THE TRAINING IMPLICATIONS OF THE I.C.T. REVOLUTION ON SECONDARY MATHEMATICS IN THE UNITED KINGDOM

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CONTENTS

This presentation will be illustrated using images of:
- the effective use of classroom software,
- training sessions for mathematics teachers in Singapore, South Africa and UK.
- proposals for on-line training resources

APPENDICES (Handouts for delegates)

1. NEW OPPORTUNITIES AND CHALLENGE FOR THE SECONDARY MATHEMATICS TEACHER

Mathematics is possibly unique amongst school subjects: not only it is taught the world over, but school children in nearly every country learn much the same content. The language of delivery of course varies, but the written notation (certainly in the 'western' cultures) is mostly the same, and the opportunities presented by I.C.T. (Information and Communications Technology) are there to be shared by all.

Since the subject came into being, the dedicated enthusiasm of countless generations of teachers has educated the worlds' school children in the finer points of mathematics using no more than a piece of chalk – and this is how it still is in the majority of mathematics classrooms today.

A growing number of mathematics teachers are now beginning to discover what the I.C.T. revolution has to offer, not only in their own personal productivity, but as a teaching aid in the classroom. This paper aims to summarise some of the variety and sparkle that can be added to a lesson if the teacher is trained and has access to appropriate software and hardware. The corresponding visualisation of the subject can dramatically improve pupils' motivation - in particular it can open the eyes of the more reluctant pupils who regard Mathematics as a dreaded necessity!

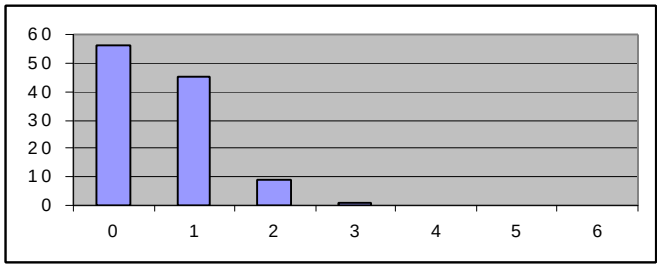
Profits	-101

Ticket	7	10	18	19	34	41

Prize	0

Lottery	2	4	34	35	36	41

Correct	Draws
0	56
1	45
2	9
3	1
4	0
5	0
6	0
Total	111



An example of a spreadsheet simulation of a series of national lottery draws: this visual approach is appealing and can illustrate the underlying principles of probability and chance (from the DISCUS project, University of Coventry, UK)

THE CHALLENGE

It is a major concern that the world's schools are becoming more and more polarised between those that have plenty of access to I.C.T., and those that have none. It is also the intention of this paper to explore what can be achieved in I.C.T. using modest resources, and to try to prioritise spending when budgets are inevitably tight.

Teachers who are fortunate enough to have new I.C.T. resources to hand are now faced with an embarrassment of riches. The challenge is to train teachers to select them carefully, and above all to use new methods sparingly. Many observers of computer-enabled classes are surprised at how little, but how effectively, the new methods are employed – the majority of a lesson is still undertaken by traditional means. The I.C.T. opportunity is easily wasted if mis-used or over-used.

2. IMPACT AND SCOPE OF NEW SOFTWARE IN THE SECONDARY MATHEMATICS CURRICULUM

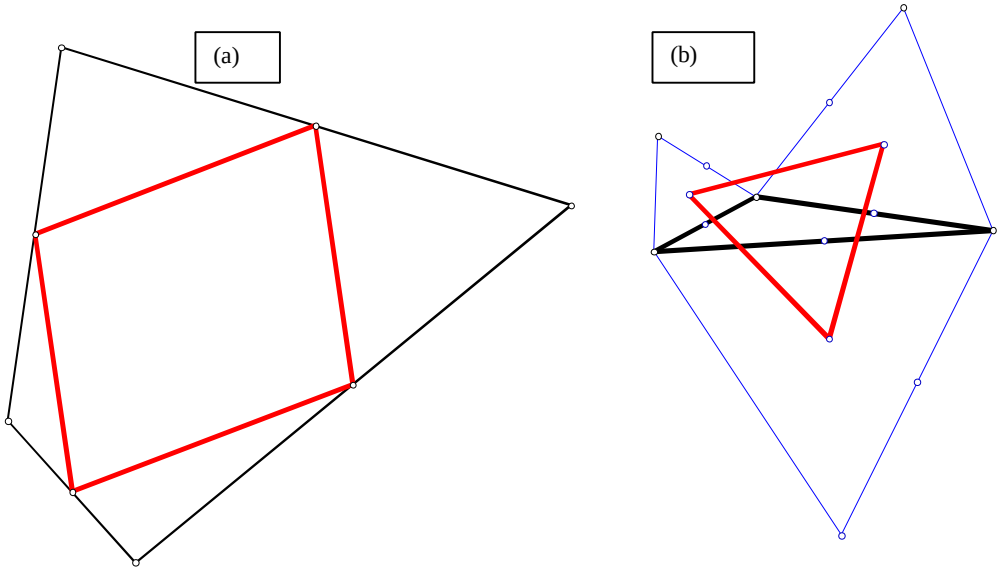
Mathematics has a rich source of new methods to draw on using I.C.T, possibly more than any other school subject. It is convenient to group them as follows, though inevitably there will be more and more overlap as the products evolve:

The Graph Plotter eg *Graphmatica, Autograph, Omnigraph, Coypu*
This is probably the most important software group: the graph plotter has great scope for visualising many of the basic concepts in mathematics. Also, this group is not expensive, and there are some very adequate plotters available for free down-load from the internet.

The Spreadsheet eg *Excel*
This important tool, designed for the business community, is now firmly established as a mathematical tool for schools. The ability to perform repetitive calculations and create graphs from data can give great satisfaction to pupils.

Statistical Analysis eg *DataDesk, Fathom, Minitab, Discus*
With the increasing occurrence of statistics in the world's school mathematics curricula, teachers can bring in 'real life' data from the internet and enliven their classes with computer-assisted analysis.

Dynamic Geometry eg *Geometer's Sketchpad, Cabri II, Geometry Inventor*
There is plenty of evidence that this visual approach to the teaching of a fundamentally visual subject is very popular, and pupils are motivated by this. However, the dynamic approach offered by the computer can very rarely substitute for a rigorous pencil-and-paper proof.



Two examples of dynamic geometry: (a) illustrating the theorem that the mid points of the sides of any quadrilateral form a parallelogram, and (b) Napoleon's Theorem (from Geometer's Sketchpad*).*

Mathematical DTP eg *Word (MS Equation Editor), MathCad*

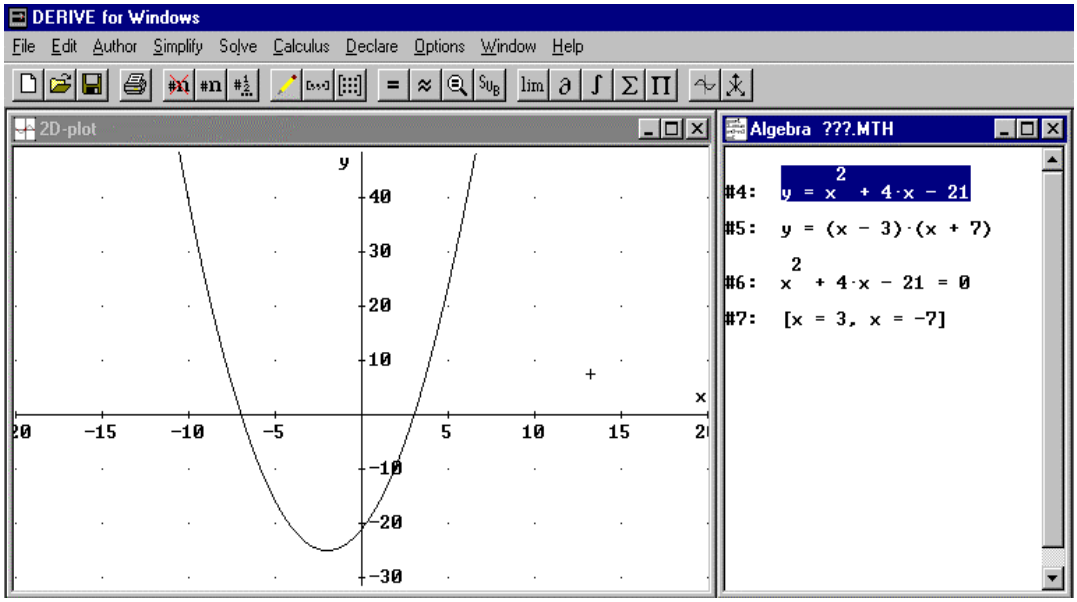
The simple way to type mathematics is to use a combination of superscript (for indices) and the standard symbols font (for various mathematical signs). For more complex expressions, the Equation editor that comes with *Word* is effective, creating an editable graphic of the formula.

