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IN THIS EDITION

The Teachers Registration Board of South Australia has commissioned the Australian Council for Educational Research to prepare this series of electronic research digests.

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The Digests

This Digest is one of a series of periodic digests produced by the Australian Council for Educational Research (ACER) for the Teachers Registration Board of South Australia.

Each digest focuses on a single topical issue, and provides a review of major messages from research on the issue. A key feature of the digests is an emphasis on what the research means for teachers and teaching. Over the course of several editions, a wide range of issues will be covered, so that teachers from different areas of schooling will find topics of relevance to their needs and interests.

Previous Issues

2007/1 *Writing to learn*
2008/1 *Managing student behaviour in the classroom*
2008/2 *Using Data to Improve Learning*

Number 1, 2009

The Digest

The use of ICT in schools in the digital age: what does the research say?

This edition of The Digest is focused on research that has investigated aspects of digital learning. The body of research sometimes described as 'e-learning research' (Andrews & Haythornthwaite, 2007) encompasses many aspects of ICT in education, at many levels and in many contexts. For the purposes of this digest, the key question is *What does research tell us about digital learning in schools?*

The first section of the digest is focused on the diverse uses of ICT in schools, and evidence about the ICT literacy of Australian students. This is followed by an overview of evidence about the impact of ICT on student learning. Two short sections present some evidence about how technology can help to improve science learning, and some findings from research on interactive whiteboards in teaching and learning. The final section offers some practical accounts of using ICT to support learning.

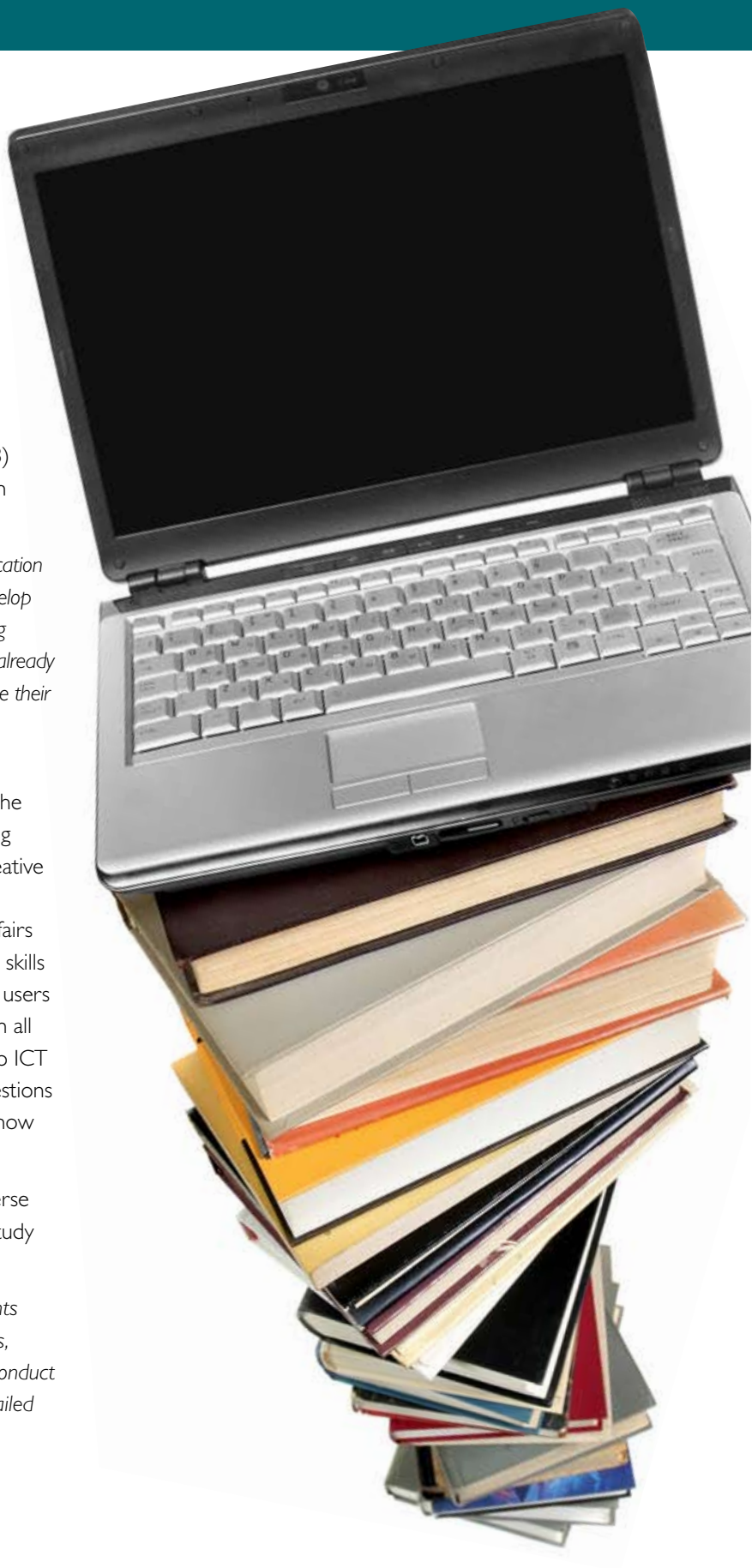
The digest draws on searches of a number of databases and bibliographic resources, including the Australian Education Index, Education Resources Information Center (ERIC), Education Research Complete, British Education Index and Scopus.

