Erratum

Please note that there is an error in paragraph 11. $f(x) \rightarrow f(ax)$ results in a stretch of scale factor a in the x direction should read $f(x) \rightarrow f(ax)$ results in a stretch of scale factor 1/a in the x direction.

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ICT in Schools: Effect of government initiatives

Secondary Mathematics

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Office for Standards in Education
Alexandra House
33 Kingsway
London
WC2B 6SE

Telephone 020 7421 6800
Web site: www.ofsted.gov.uk

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ICT in Schools: Effect of government initiatives

Secondary Mathematics

1. This report is based on subject-specific evidence from secondary schools visits made as part of the inspection of government information and communication technology (ICT) initiatives between May and December 2001. This contributed to the main report, *ICT in Schools: Effect of government initiatives*, which is available from the OFSTED Publications Centre (07002 637833) or via the OFSTED web site (www.ofsted.gov.uk).

Effect of the initiatives

Teaching and learning

2. The effect of government ICT initiatives on the quality of teaching and learning in mathematics varies considerably among schools. Overall, good practice remains uncommon.

3. Many mathematics teachers are competent in their use of ICT outside the classroom. This is demonstrated in their constructive use of ICT in the preparation of teaching materials and in the management and analysis of pupils' achievement. For example, in one strong department:

> *All the department staff had good generic ICT skills. They used word-processing and the Internet to prepare worksheets and obtained ideas for use with pupils. They confidently used the school's ICT-based assessment and reporting systems. The computer in the department o*ffice is a well-used resource.

4. In some schools improvements in ICT resources within mathematics departments have had a discernible effect on teaching and learning. For example, in one school the recent purchase of new graphical calculators and a whole-class display had influenced how staff taught sequences. Similarly, in a school where access to computer suites had improved, whole-class use of graph-plotting software supported pupils' learning and increased their motivation.

> *Pupils in a Year 7 mixed-ability class in a computer suite were plotting a range of plane 2D shapes on Cartesian axes using graph-plotting software. This was the first occasion that the pupils had used this software. They were given the choice of plotting their shape in any one, or all, of the quadrants. The lesson started with a good initial discussion with the class to clarify how to write and plot co-ordinates in all four quadrants. The teacher gave clear instructions on how to use the software. The pupils worked in pairs and this helped to alleviate any initial difficulties with the software. Importantly, the pupils shared and discussed their ideas on how and where they might plot their co-ordinates. The teacher circulated to support and challenge pupils, enabling all to make good progress. The option of plotting in any quadrant helped to ensure that the task was accessible to all.*

5. In the above example, pupils benefited from using the software in various ways. For example they:

- visualized the shapes, identified their properties and looked for relationships between starting-points and other co-ordinates
- learned through non-judgemental computer feedback if their original ideas were correct
- explored ideas independently and learned through trial and improvement
- were continuously engaged in the process and made good progress in learning about the properties of shapes and plotting in all four quadrants.

6. However, good, consistent and progressive use of ICT in mathematics is found in only a small minority of schools. In around two thirds of mathematics departments some use is made of ICT, but not to the extent that it is an established part of the curriculum. Typically there is broadly sound use of ICT, for example: graphic calculators are used to explore relationships between functions and graphs; graph-plotting software is used to link co-ordinates and shapes; low attainers are motivated in consolidating angle ideas; and spreadsheets are used for algebraic modelling. The use of these applications, however, is not consistent across the department.

7. In the remaining one third of mathematics departments, there is very little use of ICT in lessons to promote pupils' learning. Here, teachers' planning and schemes of work often lack any reference to specific ICT applications, and pupils have difficulty recalling when they have used ICT in mathematics.

8. In the best practice, teachers know when and when not to use ICT to enhance teaching and learning in mathematics lessons. These more confident teachers provide evidence of use of ICT to support more effective learning in a number of areas of mathematics. For example, the fast generation of accurate line graphs by computer can support pupils' understanding of the links between graphs and number patterns.

9. The following example of a low-attaining Year 10 mathematics set demonstrates very good teaching and learning in a classroom well resourced with ICT.