CDs eg *Escher, Art and Mathematics, MathWise, TransMath*

This medium may prove to be short-lived as the Internet takes over, but in the meantime a number of important resources are available on CDs: eg Escher pictures and a growing number of CDs for revision, or for structured learning (known as 'Interactive Learning Systems').

Symbolic Algebra systems eg *Derive, MathView*

What is becoming clear from this category is that algebraic software can now *do* much of the mathematics that is taught in schools. The challenge therefore is increasingly not only *how* to teach the subject, but *what* to teach.



The use of an algebra window alongside a plotting window allows a symbolic algebra package to be
used to illustrate a number of properties of the standard factorisable quadratic (using Derive*)*

Hand-held calculators

These are getting cheaper and more powerful almost daily. So far solar-powered calculators are restricted to the small screen 'scientific' category. Graphic models can handle numerical, graphing, algebraic and statistical operations. Many calculators can connect to OHP pallets for class display. The disadvantages are the low resolution images and awkward keyboard entry.

The Internet, Email and Video-Conferencing

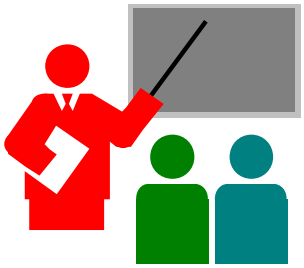
This category is the most significant development so far and easy warrants a paper in its own right. Mathematics is a global subject and there is already a huge bank of resources available to teachers from all over the world. Teachers need to learn how to find them, and how to incorporate data and graphics into their worksheets, and in their day-to-day teaching. Oundle School has made a good starting resource available on: http://www.argonet.co.uk/oundlesch/.

Email has a special potential, as teachers can use specialist discussion lists to contact other teachers and professional organisations.

The ability to send and receive pictures and sound over the internet is now a reality. The PC camera is cheap (or you can use a regular video camera); the communications software is very versatile and its free (*Net-Meeting* from Microsoft). This allows both parties to share a white board, chat line and any applications that one or other is running (eg a spreadsheet). We can now look forward to the prospect of affordable distance teaching.

3. THE IMPACT AND SCOPE OF NEW HARDWARE ON THE LEARNING ENVIRONMENT IN SECONDARY MATHEMATICS

WHOLE CLASS TEACHING



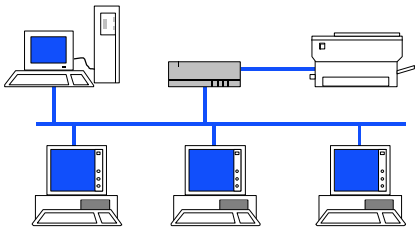
Whole-class instruction can now benefit from a dynamic new teaching environment using computer-generated images. To achieve an image that is large enough to be seen by the pupils, the options are:

(a) **a large TV** (with a suitable adapter) – the image is a bit grainy, but this is the most affordable solution, and has the surprising benefit of being able to write on the TV screen with an ordinary white-board marker.

(b) **a 'Cruiser' laptop –** this is a new concept: a high performance PC laptop with a detachable screen that then acts as an OHP pallet. The image is bright enough for most conditions, and a remote keyboard and mouse can be passed round the class for pupil input.

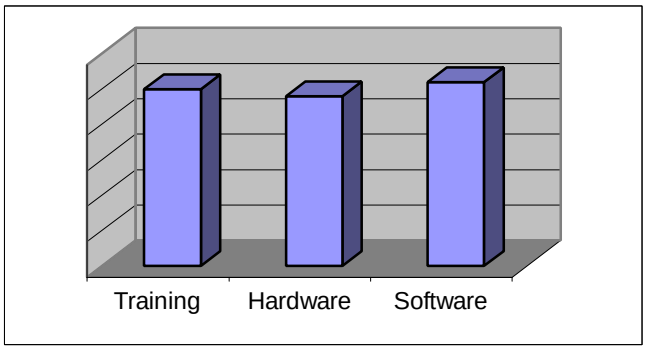
(c) **a computer projector** – ideal, but at the time of writing is still prohibitably expensive for schools. Ideally it should be ceiling mounted, shining onto a white writing surface. This avoids the glare that follows from projecting horizontally, and the teacher can also write on the image.

