ImpacT2 Project

Preliminary Study 1

Establishing the Relationship between Networked Technology and Attainment

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Details of the research design and methodology are available on research web site at http://www.nottingham.ac.uk/education/research/impact2.html.

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Executive summary

The argument developed in this paper is that a study of the relationship between information technologies (particularly networked technologies) and pupil attainment needs to be based upon two parallel strands of development.

The first strand derives its methodology directly from earlier work in the IT evaluation field, particularly the first ImpacT study (Watson, 1993) and the Integrated Learning System evaluations (Underwood, 1997; Wood, 1999). This strand explores ways of using established tests and instruments to examine the relationship between networked technology and attainment, and proposes developments which improve on earlier methods, though in an essentially incremental manner.

The first strand will lead to a series of proposals for identifying the most effective method for exploring the ICT-attainment relationship in the schools selected for intensive study, using multiple regression techniques and residual scores. We shall argue:

- that a very limited number of baseline data instruments, administered in a standardised form by a national centre, and used across all the schools in the sample, will provide a much more stable basis for making end-of-key-stage comparisons between predicted and actual attainment than has been possible in earlier studies.
- that data from Ofsted reports will provide a more stable, rigorous and objective procedure for enabling judgements to be made about schools' ICT resources and curriculum, on the basis of which two groups of schools ('Hi-ICT' and 'Average ICT') could be selected for intensive study.
- that problems in final data analysis might be reduced if the researchers agreed that (at least for some analyses) schools designated as 'High-ICT' or 'Average ICT' might be switched to the other group if it emerged that the initial assignment of the school to a category had been erroneous.

- that end-of-Key-Stage measures, (KS2 and KS3 tests in Maths, English and Science, and KS4 GCSE results in a full range of subjects) will provide a usefully broad basis for analysing attainment outcomes.
- that where interaction effects due to teacher, school or curriculum content variables might lead to a potentially confusing or inconclusive set of relationships between ICT and attainment, it may be useful to use to pool pupils within each age cohort (approximately 800), in order to explore the influence of variables such as the impact of home use of a computer.

The second strand of the proposed study is more exploratory, and its discourse is more uncompromising: this second strand suggests that there are some fundamentally new empirical and conceptual challenges involved in attempting to identify a causal relationship between pupils' use of networked technologies and improvements in their attainment, and that these cannot be captured by existing instruments.

To meet the challenges posed by this second strand of analysis, we shall propose a number of solutions:

- We shall propose that exposure to networked technologies affects student learning in ways which may not be reflected in standardised attainment tests, but which are nonetheless essential to the development of an effective learner.
- We will then explore the ways in which we think this might have an impact, and how the resulting outcomes might be evidenced.
- We shall argue that other outcome measures, which are directly or indirectly related to improved learning, have been regularly demonstrated, e.g., enhancements in specific skills, higher level conceptualisation, better problem-solving, more complex small-group talk, and improved motivation.
- We shall suggest that a concept mapping task could go some way to providing an instrument with which we could explore pupils' knowledge and learning in this area, and that such a task could be used as both a baseline and an outcome measure.
- We shall argue that a Socially Contextualised Integrated Model of Learning is necessary to describe the culture within which a pupil learns, and that in the present study, a careful analysis of the relationship between home and school uses of the computer will be an essential preliminary to conducting such an analysis.

- Finally, we shall suggest that there does not presently exist an instrument which would provide a objective, computer-based measure of the skills and knowledge-transformation capabilities which we would expect a pupil using networked technologies well to be developing; we feel that it would be valuable to use the pupils' logs which will be kept by students who participate in this project to help us to identify these skills. We also aim to continue the search for a computer-based measure of such skills during the course of the project..

1 Introduction

In this study the objective is to frame measures of learning outcomes which are likely to have been enhanced by the use of networked technologies. For the main study of ImpacT2 it will be necessary to decide how to make use of standardised instruments such as end-of-key-stage and GCSE scores across a range of subjects, in order to relate attainment to children's use of networked technologies. One strand of this preliminary study will therefore be to discuss how best to carry out such an investigation, learning lessons from previous research studies, and looking particularly closely at the ImpacT study published in 1993, based on the work of a large team at Kings College London, led by Margaret Cox and David Johnson (Watson, 1993).

However, we shall also argue that there is now a substantial weight of data from a variety of studies which suggests that the correlation between IT use and improvements in attainment as shown using national tests as standard measures is weak. An increasing number of researchers would take the view that children are learning when using networked technologies, but that what they are learning, and how they are learning, is not captured by these large-scale, often content-knowledge oriented, measures. The discussion of these issues forms the second main strand of this paper, and will lead to a proposal that ImpacT2 should broaden its conceptualisation of the notion of attainment to include some more innovative and exploratory measures.

This second strand of argument leads to some important conceptual and methodological challenges, not least because where there is evidence of improved learning related to the use of IT, studies tend to show enhancements in areas such as attitude, skills and

conceptualisation, rather than in global attainment. We shall argue that ImpacT2 needs to offer a way of documenting this 'hidden' learning in the context of networked technology usage – if indeed it exists – and identifying its direct and indirect effects. To do this, we shall need to develop a plausible model of the relationship between exposure to networked technologies and the likely impact on skills and knowledge development. This model will be developed dynamically as different methods of use are identified and mapped to plausible expected learning outcomes. The nature of networked technology is such that the nature of tasks which employ aspects of the technology will vary widely, and looking for a set of outcomes which will apply to any use may well obscure rather than clarify the nature of outcomes. We shall propose that exposure to networked technologies affects student learning in ways which may not be reflected in standardised attainment tests, but which are nonetheless essential to the development of an effective learner. We will then expand the ways in which we think this might impact, and how the resulting outcomes might be evidenced.

2 What is already known about networked technologies and attainment? [1]

This review of the literature of research into the impact of new technologies, and particularly networked technologies, on student attainment is divided into two parts. This first part discusses some important theoretical and practical issues involved in reviewing the field, and particularly the problem of ascribing causal links between information technology and attainment; it also discusses the lessons to be learned from the ImpacT study, and the implications of these for the design of the ImpacT2 Main Study.

The second part of the review forms Appendix A of this report. It presents in tabular form, and grouped thematically, summaries of 73 studies that reported benefits in terms of improved student attainment which were attributed to information technology. The findings of the review are integrated into this main report as appropriate, but it seemed to us potentially useful to make the fuller set of summaries available.

It is important to add at this point that the review is closely focused, in that it sought to focus on studies with school-related attainment variables, and gave much less prominence to the

[1] The ImpacT2 project team gratefully acknowledges the assistance of Annabel Harrison in preparing this section of the review.

very extensive literature on cognition and information technology. There are two reasons for this: the first was simply that related to the time available to research and compile the review; the second is that the aim of ImpacT2 is to focus closely on attainment as defined by schools and the agencies which manage them. We argue in this study that an exploration of the impact on attainment of networked technologies does imply a widening of this lens, but nevertheless this is our initial and primary focus, as we wanted to feel confident that we had identified and discussed the most important school-related studies before we broadened our field of view.

One further point: the summaries of 73 research studies in the Appendix do not include evaluations by our team of the quality of the study, or the soundness of its data, and it is important, therefore, to stress that there was, understandably in our view, great variability in relation to these factors across the studies quoted. While we did exclude studies which in our view made completely unsubstantiated claims, we would also want to add that the inclusion of a study in Appendix A does not mean that our team felt that the study was necessarily exemplary, or that its findings were unproblematic. There were many instances where researchers made strong claims about student gains in knowledge of attainment, but in common with others in the research community, we trusted such claims further if they were published in a peer-reviewed source.

3 Theoretical and practical issues in reviewing the impact of ICT on attainment

In the voluminous literature on computers and learning, dozens of outcome variables which have some relationship to school attainment have been reported. The influential NCET publication, *IT Works*, for example (NCET, 1994), drew together 81 studies which provided evidence of the ‘specific educational benefits that can be attributed to the use of IT’. The variables which together provide the instantiation of these educational benefits are the following (variables from parallel or confirmatory studies have been grouped together for brevity):

- Learner enthusiasm
- Learner confidence

- Cognitive processing speed
- Concentration
- Range of writing forms used
- Quality of revisions to writing
- Spelling, and presentation in writing
- Speed of learning
- Ability to organise and classify information
- Information handling skill
- Understanding in maths and science
- Learner autonomy, leading to improved motivation and improved learning
- Critical thinking
- Improved reading and comprehension
- Learning in science and maths
- Transformed power relationships in learning, leading to benefits for the learner

It is worth noting at this point that most of the studies above reported on variables that are generally held to have an important but indirect impact on student attainment. Motivation and confidence, for example, are regarded by most teachers as crucial to learning, but have indirect rather than direct effects. Most teachers know highly motivated students whose ultimate attainment was poor, despite a high work-rate; and most teachers also know some students with low self-confidence who achieved wonderfully, despite poor self-esteem.

Another important point to note is that improvement in cognitive variables such as problem-solving capability, critical thinking skill, and information-handling ability may be very important in learning, and crucial in relation to a student's long-term employment and their human achievement, but such variables may not be reflected in improved attainment scores on end-of-key-stage tests and GCSE results, especially if these instruments place a high premium on factual knowledge rather than speed or depth of processing.

The editors of *IT Works* made an attempt to identify studies which had produced tangible evidence of benefit, but very few of the studies reported on school attainment as such, and very few reported on improved attainment as measured by national assessment outcomes. Far from being causally linked, many of the benefits listed were described as potential rather than

inevitable. Benefits were also reported as being influenced by interaction effects attributable to the teacher's influence on the student's learning and the learning culture of the classroom. Finally, another weak link in the causality chain is that some studies were based on data collected under short-term case-study conditions rather than in classrooms over the long term.

One could even posit a general rule to describe this state of affairs, namely that in seeking evidence of a direct relationship between Information Technology and attainment, there is a trade-off between ecological validity and the degree of confidence with which one can ascribe causal attribution. In other words, the further one gets from the classroom, the more confident one can be that a particular intervention is directly responsible for learning gains; the closer one gets to the classroom, the less confident one can be that an intervention is directly responsible for any improvement in attainment.

It is not difficult to explain why this might be, and the main reason is related to the difficulty of conducting educational research which uses an experimental design that is capable of isolating the influence of a key independent variable – in this case the use of a specific variety of information technology. A case study example can illustrate the point. Harrison (1997) reported, in a study which was one of a small group on different aspects of the impact of Integrated Learning Systems (ILS) on schools in England, that in a primary school in the Docklands area of London, most of the pupils had formed a very negative opinion of the reading component of the PC-based program being evaluated. Staff had reported that the platform of the system was unstable, that it crashed frequently, that the pupils did not enjoy and were bored by the tasks set, and that the pupils were frequently off-task. Site visits confirmed this: in a suite of six computers, it was rare for all six to be running the program successfully; pupils who began activity on the reading module were generally off-task within five minutes, and the pupils subverted the tasks set, using a record facility in the software in creative but highly subversive and unintended ways. Teacher interviews, with one exception, gave a very negative evaluation of the software. Just as the researcher was about to leave the school, however, one of the teachers mentioned that the pupils loved reading on the computer, and it became clear that, as a result of an entirely different initiative, the same pupils were being introduced to computer versions of 'living books' (well-known stories with animated illustrations and digitised text), and that the pupils competed with each other for time on the Macintosh computers which ran this software.

Clearly, in this school, any evaluation which looked at reading attainment as an outcome measure related to ILS would run the risk of wrongly ascribing causal effects to that intervention. In fact, further enquiries revealed that the school in question was participating in more than six separate curriculum initiatives, all of which were intended to boost literacy achievement, but only three of which involved new technology.

Here, then, is an experimental design problem that could strictly speaking be fatal to most analyses which attempt to identify a causal relationship between information technology and school attainment. Broadly speaking, when it comes to new technology, it is somewhere between difficult and impossible to relate improvements in school achievement to a single cause. This is not to say that school (or indeed an individual teacher or course) does not make a difference, but rather that it is very difficult to identify the impact of technology without a classical control-group design, and such designs are extremely rare. The problem is analogous to that of asking whether books are having an impact on learning: books are a medium for transmitting information, they cover a vast range of content, structure and genres, they can be used in an infinite variety of ways. It is therefore extraordinarily difficult to make generalised statements about their impact on learning.

This issue of assessing the impact of the medium of instruction is an important one in the present study. The meta-analysis of Liao (1999) into the effects of hypermedia on students' achievement is a useful example here. Liao analysed 46 studies of hypermedia, and what he reported is instructive: in a field in which there is a good deal of 'hype', it turned out that the majority of studies of hypermedia which reported a statistically significant effect size were of one of two types: either the study had no comparison group, or if there was a comparison group, that group did not receive normal instruction, but had only a videotape of the material to be learned. By contrast, when there was a comparison group, and that group was taught by a teacher who gave handouts, or if the group was taught by another form of Computer Aided Instruction, the additional positive effects of hypermedia were trivial. What Liao's meta-analysis suggests is that it is unwise to attempt to review the effects of a medium independently of how that medium is used.

A similar finding was one of the most important points to come out of the first ImpacT study, which was funded by the DES, beginning in 1987, and it is worth summarising its main findings here. The first ImpacT report (Watson, 1993) considered the impact of Information

Technology on children's achievement in a complex and detailed series of studies. It is not uncommon, ten years since the ImpacT team collected their data, to hear negative comments about the study's data collection or sampling, so it is worth reminding ourselves that the study was at the time considered one of the most important, as well as one of the most methodologically subtle studies of IT in education to have been undertaken in the UK.

The aspects of IT which were examined closely included a wide range of curriculum or cross-curricular software, and an extensive range of generic software, such as database software, paint programs, word-processing software and LOGO. Because the types of software and information technologies studied was very broad, it is very difficult to categorise the project's findings within the form of a synoptic review, but because of the project's importance, some of what we take to be its most important findings are mentioned below:

- Working with computers increased pupils' motivation, enjoyment, concentration, pride in their work; it led to higher-level cognitive engagement with problems, and greater retention of knowledge.