A selection of relevant websites is listed, and a full reference list is provided. Links to those references for which full-text online access is freely available are also included.

ACER

Successful uses of ICT in schools

Successful learners have the essential skills in literacy and numeracy and are creative and productive users of technology, especially ICT, as a foundation for success in all learning areas



The preamble to the 2008 Melbourne Declaration on Educational Goals for Young Australians (MCEETYA, 2008) acknowledges a number of changes and new demands on Australian education.

… *rapid and continuing advances in information and communication technologies (ICT) are changing the ways people share, use, develop and process information and technology. In this digital age, young people need to be highly skilled in the use of ICT. While schools already employ these technologies in learning, there is a need to increase their effectiveness significantly over the next decade.*

This statement recognises that ICT is used extensively in schools, and also highlights accelerating changes in ICTs. The second of the two goals in the declaration is that all young Australians become successful learners, confident and creative individuals, and active and informed citizens (Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA), 2008). Successful learners have the essential skills in literacy and numeracy and are creative and productive users of technology, especially ICT, as a foundation for success in all learning areas. (MCEETYA, 2008) The explicit reference to ICT as an essential skill for successful learning raises many questions about what research has already identified in relation to how ICTs improve learning.

This perspective on Australian education reflects the diverse use of modern ICT in many countries. A recent OECD study reports that, in all OECD countries:

In schools it is now common to see ICT being used by students to write essays, find information for projects and assignments, compose music, share ideas with students in other schools, conduct simulations, build databases, create works of art and do detailed architectural drawings. (OECD, 2005b)

Within Australia and New Zealand, a survey-based evaluation of online curriculum materials produced by The Le@rning Federation has provided insights into the perceptions of teachers, school leaders and sector personnel about the uses and benefits of information and communication technologies in classrooms and the factors that encourage its classroom use. This evaluation has found a generally low adoption of ICT, due to various factors, including a lack of alignment between curriculum, pedagogy, assessment of students' performance, and high stakes testing. (Freebody, P., Reimann, P. & Tiu, A., 2008a)

The findings of the evaluation survey of The Le@rning Federation's (TLF) online curriculum materials (Freebody, P., Reimann, P. & Tiu, A., 2008b) identified a number of factors concerning the use of online curriculum material in the current school context, including, for example:

- *Teachers vary considerably in their reported rates of familiarity and professional development experiences with TLF materials, and report low levels of professional development, although higher than reported in earlier surveys.*
- *The curriculum areas with the highest use of TLF materials are mathematics, English/literacy and science. Studies of Society and the Environment and cross-curricular integrated studies now have higher reported rates of use than those reported in earlier studies.*
- *Teachers who use TLF materials continue to report very favourably on their value for students' learning and engagement.*
- *In estimating the importance of a range of factors that enable teachers to adopt new digital/online technologies in their teaching, teachers place less emphasis on those related to ease of use and support in ICT than do school leaders and sector personnel. Teachers also view pressure from outside sources for them to use ICT to be of less importance than do sector personnel. Policies and syllabuses for ICT are seen as a stronger influence by teachers than by principals and sector personnel.*

The new demands made by ICT have prompted discussion: *… it's the relatively new uses of the internet and worldwide web that are stimulating new demands and expectations in education.* (White, 2008a) There is also clear recognition of the need for research about questions of the impact of ICT on learning and education:

The internet and www have caused considerable changes to the ways we access and use information as well as communicate that are having a continuing impact on education. The sheer richness of media and the diversity of processes that can be applied to those media mean that we need research into their effects on learning. (White, 2008b)

Research addressing this topic takes many forms, including large-scale investigations of the range of ICT literacy amongst students, reports from schools and classrooms about students' responses to new teaching practices integrating a range of ICTs and students' responses to these approaches, as well as meta-analyses of rigorous research seeking to determine the impact of ICTs on learning. In different ways, all of this research explores key questions about the impact of ICT on learning.

What do we know about the ICT literacy of Australian school students?

Communication with peers and using the internet to look up information are frequent applications but there is much less frequent use of applications that involve creating, analysing or transforming information

National assessments of the ICT literacy of Australian school students in Years 6 and 10 were conducted on behalf of the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) within the National Assessment Program in 2005 and 2008. These assessments were based on a definition of ICT literacy that drew on the Framework for ICT Literacy developed by the International ICT Literacy Panel:

the ability of individuals to use ICT appropriately to access, manage, integrate and evaluate information, develop new understandings, and communicate with others in order to participate effectively in society. (MCEETYA, 2007)

The assessment framework envisaged ICT literacy as comprising six key processes:

1. *Accessing information – identifying the information needed and knowing how to find and retrieve information;*
2. *Managing information – organising and storing information for retrieval and reuse;*
3. *Evaluating – reflecting on the processes used to design and construct ICT solutions and about making judgements regarding the integrity, relevance and usefulness of information;*
4. *Developing new understandings – creating information and knowledge by synthesising, adapting, applying, designing, inventing or authoring;*
5. *Communicating with others – exchanging information by sharing knowledge and creating information products to suit the audience, the context and the medium; and*
6. *Using ICT appropriately – making critical, reflective and strategic ICT decisions and about using ICT responsibly by considering social, legal and ethical issues.* (MCEETYA, 2007)

In the 2005 national assessment, an ICT Literacy Scale was developed, and proficient standards were established for each level. At Year 6, 49% of students achieved the proficient standard, and at Year 10, 61% achieved the proficient standard. (MCEETYA, 2007)

The results of the survey provide an interesting picture, suggesting that students use ICT in relatively limited ways.

Communication with peers and using the internet to look up information are frequent applications but there is much less frequent use of applications that involve creating, analysing or transforming information. There are substantial differences between Year 6 and Year 10 suggesting that considerable growth in ICT proficiency takes place over these four years. Within each year level there are differences associated with socioeconomic background, Indigenous status and remote geographic locations. (MCEETYA, 2007)

In 2005 49% of Australian students in Year 6 were able to

generate simple search questions and select the best information source to meet a specific purpose, retrieve information from given electronic sources to answer specific, concrete questions, assemble information in a provided simple linear order to create information products, use conventionally recognised software commands to edit and reformat information products. (MCEETYA, 2007)

In 2005 61% of Australian students in Year 10 were able to

generate well-targeted searches for electronic information sources and select relevant information from within sources to meet a specific purpose, create information products with simple linear structures and use software commands to edit and reformat information products in ways that demonstrate some consideration of audience and communicative purpose. (MCEETYA, 2007)

Is ICT availability and use associated with student performance?