USING THE I.C.T. LABORATORY



With a classroom display system, the teacher remains in control, driving the pace. Taking a class to a lab needs careful thought, and the essential ingredient is the well-planned worksheet to ensure that the students benefit from a worthwhile learning experience. Pupil-controlled images add interest and there is scope for working with peers.

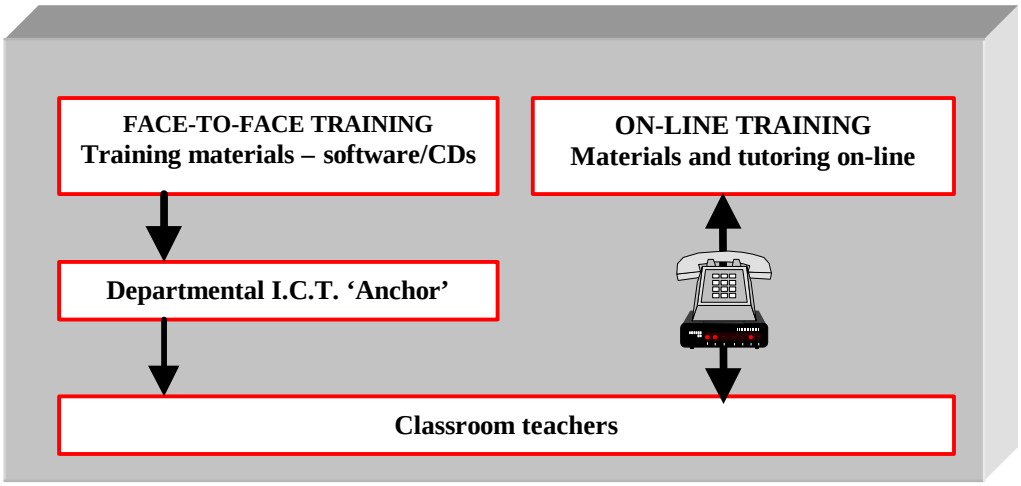
4. TRAINING STATEGIES FOR A SECONDARY MATHEMATICS DEPARTMENT



The first objectives are:

- To plan for an equal provision of the three essential ingredients: training, hardware and software. Lagging behind with any one will lead to opportunities in the other two being wasted: for example trained teachers with no I.C.T. support, or brand new equipment being ignored by teachers unaware of the possibilities. The most common error is to assume that funds are needed only for hardware and that somehow the other two will just happen!

- To convince school and curriculum managers that mathematics is a subject that can materially benefit from investment in I.C.T. Despite the many opportunities that will be obvious to the committed user, this objective can be difficult to achieve in the light of many centuries of successful teaching without them. Also without the informed backing of school Heads and Deputies, an I.C.T. departmental programme is likely to founder.



FACE-TO-FACE TRAINING

Within in each academic department a member of staff needs to be asked to act as an I.C.T. 'anchor'. This person will provide the leadership necessary to see a training programme launched and followed through in the department.

The 'anchor' would attend a regional training day, which would aim to cover an introduction to the general and subject specific skills. The format should be part presentation (when the trainer dictates the pace) and part hands-on workshop, with no more than 16 in the group. The departmental 'anchor' should be have the confidence to start using I.C.T. methods to improve personal productivity (word-processing and spreadsheets) and consider the following objectives:

- Review existing hardware and software provision in the department

- Review existing I.C.T. expertise within the department
- Recommend hardware and software purchases, probably a rolling programme over 2-3 years
- Advise over the integration of a departmental network with the school's networking plans
- Recommend which parts of the syllabus can benefit from I.C.T. methods
- Compose a 2-3 year training schedule for the rest of the department
- Indicate how I.C.T. can increase personal productivity using word-processing / spreadsheets
- Lay the foundations for a departmental intranet for electronic storage of resources.

This is a significant challenge even for an I.C.T. literate teacher.