But methodological and other difficulties led to problems:

- It proved very difficult to identify adequately and in advance which ImpacT schools were high or low IT users; this led to the unsatisfactory position of some schools which had been designated as 'low IT' having more IT activity than supposedly 'high IT' schools, and vice versa.
- Despite the use of a subtle and complex experimental design, the findings with regard to the impact of IT were somewhat inconclusive. Even when controls for initial student ability were included, effects of IT related to residual gain scores (i.e. standardised attainment scores based on obtained as compared to predicted results) were negative in 7 out of 16 cases in the 8-10 and 12-14 age group (Watson, 1999, p. 167); in other words, in 7 out of 16 cases, the children who had more IT performed worse on the outcome measures.

The major outcome from the research was the finding that IT had a highly positive effect on children's achievements when a number of variables came together – these included the

technology, pupil access to it, teacher expertise and effectiveness, and school and LEA support.

- Because of the interaction effects, however, it was difficult to impossible to identify stable and systematic relationships between IT and outcomes – an effect that was strong in one age group disappeared or was reversed in the next.

In considering the implications from the review of the literature for the conduct of the present investigation, it will be important to bear in mind the lessons learned from the first ImpacT study.

The 73 studies reported in the research summaries section of Preliminary Study 1 have been gathered from three principal sources: NCET/Becta documents and reviews; other reviews and meta-analyses of the field (including the 'Newcastle Report'); a review of key journals (with particular attention to JCAL). The reports are grouped thematically in the following order:

- **INTERNET AS A RESOURCE**
- **COMMUNICATION ON THE INTERNET**
- **HOME USE**
- **E-MAIL**
- **EDSI PROJECTS**
- **VIDEO CONFERENCING**

- SMALL GROUP TALK
- TALKING COMPUTERS
- ILS
- MULTIMEDIA
- CD-ROMS
- HYPERMEDIA
- WORDPROCESSING
- PORTABLES
- CURRICULUM/CROSS-CURRICULAR

The first six sets of studies, whose titles have been emboldened, are particularly relevant to the theme of networked technologies. The next nine sets have been included because the team regarded them as closely related to the first six, and therefore as likely to have relevance to this review. We also had in mind the fact that classroom-based research into networked technologies is relatively new, at least in the UK, and that it would therefore be useful to give attention to studies of ICT in these related fields that attempted to identify impact on attainment.

We would also wish to comment on the fact that we included some reviews of the field in this study. While recognising that secondary sources can introduce or amplify author bias, we also felt that it would be unfortunate to discard secondary sources if, in our view, they made a valuable contribution to the field. The meta-analysis of Liao (1999), for example, broke new theoretical ground, enabled useful comparisons to be made, and moved the field forward.

What the review suggests is that currently, the evidence that networked technologies improves school attainment is limited. Perhaps this is not surprising, given that most of the studies of students' use of the Internet in England have been exploratory rather than summative. Many of the evaluations of individual Educational Superhighways Initiative projects came into this category, and are best viewed as examples of evaluation of innovations in curriculum development, rather than as evaluations capable of being included in a balanced experimental design. A number of studies reported improvements in students' attitude or skills, rather in global attainment, but a number also took the view of Levin and Thurston (1996) that the Internet does offer new and potentially very powerful possibilities for learning:

> . . . networks may substantially change the relationship between education and the rest of society[;] .... The reintegration of learning into the rest of society will require a redistribution of roles, a reinvention of social structures, and a rethinking of the entire learning enterprise.(Levin and Thurston, 1996)

4 The implications for data collection in the Main Study derived from the review of the literature

In our view, and while accepting that the world of information technology has evolved rapidly in the ten years since the first ImpacT project collected data in schools, there is in our

view much to be gained from reviewing the strengths and weaknesses of that study in formulating a methodology for measuring school attainment, and in attempting to relate this to the use made by pupils of information technology.

Among the positives of the ImpacT report were the following:

- The study used a mixture of quantitative and qualitative research methods
- The study sought to use multiple regression methods to explore the amount of 'value added' in high-IT and low-IT contexts
- The study looked closely at a range of subject areas and age groups
- The study recognised the significance of interaction effects related to teacher, pupil, task and curriculum content variation
- The statistical studies were inconclusive, but interesting and illuminating
- The case studies were helpful and highly regarded
- The project team were well aware of the weaknesses in their research design and sampling, and reported these boldly.

On the negative side, there were a number of lessons to be learned:

- There were a number of occasions on which the team decided after the event that the assignment of schools to high-IT and low-IT categories had been inaccurate
- Some of the mini-studies of achievement were based on very small groups (as small as n=21) from which it would have been very difficult to make generalisations
- The main school sample was based on schools in 19 LEAs, but final statistical data was available on no more than eight classes in each age cohort
- Many teachers and schools dropped out of the project and were not replaced
- The project team recognised that teacher confidence and expertise was a factor, as was the availability of INSET, but they were unable to measure or control for this in their design.

One further issue, not dealt with in this report because it is part of the remit of Preliminary Study 2, was the problem of measuring accurately and reliably the main independent variable in the study, namely the degree of IT-related activity experienced by the pupils. Clearly in the case of the first ImpacT study, researchers had very little control over what was taught, and

had only limited data available on pupils' use of the software being evaluated, and their time on the computer.

The ImpacT2 project team agrees that a multiple-regression approach, which attempts to identify 'value added' by looking at pupils' attainment, as compared with what they might have been expected to achieve, represents the most useful potential avenue for exploring the relationship between networked technologies and attainment, and we propose the following strategies to develop from the positives and overcome the problems which limited the ImpacT study. We present these in the form of a table:

ImpacT1 Positives	**ImpacT2 Strategy**
Qualitative and quantitative approach	Retained; but improved by having a larger, more stable data set, with pupils acting as co-researchers, supported by the project team and teacher co-ordinators
Multiple regression 'value added' approach	Retained; but improved by having larger, more stable data set, with a single baseline measure for all pupils in an age cohort
Acknowledged likely impact of interaction effects	Retained; a larger data set will permit fuller investigation of these effects
Statistical effects illuminating but inconclusive	ImpacT2's larger data set will hopefully be able to differentiate between effects which are inconclusive because of sampling error, and those which are inconclusive because of interaction effects
Useful case studies	Retained; but augmented by regular contact with the 60 teacher co-ordinators
ImpacT1 Negatives	**ImpacT2 Strategy**
Inaccurate assignment of schools to high-IT and low-IT categories	(a) More valid initial assignment based on scrutiny of recent Ofsted reports (b) More sensitive gradation of IT-use categories (c) Schools to be reassigned if appropriate, following school visits
Inadequate sampling (eight classes max. , one class min. per age cohort for main statistical studies)	Use of CEM database should ensure a population of at least 25 classes per secondary age cohort
No standardised baseline measures on students	PIPS Y4 data on all Y5 pupils (likely n>900); YELLIS Y10 data on all Y10 pupils (likely n>900)
Schools dropped out of project	Schools have signed an agreement to participate, and their retaining the computer is contingent upon this
No control over teacher knowledge or teacher INSET variation	Use of NOF training data as an independent variable (and, if made available, NOF baseline data); teacher co-ordinator to provide on-site link to data on staff development
No accurate measure of the pupils' use of IT	Teacher and pupil researchers in the schools will cooperate to supply regular and valid data, delivered monthly by e-mail

Table 1: ImpacT1 positives, ImpacT1 negatives and the implications for ImpacT2 data collection strategy and methodology

Our suggestion is that these points should be carried forward as part of the first strand of the argument defining the strategy and methodology for the ImpacT2 Main Study. In the Conclusions section, we operationalise the strategic, and attempt to link our approach with parallel enquiries which address the second strand – namely the challenge for teaching, learning and measuring attainment posed by the open architecture of the Internet.

5 The representation of the problem of measuring the impact of Information and Communications Technology (ICT)

How does ICT affect learners, and how does it affect school achievement? The ImpacT2 evaluation has a particular interest in networked technologies, and therefore one version of the question we are addressing is the following: how does the use of networked technologies affect attainment?

One possible representation of this question we shall term the *Direct Impact Model of Learning*. This presents an attractively straightforward and relatively simple set of relationships, which is shown in Figure 1.

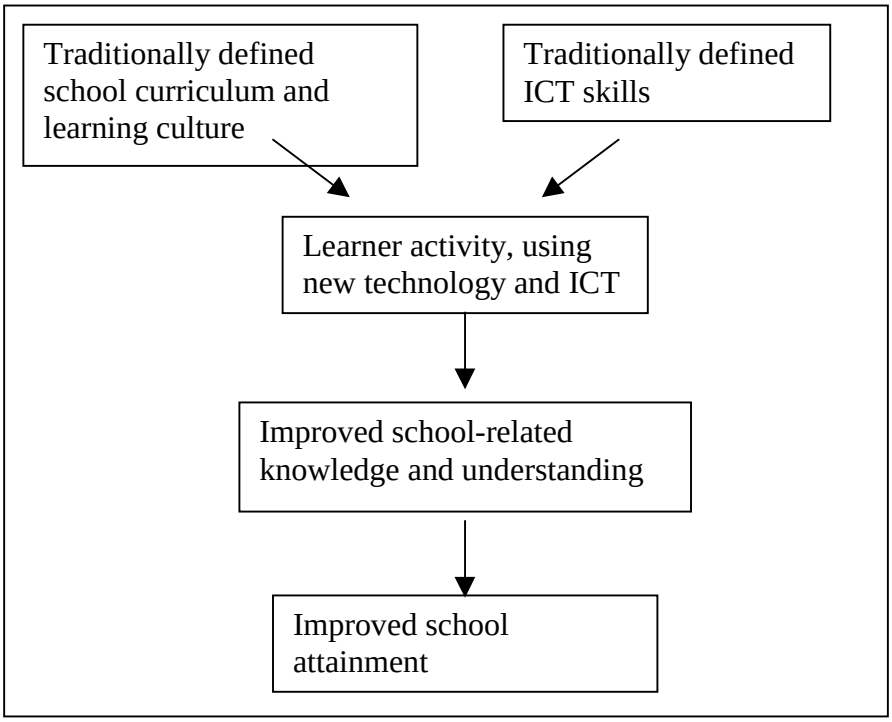

Figure 1: The Direct Impact Model of Learning, showing a direct relationship between use of ICT and learning outcomes

The Direct Impact Model of learning (DIM-L) assumes a direct relationship between levels of ICT integration into learning tasks and performance in attainment measures. The research methods which use this usually classify the nature of ICT use generally in terms of tool type (Watson 1993) and some offer particular task tasks using these tools (Moseley, Higgins *et al*. 1999). However, these models rarely if ever offer a detailed cognitive model of likely cause and effect, e.g. Why should using spreadsheets and databases in science improve performance in science reasoning tasks? The Newcastle study offers the most detailed link between features of IT use and impact on understanding (Moseley and Higgins, 1999).

Clearly some research evidence is suspect as it deals with scenarios where there is an impoverished pedagogical model, for example, with no attempt at integration of computer-based tasks with other learning. However, the DIM-L could be representing sophisticated, thoughtful teaching, with the use of excellent software (e.g. the case studies in the Newcastle Report). However, the evidence from the research literature is that:

- it is extraordinarily difficult to demonstrate a direct relationship between implementation of new technology and improved attainment as measured by national, standardised assessment measures (see, for example, ImpacT (Watson, 1993), Newcastle report (Moseley, Higgins *et al*., 1999), ILS (McFarlane, 1996; McFarlane, 1999), Multimedia meta-analysis (Liao, 1999))
- by contrast, other outcome measures, which are directly or indirectly related to improved learning, have been regularly demonstrated, for example, enhancements in specific skills, higher level conceptualisation, better problem-solving, more complex small-group talk and improved motivation. (McFarlane *et al*., 1999; Friedler and McFarlane, 1997; Cox, 1997; Bonnett *et al*., 1999)

The apparent mis-match between these two sets of outcomes needs some explanation. The examination boards would say that SATs and GCSE should pick up such improvements in what are effectively learning strategies. But there is also some evidence that use of IT can have a negative impact on content knowledge; for example, data logging expands the problem-solving/ experimental design phase of practical work, which has been shown to lower content knowledge of pupils using traditional practical methods. It is possible that

SATs and GCSE do pick up improvements in learning skills, but student gains in skills may be offset by impoverished content knowledge. Impact2 needs to look carefully at the nature of the tasks undertaken using networked technologies . In that way we should be able to offer some insight into their likely impact on learning, and the likelihood of this being reflected in attainment. This requires an examination of the wider learning context.

In this study, we shall be using end-of-key-stage standardised outcome measures as one area of focus, but we also want to attempt to represent the relationship between ICT and learning in a more complex and subtle manner, and this is represented schematically in Figure 2, the Socially Contextualised Integrated Model of Learning (SCIM-L). There are a number of reasons for doing this:

- Networked technologies introduce knowledge structures and knowledge authority relationships into learning which are fundamentally different to those which have previously obtained in schools
- These different structures in turn imply the need for learners to acquire a new or modified set of skills in dealing with these structures and authority relationships
- The ImpacT2 project has been asked to examine particularly closely learners' use of ICT in their homes; this in turn implies the need for a broader conceptualisation of computer use that one focused solely on school learning
- Increasingly, simple causal models of the impact of ICT are being replaced by models which acknowledge a complex set of interactions between the learner, the task and new technology, a set of interactions which does not posit an inevitable causal linkage between ICT and attainment, but rather propose that useful learning occurs only when certain conditions are met (and that these are met comparatively rarely in most learners' school experience)
- Using the Internet almost inevitably raises issues of social responsibility and personal autonomy; in our view, whether schools emphasise these or not, those who advise governments have a moral responsibility to attend to these issues and to include them in any account of a learning/benefit analysis.

