

“Motivating mathematics teachers to use ICT through training”  
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This paper will argue that mathematics teachers need as much help with ICT issues out of the classroom as in, and will discuss the TSM (Technology for Secondary/College Mathematics) model which always mixes courses on ‘productivity’ tools with sessions on dynamic software. Only with increased confidence in both preparing lessons and delivering them can teachers be motivated to make ICT work for them.

TSM Workshops<sup>(1)</sup> have been taking place since 1994 with an increasingly international team of tutors, either at Oundle School, or on the premises of schools and colleges in the UK and abroad. The aim of the workshop is to help those mathematics teachers who want to use ICT in their work, but who generally:

1. have little idea how to create mathematical expressions in *Word*
2. have little idea how to use the *Drawing Toolbar* to create mathematical diagrams
3. lack confidence in finding and incorporating effective web resources into their lesson plans using hyperlinks
4. are generally mystified by the mathematical possibilities of *Excel*, and are certainly worried when it appears to go wrong
5. lack confidence in planning lessons that incorporate dynamic software.

Experience from these workshops suggests that these skills should be part of the ICT toolkit for all mathematics teachers, both in their initial training and as part of their on-going in-service training. With this in mind, a 3-hour summary of these ideas has been presented successfully for the past few years at a number of PGCE Teacher Training courses in England.

There is of course a clear difference between presenting these ideas to teachers, however attentive they may be, and conducting a hands-on workshop. Even half-day or whole day courses can leave the teachers confused and overwhelmed, and asking for more time to practise. With this background, the 3-day residential TSM workshop<sup>(1)</sup> was born and is now in its fourth year.

In this paper I outline the contents of the workshops, and touch on some evidence of meeting this need.

## 1. Mathematical expressions in Word

Making *Word* mathematically friendly is a popular strand in the TSM workshops, starting with customizing the toolbar to include icons for useful actions:



Ask teachers to put ‘ $\pi$ ’ into a document and many will want to use the *Symbol* font; some will want to use the *Equation Editor*. The TSM approach is to introduce teachers to the *Unicode* font extensions which can produce a wide variety of single-line expressions, and which are, importantly, also font-independent:

$$\begin{array}{ll} \text{eg: } y = x\sqrt{1 - x^2} & y = \pi \pm \sin^{-1}(\frac{1}{2}x) \\ y = e^{\sin^2 x} & \int \sin^2 \theta d\theta = \int \frac{1}{2}(1 - \cos 2\theta) d\theta = \frac{1}{2}\theta - \frac{1}{4} \sin 2\theta + c \\ \chi^2 \sim N(\mu, \sigma^2) & \int \sin^2 \theta \cos \theta d\theta = \frac{1}{3} \sin^3 \theta + c \end{array}$$

Teachers are also shown how to make simple keyboard short-cuts for popular symbols such as  $\sqrt{\quad}$  and  $\sum$ . These short-cuts are saved with the toolbar settings in the “normal” template settings, so teachers who work on networks that have “roaming profiles” can enjoy the facilities of this template throughout their institution, For example ALT-P can be used to enter ‘ $\pi$ ’ in whatever font they may be using.

The very useful off-keyboard, but sub-Unicode, characters for ‘squared’, ‘cubed’ and ‘minus’, amongst others, allow quadratic and cubic equations to be entered trivially and without superscripts. These can be entered not only in *Word* but in any other environment, including HTML:

$$\text{eg: } y = x^3 - 2x^2 + 1$$

and teachers are shown how to use the ALT-0XXX shortcuts on the keyboard keypad for characters such as  $^{\circ}$ ,  $\pm$ ,  $^2$ ,  $^3$ ,  $-$ ,  $\text{€}$ ,  $\bullet$ ,  $\frac{1}{2}$  and  $\div$ .

The *Equation Editor*, [or *MathType* <sup>(2)</sup>], produces graphics, not text, and is best used when one-line expressions fail, eg:  $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$  and  $s^2 = \frac{1}{n} \sum fx^2 - \bar{x}^2$ .

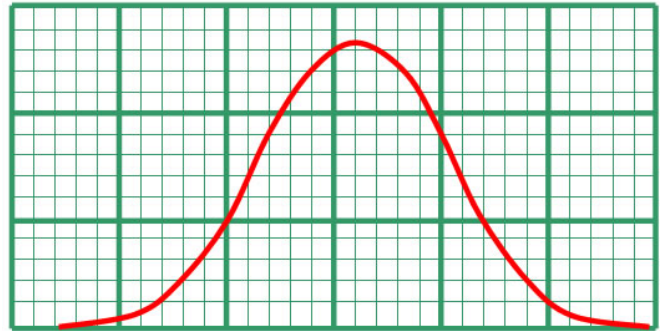
Teachers are often surprised how quickly they can master this, enabling them to enter professional looking expressions, including ‘proper’ fractions, eg  $7\frac{2}{3}$ .

