

What the research says about using ICT in Maths

This briefing is based on an analysis of available research about primary and secondary teachers' use of ICT in maths. It summarises the key findings and suggests resources for further reading.

Contents

Summary

The following key benefits have been identified from the research evidence:

- Greater collaboration between pupils
- An increased focus on strategies and interpretation
- Fast and accurate feedback to pupils using ICT
- Increased motivation amongst pupils.

Teachers can maximise the impact of ICT in maths teaching by:

- using ICT as a tool in working towards learning objectives
- developing a knowledge of the multimedia software available
- considering how to provide access to ICT resources for all
- incorporating the use of portable ICT equipment in teaching.

How ICT contributes to teaching and learning in maths

The availability of ICT has changed the nature of teaching and learning in maths. Calculators have become more advanced, allowing users to perform increasingly complex functions. A range of portable devices exists which allow pupils to collect data, and manipulate it using spreadsheets and databases. Multimedia software programs focus on specific units of study, bringing dynamic movement, sound and graphics to pupils' learning. Programmable toys or floor robots controlled by instructions in programming languages (usually Logo), were one of the earliest applications of ICT to maths, and where used, were the cause of significant changes in maths teaching.

Statutory requirements for the use of ICT in maths are enshrined in the National Curriculum, and include the effective use of calculators, production of charts and graphs, and work with geometrical shapes.

The TTA stresses the contribution that ICT can make to maths teaching in, for example:

- problem solving tasks
- practising of number skills
- exploring patterns and relationships.

There are many specific forms in which ICT may be used in maths teaching, including calculators, spreadsheets, databases and online, interactive resources. Certain benefits exist though, which are generic to the use of technology.

To judge just how ICT may enhance teaching and learning in maths, it is necessary to examine the available research evidence.

Becta
ICT Research

Key research evidence about ICT in maths

On the basis of Becta's analysis, the use of ICT in maths can have positive effects in the areas outlined below (there are references for further reading supplied alongside the findings).

General benefits

- Receiving instant feedback from computer programs when trying out ideas, encourages pupils to use conjecture and to keep exploring (Clements, 2000)
- Using the technology to carry out the manual labour of computations or drawing, frees the student to focus on strategies, and encourages a process of trial and error (Jarrett, 1998; Ruthven and Hennessy, 2002)
- ICT-based tasks provide a focus for extended collaboration between pupils (Hudson, 1997)
- The interactive nature of multimedia software motivates pupils and leads to improved performance (Moseley *et al*., 1999)
- ICT-based tools provide pupils with an advanced communication capability, allowing them to use graphics, images and text together, to demonstrate their understanding of mathematical concepts (Jarrett, 1998)

Benefits of specific technologies

Graphic calculators and computerised graphing

- Technology speeds up the graphing process, freeing pupils to analyse and reflect on the relationships between data (Hennessy *et al.*, 2001)
- ICT has been shown to produce learning gains in graph interpretation amongst pupils (Hennessy, 2000)
- Data is easily re-sorted and reordered in different ways, which supports the exploring of problems (Clements, 2000)
- Pupils are guaranteed correct representations of their input data (Sivasubramaniam, 2000)

Logo

- Logo encourages pupils to develop problem-solving skills and to act on feedback (Yelland, 2003)
- Working with Logo leads to developing and enhanced social interaction between collaborating pupils (Yelland, 2003)
- The knowledge gained from using Logo can be transferred to other areas such as map reading (Sarama and Clements, 2001)
- Using Logo develops higher levels of mathematical thinking (Clements, 2000)
- Logo helps pupils to learn geometric concepts and related skills (Clements, 2000)

Specialist software

- Computer algebra systems (CAS) can improve pupils' skills in unaided algebra and its understanding (Hennessy *et al.*, 2001)
- Maths curriculum software has been shown to motivate both teachers and pupils, leading to a deeper understanding of the subject matter and enhanced learning opportunities (RM, 2001)
- Used in conjunction with an interactive whiteboard, software can be used in whole-class teaching to overcome pupils' apprehensions, to reward them, and let them demonstrate their ability (Richardson, 2002)
- Dynamic geometry systems (DGS) allow pupils to manipulate and measure shapes on screen, and have been shown to produce a higher level of learning among pupils (Clements, 2000)