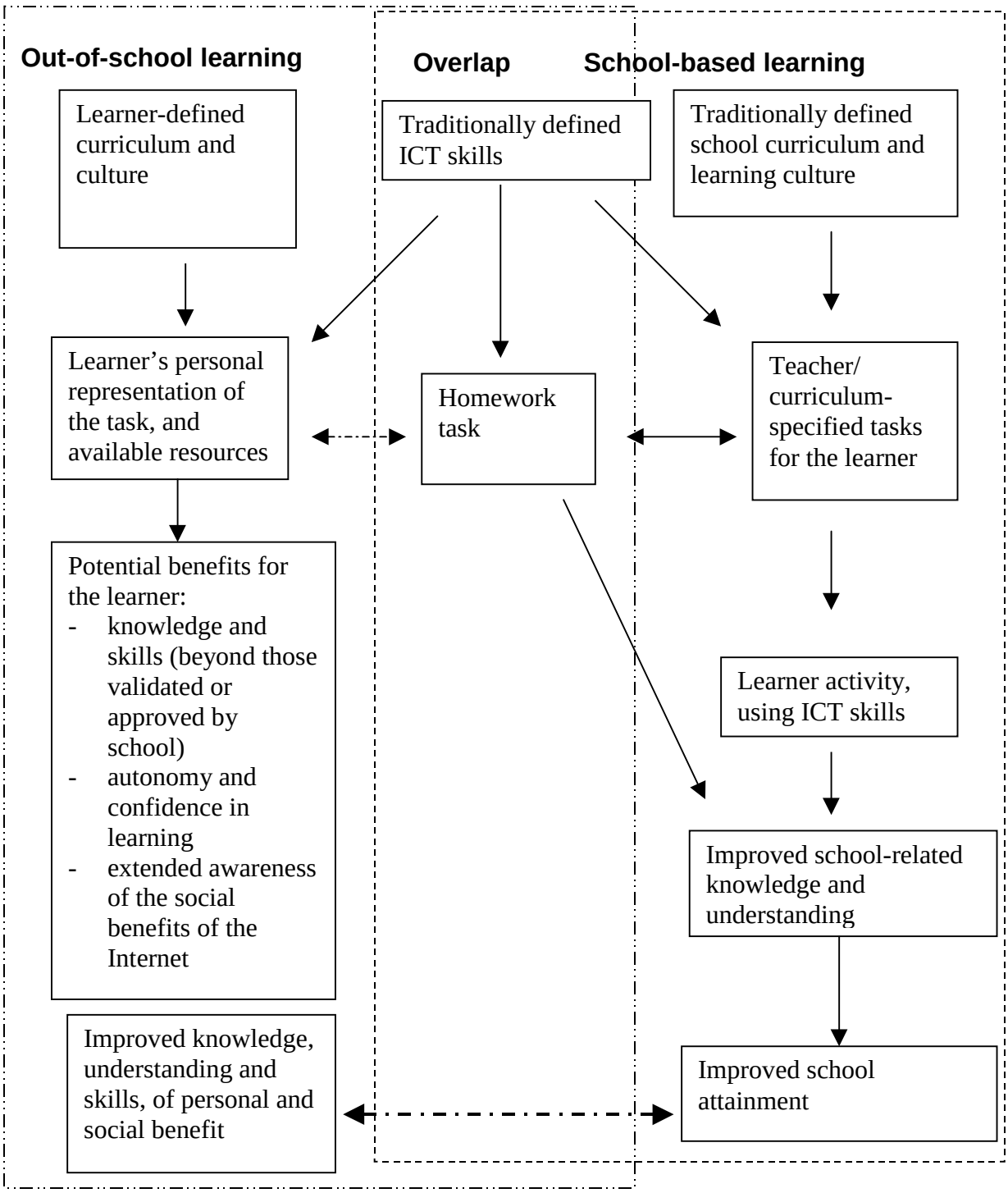

Figure 2: The Socially Contextualised Integrated Model of Learning (SCIM-L); solid arrows indicate probable causal relationships, broken arrows denote potential relationships

There are a number of structural differences in how information is presented using networked technology contexts, and the effects of these on learning have as yet to be deeply explored. The differences include the following:

- The ‘page’ of text presented by networked technologies makes no attempt to fit the aspect ratio of a standard screen, which means that scrolling is routine; this is a departure from multimedia texts designed for CD-ROM which usually fit the computer screen
- Moreover, there is a high proportion of the page devoted to messages other than the main content, which may in turn cover a range of topics; advertising is common, even on purely educational sites, and may take the form of an animated strapline designed to draw the eye more powerfully than any other element on the screen
- Even within more educationally legitimate content, there will be invitations to take any number of routes out to the next screen, many of which may be totally unrelated to the learning task in hand.

In these ways the hypertexts on the Internet vary significantly from those found on more static media. The skills needed to extract information require high-level filtering techniques, and an ability to remain clearly focused on the task in hand rather than to succumb to the ever-present invitations to ‘surf’. ‘Reading’ the on-screen text for meaning demands that the reader extract the relevant words, sentences and images from those available, and links them together to form a coherent representation of the information offered. These skills are highly context dependent, and the extent to which they relate to wider skills sets is not yet clear.

6 What are the learning outcomes that are likely to be enhanced as a result of exposure to networked technologies?

Arguably, networked technologies have changed the nature of knowledge. What is more certain is that they have facilitated a new way of representing knowledge. The texts published through networked technologies differ from preceding forms in the ways described above. As a result, a pupil’s interaction with these texts, as reader, author or more frequently co-author, requires a skill set which varies from that required to interact with other text forms.

Moreover, purposeful use of networked technologies for learning is dependent on learners and teachers understanding what such technologies make possible and how they can be used. Research carried out by the REPRESENTATION project in the UK investigated children's existing mental representations of computer systems (Crawford, Neve, Pearson and Somekh, 1999). Concept mapping was used to elicit pupils' representations of 'a computer system' prior to their access to networking facilities at school. The children made an annotated drawing of what they felt a computer could do, and this was scored, and used to estimate a child's degree of sophistication of understanding the potential of a computer.

The task showed that many children had a far richer understanding of networked technologies than the researchers or the teachers had assumed. In some cases they were able to 'depict possibilities for computer systems which go beyond the current technological reality of their lives'. The results of the concept-mapping task also showed wide variation between children in their current exposure to ICT and the degree of sophistication of their representations. This work was based on research into the links between mental representations and practical competence with tools. For example, Chalmers, French and Hofstadter (1995) show the critical importance of such representations as a necessary precursor/ enabler of achieving complex tasks with such tools:

> Representations are the fruits of perception. In order for raw data to be shaped into a coherent whole, they must go through a process of filtering and organization, yielding a structured representation that can be used by the mind for any number of purposes (p. 170)
>
> ICT provides new tools or artefacts and their use depends on how they are conceived and how the purpose of an activity is conceived (Meloche and Crawford, 1998). In order to make the decision about what the tool is to be used for, the person using it must have a mental representation of the specific potential, and the affordances of the tool in question (Crawford *et al*., *op. cit*.)

If pupils have better access to content-related resources via networked technologies than they have through conventional media, then it is reasonable to predict that they should have a wider knowledge, and possibly deeper understanding, of that content. However, conventional measurement instruments such as national tests tend to relate to a specified body of content relating to a given subject or topic as defined in the relevant syllabus. Moreover, schools use

texts and other non-computer based resources which address this content. We have already argued that simply offering computer-based versions of these does little if anything to enhance learning. Moreover, if the measurement instruments offer no opportunity to exhibit knowledge or skills beyond those specified, the additional expertise acquired through the use of networked technologies will not be reflected in the test results.

The process of gathering information from sources and creating a personal representation is affected by the increased access to both primary and secondary sources in electronic format. The concept of network literacy includes the ability to select from a range of digital sources, and careful thought needs to be given to this ability. To cut and paste a coherent collage of information is a valuable skill – but can be dismissed as mere plagiarism. There is a need, therefore, to distinguish between the following skill sets:

manipulation, e.g. the ability to capture an image
editorial e.g. the ability to select an appropriate image
design, e.g. the ability to place an image effectively
authorial input, e.g. the ability to use an image to contribute to and enhance the meaning making process.

Networked technologies offer access to an unprecedented range of information, and where home access is available this gives individual learners potential for a high degree of autonomy in their learning. Users can choose when and what they learn. The authenticity of the resulting experience will contrast sharply with at least some of the learning that pupils experience in school, and are required by school to do at home. Where school learning complements the powerful autonomous learning culture facilitated by networked technologies, there is likely to be a synergy. in, for example, a GCSE or ‘A’ level research topic. However, where it conflicts, there may well be a rejection of the task (a memorisation task , for example) and a subsequent drop in attainment . This is a likely consequence of the change in role of the learner as described in Preliminary Study 2.

The development of knowledge related to the nature, use and purpose of networked technologies represents an important set of learning outcomes. We therefore propose to monitor this through a concept mapping tool, and to develop the instrument already piloted

by Somekh and her co-workers (Crawford, Neve, Pearson and Somekh, 1999). Appendix B provides a fuller explanation of the derivation and nature of the REPRESENTATION task.

We aim to go further than this in the Main Study, however. The impact on the processes learners use to create personal knowledge, and externalise the results are harder to evidence through standardised measures. Rather we will track these through the pupil researchers. These pupils will record their own learning, and the results will be audited by the research team. The research will examine the outcomes in terms of pupils' own work, document the processes used to create it and analyse the outcomes, but we do not make the assumption that this will be an easy task.

7 What instruments already exist to measure pupils on-line networked technology skills?

Our research suggests that there are no 'off-the-shelf' measurement instruments for the kind of filtering, selection and application skills needed for, and developed by, use of networked technologies, although Venezky (Venezky, 2000) and his colleagues in a 24-nation OECD study based in CERI in Paris are addressing many of the same issues that we are addressing here, and there is a commitment on both sides to have a free exchange of information and trial material. The skills we want to analyse, ideally through automatic data capture techniques, have much in common with the skill set required for problem-solving tasks. It is perhaps unsurprising that there are no current formalised assessment tasks which address this skill set, as it is not evident in the statutory school curriculum. These skills are evidenced in the use of computer problem-solving games such as Lemmings, Voyage of the Zoombinis and SimCity. It is unlikely, however, that competence in these games would be accepted as a measure of attainment, no matter how well it could be shown to map to key skills.

The OECD project mentioned above is developing both multiple-choice online instruments to measure students' ICT knowledge and a skills test of data capture, data analysis and data synthesis. Our team shall certainly be drawing upon this work as it collaborates with the 60 teachers co-ordinators (should this be 'teacher co-ordinators'? Is this the term used in the event?) to identify what children have learned, and how this learning can be reliably demonstrated. Our aim is to develop a teacher researcher support pack and a student support

pack, and to explore the potential of using these to develop a reliable picture of students' skill development as well as their use of curriculum-based material.

At the end of the project, we aim to have pre- and post- test data on students' developing awareness and understanding of the potential of the computer, based on two administrations of the REPRESENTATION task, fifteen months apart. We aim to use this data to explore whether there is any systematic relationship between students' developing awareness of the potential of the computer and their attainment at the end of the key stage. Other parts of this review have suggested that the relationship between students' skills in using networked technologies and improved school attainment is far from simple.

One might be tempted to hypothesise that pupils with good computer skills would be those who also do well at school, but early findings from the group evaluating the REPRESENTATION task suggest that the opposite may be the case, and that knowledge of the potential of the computer may correlate poorly with school-related knowledge. In this context, it will be particularly interesting to use students' level of knowledge of the potential of networked technology as a co-variate, and to explore the possibility of interaction effects, in relation to high and low initial concept-mapping task scores, high and low baseline maths and English scores, and end-of-key-stage attainment. For these analyses, we would hope to pool data across the whole cohort, and this would have two advantages: it would be likely to reduce individual class and school effects, and it would produce a data set large enough to show major trends.

We also envisage, since the same baseline test will have been taken by all the children in each age cohort, being able to pool data on all the students who have kept logs of their ICT activity, and to consider the interrelationship between such variables as home use and www activity, and the end-of-key-stage data derived from national test results in a range of subject areas.

Many questions remain to be addressed during the course of the study, since although the team has a clear view of how the baseline and residual attainment measures can be analysed, what is much less clear is what independent variables will be set alongside these, as indicators of classroom-based ICT activity. One task facing the team, and which could usefully be addressed during the Expert Seminar, is whether there are further measures of

ICT skill development available, and if so, whether they could be adapted for the age cohorts of the ImpacT2 study. The work of the OECD/CERI group seems very promising in this respect, but it is also important to note that this project's instruments are also under development.

8 Conclusions – the methodology and instruments recommended for the Main Study

The aim of this paper has been to review current research, and from it to derive a set of principles and strategies that might be used to direct the work of the ImpacT2 Main Study. The methodology and instruments are grouped under the headings Baseline Measures, Outcome Measures and Learning Culture/Pedagogy Factors.

In relation to the first strand of the argument developed in this paper, we have drawn particularly upon what was learned from the first ImpacT project, and the implications from this for an analysis of the possible impact of networked IT on student attainment. In particular, the methodology that is suggested in the paragraphs below is derived from Table 1 earlier. Appendix C provides a fuller description of the sampling strategy used to identify the 60 schools identified as partners in the ImpacT2 Main Study.

We have also considered the implications of the second strand of research reviewed in this study, and where this takes us in relation to the use of more open-ended indicators of student learning and achievement. This section of the proposed methodology and instrumentation (Learning Culture/Pedagogy Factors) is more exploratory, and we anticipate developments, revisions and augmentations before the conclusion of the project.

The ImpacT2 project team suggest that the following methodology and instruments should be used to explore the relationship between the use of networked technology and attainment.

BASELINE MEASURES

- Baseline assessment data on students in the 55 non-Special schools from the Durham/CEM centre, to be based on Y4 PIPS, end-of-KS2 test results, and Y10 YELLIS instruments. Additional baseline data relating to Special School students, gathered from

Durham/CEM schools participating in a national project on logging the achievements and progress of students in special schools.

- Data on students' baseline understanding of the potential use of computing resources, to be collected from each school using the REPRESENTATION Project Concept Mapping Task (see Appendix B). This data to be collected in 55 non-Special schools, with concept maps scored by the three regional ImpacT2 Project support teams.

OUTCOME MEASURES

- End-of-key-stage data gathered from national assessment measures in May/June 2001 at KS2 in the 30 primary schools, KS3 and KS4 data from the 25 secondary schools (we anticipate using results in Maths, English and Science at all three Key Stages, plus the full range of GCSE subject data at KS4).
- Data on Special School student improvement and achievement provided by teachers, using nationally validated indicators and student case study frameworks.
- Data on students' End-of-Key-Stage understanding of the potential use of computing resources, using the REPRESENTATION Project Concept Mapping Task. This data to be collected in 55 non-Special schools, with concept maps scored by the three regional ImpacT2 Project support teams.
- Measures yet to be identified: end-of-key-stage data gathered in school, using computer-based task or tasks which offer opportunities to (i) access/identify information, (ii) transform information (iii) produce new representations of knowledge.

