vocabulary: No significant difference between the two groups
Jinkerson and Baggett (1993) USA	Evaluation: researcher-manipulated, RCT	To determine if the use of a spell-checker would aid students in identifying and correcting mis-spelled words in a pre-written story and to compare their performance with those making spelling corrections by hand	Sample: 20 students aged 9-11 (average age of 10.1 years) were randomly allocated to intervention or control. Intervention: students used a spell checker to identify and correct mis-spellings in a pre-written story. Control: Students identified and corrected mis-spellings in a pre-written story by hand. Outcome measurements: Oral spelling test; difference between number of words correctly spelled on the oral post-test and the number of words corrected in the story; comprehension quiz score.	RCT (individual) Data collected during and after the intervention	Oral spelling post-test: No significant differences between the groups Quiz score: No significant differences between the groups Difference between number of words correctly spelled on the oral post-test and the number of words corrected in the story: large positive and statistically significant effect for the CAI group
Jones (1994) USA	Evaluation: researcher-manipulated, RCT	To determine if the use of a word processing program during language instruction would result in a larger quantity of writing	Sample; 20 second grade students were randomly allocated to intervention or control. Intervention: The students used the Magic Slate word-processing program to independently complete seven written assignments. Control: The students used pencil and paper to complete independently seven written	RCT (individual) Pre- and post-test data	Quality of writing (holistic score): Large positive and significant effect for intervention Quantity of text (word count): No significant differences between the groups

Author, date and country	Study type	Aim	What was studied?	How was it studied?	Measure of effectiveness
		and whether it would influence the holistic writing quality of second grade students when they compose with pencil and paper	assignments. Outcome measurements: Quality of writing (holistic score); quantity of text (word count).		
Lin *et al.* (1991) USA	Evaluation: researcher-manipulated, RCT	To assess the differential effects of the critical features of computer-assisted instruction (CAI) and a more traditional paper-and-pencil approach on automatisation of word-recognition skills among mildly mentally handicapped and non-handicapped learners	Sample: 93 'non-handicapped' second grade students (mean age of 7.81 years), and 'mildly mentally handicapped' students from various grades (mean age of 8.86 years) were randomly allocated to instructional medium (CAI or paper and pencil). Intervention: CAI condition: Word Attack software program employed to teach word recognition skills (presentation and practice phases) Control: Paper and pencil condition with Flashcards and worksheets employed to teach word-recognition skills (presentation and practice phases) Outcome measurements: Accuracy and response times	RCT (individual) Pre- and post-test data	Accuracy scores (non-handicapped): No significant differences between the groups Accuracy scores (handicapped): Borderline significant positive effect for control Accuracy scores (total): Significant positive effect for control Response times (non-handicapped): Positive and significant effect for intervention Response times (handicapped): Positive and borderline significant effect for intervention
MacArthur *et al.* (1990) USA	Evaluation: researcher-manipulated, RCT	To compare computer-assisted instruction (CAI) and paper-and-pencil instruction (PPI) as a means of delivering independent spelling practice in classes for 'learning disabled' (LD) students	Sample: 44 fifth and sixth grade students were pair-matched for classroom, gender and spelling scores. One student from each pair was randomly allocated to the intervention. The instructional designs of the two programs were not identical, but rather made use of features typical of CAI and PPI drill activities. Each program exploited the potential benefits of its medium in ways consistent with the contextual constraints of independent practice. The principal differences were in procedures for feedback and review, and in the degree of student control.	RCT (individual) Pre- and post-tests Retention test	Spelling retention test: No significant difference between the groups Week 1, week 2, week 3 and week 4 spelling tests: No significant differences between the groups

Author, date and country	Study type	Aim	What was studied?	How was it studied?	Measure of effectiveness
			Intervention: The CAI program provided immediate corrective feedback on all responses and required the student to respond correctly before continuing. Words spelled incorrectly were presented later in the same day of practice. The CAI program also completely controlled the sequence of activities and in some cases regulated the pacing. Control: In the PPI program, feedback was provided by self-checking and delayed feedback from the teacher. Students were prompted by the materials to check their own work and practise the words until they spelled them correctly. Corrective feedback from the teacher was received on the following day and students corrected their previous work before doing the new work. The sequence of activities was prescribed, the daily work was presented in an organised fashion in a folder, and students were taught study procedures. However, unlike the CAI program, the materials themselves did not force students to follow the study and self-checking procedures. Outcome measurements: Spelling achievement		
Matthew (1996) USA	Evaluation: researcher - manipulated, RCT	To compare the reading comprehension and attitudes towards reading of third grade students who read CD-ROM interactive storybooks with those who read traditional print storybooks	Sample: 74 third grade students were pair-matched (37 pairs). One student in each pair was randomly allocated to either experimental or control condition. Intervention: Students in the experimental group read CD-ROM books on the computer. Control: Students in the control group read the same books in a traditional print format. Outcome measurements: Reading comprehension (open-ended questions and story re-telling)	RCT (individual) Pre- and post-test data	Open-ended questions: No significant differences between the two groups Story re-telling: Positive and significant effect for intervention (borderline significance)
Mitchell and Fox (2001)	Evaluation: researcher-	To examine the effectiveness of two	Sample: 72 kindergarten and first grade students (mean age of 76.11 months) were	RCT (individual) Pre- and post-test	PAT total test: Positive and significant effect for control

