2004 Report: ICT in schools – the impact of government initiatives

Secondary mathematics

HMI 2185

May 2004

Document reference number: HMI 2185

Web site: www.ofsted.gov.uk

Contents

Introduction

This report is based on subject-specific evidence from visits to secondary schools made as part of the inspection of the impact of government ICT initiatives between April 2002 and December 2003 and has been supplemented by evidence from other school visits where appropriate. This contributed to the main report, *ICT in schools*, which is available from the Ofsted publications centre (07002 637833) or via the Ofsted website (www.ofsted.gov.uk).

Main findings

- Despite significant government funding, the use of ICT to promote learning and progress in mathematics remains a relatively weak and underdeveloped aspect of provision.
- There is an unacceptably wide variation between schools in the use of ICT to enhance learning in mathematics. The best practice is excellent but it is not shared widely enough.
- The majority of mathematics teachers use ICT effectively outside the classroom in the preparation of teaching materials and in the analysis of data. A minority are still not confident even in this use of ICT and require further training.
- There are now many more good teaching ideas and applications from a range of sources. However, there needs to be better co-ordination and distribution of materials, ideas and resources if teachers are not to waste time searching for appropriate materials.
- Similarly, there is a good range of software available to support the teaching of mathematics but some schools need better guidance on selecting and utilising the software that best meets their needs.
- The most significant impact of ICT is when it is used to enable pupils to model, explore, analyse and refine mathematical ideas and reasoning.
- In the best practice, schools have made great strides in integrating the use of ICT into their lessons in a way that enhances learning and progress for pupils. In many schools, however, ICT activities are not written into the scheme of work and hence fail to occur consistently.
- In general, many schools make effective use of calculators but this is not always the case, even in sixth form lessons.
- Some New Opportunities Fund (NOF) training has been very successful but, more commonly, it has been ineffective in helping mathematics teachers make good use of ICT in classrooms.
- The leadership and management of ICT are very variable. Departments that are furthest forward reflect the vision and direction provided by the head of

department or the teacher responsible for ICT. Many others have not had ICT as a priority while implementing the Key Stage 3 Strategy because it was not a priority within the mathematics strand of the National Strategy.

- National Grid for Learning (NGfL) funding has had a significant effect on the availability of resources in a number of schools. Despite significant improvement in the provision of hardware resources, access to ICT facilities for mathematics departments in some schools and colleges remains inadequate. 'Mobile' technology, including graphing calculators and wireless laptops, is not used sufficiently to address such problems.

The impact of the initiatives

Teaching and learning in mathematics

The use of ICT to enhance teaching and learning, though improving, is not as effective as in many other subjects. Its use remains unsatisfactory in one school in three and is good or better in only a quarter of schools. These statistics are reflected in the sample of schools visited to inspect the impact of government initiatives in ICT.

Though there are many examples of good practice in the use of ICT to enhance teaching and learning, there are significant inconsistencies between schools, within mathematics departments, and for individual pupils.

In departments making good use of ICT, teachers typically demonstrate and model the application using a data projector or an interactive whiteboard, and use this as a focal point for whole-class discussion. In these schools, ICT may be used for the whole or part of a lesson, or by some pupils in a lesson, where and when it is appropriate. Pupils move naturally between ICT applications, and between ICT-based and other types of activity, far more than in less effective lessons.

The most effective mathematics lessons using ICT mix brief whole-class demonstrations with extended periods of individual or group work. Realistic but challenging time frames are set in which pupils have to complete discrete tasks focused on developing a secure understanding of the concepts being taught. The following was typical of such practice:

