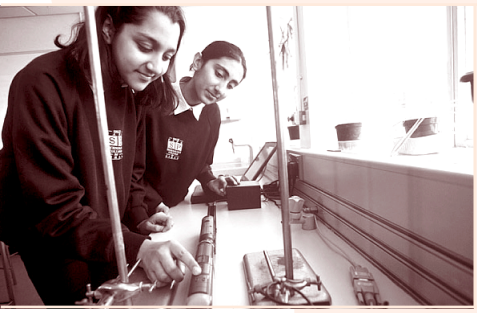

Contents

- Key research evidence on the use of ICT in science
- Explanation of findings
- Bibliography and further reading

Summary

There is a considerable body of literature on the use of ICT in science across a range of topics and age phases. This report provides an introduction to some of the key applications used in primary and secondary science and the pedagogical issues surrounding them.

Key benefits of using ICT in science:

- ICT can make science more interesting, authentic and relevant
- ICT allows more time for observation, discussion and analysis
- Using ICT increases opportunities for communication and collaboration

How teachers can maximise the impact of ICT in science:

- Be clear on how the use of ICT will support lesson objectives
- Use ICT as a tool, not just as an information resource
- Give pupils greater autonomy in their scientific investigations

What the research says about using ICT in science

This report is based on an analysis of current research about the use of ICT in the teaching and learning of science. It summarises the key findings and suggests resources for further reading.

Applications of ICT in science

The purposes for which ICT is used in science may be divided into four broad areas: data handling, information, communication and exploration. Each of these areas covers a range of software and hardware, including:

- data logging tools and digital video cameras for data capture
- spreadsheets and graphing tools for data handling and analysis
- simulations and modelling tools, including animations and virtual environments
- information resources such as the internet and CD-ROMs.

As well as the uses of ICT which are specific to science teaching, more general ICT applications have been found to be useful, including:

- portable ICT devices such as laptops and palmtops
- email and discussion groups
- school intranets
- presentation technologies such as digital projectors, interactive whiteboards, presentation software.

This report considers not just the technologies themselves but also the pedagogical implications and the support necessary to implement them.

Key research evidence about using ICT in science

On the basis of Becta's analysis, ICT can have positive effects on the teaching and learning of science in the areas outlined below. There are references for further reading supplied alongside the findings.

Benefits for teachers

- ICT allows teachers to engage and motivate pupils to a greater degree (Betts, 2003)
- The internet increases access to authentic data (Osborne and Hennessy, 2003)
- Simulations enable teachers to show experiments that would not otherwise be possible (McFarlane and Sakellariou, 2002)
- Data logging and digital video recording allow access to new sources of data in a wider range of experimental settings (Newton, 2000)
- ICT provides quicker and more accurate data collection, saving lesson time and giving better quality results (Osborne and Hennessy, 2003)

Benefits for pupils

- The mechanical aspects of practical work are reduced, allowing pupils to concentrate on interpreting and analysing data (McFarlane and Sakellariou, 2002)
- Visual modes of presentation aid understanding of concepts and processes (Trindade *et al.*, 2002)
- Instant feedback enables pupils to refine experiments and hypotheses (La Velle *et al.*, 2003)
- ICT can provide a greater capacity for project-based learning dealing with topics relevant to pupils' interests (Mistler-Jackson and Songer, 2000)
- There are more opportunities for independent, self-directed learning (La Velle *et al.*, 2003)
- School networks and the internet can provide access to learning resources outside of school hours (Lewis, 2003)
- Electronic communication enables pupils to become part of a community of learners (McFarlane and Sakellariou, 2002)
- ICT provides opportunities for collaboration with peers and professional scientists (Mistler-Jackson and Songer, 2000)

Factors for effective use

- ICT should be used only when appropriate to lesson objectives (Betts, 2003)
- Pupils need autonomy to explore and test their ideas (La Velle *et al.*, 2003)
- Teachers should encourage discussion and interaction between pupils (Newton, 2000)
- Teachers should ensure that pupils have the necessary information literacy and analytical skills (Osborne and Hennessy, 2003)
- Time saved through ICT needs to be used effectively (Newton, 2000)
- Training should be provided in a range of different ICT applications, with time for teachers to develop confidence by exploring them independently (Osborne and Hennessy, 2003)
- Laboratory design must allow ICT to be integrated safely and easily into practical work (Brown and Harper, 2003)
- Reliability and the provision of technical support are crucial (Osborne and Hennessy, 2003).