Some features of ICT availability and use were strongly associated with student performance

The implications of ICT for education, in terms of how ICT can facilitate learning, and the importance of mastery of ICT in adult life, raise questions about the extent to which young people are exposed to and use ICT, the extent of access to ICT in and out of school, and the learning outcomes they are achieving. Data in relation to these questions were collected in the 2003 Programme for International Student Assessment (PISA).

The results of the ICT component of the 2003 PISA survey indicated that:

- almost all students in OECD countries had experience in using computers;
- the length of time for which students had been using computers differed greatly across countries;
- since the 2000 PISA survey access to computers at home and at school increased;
- the majority of students had access to computers at both home and school;students used computers for a wide range of functions and not just to play games;
- one-half of the students reported frequent use of the Internet as a research tool and frequent use of word processing software;
- the vast majority of students were confident in performing basic ICT tasks such as opening, deleting and saving files. (OECD, 2005a)

The results from PISA 2003 showed that some features of ICT availability and use were strongly associated with student performance, but this was not the case for all features.

… in an age in which computers feature strongly in everyday life and in education, the minority of students who have little access to them, who use them little and who are not confident in using ICT are not performing well. This is partly because students with low home access are more likely to come from disadvantaged backgrounds, but the observed gap cannot nearly be explained by socio-economic status. Thus, the disadvantages faced by students whose parents have low educational or occupational status are likely to be exacerbated where they also do not have access to computers. The PISA evidence confirms previous studies showing the particularly strong association of performance with home access and usage. (OECD, 2005a)

A 2004 OECD education policy analysis addressed a number of significant current policy initiatives, including the extent to which ICT was being used to improve teaching and learning in schools. One finding from this analysis was that *in all OECD countries, low-achieving 15-year-olds seemed to be just as interested in using computers as other students, with no statistically significant differences emerging on a scale of interest in ICT between the scores of the lowest literacy achievers and other students.* (OECD, 2005b)

Another finding of importance to schools was that in nearly all OECD countries, low achievers' access to ICT was greater and more equitable in the school than in the home. There was an extremely strong and significant trend for low-achievers to report less access in the home than that reported by high achievers. (OECD, 2005b)

What is the evidence of impact of ICT on learning?

More substantial gains in pupil attainment are achievable where the use of ICT is planned, structured and integrated effectively

This question about evidence of the impact of ICT on learning has been the focus of a number of studies in recent years. Reviews of research, and meta-analyses synthesising research in various learning areas have yielded some evidence about positive impact on students' learning.

A professional user review of UK research was undertaken for the British Educational Research Association (BERA) in 2003. A range of sources was included in the review, which found that ICT can help students to learn and teachers to teach more effectively, although the review noted that there is not a simple message in such evidence that ICT will make a difference simply by being used. (Higgins, 2003)

Some key messages from the research

More substantial gains in pupil attainment are achievable where the use of ICT is planned, structured and integrated effectively.

Computers should be used to enhance aspects of teaching through the presentation of information in different ways and in different forms.

Effective use of ICT can support the development of understanding across the curriculum. (Higgins, 2003)

In 2003 Higgins suggested the need for flexibility in curriculum and assessment to accommodate technological change, although by 2008 it seemed clear that ICTs have brought about changes in the curriculum as the developing technologies provide new avenues for accessing knowledge.

A series of systematic reviews of research studies on the impact and effectiveness of ICTs in teaching and learning has been conducted through the EPPI-Centre at the Institute of Education, University of London. Systematic reviews seek out as much research as possible on specific research questions, and use a rigorous methodology to screen the studies to determine what can reliably be said about their findings. The research findings are then synthesised into a form accessible to policy makers and practitioners.