LEARNING CULTURE/PEDAGOGICAL FACTORS

- Systematically classified indicators of individual teacher and whole staff development in ICT, with particular reference to schools' use of NGfL/NOF funding.
- Instruments developed in partnership with the teacher researchers, providing data on the complex interactions between the learner's task, the learner's behaviour with ICT and learning outcomes.
- Instruments developed in partnership with student researchers, providing data on students' evolving knowledge and skills, and how these are positioned in relation to the learner's sense of school and non-school learning culture.

9 References

Not sure why some have a # at the start

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Learning Through Collaborative Visualization Project (1993). [Online] [see http://www.covis.nwu.edu/ accessed on 14/01/00]

Appendix A

Tabulated Review of the Literature:

How have new technologies, particularly networked technologies, affected student attainment?[1]

The studies reported in this section of Preliminary Study 1 have been gathered from three principal sources:

- NCET/Becta documents and reviews
- other reviews and meta-analyses of the field (including the 'Newcastle Report')
- a review of key journals (with particular attention to JCAL).

In addition some further references from a separately commissioned review for Becta have been added as a supplement (see note on this below.)
The reports are grouped thematically in the following order:

INTERNET AS A RESOURCE
COMMUNICATION ON THE INTERNET
HOME USE
E-MAIL
EDSI PROJECTS
VIDEO CONFERENCING

SMALL GROUP TALK
TALKING COMPUTERS
ILS
MULTIMEDIA
CD-ROMS
HYPERMEDIA
WORD PROCESSING
PORTABLES
CURRICULUM/CROSS-CURRICULAR

The first six sets of reports, whose titles have been emboldened, are particularly relevant to the theme of networked technologies. The next nine sets have been included because the team regarded them as closely related to the first six, and therefore as likely to have relevance to this review. We also had in mind the fact that classroom-based research into networked technologies is relatively new, at least in the UK, and that it would therefore be useful to give attention to studies of ICT in these related fields that attempted to identify impact on attainment. The report of the first ImpacT project (Watson, 1993) is discussed in the earlier section of this review.

[1] The ImpacT2 project team gratefully acknowledges the assistance of Annabel Harrison in preparing this section of the review.

INDEPENDENT VARIABLES	OUTCOME VARIABLES	REFERENCE
INTERNET AS A RESOURCE		
Bristol Education Online Network Project (BEON) (wide-ranging programme but video-conferencing, email and CD-ROMS [except Encarta] rarely used; OILS and CampusWorld programs mostly used, and motivation was due to the use of IT in general).	+Pupils showed "increased motivation and confidence" -but it was not "certain that learning gains in the sense of increased academic achievement had occurred". +In one school, pupils at KS2 "demonstrated improved achievement in reading, writing and in their interrogation and interpretation of information"; +"increased skills of questioning in order to find information and … improved information processing skills"; +"raised pupils' reading and, in particular, higher order reading skills"; +"gains in vocabulary as well as specific gains in knowledge"; +"increases in both the quantity and quality of pupils' writing across the ability range." -"However, in a different class in the same school, the quality of work produced and the level of IT confidence and capability displayed was considerably lower."	Bristol Education Online Network Project (BEON) http://www.sbln.org.uk
Impact of the WWW upon student learning in "user" (instructors who incorporate the Web at least 8 times in class and require its use for assignments) and "non-user" (instructors who incorporate the Web less than 3 times and do not) classes in Economics Dept, SE Missouri State University.	+"Results indicate that the use of the Web improves students' attitudes toward the course." -"However, no evidence was found to support the claim that Web-based instruction improves actual or perceived student performance."	Summary, Rebecca and Summary, Larry. (1998) The Effectiveness of the World Wide Web as an Instructional Tool. http://www.mtsu.edu/itconf/proceed98/rsummary.html
Use of the WWW – document structure in two experiments: Comparing three common document structures and The browsing effect	?"The restructuring of a document that often occurs when it is moved on-line may be more important than any effect the medium itself has." ?"readers jumping between small sections of text recalled as much as those reading a long page of material." -"The elaboration caused by the revision questions in the active review hypertext	Brown, Ian (1998) The Effect of WW Document Structure on Students' Information Retrieval *Journal of Interactive Media in Education* 12 http://www-jime.open.ac.uk/98/12/brown-98-12-t.html

	was most likely responsible for participants' poor performance on reproductive recall.”	
COMMUNICATION ON THE INTERNET		
Co-operation and collaboration of children working in groups	[They] have significantly different experiences depending on their gender and the group composition ?boys see the computer as being their domain, but ... single-gender groups [of] ... girls perform as well if not better”. ?“when boys and girls are paired together ... they are likely to perform poorly.... [except when] the girls in a foursome feel that they have group support ... (3Gs:1B)”. ?Kruger has shown that the nature of discussion influences performance. “Pairs that offered suggestions to a problem, and considered each other’s suggestions, did better in an individual test of reasoning administered later.... the consideration of rejected solutions ... was associated with the development of thinking”. - “it was in the more problem-oriented tasks, such as TRAY, that children gained success through sharing their plans and ideas. In the non-problem-oriented tasks, such as Arthur, learners needed only to agree an etiquette of task behaviour for task completion to take place ... [ie] co-operate but not necessarily collaborate.”	Underwood, Jean and Underwood, Geoffrey. (1999). Task effects on co-operative and collaborative learning with computers, in Littleton, K. and Light, P. (eds). *Learning with Computers: Analysing Productive Interaction* London and New York: Routledge Citation: Kruger, A.C. (1993) Peer collaboration: conflict, co-operation or both?, *Social Development* 2, 165-182
Educational Electronic Networks: A review of research and development	?“[A] study [1] found that student writing for a network-based newswire was much more effective than electronic penpals” +“[2] reported that writing for remote peers over a network produced better quality writing than writing an assignment for the teacher to be graded”. +“Networks have also allowed new forms of collaborative learning, both locally and world-wide. Networks have been used to create writing communities [3,4] science communities [5,6,7] mathematics communities [8] problem solving communities [9], and teacher education communities [10,11].” +“The key to the most powerful uses of networks is that they go beyond simple information access.... [They] include electronic publishing, collaborative problem solving, and joint project-based learning activities with people from around the world.” +“networks may substantially change the relationship between education and the rest of society[;] .... The reintegration of learning into the rest of society will require a redistribution of roles, a reinvention of social structures, and a rethinking of the entire learning enterprise.” ?“Studies [12,11] show that network use is most effective when it becomes an integral part of the curriculum”.	Levin, James and Thurston, Cathy. (1996) Educational Electronic Networks: A review of research and development; http://www.ed.uiuc.edu/projects/tta/papers/Levin-Thurston-96.html Citations: [1] Levin, J. A., Rogers, A., Waugh, M., & Smith, K. (1989). Observations on educational electronic networks: Appropriate activities for learning. *The Computing Teacher* 16 (May), 17-21 [2] Cohen, M., & Riel, M. (1989). The effect of distant audiences on students' writing *American Educational Research Journal*, 26 (2), 143-159. [3] Bruce, B., & Rubin, A. (1993). *Electronic quills: A situated evaluation of using computers for writing in classrooms*. Hillsdale, N. J.: Erlbaum. [4] Scardamalia, M., Bereiter, C., Brett, C., Burtis, P. J., Calhoun, C., & Smith Lea, N. (1992)

		Educational applications of a networked communal database, *Interactive Learning Environments*, 2 (1), 45-71. [5] Learning Through Collaborative Visualization Project (1993). http://www.covis.nwu.edu/ [6] Newman, D., & Goldman, S. V. (1987). Earth Lab: A local network for collaborative science classrooms. *Journal of Educational Technology Systems*, 15 (3), 237-247. [7] Ruopp, R., Gal, S., Drayton, B., & Pfister, M. (1993). *LabNet: Toward a community of practice. Hillsdale*, NJ: Erlbaum. [8] Klotz, G. (1996). The Math Forum. [Online] Available at http://forum.swarthmore.edu/build/prelim.prop.html [9] Levin, J. A., Riel, M., Miyake, N., & Cohen, M. (1987). Education on the electronic frontier: Teleapprenticeships in globally distributed educational contexts. *Contemporary Educational Psychology*, 12, 254-260. [10] Levin, J., Waugh, M., Brown, D., & Clift, R. (1994). Teaching Teleapprenticeships: A new organizational framework for improving teacher education using electronic networks *Journal of Machine-Mediated Learning*, 4 (2 & 3), 149-161. [11] Thurston, Catherine O., Secaras, Evangeline, & Levin, James A. (1996). Teaching Teleapprenticeships: An innovative model for technology integration in teacher education. *Journal of Research on Computing in Education*, 28 (5) [12] Levin, S. R. (1995). Teachers using technology: Barriers and breakthroughs. *International Journal of Educational Telecommunications*, 1 (1), 53-70.
Collaborative Learning in On-line Learning Environments	?“for effective interactions and discourse in collaborative learning, there should be an equality of opportunity for participants to assume a variety of functions or roles”; ?“it is beneficial if, through management of tasks and group conventions, participants take on a varied	Moderator: Hartley, J.Roger Summarizer: Collins-Brown, E. (1999) Effective Pedagogies for Managing Collaborative Learning in On-line Learning Environments,

	set of role, eg. questioning, challenging, explaining, constructing, tutoring. However, whether it is useful to guide these roles on-line by providing sentence openers and functional templates remains an open question." ?"the tutor has a marked effect on the discourse even when the tutor has a low-key presence.... Pilkington ... found that experimenter / single-student dialogue was more likely to prompt reflection and reasoning than paired students dialogue with the same access to the experimenter. The types of questions and roles assumed ... also differed in their interactions." ?"A structured set of curriculum tasks seemed to encourage participation in the reported case studies as did the teachers' own participation. Also discussion about the communication process itself was helpful for students to understand what was expected from them."	Formal Discussion Summary – Mar. 99, *Education Technology & Society*, 2 (2) http://ifets.gmd.de/periodical/vol_2_99/formal_discussion_0399.html Citation: Pilkington (1988)
Group work online, reviewed ethnographically.	?"Designers should expect users of the system to (mis-)use the system in ways that are unexpected.... The pedagogic design for collaborative working did not ensure its own outcome".	Jones, Chris (1998) Evaluating a collaborative online learning environment; *Active Learning*, 9
Use of Internet resources and use of the Internet to deliver course material for learning	+"improvements in student understanding and results [were] quantified at 11% in one semester"; +a side effect of the experiment was that "teaching productivity increased with immediate effect"; +"'weaker' students achieved a significant increase in examination results" which was "even higher than for 'average' students".	Gilliver, R.S., Randall, B. and Pok, Y.M. (1998) Learning in cyberspace: shaping the future; *Journal of Computer Assisted Learning*, 14 (3)
Senior student nurses (n=13) enrolled in an ITV Course at East Tennessee State University evaluate the perceived importance of engaged learning activities used.	-"students did not feel that being in an ITV [Interactive Television] course enhanced their understanding of the course material."	King, Marjorie and Witney, Lois W. (1998) Evaluation of Engaged Learning Activities Used in an Interactive Television Course.
Projects online - with access to Scholastic Network and the Internet: approximately 500 4th and 6th graders in 28 elementary and middle school classes from 7 large urban districts across the USA were divided into two groups: 14 experimental	+"Overall, students with access to Scholastic Network and the Internet produced better projects than students without online access. They received higher scores in all 9 learning measures [,] … statistically significant for 5 of the 9 measures"; +" students with online access were more effective in their ability to: present their work, state a civil rights issue, present a full picture (who, what, when, where, why, how), bring together different points of view, and produce a complete project…. [Although] both experimental and control classes undertook the same projects and both were encouraged to take advantage of	Follansbee, Sari, Hughes, Bob, Pisha, Bart and Stahl, Skip (1997) Can online communications improve student performance? Results of a controlled study; *ERS Spectrum*, 15 (1) 15-26 http://www.cast.org/publications/stsstudy/

classes (with online access to Scholastic Network and the Internet) and 14 control classes (without). In each city, two classes in each of two schools were selected: an experimental and control 4th grade class from one school, and an experimental and control 6th grade class from the other school.	computer tools and resources in the Civil Rights Unit…. students in the control group did use computers although they did not go online. This targets online use as a key differentiating factor in student performance within this study." +"Students who used online access became more confident and students without online access became less confident, over the course of the study, in carrying out and presenting a research project." - "Unrelated competencies, such as basic skills in reading, writing, arithmetic, did not show similar boosts in confidence." +"experimental group … students found information more quickly, drew resources from a larger number sources in a wider variety of formats, and dealt with information in ways that made the material more relevant to their lives…. e-mail and message boards helped their students learn from other students, teachers and the community at large." -"In contrast to control teachers, who reported increasing satisfaction with support from administrators and technology staff over the course of the study, the experimental teachers reported decreasing satisfaction."	
HOME USE		
Other factors: whether students have a computer at home; gender.	- "home computers are widening the educational gap between children from rich and poor backgrounds. This is the key finding of a 3 year report by academics at Cardiff University, which found that this gap is apparent for A level students as well as in secondary schools. The report also suggests that boys remain more confident than girls in the use of ICT." [1] - "Girls are thirteen times less likely than boys to have access to a home computer", -but "boys are far more likely than girls to use their computers for games – often exclusively". +"Using a computer at home helps children at school" to +" [be] more enthusiastic users of IT at school"; +"get more time on computers in schools"; +"[be] more confident at using IT in school"; +"see computers as useful"; +"consider themselves better at using IT at school". [2] [p.6]	[1] O'Leary, John (1998) Computer use at home gives pupils school advantage, *ICT in Education News Bulletin* July Citation: *Times* 6th July 1998, p.8 [2] *NCET Information Technology Works* NCET:1994 Based on research by Kirkman, C. (1993) Computer experience and attitudes in 12-year-old students: implications for the UK National Curriculum; *Journal of Computer Assisted Learning,* 9 (1) and / or Martin, R. (1991) School children's attitudes towards computers as a function of gender, course subjects and availability of home computers, *Journal of Computer Assisted Learning* 7 (3)
EMAIL		
Pragmatic aspects of 196 messages of spontaneous electronic network	+Apart from the multiple sendings of one message by a particular pupil, messages classed as interactive were the most frequent type and "this type is indispensible for the establishment of exchanges in	Zyngier, Sonia and Seidl de Moura, Maria Lucia (1997) Pragmatic aspects of spontaneous electronic network communication