> *In the first part of the lesson, a mental and oral starter used a 100 square (created by the teacher using a spreadsheet and projected onto an interactive whiteboard) to support mental addition and subtraction of two digit numbers. Pupils extended their number skills through good use of this large display. Pupils were asked to visualize and work out the numbers at different distances away from highlighted numbers on the grid. Effective use of visualization helped to improve number skills, for example with pupils asked to close their eyes after viewing an initial number on grid. The teacher's skilful questioning supported pupils if they had difficulties establishing the position and value of the 'shifted' number.*
>
> *The main part of the lesson involved pupils continuing with a GCSE coursework assignment: 'generating and describing simple integer, linear sequences using geometrical patterns as a context'. The teacher used a spreadsheet, projected onto the interactive whiteboard, to generate and explore the graphs of sequences, linking the shape and gradient of these with the number sequence. One pupil worked at the laptop, entering the data. After observing the demonstration the pupils entered their own data and plotted the graphs. These were printed off for inclusion in their GCSE coursework.*
>
> *The teacher made very good use of whole-class display to demonstrate how to enter data and select appropriate graphs for plotting their sequences. Excellent questioning established pupils' prior knowledge about spreadsheets. Whole-class display and the use of one of their sets of data for demonstration ensured that all pupils were involved. The teacher asked the pupils why*

the graph generated by the computer was a straight line. Some were able to explain that this was 'because the sequence/pattern goes up by the same amount'. Pupils were familiar with the spreadsheet application and quickly learned how to generate a range of graphs based on their data. AII pupils were fully engaged and involved throughout the lesson; they listened attentively during whole-class discussions and remained on task when working individually. Pupils displayed excellent attitudes and learned a lot, even though the level of their work was below that expected for their age.

10. The ICT use was efficient in this lesson because it enabled the pupils to generate several graphs quickly and accurately, a particularly important factor with this low-attaining group. This approach also improved their motivation. Some pupils noticed that their graphs had 'kinks' and used this fact to recheck their number sequences against the geometrical patterns. This immediate feedback provided by ICT enabled the pupils to review their work and correct the errors.

11. In the following example of a very good lesson, ICT is used inside and outside the classroom to enhance the teaching and learning for pupils in a high-attaining Year 11 set. The group worked on a module on transformations of graphs in a mathematics classroom with an interactive whiteboard, attached PC and projector. The homework set in the previous lesson had been to consider the effect of the following transformations on a selection of linear and quadratic functions:

$f(x) \rightarrow f(x+a)$ where a is a constant

$f(x) \rightarrow f(x) + a$ where a is a constant

*Pupils had been instructed to do the homework on either graphic calculators (usually their own) or the graph-plotting software (Omnigraph) on the school network (accessed through machines in the computer suites or the school library). The lesson started with the teacher checking that all pupils had been able to complete the homework tasks. In turn, a number of pupils were asked to come out to the whiteboard to demonstrate their solutions and their reasoning. They responded confidently to questions/queries f*rom other members of the group.

*The main part of the lesson involved pupils' in considering the effect of a number of other transformations given by the teacher. The pupils chose their own linear and/or quadratic grap*hs to convince themselves that:

$f(x) \rightarrow af(x)$ results in a stretch of scale factor a in the y direction

$f(x) \rightarrow f(ax)$ results in a stretch of scale factor a in the x direction

$f(x) \rightarrow -f(x)$ results in a reflection in the x-axis

$f(x) \rightarrow f(-x)$ results in a reflection in the y-axis

At regular intervals the teacher asked specific questions of targeted individuals to check on their understanding of what was happening with particular graphs. He asked some very high attaining pupils to consider whether the transformations would hold with graphs of trigonometric functions (for example: f(x)=3sinx and f(x)=sin3x).

By the end of this part of the lesson all the pupils were able to explain the transformations and make the correct connections between the related functions and the resulting graphs and transformations. A small number of pupils needed more practice and consolidation but were managing – aided by their use of ICT - to sustain the pace required by the teacher.

In the final 10 minutes of the lesson pupils confidently compiled a summary of their results in their notebook – including relevant examples of their choice – for their future reference/revision purposes. As was common practice in their maths lessons, each pupil compared notes with at

least one other member of the group to establish whether or not there were other aspects that they wished to include.

Overall, this was a very good lesson with effective use of ICT to enable pupils to develop a secure understanding of the mathematics being taught. There was good pace, high expectations and evidence of good progress in knowledge skills and understanding for most pupils. The class teacher was very clear about the role of ICT and its potential to enhance maths teaching and was fully familiar and confident with the graph-drawing software and the use of the interactive whiteboard.

12. The use of ICT in this lesson enhanced the learning for pupils because it:

- enabled the teacher to provide different levels of challenge for pupils according to their prior attainment
- allowed pupils to experiment with changing the functions and receive feedback showing the effects of these changes on the graphs
- was available beyond the lesson so pupils could decide if they wished to have more practice to consolidate their understanding or pursue the challenge further.