All equation objects are (at first) placed as ‘in-line with text’ objects, and can therefore be given simple shortcuts in the “Tools” => “Autocorrect” feature in *Word* (eg ‘sd’ to enter the variance formula above, or ‘2/3’ to enter  $\frac{2}{3}$ ).

## 2. Mathematical Diagrams in Word

The drawing toolbar offers many possibilities for the creation of mathematically correct diagrams, including regular polygons, and shapes.

A few special tricks are popular, and are quickly picked up, including the judicious use of Shift and Ctrl. The scribble tool (using Bezier fitting) and the undocumented Ctrl-D which performs intelligent duplication (eg to create the graph paper) always give pleasure.



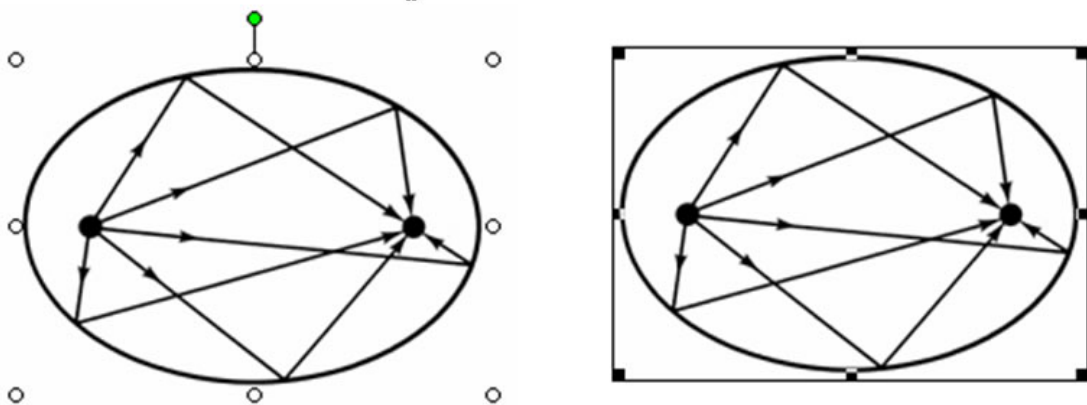
Teachers who are discovering how to create expressions and diagrams this way are now able to generate high quality worksheets, and can be highly motivated by this.

## 3. Finding and incorporating effective web resources

To accompany the TSM workshops, an extensive site of carefully researched web resources has been assembled at

<http://www.tsm-resources.com>

Firstly, teachers are shown how easy it is to copy and paste images from a web page into a resource they are creating in *Word*. Most mathematical documents in Word are likely to be a mix of text and graphics, and it is unfortunate that many teachers do not know how to control such a mix. The TSM courses prioritise understanding of how to manipulate images, using the “Picture” toolbar, together with the concept of “in-line with text” and other wrapping options.



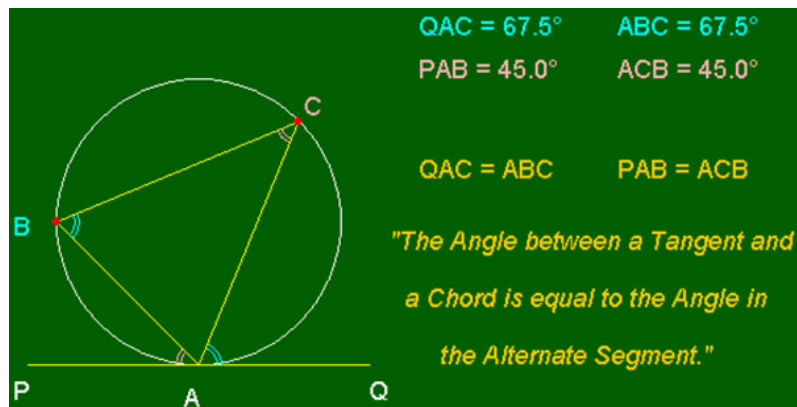
*Two selected graphics in Word: ‘floating’, allowing wrapping (left) and ‘in-line-with-text’ (right). This, incidentally, is a good example of a web resource that can show how mathematics is applied to different areas: here the properties of the ellipse can be used in non-invasive surgery, using an elliptical mirror to focus the radiation<sup>(3)</sup>.*

Of all academic disciplines, Mathematics has by far the broadest selection of ICT tools to add a sparkle to lessons, including many and varied opportunities to bring the rich history of the subject seamlessly and entertainingly into the classroom.