> *The lesson began with a short, purposeful introduction from the teacher, recapping the work from the last lesson on fractions of quantities and checking that pupils were able to convert improper fractions to mixed numbers. This was followed by a brief whole-class session, with the teacher asking a series of questions on fractions and pupils responding on mini-whiteboards. The teacher constantly sought explanation or justification and corrected errors. Ten minutes into the lesson, the class was put into groups of four and given a set of three fraction problems to solve as a group – good emphasis was placed on working together to agree and ensuring that all in the group could explain the solutions. Good use was made of the 'timer' set on the interactive whiteboard to count down to the time when pupils were required to give answers. The teacher then used an interesting strategy for checking answers – each group's problem was on a pre-prepared worksheet on the whiteboard; in turn, each group*

used an infrared tablet to demonstrate how they had solved each problem; pupils were clearly motivated by the use of ICT and were keen to show their answers and support their explanations when questioned or challenged by others in the class to justify their answers, for example having to show that 14/8 was the same as 1¾.

Some very good lessons are based on teaching ideas and applications from, for example, the Qualifications and Curriculum Authority (QCA), the Department for Education and Skills (DfES) via the Standards site and the British Educational Communications and Technology Agency (BECTA). The following successful lesson with Year 7 pupils was based on an idea from a subject association website. It was part of a unit of work on decimals and percentages. The lesson took place in the main computer suite containing an interactive whiteboard and sufficient computers for one per pupil. However, the teacher required some pupils to work in carefully chosen pairs.

The focus of the lesson was on developing pupils' understanding of decimal place value to 3 decimal places and beyond. It began with the use of a 'guess my number game' with pupils required to guess numbers between 0 and 10, to 1 decimal place, by systematic search. This task, a prepared interactive spreadsheet taken from an internet site and adapted by the teacher, engaged pupils' attention immediately with the more able progressing to the more challenging game (to 2 and 3 decimal places).

After a few minutes, the teacher made very good use of the whole-class display facility and an electronic number line with zoom capability, to discuss the placement of numbers with two and three decimal places. Several pupils came to the board to place specified numbers on the number line.

Pupils then returned to their computer and were challenged to place/order numbers to 1,2 and 3 decimal places; there was a selection of carefully graded activities to challenge pupils working at different levels; a group of the most able pupils soon moved on to creating their own problems, within the software, for others in their group to solve, using numbers to 4,5 and 6 decimal places.

The lesson concluded with a brief whole-class session where pupils were asked to explain why it was easy to 'fall into the trap' of thinking that, for example 1.3 is smaller than 1.25. Many were able to justify their explanation with appropriate reference to the interactive number line. The teacher finished by setting them the homework task of producing 10 pairs of decimals where the same 'mistakes' could arise.

In this lesson, the use of ICT enhanced the learning for many pupils because it provided the visual support for their learning, in the form of number lines, and gave them the opportunity to 'zoom in' and focus on the relative place value of particular digits.

Good teaching using ICT also takes place in ordinary mathematics classrooms, as in this Year 9 lesson where the teacher had a single laptop and data-projector:

The teacher captured the attention of the class with an informal discussion about when sets of data are connected and when they are not, using well-chosen examples on prepared slides. He followed up with some graphs illustrating correlation (on spreadsheet software), which he displayed on the board using the data-projector. Pupils were able to see how the graphs relate to the data. The teacher illustrated correlation by means of three diagrams – one showing good positive correlation, one

showing good negative correlation and one illustrating no correlation. Because of the well-managed and good-quality discussion, the teacher was able to assess effectively the pupils' understanding of the key ideas, and to judge the pace of the lesson well.

Pupils moved on to plotting scatter diagrams based on paired data, using questions from a worksheet. The teacher provided guidance but did not spoon-feed. Pupils were expected to work in pairs to examine the data, select appropriate scales, and plot the points. High expectations led to good responses; all pupils were involved and tried their best. The teacher monitored progress well, and gave good feedback individually. On occasions he called the group together briefly to give some collective feedback and ask specific questions.

Towards the end of the lesson, in further class discussion, the teacher's good questioning helped to focus on the key idea of best fit. Individual pupils come to the board to try their own lines of best fit on a set of projected scatter graphs. The prepared examples were well chosen so pupils understood that in some cases the line of best fit is easy to estimate, and in other cases, it is nearly impossible to estimate. The lesson had well-focused objectives, and the pupils, of below average prior attainment, achieved very well. They learned new skills, asked questions, and discussed their work in a sensible and mature way.