communication in a Brazilian elementary school setting, from an interdisciplinary venture, integrating linguistics and cognitive psychology.	cooperative learning." +"Less frequent, phatic-interactive messages are also very important, due to their interest in maintaining the channel of communication open." +"exchanges with continuity .... involved about 20 percent ... [and are] also indispensible to the joint construction of knowledge." +"when the pupils added personal touches to their reports or projects, they produced more informal, more intimate, and more dialogic messages." ?"the language of electronic messages has a singular nature and structural aspects and does not require teacher support. Excessive guidance can lead to distortion and to a limitation of the potential which this technological tool offers." +"the presence of modality in the messages indicate[s] that electronic communication promotes a dynamic and interactive posture by means of which the participant is able to evaluate and position him- or herself. In this sense, electronic network communication can stimulate criticism and promote freedom to create, stimulating awareness of the context in which the individuals live. In addition, it may promote exchange and the negotiation of meaning, which are the basis of a cooperative construction of knowledge."	in a school setting, *Text: an interdisciplinary journal for the study of discourse*, 17 (1)
Email – ePals communicate across the globe	+"By corresponding and sharing their interests with teachers and students in other countries, users gain positive experiences and become repeat site users …. and influential Internet-savvy classrooms." - John Irving, co-founder and Vice President.	http://www.epals.com/press/1999/12000epals.html – accessed at Feb 2000
EDSI PROJECTS		
EDSI Projects Evaluation	+Improved exam results and improved motivation. + "Special Needs pupils can make fantastic progress with ICT". -But "the effectiveness of ICT within each school across the projects depends upon the attitude of management, the quality of the technological solution and the culture towards ICT in the school." +"Students that use the Internet in a structured way DO develop their investigational techniques and there is a good correlation to improved exam results and the development of what these boolean search techniques …. what we hear we forget, what we see we remember and what we do we understand."	http://edsi.ngfl.gov.uk/
VIDEOCONFERENCING		
Project ConnectEd (also known as Project IntraNet)	+"Raised standards, value added and improved quality of work." +Even casual use under open access showed that "most pupils do explore what is available with some purpose." +"With more structured use of the Internet, "there was clear evidence of enhanced learning." +"An assignment in A-Level IT … the students	Project ConnectEd (also known as Project IntraNet) http://www.vtc.ngfl.gov.uk/cgi-bin/edsi.cgi?DOC=A2&SECT=2&PARA=41 – accessed at April 2000

	achieved higher marks than the previous [year] … as a consequence of access to up-to-date materials on the Net and because of the application skills the students had to use to cut down the information to fit the criteria of the assignment." +"increased motivation reported [as shown by] …. So much voluntary uptake by pupils". ?Use of videoconferencing shows no specific learning gains [claims that "teachers and pupils did gain a great deal" are not substantiated] except +"evidence of increased motivation".	
Computers with keyboard + video-conferencing link out in the community (in a pub, a shopping centre, a tele-working centre and a cyber café, in various Derbyshire locations).	+The courses "reflect the need to start with the learner rather than the course or the learning", providing "a comprehensive education and training system for students … [to] study at a time, place and pace to suit them." [?No results available but perhaps, without this, non-mobile students would not even take the course.]	Hodges, Lucy (1999) Mine's a pint and a GCSE, please *ICT in Education News Bulletin* April Citation: *Independent* (Education Supplement) 25th March 1999, 2-3
Desktop Video Conferencing Telecommunications at Robin Hood School: fast-track maths group from Year 5 used videoconferencing with a member of the maths department at Exeter University for three months; two classes in Year 2 … linked with a school in remote Scotland on the Isle of Mull, as part of a geography project on contrasting areas.	+"Tremendous enthusiasm from staff and pupils and an increase in self-esteem and confidence." +"A boost to KS1 - often these projects happen in KS2." +"As teachers gain confidence they become more ambitious (for example, the video idea) and technology becomes just another tool for learning." ?A clear need to brief children and prepare questions.	Desktop Video Conferencing Telecommunications at Robin Hood School http://www.becta.org.uk/technology/desktopvc/telecomms/intro2.html
Language teaching project at Monkseaton Community High School, which uses a combination of traditional teaching, CD-ROMs and video conferencing with peers matched according to age, interests, linguistic	+"The most significant result of the investigation is that the data shows that on average the students achieve, on average, one grade higher at GCSE French than the Yellis system predicts." [1] +Students participating "had almost one-third of an A-level grade improvement on those who did no video conferencing". [2] +Students in Years 12 and 13 speak of how video conferencing "improved their use of language, their understanding of the French and German cultures, and … their confidence in using the target language". [Results confirmed by staff and	[1] Slide 8 School Focused Research http://www.rm.com/schools/seminars98/slides/session_3/stream_a/sld008.htm – accessed at April 2000 [2] EDSI Report: 2. THE STUDENTS ACROSS EUROPE PROJECT http://edsi.ngfl.gov.uk/ [3] Lightfoot Liz (1998)

competence and confidence.	observers, ?although "there are too many variables in this data which are not 'controlled'".] [2] +"Video conferencing is seen as strongly motivating by the pupils, and as a means of developing their self-esteem" / "self-confidence". [2] +"The students have shown a significantly higher motivation to work in the EC than the UK population."[1]	*ICT in Education News Bulletin* July French without fears Citation: Daily Telegraph 24th June 1998, p.21 http://www.becta.org.uk/information/ictnews/199807/ICT01754.html
SMALL GROUP TALK		
The talk of primary school children working together at the computer on a range of activities and using various kinds of software, studied by the Spoken Language and New Technology (SLANT) research project	?"Although software is … a defining influence on activities, … in practice the procedures and outcomes of any computer-based activity are shaped by the talk and joint activity of teachers and pupils." ?"for stimulating 'talk for learning', … it is useful to think of the talk which goes on as being influenced by three types of variables: those relating to the hardware and software, those relating to the organizational and supportive activities of a teacher, and those relating to children's styles of interaction and their interpretation of the requirements of the activity." [1] +However, there was some (good) exploratory even without their expectations being made clear by the teachers.	[1] Mercer, N. (1994) The quality of talk in children's joint activity at the computer, *Journal of Computer Assisted Learning*, 10 (1) [2] Neil Mercer speaking at the 2000 ITTE International Reseach Forum held at the London Olympia Conference Centre, 11.1.00
TALKING COMPUTERS		
Mastery learning technique and rule-based approach to spelling, learnt from the *Selfspell* and *Spellmaster* programs by dyslexic children	+Both programs "proved effective in remediating the spelling errors for a group of dyslexic children with low spelling ages. +Performance on the delayed test showed some decline, but nevertheless was significantly better than at pre-test."	Fawcett, A.J., Nicolson, R.I. and Morris, S. (1993) Computer-based spelling remediation for dyslexic children, *Journal of Computer Assisted Learning* l 9 (3)
Voice-driven computers used by dyslexic students, in tests carried out by Devon County Council psychology service. "The … IBM computer programs used allow the printing of words straight from speech."	+"the use of voice driven computers is allowing dyslexic students to make significant learning gains … a sample of 14 year olds have made an average of one year's reading progress in only 10 hours work."	http://www.becta.org.uk/information/ictnews_990712/feb98/outfile025.html Pyke, Nicholas 1998 Voice driven computers help dyslexics to read, *ICT in Education News* February Citation: *TES* 13th February 1998, 3
The Indirect Learning (IDL) system, a speaking-computer based multi-sensory system with echoing back of spoken responses by the computer.	+ "The sample group demonstrated significant improvements in reading and spelling ages over the course of the evaluation."	Scrase, Richard (1998) An evaluation of a multi-sensory speaking-computer based system (Starcross-IDL) designed to teach the literacy skills of reading and spelling *ICT in Education News Bulletin* July Citation: *British Journal of*

		Educational Technology 29 (3), 211-224
Using scanners linked to talking computers as tools for teaching children to read: thirteen year 2 sighted children	+"this system could provide children with an alternative way of accessing text, at least for enjoyment"; +"The average reading score increased from 6.11 to 7.2" – a significant increase; +"spelling score increased from 9.23 to 9.62 during the trial", and one child "had a significant improvement in spelling score"; +"Children with "global" reading-delay … make the most progress with this system"; "Using talking computers as aids to writing [as opposed to reading] would presumably have a greater effect on spelling skills"; -"Children with specific reading difficulties make little or no progress with this system, presumably because they lack the necessary phonological sub-skills to be able to inter-relate sight and sound".	Scrase, Richard (1997) Using scanners linked to talking computers as tools for teaching children to read, *British Journal of Educational Technology*, 28 (4), 308-310
Computing programs which use digitised speech in a ten-week trial involving an average of five hours' work at the computer.	+"children's average gain in reading age was nine months, while their average gain in comprehension was six months." [p.15]	*NCET Information Technology Works* NCET:1994 Citations: Hartas, Christine and Moseley, David (1993) Say that again please: A scheme to boost reading skills using a computer with digitised speech, *Support for Learning* 8 (1) Moseley, D.V. (1992) 'Visual and linguistic determinants of reading fluency in dyslexics: A classroom study with speaking computers', in Groner, R. et al (eds), *Reading and Reading disorders: International perspectives* Elsevier
ILS		
Integrated learning systems (SuccessMaker, by Research Machines) in a group of one secondary and 4 primary schools in Tyneside.	+"[ILS] have been used successfully … to improve pupils' motivation…. The schools found that over a 13 week period, 70 per cent of pupils made at least 6 months learning gains on the mathematics module."	O'Connor, Jon (1998) Success breeds willing learners *ICT in Education News* May Citation: TES (Online Education Supplement) 15th May 1998,.30-31
ILS (SuccessMaker) Phases 1 and 2	+In mathematics, "ILS pupils … outperformed their controls after about six months' experience on the system … the effect size … was +0.45" in Phase 1 and in Phase 2, "around +0.1 … after only 2-3 months", though results varied from school to school. ?There was no evidence for learning gains with	*The UK ILS Evaluations: a final report* Becta:1998

	SuccessMaker English, but it was "judged possible that longer periods of exposure to ILS than those investigated might lead to significant gains".	
ILS (SuccessMaker, Global and Jostens) Phase 3	+"There was a significant, positive effect [later reference to "small" difference!] of ILS on measured performance gains (an effect size of +0.06 for mathematics and +0.08 for English)" in year 8 ILS pupils. -"Year 5 ILS pupils achieved lower gains than non-ILS controls in mathematics, English and general cognitive performance (effect size –0.05 for maths and 0.02 for English)" – low but "statistically significant" differences. -Year 9 and Year 11 ILS pupils achieved "marginally lower outcomes" than non-ILS controls (effect sizes ranged from –0.04 to -0.62 for Year 9 in mathematics, -0.03 to –1.29 for Year 1 overall) ?Motivation, behaviour and attitudes of pupils remained unchanged, except for +"positive impacts on pupils' attitudes towards writing and towards future work with computers" were found. ?Pupils with special educational needs showed "no clear-cut differences in achievement in literacy", +though pupils did show "signs of enhanced motivation and self-esteem".	*The UK ILS Evaluations: a final report* Becta:1998
MULTIMEDIA		
Extracting meaningful information from non-text based sources using a hypermedia package in an enquiry activity	+"All students demonstrated a capacity to analyse the multimedia sources and to gather relevant information from them." ?"The level of inquiry demonstrated by most students was not conducive to investigative and analytic data gathering."	Oliver, Ron and Perzylo, Lesa (1994) Children's Information Skills: Making Effective Use of Multimedia Sources; *Educational and Training Technology International*, 31 (3) 219-230
Multimedia (anwering with simple mouse clicks in most cases) vs audio or video (using the traditional pen and paper) in second language listening activities	+"higher levels of comprehension and language recall were achieved while listening in the multimedia environment." +"It may be that instant feedback which funnels learners into an ongoing accurate interpretation of the main communicative elements of the listening texts has the effect of making such input comprehensible" +"[Along with the efficiency gains of multimedia,] exposure to [such comprehensible] language input ... might serve to encourage language recall and subsequent acquisition". ?"application developers need to make certain that they are not hindering the comprehension process when they design comprehension tasks".	Brett, Paul (1997) A comparative study of the effects of the use of multimedia on listening comprehension, *System* 25 (1) 39-53
The introduction of multimedia in 15 inner city schools. The National Literacy	+Claims "improved literacy and other basic skills…. Children in the sample were recorded as making gains in reading of 23 months, and spelling gains of 20 months."	Scott, David, et al (1998) Computer based literacy programmes in inner city schools, *ICT in Education News Bulletin* October