Findings from systematic reviews of ICTs on aspects of literacy learning in English

The EPPI-Centre has undertaken several systematic reviews of the effectiveness of ICTs in different aspects of literacy learning in English. The first of these (Andrews, et al, 2002) identified the interest in the impact of information and communication technologies (especially computers, networked computers, mobile phones) on young people's learning, and investigated the impact of networked technologies – the internet and email – on literacy learning. The results of the review were suggestive rather than conclusive, but in general, *the studies assumed that networked ICT had a positive impact, and explored how that impact was made. Increased motivation for literacy, empowerment and ownership were considered to be important factors. Most studies used a pre-digital conception of literacy.* (Andrews et al., 2002)

The report of this review drew out the implications of the findings for teaching, and suggested that, *In practice, more attention needs to be given to how ICT is used both within the classroom and at home to see it as one tool of many which can support literacy learning.* (Andrews, Burn, Leach, Locke, Low, & Torgerson, 2002) The review recommended that further in-depth work be done on areas such as email, conferencing and the internet; writing and composing multimedia; on-screen reading and hybridity of the verbal and visual in multimedia, and noted that a range of research methods and types of study were needed, including teachers' action research projects.

More recently, a systematic review addressed the question, *what is the evidence for the effectiveness of different ICTs in the teaching and learning of English (written composition), 5–16?* (Andrews et al., 2006)

Interestingly, the findings of the review were reported as follows: *… it was not possible to arrive at a clear answer to our in-depth research question. Rather, we wish to report that the field is in a pre-paradigmatic state where definitions of English, literacy and ICT are still relatively unclear and where the causal and/or symbiotic relationship between them has yet to be fully theorised. The most authoritative study in terms of the present review … showed that ICT made little difference to an experimental group of 'learning disabled' students in terms of writing quality, but that, for lower-order writing skills, improvements happened at a faster rate for such students as well as there being an increase in self-esteem for these students.*

The report provided some advice to teachers, suggesting that ICT *is best seen as another tool in the repertoire available to learners and teachers for expression and communication. Custom-made word processing and other software programs should be considered by teachers, as some of these prove to be more attuned to the writing process than others. Teachers also need to be aware that there are times when the use of ICT is appropriate for a particular writing task (or part of that task), and other times when different media are more appropriate.* (Andrews et al., 2006)

Findings from systematic reviews of ICTs in science, mathematics, and writing

A systematic review of research in science learning posed the question: *what is the effect of ICT teaching activities in science lessons on students' understanding of science ideas?* (Hogarth, Bennett, Lubben, Campbell & Robinson, 2006) The in-depth review of research from 2000-2005 identified evaluation studies from 10 countries on the use of simulation to teach the understanding of science ideas. These studies included a control and pre- and post-testing of achievement of students aged 11-16.

The findings of the systematic review suggested that simulation has potential value in classrooms:

- Simulations fell into two main categories – simulation of specific experiments and simulations of a wider scientific situations ... . Both types of simulation can improve students' understanding compared to non-ICT/traditional teaching and learning activities.
- Students' use of ICT simulations helped them to improve their understanding of science ideas more effectively compared to the use on non-ICT teaching activities.
- Students' use of ICT simulations was more effective than using non-ICT teaching activities for improving basic science ideas including science understanding and the scientific approach.
- However the improvement in higher levels of understanding (for example, the transfer of scientific knowledge from one situation to another and experimental design) can equally well be achieved when students use traditional (non-ICT) teaching approaches.
- The gains in students' learning when using ICT simulations were further enhanced when teachers actively scaffolded or guided students through the ICT simulations. (Hogarth et al., 2006)

A systematic review of ICTs in mathematics found evidence to answer the research question: *How have different information and communication technologies (ICTs) contributed to the development of understanding of algebra for pupils up to the age of 16?* Major findings were that:

- pupils achieve general gains of understanding when using one type of ICT
- students successfully use visualisation with graphing software to fit graphs to datasets, to solve equations and to transform functions.
- pupils working in a computer environment reach higher levels of thinking and are able to explain their thinking better than pupils working in a paper and pencil medium.
- lower attaining students prefer to work arithmetically with tables of values and only later move to integrate the tables of values with computer-generated graphs.
- pupils have difficulty moving between symbolic, tabular and graphical forms when solving equations.
- students do not always know how to use the technology, interpret ambiguities in the output or exercise critical judgment when using some of the advanced calculators. (Goulding & Kyriacou, 2008)

The report of this systematic review drew on the findings to provide practical advice for teachers. This example relates to the management of individual, small group work and whole class work.