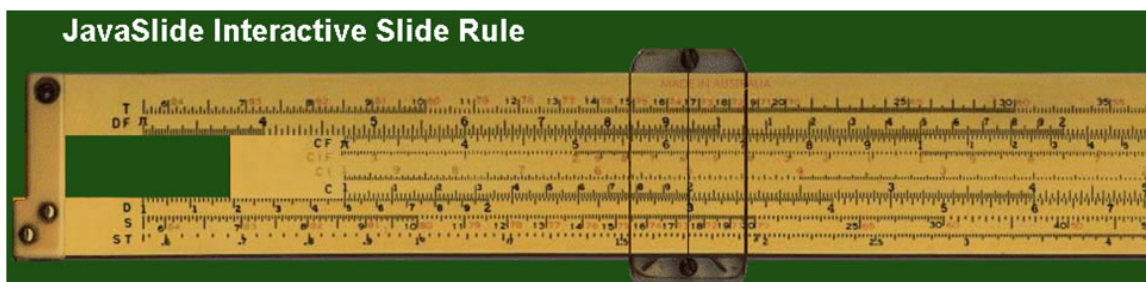


*The map from the “Who drives on the left” web site <sup>(4)</sup>. This offers an excellent example of a set of data with a huge number of outliers (all in India!)*

There are two main types of web site: ‘passive’ (like the example above, and the NRIC’s amazingly useful ‘PLUS Mathematics’ magazine <sup>(5)</sup>) and ‘active’. Active sites mainly use Java applets, offering teachers a safe taste of dynamic software which will always work, but which usually has a limited objective.



*One of the suite of “Waldo” Java Applets from Ron Barrow <sup>(6)</sup>. Here the Alternat Segment Theorem can be animated by moving ‘B’ or ‘C’*



*A lesson on logarithms can be brought to life with a Java-based slide rule <sup>(7)</sup>*

### Working off-line:

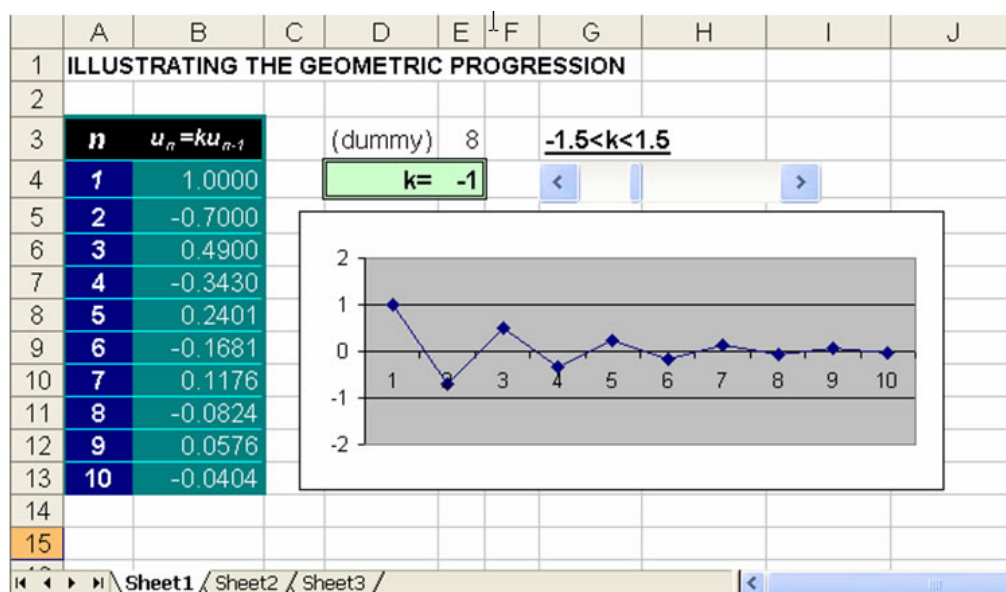
Many teachers seem unaware that web sites are automatically saved in the folder ‘Temporary Internet Files’ on their hard drive. There are two main advantages for the classroom teacher to run previously visited web resources ‘off-line’ in the classroom:

- Lessons can incorporate the intended sites. No others will run while working off-line, thus avoiding the temptation to surf away from the lesson plan!
- Off-line web sites load instantly since they are coming straight off the hard drive. This avoids any possible network delays which would otherwise spoil a lesson.