About Becta's 'What the Research Says…' series

This series of briefing papers is designed in particular for teachers, ICT co-ordinators and school managers, in order to provide an initial idea of the available research evidence for the use of Information and Communications Technology (ICT) in schools and colleges. We welcome feedback and suggestions for further titles in the series (contact details can be found at the end of this briefing).

Integrating ICT in science lessons – a case study

Until recently the science department at Clapton School in London made relatively little use of ICT. According to teacher Paul Drayton, the availability of new laptop computers has helped to change this.

Paul and his colleagues felt that taking pupils to the computer room made integrating ICT more difficult and the science content of a task less evident. Using laptops in the lab shifts the focus back to science.

"One surprising result was that ICT actually stimulated discussions between pupils and teacher," Paul says. "As they planned their investigations, pupils were willing to put forward and accept ideas, knowing that what was on the screen could easily be changed. This was true both for pupils working at a basic level and for those who needed some help to develop more sophisticated ideas. The spreadsheet allowed pupils and teachers to talk about which type of graph to use, what the graph might look like and what the effect of changing a value might be. With minimal encouragement, pupils would 'play' with numbers. It is hard to imagine doing this without the instant feedback provided by a spreadsheet."

Paul and his colleagues have found that even apparently simple uses of ICT can have unexpected benefits when they have been planned to meet a need in the science curriculum.

The full version of this article is available on the Virtual Teacher Centre [http://vtc.ngfl.gov.uk].

Explanation of findings

The use of ICT across the science curriculum is varied and, as with ICT more generally, its impact depends on the context and the ways in which it is used. Although it is often difficult to draw clear conclusions, some of the areas where ICT has been found to have positive effects are described below.

Enhancing practical work

Research indicates that ICT can play a major role in enhancing and extending practical work. Handheld computers, for example, offer new possibilities for collecting and analysing data in the field (Newton, 2000), while digital video can be used to capture processes that cannot be seen in real time (McFarlane and Sakellariou, 2002).

However, perhaps the most important application in supporting practical work is data logging. These tools – which record and store measurements electronically – collect data more quickly and accurately, improving the quality and quantity of results (Newton, 2000). Data logging increases not just efficiency but also flexibility, allowing data to be collected outside the lab or over extended periods (Osborne and Hennessy, 2003).

Exploring ideas

Combining data logging with graphing software makes it easier for pupils to present their data, which gives more time to explore and discuss the underlying concepts (Newton, 2000). This capacity of ICT to shift the focus of practical work from mechanical to analytical tasks is seen as a key advantage (McFarlane and Sakellariou, 2002).

While data logging and graphing tools reduce the mechanical aspects, simulations remove them completely. Studies suggest that by eliminating experimental error and increasing visual impact, simulations can improve scientific understanding (Huppert *et al.*, 2002; Trindade *et al.*, 2002). However, to realise their full potential, simulations need to be interactive: the capacity to make predictions, test hypotheses and receive instant feedback helps develop pupils' investigative and higher-order thinking skills (La Velle *et al.*, 2003). Girls in particular seem to benefit from their use, possibly because they offer a non-competitive environment in which to explore ideas (Huppert *et al.*, 2002).

Motivating pupils

A key problem in science is that many pupils lose interest in the subject as they progress through school (Murphy, 2003). Research suggests that ICT may help combat this by giving pupils more control over their learning and allowing them to study topics relevant to their own lives (Osborne and Collins, 2000).

While data logging and modelling tools give pupils a greater degree of choice, it is perhaps the use of the internet in project-based learning that has the greatest motivational potential (Mistler-Jackson and Songer, 2000). The internet gives pupils access to authentic data, enables them to collaborate with both peers and scientists, and ultimately allows them to make a contribution to 'real' science. Project-based learning also accommodates a wider range of abilities and learning styles (Dede, 2000). Using presentation technologies to then enable pupils to communicate their work to their peers both reinforces learning and raises self-confidence (Murphy, 2003).

Changing pedagogy

The effective use of ICT in science places considerable pedagogical demands on teachers. Teachers need to be clear on how a particular application will meet learning objectives (Thomas, 2001) and should be aware of its implications: for example, the 'sanitised' data produced by simulations may lead to misconceptions (Osborne and Hennessy, 2003). Similarly, pupils need information literacy skills so they can evaluate the evidence they find on the internet (Slotta and Linn, 2000).