Opportunities for students to experiment with technology

Teachers need to negotiate a balance between the individual constructions which may develop when pupils work alone or in small groups with the technology, and common knowledge developed within the whole class. Although this is a consideration in any teaching situation, technology may be particularly fruitful in encouraging individual experimentation. This is desirable but needs to be tempered by teachers encouraging sharing within the whole class. The last point is also relevant when considering the use of electronic whiteboards and computers connected to data projectors. If this is completely within the control of the teacher, then pupils may not have the opportunity to experiment with the technology themselves. (Goulding & Kyriacou, 2008)

Other large-scale reviews of studies of ICT impact on schools provide further perspectives. A review from European Schoolnet of the impact on schools in Europe identified the following findings from a review of 17 recent impact studies and surveys at the national European and international levels. The authors summarised the findings of ICT impact in eight statements:

1 ICT impacts positively on educational performance in primary schools, particular in English and less so on science and not in mathematics.
2. Use of ICT improves attainment levels of school children in English- as a home language- (above all), in Science and in Design and technology between ages 7 and 16, particularly in primary schools.
3. In OECD countries there is a positive association between the length of time of ICT use and students' performance in PISA mathematics tests.
4. Schools with higher levels of e-maturity demonstrate a more rapid increase in performance scores than those with lower levels.
5. Schools with good ICT resources achieve better results than those that are poorly equipped.
6. ICT investment impacts on educational standards most when there is fertile ground in schools for making efficient use of it.

7 Broadband access in classrooms results in significant improvements in pupils' performance in national tests taken at age 16.

8. Introducing interactive whiteboards results in pupils' performance in national tests in English (particularly for low-achieving pupils and for writing), mathematics and science, improving more than that of pupils in schools without interactive whiteboards. (Balanskat, Blamire, & Kefala, 2006)

ICTs in science classrooms

The crucial role of the teacher in orchestrating the learning environment at cognitive, pedagogical and technological levels

Another meta-review (Todorova, Fischer, Ludvigsen & de Jong, n.d.) addressed the question: *"how can technology help to improve science education?"* This review distinguished two broad functions of technology with special relevance for science education, serving as a means for

a. *experiencing natural systems and phenomena, and*
b. *facilitating science learning processes.*

The report of this review notes the crucial role of the teacher in orchestrating the learning environment at cognitive, pedagogical and technological levels.

Experiencing natural systems and phenomena	Facilitating science learning processes
Simulating and modelling phenomena … enables learners to investigate and understand more complex models than in a school laboratory	*Accessing a variety of resources* … access to scientific texts and lectures, news, hypertext and hypermedia materials or scientific data, is a function of technology with high relevance for science learning.
Visualising systems and phenomena … two- and three-dimensional graphs, video, animations and virtual environments can make explicit underlying models and concepts, represent complex data sets, and illustrate ideas.	*Scaffolding* … technology can provide scaffolding through prompts, hints, questions, concept maps, tutorials, intelligent tutoring applications.
Data capture and display … data-collecting and logging appliances, microcomputer-based laboratories, databases, spreadsheets and graphing tools are used to capture and display real data.	*Communicating and collaborating* … emails, weblogs, discussion boards, chat-rooms and collaborative electronic environments facilitate students' working together on tasks, sharing their knowledge and expertise, and producing joint outcomes. (Todorova et al., n.d.)

Interactive whiteboards

Positive impacts depend on the ways in which interactive whiteboards are used

Interactive whiteboards are a relatively recent technological innovation in schools, and while there is limited research literature in refereed academic journals about their impact on students' learning, there are many projects that have been undertaken at local and school level that have been reported in the professional literature.

A 2007 account of innovative uses of interactive whiteboards in Western Australian country schools presents evidence from a number of classrooms about ways in which the introduction of interactive whiteboards are reported to have improved teaching. One teacher noted that:

'As a teacher, the use of the interactive whiteboard is very rewarding as you can actually see your students taking an active interest in their education and developing in ways, that in my opinion, are not possible under conventional teaching practices.' (Bayne, 2007)

The ICT specialist at another of the schools in Bayne's account described some of the changes in teaching that he had observed.