The ICT played a significant part in the lesson. The prepared graphs were helpful in giving high-quality illustrations of correlated data, and the computer enabled quick and easy switching from one diagram to another. The use of a wireless mouse meant that the teacher was not fixed to one spot, and could add more life to his delivery and management of the whole-class discussion.

In mathematics work, calculators are an obvious ICT tool. Many schools make effective use of calculators, but relatively few use graphing calculators to overcome the difficulties of access to school computer suites. The following high-ability Year 10 group were planning to sit General Certificate of Secondary Education (GCSE) in November of Year 11. They had spent the previous lesson rearranging equations, including completing the square. The lesson took place in a normal classroom where pupils each had access to a graphing calculator and the teacher had an overhead projector model for display purposes.

Following a brisk revision of the features of $y = mx + c$ pupils explored the effects of changes to the values the a,b,c in $y = ax^2 + bx + c$, starting with understanding different values of a in $y = ax^2$. The teacher maintained good pace with mini plenaries to discuss different points. This promoted good discussion about the impact of different changes and why this happens. The activity was very effective because of the active contribution of all pupils who used individual whiteboards to show sketches, providing the teacher with immediate feedback. He adjusted the pace and demand according to need. Expectations were high. For example, pupils were expected to factorise, e.g. $y = x^2 + 5x + 6$, complete the square and understand the features of intercepts and minimum point. A good, brisk plenary used a prepared set of four quadratic equations and four graphs that pupils had to match correctly, justifying their choice.

In contrast to such good use of calculators, poor practice typically involves inappropriate use by students for simple arithmetic. Many students are insufficiently familiar with graphing calculators and their functions.

Standards and achievement in mathematics

The effect of ICT on standards and achievement was judged to be significant in mathematics in over a third of schools visited. In a small minority, inappropriate use of ICT had a detrimental effect on standards and achievement. The most significant impact is when ICT is used to enable pupils to model mathematical ideas, explore effects of changes, critically analyse their own and others' work, discuss strengths and weaknesses of different strategies, suggest improvements and independently refine their methods and reasoning.

As in the following case study, many of the departments making very good use of ICT are also ones which are well managed and provide effective subject teaching and learning for their pupils. When pupils achieve well in these schools it is often not possible to establish a direct link between achievement levels and ICT use because several other factors have also contributed. However, the following was one of the most outstanding examples seen on the mathematics visits. Here, ICT was used effectively by all teachers and so had a pervasive impact on the way teachers teach and pupils learn mathematics. It was clear in these classrooms that the use of ICT enhanced pupils' learning and raised their achievement. Their context and approach are described in detail below in order to illustrate what can be achieved when ICT is appropriately integrated into the teaching and learning of mathematics.

Case Study

The school is smaller than many secondary schools, with approximately 750 students. It has a comprehensive intake with prior attainment in mathematics broadly in line with national averages. It has Technology College status and has secured significant additional funding through this route. Achievement in mathematics is very good and the progress of pupils is noticeable through both Key Stage 3 and Key Stage 4. The majority of pupils make at least two National Curriculum levels progress in mathematics during Key Stage 3 and a significant number achieve three levels higher than their entry levels at the start of Key Stage 3. GCSE attainment is high, with over 70% of pupils achieving grade A-C in mathematics compared to a national average below 50%. The evidence from the visit was that the use of ICT makes a measurable contribution to this achievement and the standards pupils attain.*

The school has a distinctive approach to continuing professional development based on coaching and peer observation and the mathematics department has a strong commitment to developing the use of ICT as part of this program. ICT capability is taught through subjects and the mathematics department's responsibility is to develop all pupils' ICT capability in relation to spreadsheet and modelling skills. They do so very effectively. They have access to very good resources to support this including:

- *all teachers have laptops that are in constant use for administration, progress tracking and teaching purposes*
- *most of the mathematics classrooms have an interactive whiteboard and data projector*
- *the department has a separate area with a suite of networked PCs; it also has access to the main computer suites through the usual booking system*
- *there are 20 wireless linked laptops available for classroom use.*

In mathematics lessons, teachers have high expectations and pupils respond well to their demands. The quality of teaching is good and pupils' motivation and attitudes to learning are very positive, resulting in pupils' high levels of self-belief. The very good use of ICT to enhance pupils' learning and attainment was seen in lessons as a significant contributory factor to the success of the department. In particular:

- *teachers' use of well-prepared multi-media presentations containing the lesson objectives, main teaching points and a range of problems for pupils to solve enabled the lessons to progress with very good pace and challenge*
- *in a wide range of topics, visual images were presented in order that they could be manipulated and the effects investigated; this enabled pupils to generalise, reason and hypothesise before testing out the results*
- *the interactive whiteboard and associated 'Activote' devices were used very effectively to check the group's understanding, enabling the teacher to correct any misconceptions before they became problematic*
- *pupils had their own electronic work folders for mathematics and often used their school email addresses to email work home and back again; many also took advantage of the facility to use the school's ICT suites during homework clubs*
- *mathematics staff have the prior attainment data on their laptops and make use of, for example, Key Stage 2 results, Cognitive Ability Tests (CATs) scores, to help them target work appropriately*
- *ICT has provided more variety and catered for a broader range of learning styles resulting in improved motivation.*

As well as supporting higher-level skills, standards are raised where skill practice software is used to support the learning of basic number skills and for highly focused examination revision. In the best of this practice, teachers select appropriate packages and pupils use these to clarify and consolidate their understanding of particular mathematical ideas.

Implementation in schools

Leadership and management

The leadership and management of ICT development in mathematics departments have improved since 2002. In the schools visited, although they remain unsatisfactory in one school in three, they are good or very good in almost half. In departments where the effect has been greatest there is almost always at least one influential member of the department with vision and ICT expertise, who has thought through the ways in which ICT can enhance teaching and learning. The following example was typical of the best practice:

> *Leadership of ICT in mathematics is very strong. There is an 'expert teacher' in the department who makes very good use of ICT and has now been given this responsibility within the department. There is a clear commitment to identifying appropriate places in the scheme of work, for each year group, where ICT most enhances the teaching and learning. Good-quality classroom activities are then chosen and modelled for teachers of each group. The teacher in charge has a very good vision of the potential of ICT, a clear overview of the necessary developments and a detailed understanding of staff development needs.*

As in the example above, the most effective use of ICT occurs where mandatory activities with clear mathematical aims and objectives are identified and planned for in schemes of work. Many schemes go no further than offering possible activities, and the extent and frequency of use with different groups depend very much on the interest and inclination of their teacher. Too often, pupils' ICT experience is not monitored to establish the impact on standards. It is therefore not surprising that departments are rarely able to say which ICT resources and types of teaching strategies were having the most impact. In order to allow them to do so, monitoring needs to be more rigorous and to focus on the impact of ICT on achievement, not just on quantity or frequency of use.

A related issue is the degree to which heads of department recognised the opportunity for developing ICT in mathematics as part of their response to the Key Stage 3 Strategy. Many did not, because they did not believe it to be a priority, initially, within the mathematics strand of the National Strategy.

Since 2002 there has also been a significant increase in mathematics departments in the use of ICT for assessment, recording and reporting. Many now use ICT effectively in the management and analysis of pupils' achievement. This usually includes the use of centralised systems to access baseline data and the use of records for tracking of pupils' progress, using the school's assessment management systems. Despite this,

electronic evidence rarely contributes to the recording and assessment of pupils' work in mathematics, even where ICT has been used extensively in a specific topic.

Staff development

Although the NOF training had some successes, for the overwhelming majority of mathematics teachers it did not meet their needs and has not therefore had any discernible effect on either the quality of mathematics teaching or on pupils' achievement.