Association (NLA) Docklands Learning Acceleration Project ran for 2 years (1995-1997) in 3 London Boroughs with year 3 and year 4 children. The schools used Acorn pocketbooks and the Integrated Learning System (ILS) Global Learning System.		Citation: *Education Journal* September 1998, 27-28
Talk used by students working with interactive multimedia program	+"a multimedia program based on a situated learning approach could provide a learning environment capable of supporting and maintaining substantial levels of higher-order thinking": +"analysis of types of talk used by students as they worked with the interactive multimedia program clearly shows that the majority of their thinking was higher order, as defined by Resnick"; +"the instructional design embraced in the situated learning program, and its implementation in this study, successfully combined a number of enabling elements and components frequently lacking in contemporary learning settings"; ?"students who did not know each other before … appeared to use different types and proportions of thinking to the groups who had worked together before"; +"[a] high[er] proportion of argument and challenge [was] found in two of the groups…. one group appeared to use this process to enlighten the meaning they constructed, the other group did not…. further research is needed … to determine the factors which lead to the construction of meaning from multiple perspectives".	Herrington, Jan and Oliver, Ron (1999) Using Situated Learning and Multimedia to Investigate, *Journal of Educational Multimedia and Hypermedia* 8 (4) 401-421
CD-ROMS		
Reading for Information with CD-ROM at KS2 as part of the IT in English project.	+"Children found they could create professional-looking work … that made them feel successful"; +"They felt it was quicker to find information on the CD-ROM rather than in books, … if the information was actually there"; +"an extra enthusiasm and concentration span" and +"an increase in the less-able children's confidence in having a go" were noted; [1] +"[the children] seemed to work more in collaboration"; +"the highly motivating [friendship] group work on the computer … enabled advanced speaking and listening skills to be acquired and reinforced"; +"there were none of the problems that can	Darby, Ruth [6], Dawes, Lorraine, Dennison, Andrea [2], Gallagher, Chris [5], Loomes, Wendy [3], Reid, Helen [1] and Stanton, Justine [4] (1997) Reading on Screen: Exploring Issues in Reading for Information with CD-ROM, *English in Education* 31 (2) 45-53

	sometimes arise with collaborative group work, such as one member …'s handwriting not being as neat as the others"; [2] +"The children realised that they could have obtained the information from books, but generally felt that the search facilities in the CD-ROM meant that they could find specific information more quickly"; +"they preferred to use the CD-ROM than walk down to the library and get a book"; ? "Most … were willing to spend more time … than they would normally take with text from a book …. [but] it may have been because on the computer they were working in pairs or threes"; +"[they] were more willing to edit the text on screen than … writing in a book"; [3] +"When researching facts in books, many children are content to copy out the detail found on one page – with CD-ROM, … they would have happily checked [five sources]"; +"[the CD-ROM] didn't remove or replace books; … it gave the class the key to using written material as a prop for their own writing"; [4] "some less-able children are more capable of using a CD-ROM operating system than … a contents page and index"; [5] ?"hardware and software have to be available"; ?"teachers [have to] feel confident about their own IT skills"; ?"[teachers have to be] able to reflect upon the work and share insights with a larger group"; "Long-term planning for the integration of IT with children's current learning is necessary".; ?"teachers need to recognise what IT skills children need"; ?"the teacher needs to be available to intervene and move children forward by asking 'What if?' questions". [6]	
CD-Roms	+"The use of CD-Rom increases children's understanding of the subject covered"; + "the use of CD-Rom encourage[s] … children to use other kinds of IT".	*CD-Roms in Primary Schools* NCET:1995
CD-Rom storybooks – effects on primary pupils' attitudes to reading	+but "reluctant readers … demonstrated a strong positive attitude towards reading *Discis* CD-Rom storybooks and it would appear that this positive attitude to reading is also developed … to their reading of traditional materials".	N.Adam and M.Wild (1997) Applying CD-Rom interactive storybooks to learning to read, *Journal of Computer Assisted Learning* 13 (2)
HYPERMEDIA		
Use of hypertext HyperCard - comparing the impact of HyperCard stacks and regular	?"For selected individuals involved in HyperCard there appeared to be a shift in the kinds of questions pursued. However, … [these] shifts could also be attributed to topic, background knowledge, or the direction of their projects"; +"for some individuals hypertext seems to stimulate	Tierney, Robert J., Kieffer, Ron, Whalin, Kathleen, Desai, Laurie, Gale Moss, Antonia, Harris, Jo Ellen, and Hopper, John (1999) Assessing the impact of hypertext on learners' architecture of literacy

textbook presentations of ideas in biology on 9th grade students assigned to study these materials; students developing their own HyperCard stacks and regular texts across parallel topics in two subject areas.	greater flexibility and complexity of ideas."	learning spaces in different disciplines: Follow-up studies, *Reading Online* http://www.readingonline.org/research/impact/
Problem-solving performance of 103 Management Information Systems majors of a hypertext-based learning aid versus a computer-based linear text learning aid, compared on 3 levels of task complexity: analysis, synthesis, and evaluation.	?"Results indicated that users of the hypertext-based learning aid were more effective and efficient at the highest level of complexity tested. [Therefore] … hypertext-based learning aids would be more appropriate to more complex learning tasks than to less complex ones."	Ramirez, Alejandro and Rivard, Suzanne. Hypermedia Aids for Advanced Learning in Complex and Ill-Structured Knowledge Domains. 14p., In: Proceedings of the International Academy for Information Management (IAIM) Annual Conference (13th, Helsinki, Finland, December 11-13, 1998), see *IR* 057 374.
Effects of Hypermedia on Students' Achievement	+"the effects of hypermedia in instruction are positive over nonhypermedia instruction as a whole, however, effects may be varied depending on what type of instruction that hypermedia compares to"; +"hypermedia instruction is more effective when there is no instruction for the comparison group or when the comparison group used videotape instruction." -"However, CAI and text instructions are slightly more effective than hypermedia instruction". -"technology [per se] will [not] dramatically increase students' academic achievement": other factors ("instrumentation, type of research design, type of delivery system, and comparison group) had a statistically significant impact on the mean ES".	Liao, Yuen-Kuang Cliff (1999) Effects of Hypermedia on Students' Achievement: A Meta-Analysis, *Journal of Educational Multimedia and Hypermedia* 8 (3) 255-277
Hypermedia program used by high and low prior knowledge adults, in project Guiding instruction in hypermedia.	+ "Low prior knowledge participants achieved the same high level of learning with the hypermedia program as did high prior knowledge participants, suggesting that hypermedia may have the potential for overcoming limitations in prior knowledge for comprehension and learning, at least among adults." [1] +The "newer technologies for information and communication … [are] especially sensitive to individual differences…. Hypermedia, Internet, and other recent technologies combine multiple media forms within a dynamic and interactive information structure under the control of the user."	Leu, Donald Literacy and Technology: Deictic Consequences for Literacy Education in an Information Age To appear in M. L. Kamil, P. Mosenthal, P. D. Pearson, and R. Barr (Eds.) *Handbook of Reading Research*, Volume III. Mahway, NJ: Erlbaum. http://web.syr.edu/~djleu/Handbook.html Citation [1] Hillinger, M. & Leu, D.J. (1994). Guiding instruction in

		hypermedia, *Proceedings of the Human Factors and Ergonomics Society's 38th Annual Meeting*, 266-270.
Use of hypermedia reflective writing frameworks.	+“the prompt questions encouraged some pupils to shift from descriptive writing to subjective reasoning”; +“the increased ability of pupils to ask the ‘right’ questions combined with improvements in self-perception led to more pupils being able to get help from their teacher and subsequently to reason more objectively”; +“access to IT meant that pupils were more able to concentrate on their writing”; +“the combined effects led to some improvements in the pupils’ ability to reason”.	Deadman, G. (1997) Pupils’ reflective writing within a hypermedia framework, *Journal of Computer Assisted Learning* 13 (1)
WORDPROCESSING		
Word-processing	+“[People] who find writing difficult can … express themselves on a word processor”; +spell checks help students increase their vocabulary and “the quality of their writing”; +“reluctant writers can be encouraged to put together stories using … sound and pictures as well as text”; +“[new] writers become more adventurous” when allowed to “make changes easily”; +confident grows through the ability to produce a piece of work . [p.6]	*NCET Information Technology Works* NCET:1994
PORTABLES		
Personal portable computers provided to pupils of one primary, one special education, and seven secondary schools for one year.	?The difference between the control group’s performance in maths, English and science and that of the group with access to the computers “was not significant or, at best, was marginal over one school year”; [1] ?“In the current study it could be argued that teacher insecurity with process activities … may have been transmitted to the experimental pupils in science and mathematics lessons, causing them to feel insecure in class and to enjoy their work less”; +in English, “the proportion of experimental pupils who enjoyed their discipline exceeded the proportion of control pupils”; +in science, “greater proportions of experimental than control pupils [felt] … they were *doing well*”; ?“there was little *significant* affective improvement overall (in the statistical sense) when these pupils were given access to information technology”. [2]	[1] Gardner, J., Morrison, H., and Jarman, R. (1993) The impact of high access to computers on learning, *Journal of Computer Assisted Learning* 9 (1) [2] Morrison, H. Gardner, J. Reilly, C. and McNally, H. (1993) The impact of portable computers on pupils’ attitudes to study, *Journal of Computer Assisted Learning* 9 (3)
Portable computers used in the home, field, and laboratory as well as in the classroom	“can facilitate: +learning in various settings … +differentiated teaching through reinforcement and extension of learning +concentration on the content and quality of work by eradicating … handwriting … +learning activities in which pupils are fully active	*NCET Portable Computers Pilot Evaluation Report* NCET: 1994

	and have opportunities to work collaboratively … [and stay] fully involved investigative and analytical learning approaches +enhanced presentation of school work by providing facilities for editing and visual display including graphs, ….” [p.11]; improved accuracy and volume of work [p.35] +“Open access to portables can help pupils to make more effective choices between alternative ways of tackling a particular task … -conversely, pupils often use portables … inefficient[ly]” [p.13] +“Portables can be used effectively with pupils with a wide range of learning needs and difficulties”: to “help disabled pupils to be integrated in mainstream education”, to “improv[e] … [the SEN pupil’s] self-esteem , motivation and … overall attitude to learning” [p.35] +In the field, portables can be used when it’s raining, -though battery failure can be a problem	
CURRICULAR / CROSS-CURRICULAR		
Students’ perspectives on teaching and learning: a long-term case study of technology implementation situated in the context of the Technology-Enhanced Secondary Science Instruction project.	?“In attempting to assess the impact of technological innovations in science teaching and learning, it is necessary to move beyond the limited focus of subject matter learning outcomes to a more comprehensive examination of how the use of multiple technologies effects the content and context of student learning. We argue that one must study the technological and pedagogical relationships that emerge from the interplay between thoughtfully implemented technologies and the social setting of the classroom.” ?“students focused on, and spoke more about issues pertaining to learning, than about technology or science.... [which is] significant, and indicative that the pedagogical and social milieu of a technology-rich classroom is every bit as influential as the technology itself. The students ... had well-defined views about the value and uses of technology, but these seemed to be of secondary importance to their strong emerging perspectives on learning.” +“Independence, responsibility, and freedom were among the ideas and principles of TESSI that the students valued and remembered most. These were the effects *of* technology.... technology served as both a catalyst and a vehicle for successfully encouraging students to reexamine and change their beliefs about, and approaches to, learning.” +“the technologies “legitimized participation” in school and the classroom in novel ways” having changed them.	Pedretti, Erminia, Mayer-Smith, Jolie and Woodrow, Janice (1998) Technology, Text, and Talk: Students’ Perspectives on Teaching and Learning in a Technology-Enhanced Secondary Science Classroom, *Science Education* 82 (5)569-589
Enhancing quality in learning through IT	?“Just as with any tool, if computers are used primarily to service the teacher’s needs for organisation and control, they will make little impact on children’s learning.” ?“Effective use of information technology ... has to	Davis, Niki, Desforges, Charles, Jessel, John, Somekh, Bridget, Taylor, Chris, and Vaughn, Gay Can quality in learning be enhanced through the use of IT?

	be acquired" and this is "only possible by doing". ?"To have a positive impact on the quality of learning, the aims for information technology in education must go beyond the acquisition of skills – say to access a database – and engage at a higher level by asking, 'What questions can I now ask, with the help of this database, that I couldn't ask before, and what supplementary questions may there be?'" +"To improve the quality of learning there is a need to achieve the best possible match between ... authenticity to the classroom and authenticity to a particular discipline or field of study.... Computer tasks ... can be more authentic than traditional tasks" +" [Room change or enforced group / pair work are] a necessary but insufficient condition for change.... IT tools can be used as a means of circumventing some of the classroom constraints on setting cognitive learning tasks." +"the structure of support can be more flexible to the learner's needs in carrying the task through. The degree of interactivity in the software – whether it be through extensions and modifications of the task in response to the learner, or through the demand on the learners to decide upon appropriate questions for interrogating an information bank, or through the tangible products of creativity (in writing, design work or music) – can sustain a higher than normal degree of on-task engagement and 'mindfulness'. This fills a gap otherwise left by the teacher's inability, through pressure of time, to provide sufficient appropriate interventions to sustain the task." +"Group work around a computer may be more genuinely collaborative than other group work, thereby enabling more focused group talk. This is turn may enable learners to go further in developing their powers of hypothesising and problem-solving without needing to resort to the teacher for help."	[pp14-27]
Using computers to enhance reading through a combination of the '3Rs' (rigour, routine and reinforcement) and autonomous learning. The project developed out of a course for teachers called "Computers can help make reading easier" as part of the Sheffield Year	+Claims "learning gains …have been made". [No specific data found.]	Lester, Marg (1998) ICT and the '3Rs' help struggling readers, *ICT in Education News* March Main citation: MAPE January 1998, 21-25

of Reading initiative.		
Collaborative use of educational technology in an informal setting focussing on computer literacy, comprehension skills, game-playing skills, academic skills, with hundreds of primary school children from low-income groups, who gained access to computers via after school clubs. Participation was voluntary and support came from their peers and from adult volunteers.	+"The researchers conclude by summarising some of the cognitive changes gained by the children, ?but feel more research is needed to pinpoint how productive learning takes place using educational technology."	http://www.becta.org.uk/information/ictnews/199904/ICT02507.html Mayer, Richard E, Schustack Miriam W, Blanton, William E (1999) What do children learn from using computers in an informal, collaborative setting? *ICT in Education News Bulletin* April Citation: *Educational Technology* March/April 1999, pp.27-31
Gifted children's use of LOGO to enhance their mathematics achievement and creativity	+"the LOGO (experimental) group significantly outperformed the CAL (control) group on the assessment of mathematics achievement and +an assessment of both figural and verbal creativity"	Subhi, T. (1999) The impact of LOGO on gifted children's achievement and creativity, *Journal of Computer Assisted Learning* 15 (2)
IT in the classroom	+allows independence to develop in the student (speed and location of and materials used for learning; +"allows a student to go back …, ask for clarification and make mistakes without being shown up"; +"can be used to overcome physical disabilities and to open up learning opportunities for … even [those] unable to attend classes … using distance learning". [p.4] +"It can often compensate for the communication and learning difficulties of students with physical and sensory impairments". [p.19]	*NCET Information Technology Works* NCET:1994
Traditional Teaching vs. Computer-Mediated Collaborative Learning (CMCL)	+"The largest distinction between traditional teaching and CMCL can be seen in the distribution of power …. CMCL is a very student-centered approach with a balance of power within the learning environment." +"The movement toward CMCL also results in a shift of educational atmosphere from the competitive classroom to the cooperative, extended learning community." +"A final difference between the two can be drawn by examining the nature of the learning experience:	Traditional Teaching vs. Computer-Mediated Collaborative Learning (CMCL) http://www.quasar.ualberta.ca/edse401/August/Together/research.html – accessed at April 2000