Portables

- Pupils can participate in collecting or generating data for work in numeracy by using portable equipment (Moseley *et al.*, 1999)
- When pupils understand the context of the figures used in graphing, they are more likely to understand the relationships demonstrated between variables (McFarlane *et al.*, 1995)
- Portable equipment enables the study of maths to move out of the classroom and to incorporate fieldwork investigations (Jarrett, 1998)

Factors for effective use

- The most appropriate hardware, software, and support is available to teacher and pupils
- Pupils are equipped with ICT skills which are adequate to achieve the objectives set for them
- There is appropriate mediation by the teacher between pupils and computers, so that where pupils are expected to become active learners, the teacher provides support rather than direction
- Pupils are encouraged to take advantage of the automation of tasks and instant feedback by ICT, making use of conjecture and applying trial and error methods in their work
- Teachers are aware of the range of software available, and select programs to support particular learning skills
- On and off-computer time is balanced in accordance with learning needs
- Pupils with special needs have equal access to ICT through access devices.

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 maths lessons – a case study

ICT gives teachers the tools to allow pupils to perform complex tasks similar to those in the adult world. Year 10 pupils at Wrockwardine Wood School, Telford, combined maths, science and ICT in a recent modelling project. The computer made it possible for them to ask complicated 'What if…?' questions about the life of fish in an imaginary pond.

The topic of population ecology was chosen as it has so many interdependent variables.

Initially simple paper-based activities were completed, which started with basic number patterns for the fish and then moved on to more complex patterns, involving more variables, functions and graphs.

Next, powerful modelling software helped pupils explore a sophisticated set of 'What if…?' scenarios. The use of modelling techniques meant that the pupils could investigate a life-like situation using realistic numbers, and could immediately see the answers to their questions, as these appeared as graphs. They investigated the effects of birth and death rates, maturity and number of offspring on the population in the pond. Pupils learned how to develop a systematic method of enquiry, controlling variables rather than changing everything at once. "It was not very realistic to talk about one or two fish, but the computer used real numbers," remarked one pupil. "It seemed hard at first, but once you know what the buttons do, it's easy," said another.

This case study is also available on the ICT Advice website [www.ictadvice.org.uk/].

Explanation of findings

As with ICT more generally, direct causal effects are not always easily identifiable. Drawing clear conclusions on the effects of ICT from the range of research evidence and reports available can be problematic. There are a number of factors that limit effective comparisons, such as differences in sample sizes, methodologies and effects, and the extent and purpose of ICT use involved.

Collaboration between pupils

ICT seems to provide a focal point which encourages interaction between pupils, as well as between pupils and the technology itself. Goos (2001) found that the use of graphic calculators facilitated communication and the sharing of knowledge between pupils. It was both a stimulus and partner in discussions during group work. Pupils also shared their findings in a whole-class discussion using a data projector, and demonstrated further cooperation during the presentation, by co-ordinating use of the computer keyboard, projector, remote control and laser pen. As well as co-operating, pupils may also disagree more when using ICT, but they are likely to successfully resolve these disagreements, often by using ICT to prove a point (Clements, 2000). Hennessy (2001) describes how a graphic calculator was used in this way by pupils, to mediate during collaboration over a problem-solving activity. It provided an external reference point in discussions, a means for comparison of ideas which supported a highly productive investigation. Hudson (1997) investigated the use of a particular curriculum software package, and once again found a rich interaction occurring, both between pupils and with the software, under relatively unsupervised conditions, for much longer periods of time than had been achieved previously.

The use of portable technologies

Portable equipment is not necessarily used outside the classroom, it may be the means to integrate activities into maths lessons while pupils work in the classroom at their normal tables. Moseley (1999) reports the pleasure pupils feel in using portable equipment, and detailed case studies demonstrate how equipment may be used to capture data. Pupils themselves suggested activities, both inside and out in the playground, which were made feasible by the portable nature of the equipment. The generation of decimals in a context that they could understand (various timing activities), and subsequent examination of these numbers led to the teacher altering her expectations of what the whole class could achieve. A significant learning gain was demonstrated by completion of a standardised maths test.