13. In contrast, although they know the general advantages of ICT use, many mathematics teachers remain unaware of the potential of specific software and tools: for example, the power of the data handling facilities on graphical calculators or the facility of graph plotting software to transform general shapes. They are less able to employ ICT to meet the different needs of pupils, and because of weak planning are more liable to be drawn in to teaching ICT skills to the detriment of the mathematics which the ICT is intended to support.

Pupils' achievement

14. Pupils' knowledge and understanding of mathematics can be enhanced through ICT applications such as the use of dynamic geometry packages, graph-plotting packages, graphical calculators and spreadsheets. For example, in GCSE coursework investigations, pupils can explore ideas quickly and efficiently, as illustrated by the common optimisation problem:

The polygon-fencing problem involved a fixed perimeter and increasing numbers of sides. Some pupils used a spreadsheet to formulate and explore areas enclosed for increasing numbers of sides and to plot their results, with relative ease, and noting how the area approached a limiting value. Those carrying out calculations by hand and scientific calculator tended not to include the idea of a limit in their work.

15. In their work on shape, space and measures pupils often make some use of the programming language, LOGO, or a variety of small programs. Occasionally, LOGO is used to contribute to other areas of mathematical learning, for example to pupils' understanding of external angles of polygons. In one good lesson on angles, software was used that generated a range of angles for pupils to estimate. Pupils made good progress because the ICT activity was mixed with relevant practical work and discussion:

A good initial discussion to review acute, obtuse and reflex angles was followed by a practical task of using a protractor and ruler to construct angles accurately. There was good class management of this difficult low-attaining group. The move on to the 'Angles' program helped maintain interest and consolidate understanding of angle. The use of ICT provided a range of

challenges with rapid feedback on success. The teacher made good use of a plenary session to review what had been learned.

16. ICT is also being used to raise attainment where practice software is used to support the learning of key skills and for examination revision.

17. In the best practice, teachers see how ICT can be used to support the learning and raise the achievement of pupils of different levels of attainment. For example, low-attaining pupils are enabled to construct charts to represent data, while the progress of high-attaining pupils is enhanced by the use of the Internet to research Pythagorean triples. In such cases, too, effective teaching maintains a focus on mathematical objectives, without being distracted towards the teaching of ICT skills.

Implementation in schools

Management

18. The management of ICT developments within mathematics departments is generally weak. Where whole-school management of ICT is satisfactory or better, effective development planning for ICT in terms of overall curriculum, resources and staff development, tend to be reflected in the vision and direction provided by the head of department. However, most mathematics departments do not have ICT as a priority. In only about one in three of departments is ICT mentioned in subject development plans, despite the current initiatives such as NOF-funded training and NGfL. In nearly half, the leadership lacks a clear vision about how the use of ICT might develop and there are few strategies for monitoring and evaluating ICT work in the department. Recruiting difficulties, staff changes and the Key Stage 3 Strategy are generally seen as higher priorities than ICT.

19. In those departments with effective ICT leadership there is at least one teacher with enthusiasm for and expertise in ICT, who is able to support others, as illustrated in this example:

The head of department was enthusiastic, keen on using ICT in own her teaching and willing to share good practice with colleagues. She encouraged lesson observations, such as inviting colleagues to observe her use of the interactive whiteboard. She was well informed about how ICT was used within the department. There were regular informal discussions between colleagues about the effective use of ICT to support teaching and learning.

20. In another school:

The head of department actively encouraged all staff to use ICT and included such use as a regular item on the agenda at departmental meetings. He required teachers to provide feedback in these meetings following any ICT INSET or visit to other schools. Teachers planned the ICT together when they worked on common units and revised the materials in light of the outcomes. As a result, teachers developed a clear idea about effective use of ICT in the teaching and learning of mathematics.

21. More generally, the effect of ICT initiatives on the planned mathematics curriculum in schools is limited. Although most departments have been in the process of revising their schemes of work, in only one in three departments do the schemes refer to specific ICT applications.

22. Often in these schools, individual teachers make their own opportunities for ICT use. For example, in one school, individual teachers used spreadsheets and graph-plotting software to support pupils' learning even though this was not mentioned or required by the scheme of work. While such lessons are valuable, they tend to be isolated, and so fail to contribute to a coherent and progressive experience of ICT use in mathematics. At the other extreme, in a few schools the scheme of work has an unrealistic number of references to ICT, especially when taking the individual department's access to hardware into account. These mismatches between planning and practice further indicate why the use of ICT in mathematics is patchy.