The shortcomings most often identified are that providers offered insufficient subject-specific exemplification, and that training lacked an appropriate focus on specific aspects of the mathematics curriculum. Often the training relied too much on teachers' use of their own time. However, in most of the schools, including those where clear benefits of ICT use are yet to be felt, subsequent action taken by the school has improved the confidence and competence of staff. Such action includes the use of external courses focusing on ICT use for particular mathematics topics, or of ICT expertise already within the school. In-house training often provides the best opportunity to address the sensitivities and different starting points of teachers, based on a detailed analysis of the needs of the individuals.

Most mathematics teachers recognise that, as technology develops, it will continue to have an effect on the mathematics curriculum and its assessment. Keeping abreast of such developments and their potential for mathematics teaching is a major challenge with significant implications for the continuing professional development (CPD) of teachers. Successful schools have used a range of strategies to support CPD and share good practice including:

- organising practical workshops on the use of mathematics software applications such as graphing or dynamic geometry packages
- the involvement of groups of staff with particular expertise in planning specific units in the scheme of work
- trialing activities using ICT before deciding whether to incorporate them into the units of work for all groups
- ensuring that staff have time to try out the planned activities themselves, with opportunities for evaluation before using them with pupils
- the use of departmental meetings to model ICT activities that have identifiable benefits before agreeing which activities to incorporate in the schemes of work
- writing both pupils' and teachers' versions of any supporting materials for the planned units.

Resources and accommodation

NGfL funding has had a measurable effect on the provision of hardware in many of the mathematics departments visited. The 'Laptops for Teachers' scheme had a significant impact on improving access to ICT in over half of the schools visited, and a number of these schools had provided additional funding to enable all members of the mathematics department to have a laptop. In all these cases, good use was made of the laptops for the purposes of administration, accessing the internet, preparing resources and classroom activities.

In some schools, however, the benefits brought by increased funding and improved facilities have not necessarily filtered through to mathematics. In schools where access to rooms with ICT facilities is limited, it is difficult to integrate the uses of ICT seamlessly into the mathematics units of work for all teaching groups, particularly so where the unit relies heavily on the use of ICT. Some departments have successfully addressed this issue by making judicious use of hand-held technology such as graphing calculators while others use wireless laptops to good effect.

A number of schools have used a range of funding sources to purchase interactive whiteboards, in some cases together with associated software. Over half of the schools visited had at least one such board within the mathematics department. One of the best examples of such resource provision is in a specialist school where, in addition to reasonable access to the school's ICT suites, all eight mathematics classrooms are equipped with an interactive whiteboard, integral software, ceiling mounted data projector and networked PC. This equipment came with dedicated training for all mathematics staff. As a consequence, the staff are confident and enthusiastic users of the full range of facilities. They share worksheets and presentations freely across the team, providing a good exchange of ideas and commonality of activities for parallel teaching groups.

The availability of software to support the teaching of mathematics has improved since 2002. It was satisfactory in the majority of schools and good in almost half of the schools visited. In most schools there was a mixture of generic software and subject-specific packages. Most departments have good access to spreadsheets, databases, graph-plotting software, LOGO and to specific items of software to support skills learning. An increasing number of teachers are making more use of the internet but use of the powerful dynamic geometry or algebra software available remains more limited.

Though there is an extensive range of software available for mathematics, teachers report having difficulties deciding on the best materials to use for particular aspects of mathematics. Many felt that they needed more guidance in order to prioritise effectively.

Technical support is increasingly available to departments and the quality of this support is often good. The ready availability of a technician to mathematics departments almost invariably has a significant effect on improving teachers' confidence, the effective use of lesson time and, as a result, the quality of teaching and learning. In schools where technical support is insufficient, teachers often limit their ambitions for ICT work in mathematics classrooms

Other staff, such as Learning Support Assistants, are often effective users of skill development programs such as Independent Learning Systems. Where the use of these programs is carefully planned and targeted, such staff provide valuable support for pupils and monitor their progress carefully.