'For their own part, teachers are reporting more streamlined and organised planning, preparation and execution of their lessons due to their use of the interactive whiteboard notebook software and direct access to all the resources on the school network.' (Bayne, 2007)

A small scale, school-based action learning study conducted in a remote Western Australian school explored the impact of the introduction of interactive whiteboards on the teaching practices of a group of teachers. The focus of the action research was on ways that teachers thought about their teaching and planned for the achievement of learning outcomes with the introduction of interactive whiteboards. Findings from this study demonstrated that the use of interactive whiteboards encouraged reflective practice and lead to increased awareness of the benefits of interactive teaching and learning. It is of interest that the study also indicated that changing classroom practices takes time, and teachers progressed though stages of development in the ways they utilised new technology. (Sparrow, Frid & Smith, 2008)

An analysis of the emerging body of literature on the effective use of interactive whiteboards in teaching and learning was conducted by the British Educational Communications and Technology Agency (Becta). The analysis indicated that interactive whiteboards can have positive effects on teaching and learning in general, and provide benefits for teachers and for students. The report notes that positive impacts depend on the ways in which interactive whiteboards are used, and that, although the literature on this technology is emergent, and further research, both qualitative and quantitative, will be needed, there was evidence of good practice and positive outcomes across the curriculum. (Becta, 2003)

One of the studies included in the Becta analysis identified three levels of whiteboard use:

- *to increase efficiency, enabling teachers to draw upon a variety of ICT-based resources without disruption or loss of pace*
- *to extend learning, using more engaging materials to explain concepts*
- *to transform learning, creating new learning styles stimulated by interaction with the whiteboard.* (Glover & Miller, 2001)

Exploring impact on learning

This new form of instruction gave me chance to interact with all of my students

Two recent studies provide insights into the nature of learning with technology.

Responding to researchers' recognition that in *an age of information, it is important to identify the information-seeking strategies that we use while reading on the Internet to better inform both research and practice*, Coiro and Dobler (2007) undertook a qualitative study to explore the nature of reading comprehension processes while reading on the Internet. Two research questions guided the study:

1. *What characterizes the reading process as skilled readers search for and locate information on the Internet?*
2. *What informs the choices that skilled readers make as they search for and locate information on the Internet?* (Coiro & Dobler, 2007)

The sample comprised 11 skilled sixth grade readers from three middle schools in the central and northeastern United States. These students met individually with a researcher, and completed two separate tasks that involved reading on the Internet, and in a follow-up interview answered specific questions about their strategy use. Four phases of qualitative analysis were used to investigate the data.

Coiro and Dobler found that *the skilled readers in their study shared insights that suggested that successful Internet reading experiences appeared to simultaneously require both similar and more complex applications of (1) prior knowledge sources, (2) inferential reasoning strategies, and (3) self-regulated reading processes.* (Coiro & Dobler, 2007)

The students used both familiar knowledge sources and new knowledge sources to comprehend the Internet text. The researchers observed skilled readers actively applying a range of inferential reading strategies with students' responses to interview questions identifying the strategy. For example, one student said:

'I'm going to choose "Weather for hurricanes and typhoons" [clicked on link], and now I'm going to read the lists of sites and information about them to see if they're good, and this looks like a good site, 'cuz it says [after the hyperlink] "See how hurricanes are formed" and it might have information on hurricanes losing their power.' (Coiro & Dobler, 2007)

Data from the study suggested that *higher achieving sixth-grade readers with Internet reading experience are aware of and demonstrate strategic online reading processes to a higher degree than their less skilled peers with Internet reading experience.* (Coiro & Dobler, 2007)

Another example of insight into how students use ICT to learn is found in a teachers' description of an electronic discussion board-related assignment completed by her grade ten history students.