ON-LINE TRAINING

Those schools that are fortunate enough to be able to send an 'anchor' teacher to a regional training day will have made a good start, but training must be on-going, and there is also the requirement to train the other members of the department. There can never be enough trainers for this 'face-to-face' approach, and the Internet offers a very practicable solution, requiring:

- teachers who are motivated to learn this way
- reasonably fast internet connectivity
- training materials of sufficient quality, and in the local language
- tutorial help on-line

TEACHER OWNERSHIP OF HARDWARE

It is important that any training programme that is devised for mathematics teachers includes the use of I.C.T. to help with their personal productivity. This should include word-processing for work-sheets, using email as a professional communications tool, and using the internet as a classroom resource, etc. Experience has shown that confidence with this technology cannot be really secure until a teacher owns a computer or has easy access to one at school and at home.

It should be a high priority in any I.C.T. Masterplan, to assist with a teacher purchase scheme (if there is a likelihood of the teachers being able to afford one). It is also likely that portable computers will get cheaper and more powerful.

Already mentioned is the 'Cruiser' laptop with detachable lid for whole-class teaching. If a school authority is encouraging teachers to own their own machines, this solution is attractive because it provides the classroom computer and display system all at once. The solution is also particularly appropriate for schools that do not have classrooms dedicated to mathematics.

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5. COST IMPLICATIONS OF TECHNOLOGY IN THE CURRICULUM

This has to be the most difficult area of this subject, with all three costs centres (training, software and hardware) wildly affected by local variations.

FACE-TO-FACE TRAINING
When any country starts to total up the man-hours of training required to bring even one teacher per school up to speed with the use of I.C.T. in the classroom, the figures immediately suggest a major investment in time and resources. One full day per 'anchor' teacher and at least 2 half-day follow-ups are recommended. The cost of training and supporting the trainers is also significant, especially as they are likely to be seconded from the classroom.

ON-LINE TRAINING
This would need to be set up by local governments, tailored to local needs, language, etc. The on-line tutors would need to be trained and in place.

PURCHASE OF SOFTWARE

There is an increasing availability of high quality software free of charge from the internet. The list includes Graph Plotters, a Dynamic Geometry package and a large number of 'Java' internet applications that can be down-loaded quite legally. These are obviously not as polished as the commercial applications, but represent a good start for a cash-starved mathematics department.

Of the commercial products, a graph plotter, a word-processor, a spreadsheet and possibly a dynamic geometry package should be the first items to go for. The unit cost can be reduced considerably by buying site licences.

PURCHASE OF HARDWARE
With so many schools in the world struggling to find the most basic of resources it will be useful first of all to consider what you can achieve with the bare minimum, and progress from there:

1. No electricity
- wind-up technology is here, and able to power simple computers such as the Apple E-mate.
- solar powered devices are not yet powerful enough to perform more than simple calculations.
- mobile power units that generate electricity to run a small network have been trialled.

2. No telephone connection
- the only feasible way to connect to the internet without a land-line is through a satellite connection. With the internet having such enormous potential in remote areas, it is likely that this method of connectivity will be a priority for the local educational technology planners.

3. Just old computers and no funds to upgrade
- there is a surprising amount that mathematics teachers can achieve with old equipment (say 286- and 386-DOS computers). A number of important mathematical products were sufficiently well developed before the advent of *Windows* that their early DOS versions are still useful and still available. In particular *Excel* (spreadsheet), *Derive* (symbolic algebra) and *Cabri Geometre* (dynamic geometry).

4. With a school network in place
- The network is the backbone of I.C.T. success, with it resources and applications can be shared round the community. Another significant development is a networking tool that will allow older computers to sit on a modern network and act as 'dumb terminals' (or 'thin clients'). The picture is only just becoming clear, but the implications for under-resourced schools are obvious: the hardware that sits on the end of a network is likely to get cheaper and cheaper.

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6. CONCLUSIONS

The main concern with I.C.T. in schools is that there is a serious likelihood of scarce resources being wasted on software and hardware that is inappropriately used or not used at all. Everyone is clamouring for computers and far too many are being installed in schools throughout the world without due thought for their use.

The hardware that delivers the software is certain to change, and become more and more affordable, especially when connected to a network. It is also likely that the comparatively inexpensive calculators and palm-top categories will gradually close the performance gap to provide rich learning tools for pupils to use in the classroom.

Mathematics is fortunate – there are many obvious advantages to using I.C.T. methods in the teaching and learning process, and this is not the case in many school subjects. However obvious the advantages may be, the training of teachers to put them into practice is vital.

What is now clearly needed is an international initiative to set up a programme for training the trainers, and at the same time a parallel initiative to put these training resources on the internet so they can be made available to all.