23. ICT is used more often in mathematics departments for assessment, recording and reporting than to support teaching and learning in classrooms. The use of ICT has improved the management and analysis of pupils' achievements in mathematics. Although a few departments are at an early stage of computerised assessment records, in over one third there is good use of ICT for tracking pupils' progress, target-setting and the analysis of results. In some schools these have been built up over time and staff feel they have contributed to raising expectations and improving examination results. Good practice includes, for example, the recording of Key Stage 2 results, CAT scores, and coursework and target grades. Such data are easily accessible to staff, who are usually confident with spreadsheets, and provide them with a good overview of the progress of the pupils they teach.

Staff development

24. Some mathematics teachers and departments have improved their use of ICT as a result of the NOF-funded training. About one in three departments indicate that involvement in the training has raised awareness or provided motivation for development.

25. However, the overwhelming view of mathematics teachers is that the NOF-funded training has not met either their personal or pedagogical needs. In about two out of three schools there is little evidence that the training is yet having an effect on either the quality of mathematics teaching or on pupils' achievement. Teachers are frustrated by the lack of subject-specific focus in the training. In particular many teachers feel strongly that the training involves a daunting quantity of material and relies too much on teachers' own time. Some teachers feel that the training has been counter-productive, coming at a time of other key initiatives, especially the Key Stage 3 Strategy.

26. More positive features of staff development in mathematics often stem from ICT expertise already within the school. In a majority of schools, in-house training or other support has had a greater effect than NOF funded training.

Resources and accommodation

27. Improvements in recent years to the pupil to computer ratio have improved pupils access to hardware and software. In the schools visited, the overall pupil to computer ratio varied widely from about 3:1 to 15:1. Access to suitable resources is satisfactory or better in about four out of five mathematics departments. One of the best examples is illustrated in the following example:

Access and take-up by pupils are both very good; pupils have access to the computer suites and the library machines before school from 8.00am and after school until 5.30pm. There is also a Saturday morning computer club available each week. Many pupils use these facilities whenever they need them and only experience problems of access during the peak GCSE/A/AS examination revision times when older pupils are on study leave.

28. The quantity and quality of ICT resources within mathematics departments vary considerably. Many departments possess one or more computers and a set of graphical calculators, but often these are old and little used. A few do not have their own computers, while in others, the provision of a laptop has been the main contribution to developing the use of ICT in the teaching. The following description of a department's access to suitable ICT hardware is more typical:

There are sufficient computers in the school suite, but just one computer on a trolley for use in the mathematics rooms. This computer does not have the capacity to use the school network. Twelve very old graphical calculators are rarely used, although the department is planning to purchase a modern set and may also be equipped with one laptop from the NGfL budget.

29. In the small minority of schools where ICT resources and accommodation are very good, these have a favourable effect on achievement in mathematics. However, even where mathematics departments have their own computer rooms, their use is not always well planned and in several cases they are insufficiently used. For example, computers are often sited on surfaces alongside or at the rear of classrooms, or in corridor spaces. Few departments have effective plans for using these facilities. Also the layout of some computer rooms is unhelpful, especially when they lack a clear focal point for demonstration and whole-class teaching.

30. Although many schools have created additional networked rooms for general use, these do not lead to increased use by mathematics teachers. This can sometimes be attributed to factors beyond their control, such as the increased use of such rooms for teaching specific ICT and related courses, but it is also frequently due to weaknesses in department planning.

31. Pupils' access to a range of mathematics software also varies greatly. It is satisfactory or better in about four out of five schools and good in about one third. Most departments have good access to spreadsheets, graph-plotting software, LOGO and to specific items of software to support skills learning. Very good access is illustrated in the following example:

The use of the electronic whiteboard, the Internet and powerful software packages (dynamic geometry software, graph-plotters, spreadsheets) has broadened the range of resources available and opened up opportunities for more interactive teaching.

32. In general, however, very little use is currently made of the powerful dynamic geometry or algebra software available. Teachers are becoming aware and confident in using the Internet, often for their own preparation.

33. Technical support, where available, contributes much to the use and reliability of ICT resources. Technicians often play a key role in setting up networks so that mathematics lesson time is efficiently used, and in some situations they provide valuable practical support for pupils and teachers during lessons.