Author, date and country	Study type	Aim	What was studied?	How was it studied?	Measure of effectiveness
USA	manipulated, RCT	computer programs designed to increase phonological awareness in young children. To compare the effects of computer-administered phonological awareness instruction with the effects of teacher-delivered phonological instruction	randomly allocation to intervention or control condition (three different groups). Intervention: Phonological awareness software – Daisy Quest and Daisy's Castle. Instruction and practice in rhyme identification, and in the identification of beginning, middle, and ending sounds in words; teaching and reinforcement of segmenting words into individual phonemes and blending were provided through the computer software. Both programs are highly interactive with colourful graphics and speech. Control: Teacher-delivered instructional materials. Learning activities for teacher-delivered phonological awareness instruction were selected from the 'Phonological Awareness Kit' (1997). The activities targeted the same phonological awareness processes that were included in the two computer-administered programs. Explicit phonological awareness instruction was presented for each phonological process followed by practice activities which employed picture cues, sound boxes, manipulatives or games. The children received instruction in identifying rhyme; in isolating initial, middle and ending sounds in words; in segmenting; and in blending phonemes to produce words. Outcome measures: Phonological Awareness Test (PAT)	data	Rhyming, isolation, segmentation and blending: No significant differences between the groups
Reinking and Rickman (1990) USA	Evaluation: Researcher-manipulated, RCT	To investigate whether intermediate-grade readers' vocabulary learning and comprehension would be affected by displaying texts on a computer	Sample: 60 sixth-grade students were randomly allocated to one of four treatment conditions: *Dictionary condition* (control): Passages were presented on typed pages and were accompanied by a dictionary. *Glossary condition* (control): Passages were presented on typed pages and were accompanied by a separate typed glossary page.	RCT (individual) Post-test data	Vocabulary test: Select definitions condition *v.* dictionary condition: Large positive and significant effect for intervention Select definitions *v.* Glossary condition: Large positive and significant effect for intervention All definitions condition *v.* Dictionary condition: Large positive and significant effect for intervention

Author, date and country	Study type	Aim	What was studied?	How was it studied?	Measure of effectiveness
		screen that provided the meanings of difficult words	*Select definitions condition* (intervention): Passages were presented on a computer screen. Each computer screen displaying a section of the text enabled readers to request the definitions of the words on the screen. *All definitions condition* (intervention): Passages were presented on the computer screen./ Subjects could not proceed to a subsequent segment of the text until they had viewed the meanings of the target words in the previous segment. Outcome measurements: Comprehension test and vocabulary test.		All definitions condition *v.* Glossary condition: large positive and significant effect for intervention Comprehension test: Select definitions condition *v.* Dictionary condition: No significant difference between the groups Select definitions *v.* Glossary condition: No significant difference All definitions condition *v.* Dictionary condition: No significant difference All definitions condition *v.* Glossary condition: No significant difference
Swanson and Trahan 1992) USA	Evaluation: researcher-manipulated, RCT	To determine the degree to which computer-mediated presentation of text influence learning disabled children's reading comprehension, and whether cognitive factors related to metacognition, attribution, and working memory influence treatment effects. To determine which cognitive variables are most likely to affect directly learning disabled readers' comprehension of computer-mediated text.	Sample: 120 learning disabled 4th, 5th and 6th grade students within ability group and grade level were randomly allocated to one of four treatment conditions. *Control:* Readers were administered all the pre- and post-test measures but received no direct reading comprehension intervention related to the passages. They continued to receive their normal classroom instruction. *Paper (off-line):* Readers in this condition received both traditional and cloze comprehension passages in printed form. *Computer presentation:* No optional re-reading. As in the offline condition, readers in this condition read the traditional and cloze story passages once, before answering the comprehension question. The only difference between the paper presentation was that the text was computer mediated. *Computer re-reading:* Readers were directed to re-read all or portions of the passages before answering comprehension items or cloze fill-ins. For this effectiveness review, the paper offline condition was compared with the computer no re-read condition.	RCT (individual) Pre- and post-test data	Learning disabled: No significant differences between the groups in five out of six of the outcome measurements. Positive and significant effect for control in word meaning. Average readers: No significant differences between the groups in all six outcome measurements

Author, date and country	Study type	Aim	What was studied?	How was it studied?	Measure of effectiveness
			Outcome measurements: Level B of the Nelson Reading Skills Test Working Memory Span Test		
Zhang *et al.* (1995) USA	Evaluation: researcher-manipulated, RCT	To assess the impact of specifically designed computer software tools on the quality of the writing of children performing at least one year behind their school grade level.	Sample: 33 'learning disabled' students, ranging in age from 7.7 to 13.2 years were matched into 11 triads. The students were matched by their teachers according to their standardised test score, grade level, writing level and IQ score. From these triads, students of each grade were randomly assigned to one of three groups. Each group contained the same number of students from different grades. Intervention: The students used a specifically designed computer software tool (ROBO-Writer) for writing texts. Control: The students used a popular word-processing program (Microsoft Word Version 4.0) for writing texts. Control: The students used traditional paper and pencil methods for writing texts. Outcome measurements: Writing samples – spelling and grammatical errors, number of words and holistic scoring	RCT (individual) Pre- and post-test data	Positive and significant effect for intervention (ROBO writer) in holistic scoring, spelling and grammatical errors (three outcome measurements). No significant difference for number of words (one outcome measurement).