Research suggests the key to making effective use of ICT is giving pupils more responsibility for their work (Newton, 2000). Teachers should therefore act as facilitators, guiding investigations and encouraging discussion. However, the science curriculum requires teachers to convey large amounts of content, a factor which remains a barrier to innovation (Osborne and Hennessy, 2003).

Key questions for schools

- Are teachers trained in both the technical and pedagogical aspects of a variety of ICT applications?
- Do teachers have access to ICT in science labs and teaching rooms?
- Is there sufficient technical support?

Key areas for further research

The literature on the use of ICT in science is extensive, covering a range of subjects, sectors and applications. It is international in nature, with significant studies coming from the UK, North America, the Far East and Australia. The sheer volume of material can make interpretation difficult, but fortunately there have been several recent literature reviews, notably those by Osborne and Hennessy (2003) and McFarlane and Sakellariou (2002).

Within the literature, certain technologies and age phases are better represented than others. While applications such as data logging are covered in reasonable depth, there is less evidence on newer technologies. Similarly, science in secondary schools is better represented than science in primary schools, though this may be because the primary science curriculum is relatively new.

Despite the extent of the literature, findings on the impact of ICT in science are still largely tentative. Even less clear is the exact nature of the pedagogies necessary to achieve these positive outcomes. There are signs, however, that researchers are increasingly aware of the need to define effective pedagogy and build models of good practice.

Key areas for further research

Although there is a considerable amount of literature on the use of ICT in science, certain aspects require further research, in particular:

- the use of ICT in primary science
- the interpretative and exploratory capabilities of ICT and the pedagogy required to exploit them
- newer types of ICT, such as tablet PCs and handheld computers
- attitudes of both pupils and teachers towards the use of ICT in science.

As with ICT in all subjects, research is also needed into the factors which either prevent or enable its effective use.

Becta advice for integrating ICT

Becta is working in partnership with the subject associations to provide support for the use of ICT in specific subjects. A series of termly, subject focused, online newsletters is available, along with a growing number of publications in a series which showcases a selection of quality web-based resources to support primary and secondary subject teachers. A wide range of face-to-face and online training events, focusing on integrating ICT into specific subjects, is also taking place. For more information on all of these activities visit the Becta ICT Advice website [http://www.ictadvice.org.uk/].

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Becta's ICT Research Network

If you're interested in research on the use of ICT in education, you can join Becta's ICT Research Network.

The ICT Research Network seeks to encourage the exchange of information in order to inform the national agenda and professional practice.

Membership is free and is open to:

- teachers
- ICT co-ordinators
- ICT advisors
- school managers
- researchers
- policy makers
- research sponsors
- industry.

The Network provides them with an opportunity to:

- exchange information on current research
- develop partnerships
- discuss priorities for further investigation
- focus research on issues of importance to practitioners and policy makers.

They can do this via:

- an email discussion list
- publications
- conferences and events.

More information on Becta's ICT Research Network can be found at:
www.becta.org.uk/research/ictrn
Alternatively, email: ictrn@becta.org.uk or write to: Michael Harris, ICT Research Network, Becta, Millburn Hill Road, Science Park, Coventry CV4 7JJ.

www.becta.org.uk/research

About Becta

Becta is the Government's lead agency for information and communications technology (ICT) in education and supports UK Government, national organisations, schools and colleges in the use and development of ICT in education to raise standards, widen access, improve skills and encourage effective management.

About the ICT in Schools Programme

The ICT in Schools Programme is the Government's key initiative to stimulate and support the use of information and communications technology (ICT) to improve standards and to encourage new ways of teaching and learning. The enormous potential of ICT means that for the first time it is becoming possible for each child to be educated in a way and at a pace which suits them, recognising that each is different, with different abilities, interests and needs. The challenge over the next four years will be to successfully embed ICT in every facet of teaching and learning where it can have a direct impact on raising standards of attainment. A vision for the future of ICT in schools can be found in the paper *Fulfilling the Potential – Transforming Teaching and Learning through ICT in Schools*, available on the DfES ICT in Schools website **http://www.dfes.gov.uk/ictinschools/publications/**

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