	many small tasks organized within disciplines versus authentic, interdisciplinary projects and problems.”	
Use of ICT to strengthen literacy and numeracy: developing basic literacy and counting skills and an understanding of addition and subtraction [reception]; presenting texts and supporting writing, improving reading and spelling, developing story-writing skills and teaching calculation skills [year 2]; teaching correct use of omissive apostrophes, reading challenging texts with speech and dictionary support, using short rhymes and other texts to enhance reading comprehension, developing writing skills, understanding of decimals, mental calculation skills through pattern and number, supporting number skills [year 4].	+“In the autumn term of the project 14 out of 16 projects made significant gains in tests “used to measure pupils’ progress and to provide detailed formative assessment information”. +“In numeracy the overall average improvement was 2.8 months per month.” +“The average improvement in literacy was 5.1 months of progress per month.” +“Similar gain was achieved by both … high and average value-added [rated teachers]”. +“Where a teacher has a strong preference for a particular approach or a subject this was found to be an effective starting point for developing more effective teaching with ICT. Success achieved … could then be used … for extending development into less familiar or less comfortable areas.” [p.16] +“ICT can help teachers to focus pupils’ learning”. [p.17] +“ICT was powerful in presenting or representing information”. -“There was no evidence of a link between pupils’ learning gains and [the systematic use of ICT]”, but use was very limited. [p.22-23] +“The teachers in the project found it necessary to: identify … what skills the pupils needed…; ensure that the pupils’ skills were adequate so that pupils could concentrate on the specific subject objectives”. [p.23]	Moseley, David, Higgins, Steve et al *Ways forward with ICT: Effective Pedagogy using Information and Communications Technology for Literacy and Numeracy in Primary Schools* Newcastle University: 1999
Mathematics and IT at KS 3 and 4 as directed by the NCET provides opportunities “to develop a social justice curriculum in and through the teaching and learning of mathematics”	“paralleling the six ‘entitlement’ opportunities in mathematics, there are six contributions to critical schooling for democracy …. : +“willingness to conjecture”; +“opportunities for analysis and critique; +“alternatives to learning as the proficient implementation of received procedures; +“a sense of personal epistemological authority; +“awareness of how mathematics is modelling our society and an ability to interpret this; +“a sense of the learner as the author of knowledge.”	Povey, H. (1997) IT in mathematics classrooms, *Journal of Computer Assisted Learning* 13 (2)
Various uses of IT across the	+“pupil motivation in the context of IT use is some fourteen or so percentage points higher than when	*IT and Pupil Motivation* *A Collaborative Study of Staff and*

curriculum in nine schools.	IT activities take place in a range of subjects compared with use only in IT lessons." [p.6]	*Pupil Attitudes and Experiences* Keele University / NCET:1997
The Jersey Computer Assisted Reading Development Programme for slow readers	+"IT can help increase reading gains when used with precision and backed up by teachers."	What works for slow readers http://www.nfer.ac.uk/pubs/slow.htm
IT use with two deaf Aboriginal girls in a deaf unit.	+"these deaf girls were able to learn to use language in the context of computer-based learning using commercial software and … to use all the required Auslan signs"; +"the computer intervention produced remarkable improvements in the attending behaviour of the girls"; +"these aboriginal girls were neither daunted nor confused by the technology, nor the language used". [?No control.]	Bailey, J. and Weippert, H. (1992) Computer technology and deaf aboriginal children; *Journal of Computer Assisted Learning* 8 (2)

Additional Items from the Becta Review

Home Use		
US study of 8th grade students' use of computers in school and at home, correlated with mathematical achievement.	The study stresses the impact of 8th grade students using computers at home: '*students who use computers frequently at home demonstrate higher levels of academic achievement, whereas those who use computers frequently at school evince lower levels.*' (Chapter 3, p.3) However 4th grade students who used computers at home had lower levels of achievement than their non-using counterparts.	# Wenglinsky, H. (1998). *Does it Compute? The Relationship Between Educational Technology and Student Achievement in Mathematics*. Princeton, NJ: Educational Testing Service Policy Information Centre.
ILS		
ILS introduced into one US secondary school with the aim of improving students' reading skills. Sixty computers were set up in a double classroom with two full time computer assistants to guide student activity in	Reported that: 1. after two years students' results in reading/language/writing were substantially better. 2. the gain in scores was considerably greater than the minimum federal requirement for the school (i.e. taking into account the socio-economic profile of the area). '*Our school cannot attribute all of the reading gains entirely to computer assisted instruction. However, we had never seen such strong gains prior to the 100 minute language art block and the twenty minute computer period. We believe that using computers for reading instruction*	# Potter, L. and Small, J. (1998). Utilizing computers for reading improvement in a junior high: a case study. *International Journal of Instructional Media*. 25 (4), pp.383-387

the ILS classroom. The language arts classes had 75 minutes allocated to the regular classroom-based activities and 20 minutes to ILS.	*helped our students and was a very efficient use of resources.'* (p.386)	
Multimedia		
Project involved 22 primary and secondary US schools, and aimed to '*design and implement collaborative, student-centred activities … facilitated by multimedia and telecommunications technologies*'	Results: 1. Increased use of technology by students in all sites. 2. In the 1st year, 7/22 sites reported students taking on a teaching role, rising to 14/19 in the 2nd year. 1. In the 1st year, 16/22 sites reported increased student motivation or independence as learners, falling in the 2nd year to 7/19 respondents. 2. Effects on achievement: '*…Of the eight sites that reported increased achievement in core subjects, three could point to increased test scores; the others based their assessment on student products.*' There was some evidence of increased higher-order thinking skills but only from secondary schools.	# Moursund, D., Bielfeldt, T., Underwood, S. and Underwood, D. (1998). *The Road Ahead. Project Evaluation 1995-97*. www.nfie.org/ra/eval/index.html
Wordprocessing		
Project designed '*…to inquire into a viable approach of using computer technology to integrate with curricular studies in order to develop the at-risk students' learning in general*'.	The work of 'at risk' (NT) secondary students in Singapore was compared with that of normal academic students of the same age in several subjects. The project involved the NT students learning in a computer-enriched environment and being encouraged to do extra language-based activities, such as keeping diaries, etc. The post-treatment results showed: 1. greatest gains in performance for the NT students in English 2. substantial gains for the NT students in computer applications 3. the percentage of NT students who achieved distinctions and passes increased in all areas: English, mathematics, computer applications and elements of office administration.	# Chen, A-Y. and Looi, C.K. (1999). Teaching, learning and inquiry strategies using computer technology. *Journal of Computer Assisted Learning*. 15 (2), pp.162-172
Portables		
7th and 10th grade students in 29 US	Reported that: 1. more laptop users than non-users used active	# Rockman, S., Chessler, M. and Walker, L. (1998). *Powerful*

secondary schools given laptops and MS Office software with full-time access at school and at home. Non-laptop using students were also studied for comparison.	learning strategies in writing for school (statistically significant). 2. more laptop users use computers for locating/organising/analysing/communicating information (statistically significant). 3. two-thirds of teachers reported increased levels of cooperative learning and group work since the laptop programme started. 4. when asked to name the one academic skill most affected by students using laptops, the largest number (more than one third of teachers) named writing and 25 per cent named students thinking in more complex ways. 5. 66 per cent of teachers considered that laptop access had led to an increase in the amount of higher-order thinking shown by students. 6. 87 per cent of teachers stated laptop use had led to an increase in the quality of students' work. 7. 71 per cent of teachers felt that laptop use had led to students being more interested in school. 65 per cent of teachers felt that laptop use had increased student learning and understanding.	*Tools for Schooling: Second Year of the Laptop Program*. San Francisco, CA: Rockman et al. see also www.microsoft.com/Education/instruction/articles/aal_rockman.asp
Curriculum/Cross-Curricular		
Study in which 70 US 10th grade students were randomly assigned to either experimental or control group (2x35) to receive traditional or traditional plus CAI lessons. Pre-test confirmed the equivalence of the two groups.	The post-test showed that the experimental group had higher scores than the control group (significant at $p<0.05$). The attitude survey showed that students in the experimental group were more motivated and had more positive attitudes (significant at $p<0.05$).	# Adonri, O.E. and Gittman, E. (1998). *Effect of Computer Assisted Instruction on Students' Achievement in Global Studies*. Paper presented at the Annual Meeting of the Northeastern Educational Research Association, Ellenville, New York Oct 28-30.
A trailer article for the *Software Publishers Report on the Effectiveness of Technology in Education 1990-97*, summarising	The article gives the following examples of benefits to student achievement: • *'A team at Vanderbilt University studied at-risk, inner-city kindergartners for three months and found that a group learning in a multimedia language arts environment showed significantly superior gains in auditory, language, decoding-in-context and*	# Bialo, E.R. and Solomon, G. (1997). Open your eyes: the evidence is there! *Technology and Learning*. September. www.nyscate.org/ammo1.html – accessed at April 2000

the results of five studies.	*story-composition skills over a control group not using the computer.* • *In a study of Indiana's Buddy System, which places computers in the homes of upper elementary school students, Buddy students demonstrated gains in writing proficiency more than three times those of students in comparison schools.* • *Two studies by researchers at the Stevens Institute of Technology demonstrated the positive effects of commercially-available high school mathematics software on retention of math skills, based on their performance on a delayed post-test.* • *Two Israeli researchers found that adding computerized lab analysis tools and simulations to the high school biology curriculum led to significantly better content knowledge and science process skills.* • *Another study comparing elementary school students who received traditional classroom instruction to those using software with video vignettes designed to stimulate mathematical problem solving found that the video-using students showed less anxiety toward math, were more likely to see it as relevant to everyday life, and were better able to appreciate complex challenges.'*	
Meta-analysis of results from 26 US secondary school research studies (total 3694 students) conducted 1984-1995 to determine effect of using CAI on student achievement, comparing results achieved by traditional teaching only; traditional teaching plus CAI; and CAI only.	Results: 1. a positive effect for CAI, although the mean effect size was very small: '*…students exposed to CAI showed higher academic achievement than 57.2% of those students exposed to traditional instruction*' (p.328). '*…the mean effect of CAI on student achievement, as determined by the calculated effect sizes generated by the individual studies generally declined over the* [11 year] *period*' (p.328). Factors that could partly explain the negative effect sizes evident in the later years, including: changes in hardware/software; reduction of the 'halo' effect which might have accounted for the more positive results in earlier years; and the increased availability of computers in the home environment.	# Christmann, E., Badgett, J. and Lucking, R. (1997). Progressive comparison of the effects of computer-assisted instruction on the academic achievement of secondary students. *Journal of Research on Computing in Education*. 29 (4), pp.325-337.
Pre- and post-test study involved an	The analysis of results showed: 1. no statistically significant differences in the	# Huppert, J., Yaakobi, J. and Lazarowitz, R. (1998). Learning

experimental and control group of Israeli 10th grade biology students. Both groups received classroom teaching and lab work; the experimental group also used computer simulated experiments and prior computer awareness sessions to reduce the 'halo' effect..	pre-test results of the two groups; 2. the experimental group achieved statistically significant higher mean scores on the post-test than the control group; Further analysis by gender showed no significant difference in the results for the experimental group boys as compared with the control group boys, but a considerable difference in the results for the girls in the two groups, with those in the experimental group scoring higher than those in the control group; The difference between girls' results probably explains the overall significant difference between the experimental and control groups.	microbiology with computer simulations: students' academic achievement by method and gender. *Research in Science and Technological Education*. 16 (2), pp.231-245.
Case study comparing work done by music students in three English secondary schools: A had computers, keyboards and sequencers. B had computers and keyboards but no sequencers. C had keyboards and sequencers but no computers.	Results: 1. School A: a higher percentage of students achieved higher grades in GCSE music. 2. School B: students working on computers had achievement at or higher than expected by their teacher, as compared with students working only with keyboards Teachers' perceptions were that students achieved more when using computers.	# Rogers, K. (1997). Resourcing music technology in secondary schools. *British Journal of Music Education*. 14 (2), pp.129-136.
Report which summarises the results of five large-scale and two small-scale US studies covering primary and secondary schooling.	Schacter's conclusion is that '… *students with access to* *a) computer assisted instruction, or* *b) integrated learning systems technology, or* *c) simulations and software that teaches higher order thinking, or* *d) collaborative networked technologies, or* *e) design and programming technologies, show positive gains in achievement on researcher constructed tests, standardized tests, and national tests*.' (p.9)	Schacter, J. (1999). *The Impact of Educational Technology on Student Achievement: What the Most Current Research Has to Say*. http://www.mff.org/edtech/
A synthesis of the findings of US research studies covering primary and secondary	Concludes that: • educational technology has a significant positive effect on student achievement, across all age groups (pre-school to higher education), across subject areas and for both	Software Publishers Association. (1998). Report on the effectiveness of technology in schools, 1990-97: Executive Summary. *Technology*

schooling conducted 1990-1997. 219 studies used from original set of over 1500: a large number rejected because of methodological weaknesses/focus on other topics regarded as peripheral.	mainstream and special educational needs students; • educational technology has positive effects on student attitudes: increased motivation, self-confidence and self-esteem when using computer-based instruction .	*Connection.* 5 (3), pp.25-27.
Associations between secondary school students' use of computers (including home use) and achievement in written tests in mathematics and science, and performance in practical, problem-solving tasks in these subjects.	Results: 1. a negative association between using computers in mathematics lessons and achievement in a mathematics test 2. a negative association between using computers in science lessons and achievement in a science test 3. a negative association between playing computer games at home and achievement in a mathematics test 4. a negative association between playing computer games at home and achievement in a science test 5. a positive association between using computers at home to help with homework or to help generally with school work and achievement in a mathematics test 6. a positive association between using computers at home to help with homework or to help generally with school work and achievement in a science test 7. a positive association between using computers at home to help with homework and score on a spatial skills scale (constructed from questions in practical tasks which demanded spatial skills in a problem-solving context) 8. a two-way interaction between gender and most frequently used application at home and score on a strategy scale (constructed from questions in practical tasks which demanded evidence of using a strategy in a problem-solving context): girls who spent more time at home using word processors than any other application achieved the highest mean score on the strategy scale (i.e. higher than other girls/boys who used another application most).	# Harris, S. (1999). *Computers in Schools and at Home: Gender Differences in Use, Teaching and Achievement within the Results for England in the Third International Mathematics and Science Study (TIMSS).* Unpublished PhD thesis. University of Reading.

Note: The Becta Literature Review

This review (Harris, 2000) was commissioned by Becta independently of the Impact2 preliminary studies, and designed for a rather different purpose. It was however felt that some material from it could usefully be added to the studies. In Study 1 this has been done by inclusion of the appropriate items as a supplement to the tabulated review (Appendix A) while in Study 2 mention of the references has been incorporated directly into the text. As the items added were not studies that a member of the Impact 2 team had necessarily seen, they are indicated by a hash mark in the Study 1 and Study 2 reference lists.