To begin, she immersed her classes in an electronic discussion board system. The first online discussion was conducted in response to this initial question:

Based on your reading of Chapter 22 and your class notes, do you believe that the causes of the French Revolution were primarily economic or primarily political? Explain your response using examples to support your argument. You must respond first by giving your point of view. Then, revisit the discussion three more times on three different days to contribute to your group's conversation. (Snyder, 2008)

In practical terms, Snyder found that 10 students was the optimal number per discussion group, and four postings was a manageable number in a 10-person discussion group. She found that two weeks enabled students to overcome any technological obstacles and provided an opportunity for the discussions to blossom. She monitored the discussion daily, and at the end of the two weeks gave specific feedback to each group, highlighting good insights and communication techniques. She concluded that:

Perhaps the most rewarding aspect of instituting this feature into my 10th grade class was that at the end of the year, I felt like I knew my students' abilities much better than I ever had. Reading their posts provided me with insight into how they were thinking and reasoning. It is yet another tool to assess students' learning. … This new form of instruction gave me chance to interact with all of my students and learn their abilities in much more helpful detail. (Snyder, 2008)

comment

The body of research on the impact of technological innovations continues to expand as the take-up of ICT in schools increases. The possibilities of integrating technological communication and information resources into effective classroom practices are widely acknowledged, and there is a growing body of evidence indicating the positive impact of such practices. Evidence about the nature of students' levels of ICT literacy and about the diverse ways in which ICT is used in contemporary classrooms has many implications for future directions in education.

There is clear recognition of the need to expand the range and scope of research methodologies in the area, and the need for teachers to be

more involved in the design of ICT artefacts, and … to be more involved in research on how students use these artefacts. (Freebody, Reimann & Tiu, 2008a)

White (2008b) draws attention to the

… sheer richness of media that is available and the diversity of processes that can be applied to those media mean that we need research into their effects on learning. We also need to look at the capacity for education to explore these aspects of the use of ICT in education if we're to enable progress that is more than haphazard.

This digest has drawn on rigorous large scale studies to help in providing a map of the challenging territory of ICT in education, as well as on more focussed studies of classroom practices. The need to continue and broaden research into the impact of ICTs is emphasised in the following recommendation about the uses of ICT in schools:

Learning objects, and ICT more generally, need to be seen as both curricular and technical interventions into classrooms. In that regard their use poses challenges to teachers and students that are cognitive, attitudinal, technical and practical. Studying their adoption, adaptation and sustained use therefore means building up detailed knowledge from a variety of case sites, targeting practices and outcomes in close-up designed-based interventions in which everyday practices – initiations, modifications, challenges, responses and outcomes – are documented and disseminated. (Freebody, Reimann, Tiu, 2008a)

A number of key messages emerge from the body of research evidence about the uses of ICT in schools in the digital age:

- teachers' confidence about using ICT in the classroom is variable;
- ICT learning objects are used mostly in mathematics, English and science;
- the use of computers is common at home and at school;
- students use ICT in limited ways. Information access and searching are common, but creating, analysing and transforming information are less common.

ICT improves student engagement, supports learning in a variety of ways, and is both a tool and process for new ways of thinking and learning. For example, simulations are powerful learning tools. ICT can assist general gains in mathematics and has a positive impact in primary schools especially, in English. Student performance improves with time when using ICT, but low access to ICT and low confidence in using ICT corresponds to low performance. Innovative uses of ICT continue to evolve: for example, teachers can provide new learning opportunities for students by using interactive whiteboards, or electronic discussion board systems. Overall, the effective use of ICT in schools is planned, structured and integrated.

USEFUL WEBSITES

The EPPI-Centre in the Social Sciences Research Unit at the Institute of Education, University of London provides access to an extensive evidence library of reports of systematic reviews of research evidence. Many of these reports present findings of research and indicate practical implications for teaching.
http://eppi.ioe.ac.uk

The Le@rning Federation develops digital curriculum content for all Australian and New Zealand schools. The project is a collaborative initiative of all Australian and New Zealand governments. The 'Teacher ideas' section of the website provides access to teachers' accounts of successful practices.
http://www.thelearningfederation.edu.au/default.asp

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