Effect on teachers and their pedagogical beliefs

Collaboration between pupils using ICT clearly alters the nature of the classroom as relationships between pupils and teachers change. At times the teacher will be more of a leading team player than a sole dispenser of knowledge, and this may conflict with their pedagogical beliefs. Jarrett (1998) reports three changes among teachers using technology:

- Raised expectations of pupils
- A more student-centred approach to teaching
- Greater willingness to experiment.

This implies that ICT supports a constructivist pedagogy, where pupils use technology to explore and reach an understanding of mathematical concepts. Connell (1998) investigated the effect of the teacher's pedagogical beliefs on the effectiveness of ICT, comparing a classroom run along constructivist principles (where pupils were encouraged to explore and test) with one where the technology was used primarily as a presentational tool for pre-packaged material, more akin to a behaviourist approach. At the end of the study, pupils in the constructivist class showed a marked improvement relative to the other class, suggesting that it is necessary to align the philosophy of the classroom with the use of ICT.

Ruthven and Hennessy (2002) examined the pedagogical ideas behind maths teachers' use of ICT. What they found though, suggested that the opposition between constructivist and behaviourist philosophies is unhelpful in the UK context: teachers were using both approaches in their teaching, and finding them to be complementary. It was clear to teachers that the use of ICT was changing classroom conditions, but they accepted this, and welcomed the fact that it assisted the conducting of investigations by pupils. In doing this, it was assisting teachers to realise what was already established practice, more effectively. Certain aspects of ICT though (such as 'tinkering', where pupils used ICT to explore and manipulate results) were causing teachers to reconsider their practice, and to develop their pedagogical thinking.

Key questions for schools

- Are teachers inhibited by their lack of knowledge of hardware and software to support maths teaching?
- Are your ICT resources and infrastructure sufficient to support an increase in use?
- How will you measure the impact on pupils of using more ICT in maths?
- What other sources of advice and support are available?

Key areas for further research

Further research is needed to address the following questions:

- Are valuable manual skills being lost as pupils exploit the capabilities of ICT in calculations and graphing?
- What is the impact of computerised graphing on assessment?
- Is there a risk that variable access to ICT causes inequities in maths education?

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

About the research literature

A substantial body of research literature exists, from both the UK and US. There are also case studies and a large amount of anecdotal material. Most research concentrates on a specific technology however, such as data logging with portable computers, or the use of DGS. Further inquiry into the underlying pedagogy of the mathematics classroom is required, and consideration of how this is being affected by the use of technology. Researchers have welcomed the fact that ICT takes the manual labour away from tasks such as graphing, but ultimately will this make the subject harder, as pupils are expected to develop a higher order of thinking skills? Certain types of calculator have been allowed into the assessment process, and there is debate on the whole issue of how far the use of technology should be permitted to replace manual skills.

The extent of the research literature may lead one to believe that the use of ICT is more widespread than is actually the case: evidence from both Ofsted and the ImpaCT2 project (Harrison *et al.*, 2002; Ofsted, 2002) suggests that the use of ICT in maths is at a low level, and Ofsted reports that progress is slow. The evidence is there, however, to show the benefits of ICT, and much of it is relevant to schools in the UK. Schools have also received useful software under the National Numeracy Strategy, but according to Ofsted this has had little impact, and it may be that there has simply not been enough guidance on using it effectively (Ofsted, 2002).

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 in specific subjects, are also taking place. For more information on all of these activities, visit the Becta ICT Advice website [http://www.ictadvice.org.uk/].

Bibliography and further reading

The research referred to in this briefing represents a selection from the rapidly growing field of ICT research related to ICT and mathematics in particular, and should not be regarded as a definitive list of the 'most important' research in this area.

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This briefing and others in the 'What the Research Says' series can be found on the Becta Research website at: **www.becta.org.uk/research**

Becta's ICT Advice site provides further information, services and tools for those who use, implement and manage ICT in schools: **www.ictadvice.org.uk**

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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