The review covers 44 studies, including some very briefly mentioned and labelled unsuitable for further consideration. Of the 44 studies, 13 have been added to Study 1 and 8 to Study 2. The remainder were excluded on one or more of the following grounds:

- insufficient detail to identify the broad type of ICT involved and/or the effects on attainment
- already included in Study 1 or Study 2
- computer used only in administration of tests, rather than being an element in the teaching/learning situation being tests
- manifestly poor design.

The addition of these items did not change the general thrust of the analysis in either study, except to give a rather more positive picture of the value of conventional pre- and post-test studies as ways of identifying the impact of standalone IT on attainment. It did however lead to a reconsideration of our earlier decision to leave gender off the list of contextual factors in Study 2; this omission was also noted in the Expert Seminar. It is perhaps worth observing that only one of the items added to Study 1 is actually in the priority list of topics indicated on p35 of Study 2, the remainder being in the area of relevant related topics.

<u>Reference</u>

Harris S. (1999) Empirical Evidence relating to the Impact of Information and Communication Technologies on the Achievement of Primary and Secondary School Students: A review of international literature 1997-1999. Unpublished report prepared for Becta.

Appendix B

Draft concept mapping task (drawing upon the REPRESENTATION project)

Benchmark data of pupils' representations of ICT will be collected in schools at the beginning of the project and repeated after 18 months, to measure changes in their representations. The repeated tasks could either be with the same children or with children of the same age (the analysis of these two approaches would obviously reveal very different things, the latter would be administratively easier).

To enable us to compare the representations of pupils in different schools, the task will be introduced by standardised instructions (i.e. the administrator of the test must use precisely the same words in every case). Try to give the children enough space to lay out the large paper for the concept mapping ('ideas webs').

Note: If the teachers are worried about using ideas webs as a technique, having never used it before, it would be easy to have a 'trial run' of ideas webs with the children, perhaps one week in advance of doing the Task, using a different theme such as 'Holidays'. Use the instructions under 'Explanations about Ideas Webs'.

The Task (in two parts)

(Ideally, part one (drawing) and part two (writing) should be done on two different days with a gap of not more than 7 - 10 days in between.)

Part One: Drawing

Introduction

(Time allowed for introduction:15 minutes. Use these words. Don't change the words because that will change the task.)

Today we want you to help us with some drawing work for ImpacT2. ImpacT2 is a research project and through your drawings you will be helping the researchers.

All the pupils in the ImpacT2 schools are going to take part in this work and the aim is to communicate with the researchers, pupils and teachers through your drawings.

Drawing is a useful way of communicating your ideas. (Pause for short discussion: Ask if any of the children have noticed this in their lives - e.g. advertisements, road signs.)

So you will be communicating mainly through drawing, but don't worry if you want to use a few words to label things in your drawing.

This is an investigation, not a test. We want to know what you think, not what you have learnt at school, or what the person sitting next to you thinks. Please draw what is in your own mind. You can draw things that are imaginative and fun as well as things you know.

Explanation about Ideas webs

We want you to tell us your ideas by drawing an Ideas Web instead of writing. You start with your first drawing and then you draw other things as they come to your mind. The order in which you do the drawings is not important but it is important that you draw lines between the drawings that you feel are linked. The idea is to draw all the things you want to tell people about and show how they are linked in your mind by drawing lines between them. Make the joins how you want them and don't worry if your final drawing has very few lines or a lot of lines as that will depend on your ideas. You can write a few words to label any of your drawings, if you want to, but no large areas of writing. Please don't make your drawings too small. We have given you a large piece of paper so you have plenty of room to draw everything you want.

What you have to do

(Note for teacher/researcher:

- Time allowed - 30 minutes
- Large sheets of A3 white paper (297 x 420 mm), pencils (not very fine lines) or black ball point or felt tip pens (better not colour))

We want to know your ideas about Computers in Today's World. So that will be the title of your Ideas Web. When we were your age computers were hardly spoken about. Today it is very different. We want you to think about your world and all the types of computers within it. What would you say was the most simple computer system, and the most complex computer system you can think of? Where are computers placed at home … at school … in the outside world … or in the work place? Are they connected in any way? Think of all the people who use them. And why they use them. Take a minute of two to think before you start drawing. (Suggest that children might close their eyes and put their heads down on their folded arms for this thinking time.).

Write on the White Board:

'Computers in my world'

Draw an 'Ideas Web' to show the different types and uses of computers in your world.

Part Two: Writing

Introduction

This is the second part of the work we want you to do to help the researchers in ImpacT2. This time we want you to write about the Ideas Web you did last week.

What you have to do

An Alien from another world has been watching people here on the planet Earth very carefully. It has been able to see everything but not ask questions about things it has seen. We want you to describe a computer system to this ‘Alien’ from another world who has no knowledge of such things. Write down what you would say if you were speaking to the 'Alien'. You need to explain all the things that were in your Ideas Web. And don't forget this is not a test. We want to know your own ideas, so just write as best as you can without worrying about using a dictionary to check words. You can be imaginative and have fun.

What would the 'Alien' need to know to understand computer systems in our world and what they can do?

(Note for teacher/researcher:

- Time allowed - 15 minutes
- A4 white paper
- Black fibre tip of ball point pens (important for scanning))

Write on the White Board:

'Telling an Alien from another world about computer systems'

Describe a computer system to an ‘Alien’ from another world, who has no knowledge of such things.

Appendix C

ImpacT2 Evaluation: The Criteria for the selection of schools

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The ImpacT2 study required a sample of 60 schools. The composition of this sample was to be as follows (see the Invitation to Tender: DfEE/Becta, October 1999)

25 secondary schools
30 primary schools
3 schools for the emotionally and behaviourally disturbed (EBD).
2 schools for those with learning difficulties other than EBD.

Below is described the selection process for the 54 mainstream schools that took part in the study.

Schools were selected randomly from a sample drawn up considering the following criteria:

Availability of monitoring data

It was decided that relevant CEM Centre value added monitoring data should be available for each school in the study. Three cohorts were to be considered: the year group taking GCSE examinations in the summer of 2001, the year group taking Key Stage 3 assessments in the summer of 2001 and the year group taking Key Stage 2 assessments in the summer of 2001.

In the case of the GCSE cohort the selection of monitoring project was straightforward. Some 1,200 schools joined the two-year variant of Yellis in 1999, setting the Yellis assessment to their Year 10 pupils in the autumn of that year. These pupils will be part of the cohort taking GCSE examinations in summer 2001. The time increment between the Yellis test and GCSE examinations means that there will have been over five terms for any effects due to a school's ICT provision to have an impact on each pupil's schooling. There will of course be some attrition of pupils during this period due to parents moving house, etc., but during the GCSE component of education such attrition rates are low.

However, the need to select schools that were part of the Yellis Project at the required time complicated the selection of baseline data for monitoring the Key Stage 3 cohort. The CEM Centre does run a monitoring project that has the Key Stage 3 assessments as on outcome measure, named MidYIS. The MidYIS assessment is set to pupils in the autumn term of either Year 7, 8 or 9. Hence baseline data on pupils sitting Key Stage 3 in the summer of 2001 are available for those that sat MidYIS Year 7 in autumn 1998 or MidYIS Year 8 in autumn 1999, as well as those who will sit MidYIS Year 9 in autumn 2000.

The MidYIS Year 9 option was discarded as giving too little time for any effects attributable to ICT provision to have an impact between the MidYIS and Key Stage 3 assessments. This left MidYIS Year 7 or MidYIS Year 8 as possible monitoring instruments. However, as GCSE results are to be monitored for the same schools, both MidYIS **and** Yellis data would need to be available. Only 362 schools administered both the MidYIS Year 7 assessment in autumn 1998 **and** the Yellis Year 10 assessment in autumn 1999, with only 146 schools administering both the MidYIS Year 8 assessment in autumn 1999 **and** the Yellis Year 10 assessment in autumn 1999. These numbers would not be a sufficient basis for identifying an adequate sample. We therefore propose to use the Key Stage 2 assessment results as a baseline for the measure of Key Stage 3 outcomes in 2001. We will also take advice from the expert seminar concerning the possible augmentation of these baseline data with data from MidYIS Year 9 (sat in autumn 2000). This would improve the reliability of the baseline, but clearly data gathered in autumn 2000 could not take account of any benefits of IT intervention throughout earlier parts of the Key Stage.

Selection of monitoring project for the Key Stage 2 cohort was complicated by the variety of instruments available. The CEM Centre's PIPS team runs four projects germane to this group: PIPS Year 4, PIPS Start of Year 5, PIPS End of Year 5 and PIPS Year 6.

The Year 6 assessment is set just one term ahead of the Key Stage 2 assessments. Using it as a monitoring tool would guarantee very low attrition rates between the Year 6 and Key Stage 2 assessments, but there would have been very little time for any effects attributable to ICT provision having an impact. The Year 6 option was therefore rejected.

The Start of Year 5 and End of Year 5 assessments are set in terms one and three respectively. The year group sitting these assessments in academic year 1999/2000 is the one sitting the Key Stage 2 assessments in 2001. However currently both projects are small, each subscribed to by less than 300 schools. It was decided that this sample was too small when bearing in mind the other criteria to be applied, hence both Year 5 options were rejected.

The Year 4 assessment is set in term three. The year group that sat this assessment in academic year 1998/1999 will be the one sitting the Key Stage 2 assessments in 2001. There will be some six terms between the Year 4 assessment and Key Stage 2 assessments, allowing considerable time for any effects due to ICT provision to have an impact. Unfortunately the primary school population is less stable than the secondary school population, and there is likely to be considerable attrition over two academic years. Nevertheless, it was decided that the advantages of the large Year 4 sample size (circa 1,500 schools) and the reasonable time increment between assessments outweighed the drawbacks of such attrition (estimated in the region 20%), thus the Year 4 assessment was selected.

To summarise, only schools that set the Yellis test to their Year 10 pupils in 1999/2000 or set the PIPS Year 4 test to their Year 4 pupils in 1998/1999 were considered.

Effectiveness of ICT Provision

The schools selected needed to be proficient in the use of ICT. It was decided to draw upon data from Ofsted reports. While performing an inspection, inspectors are required to rate a school's IT provision on a scale of 1-7 (1 being the highest standard, 7 the lowest, 9 signifying not applicable). These data were requested from Ofsted for those schools inspected during or after 1997. This limit was selected to ensure that the standard of ICT provision recorded was relevant to the cohorts being studied. Only schools with a rating of 1 or 2 were considered for a "High IT" sample, with those with a rating of 4 being considered for an "Average IT" sample.

For schools with a school attainment rating of 1-4, the ICT provision ratings were distributed as follows:

Ofsted IT Provision Rating	Primary (%)	Secondary (%)
1	0.6	2.2
2	5.4	9.1
3	23.3	18.2
4	46.0	32.2
5	20.9	28.1
6	2.8	9.0
7	0.1	0.8
9	0.8	0.4

Thus the "High IT" sample can be thought of as being drawn from the top 6% of primary and top 11.3% of secondary schools, according to Ofsted reports. The "Average IT" sample is drawn from between the 24th and 70th percentiles for primary schools and from between the 38th and 70th percentiles for secondary schools.

The Ofsted data set was matched to the CEM Centre's data set by school DfEE number. To confirm that the subset of schools for which CEM Centre data was available was not atypical, the distribution of school attainment ratings within the Ofsted data was compared with that within the matched CEM Centre data set:

OFSTED School Attainment Rating	OFSTED data set (%)	OFSTED data for which CEM Centre data available (%)
1	0.1	0.2
2	3.2	3.4
3	30.8	31.1
4	65.9	65.3

NB: It should be borne in mind that only data pertaining to schools with an attainment rating of 1-4 was requested from OFSTED.

As can be seen from the above table, the distributions are almost identical.

Standard of School

It was felt that any schools combining highly effective ICT provision with generally low levels of attainment were likely to be atypical, and the presence of such schools in a sample of 54 could skew the data. For this reason OFSTED was also asked for the school attainment rating from each of the above inspections. Only schools with a rating of 1-4 were considered.

With suitable schools identified by the above criteria, the sample for study was selected. Half the mainstream schools selected had high IT ratings (1 or 2). The other half had average ratings (4). Lists of schools identified by Becta as being “IT active” or having submitted IT development plans via their LEAs were also examined, and schools from those lists that satisfied the above criteria were identified.

Suitable schools were drawn at random until ten primary and eight secondary schools were selected in each of three geographical zones into which England had been divided.

Geographical Location

To both aid in the administration of the study and ensure a spread of schools across England, schools were identified as being located in one of three geographical zones:

- West
- East
- South

The vertex for these zones was initially placed at Rugby, this being a suitably central location within England. The Southern zone was initially defined by two straight lines running from Rugby down to the Severn Estuary and the Thames Estuary. Originally it was envisaged that the boundary between the West and East zones would be a line running due North from Rugby. On inspection however it was evident that such a division would leave the Eastern zone considerably inferior in both area and population to the other zones, with the Western zone including the population centres of the West Midlands, Merseyside, Greater Manchester, West Yorkshire, Tyne & Wear and most of South Yorkshire. To achieve a more demographically equitable division, the East/West boundary was adjusted to become a straight line from Rugby to the point at which the borders of Scotland, Cumbria and Northumberland meet. This alteration moves Tyne & Wear, South Yorkshire and much of West Yorkshire into the Eastern zone. The Western zone is now the smallest in terms of area, but retains the highly populous West Midlands, Merseyside and Greater Manchester conurbations. The final adjustment was to force the boundaries to follow those of the current local education authorities whilst keeping close to the original straight lines.

Final check of suitability

As a final check the actual OFSTED Inspection Report for each of the selected schools was viewed to check for any discrepancy between the ratings considered as part of the selection criteria and the comments within the main body of the report. Where any discrepancy was found the school was rejected and another from within the same zone selected at random to take its place.

Reserve Schools

The above selection process was repeated from the remaining schools to provide a “shadow” set of schools to be used as a reserve in the event of first-choice schools withdrawing from the study.

Invitation Letter sent to the Selected Schools

A letter was drafted, circulated among the ImpacT2 project teams, approved by Becta, and sent to the headteacher of the 60 selected schools, inviting them to participate in the ImpacT2 evaluation. For any schools which declined, a school from the “shadow” set was substituted, and a further invitation issued.