### 4. The mathematical possibilities of Excel

TSM courses always include a section on spreadsheets, trying to help teachers to realise the potential of putting *Excel* to work for them. Initially some of the pitfalls are pointed out, conscious of the damage they can do to a teacher’s confidence:

- *Excel* does not know about Degrees, forcing the use of the RADIANS key word.
- *Excel* only works to 15 decimal places, so avoid setting it higher (eg to display  $\pi$ !)
- Formula results can be truncated, eg in the next example: ‘k’ should be  $-0.7$ !



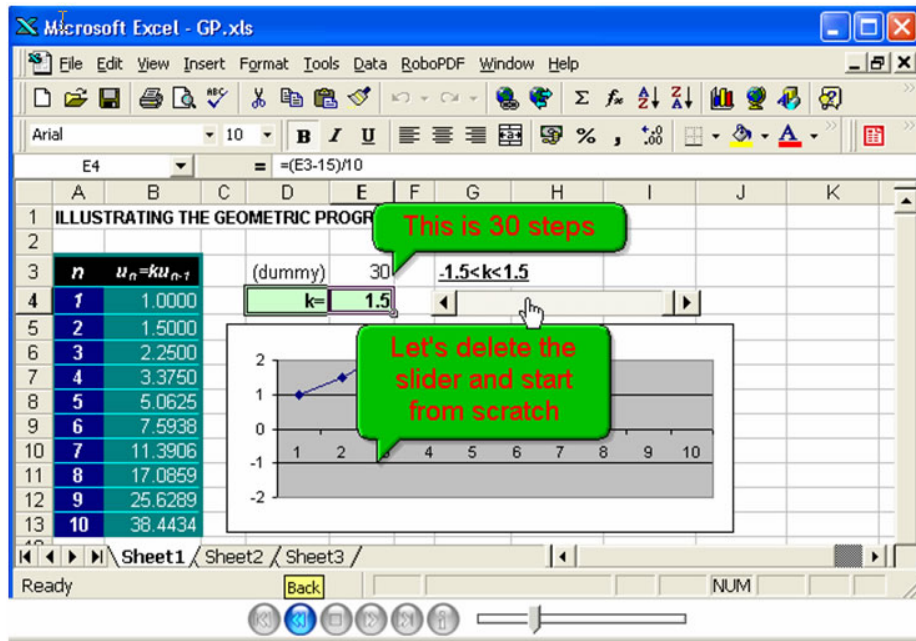
TSM Courses usually include *Excel* topics at different levels, but for the beginners the following are often included:

- creating series
- elementary statistics (including random sorting)
- how to set up a Slider Bar (as in the above illustration of a GP).

Invariably teachers will forget a detail from earlier in the session. With this in mind, a number of Flash Tutorials have been created (eg on “How to add a Slider Bar in *Excel*”), using the excellent discrete recording software *Turbo Demo*<sup>(7)</sup>, and placed on the associated TSM page “Useful Files for Mathematics Teaching”:

<http://www.tsm-resources.com/useful-files.html>





*In a Turbo Demo tutorial, the creator can place instructions and comments during the editing process. Playback controls allow users to stop, start and re-play. The result has been “authored once” for “learning anywhere”.*

## 5. Planning lessons that incorporate dynamic software

TSM courses also discuss which technology works best, and the benefits of using ICT in a whole-class situation. For example, teachers might be invited to discuss the technology along the following lines:

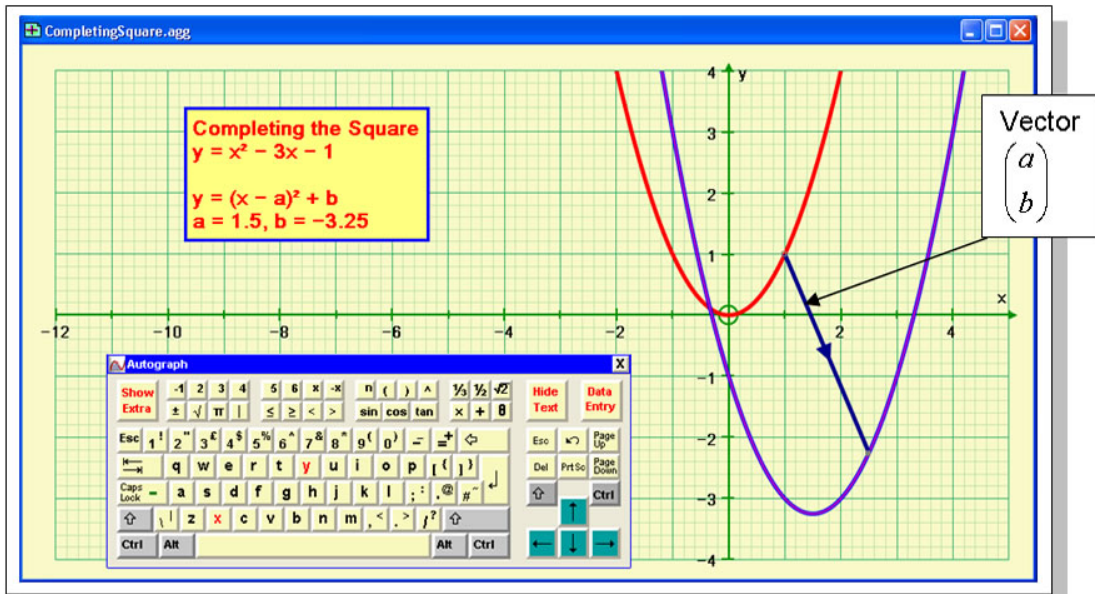
- fixed (ceiling-mounted) data projectors: many now regard these as a tool of the trade, and they are becoming at the same time brighter and more affordable. Bulb replacements though remain a serious budget cost.
- interactive whiteboards (IBW): these can add many effective ‘tactile’ opportunities both for pupils and teachers
- the emerging use of the Tablet laptop: this could supplant the IWB as it solves the problem of the awkward shadow, the teacher being ‘in the way’ and also in some sense ‘trapped’ at the front. With the Tablet the ICT elements of a lesson can be run from anywhere in the room. However the essential wireless link to the projector is still rather slow, preventing videos and fast animations from working.
- voting tools, and Bluetooth long-range mice: these form part of an ever growing list of possibilities for the ICT driven classroom.

Teachers might also consider how to conduct the lessons along the following lines:

- a need to ensure that the pupils are fully engaged and not in any sense just watching a ‘show’
- a sensible balance to be struck to ensure a variety of approaches, and to be absolutely sure that what excites you as the teacher also excites the pupils.

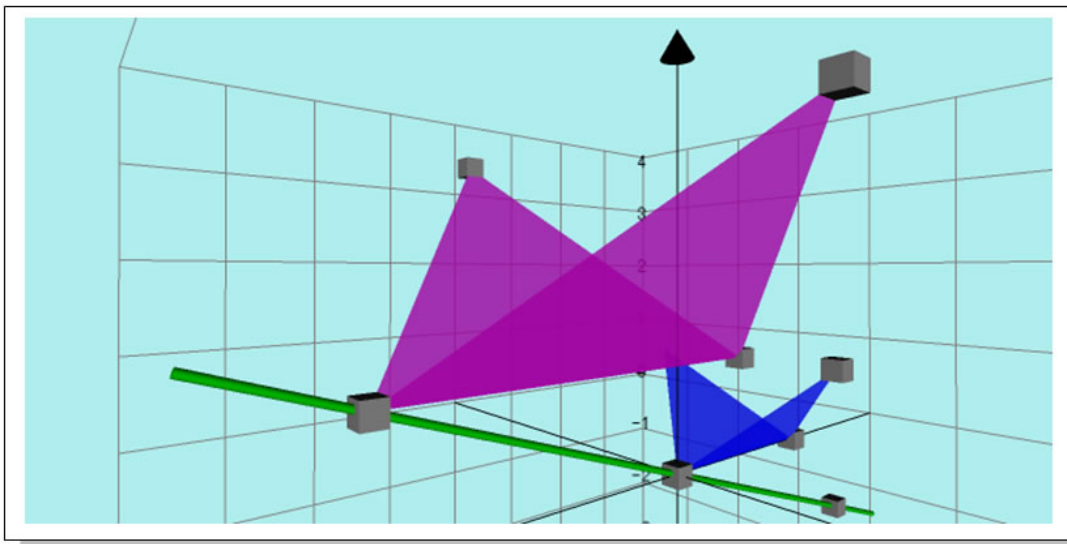
To help with planning lessons which incorporate moving images, TSM offers courses on *Sketchpad*, *Cabri* and *Autograph* to show how basic concepts can be covered more effectively. It is not easy to represent this dynamic approach in a static paper, so readers are invited to look at the Turbo Demo tutorials given on

<http://www.tsm-resources.com/useful-files.html>

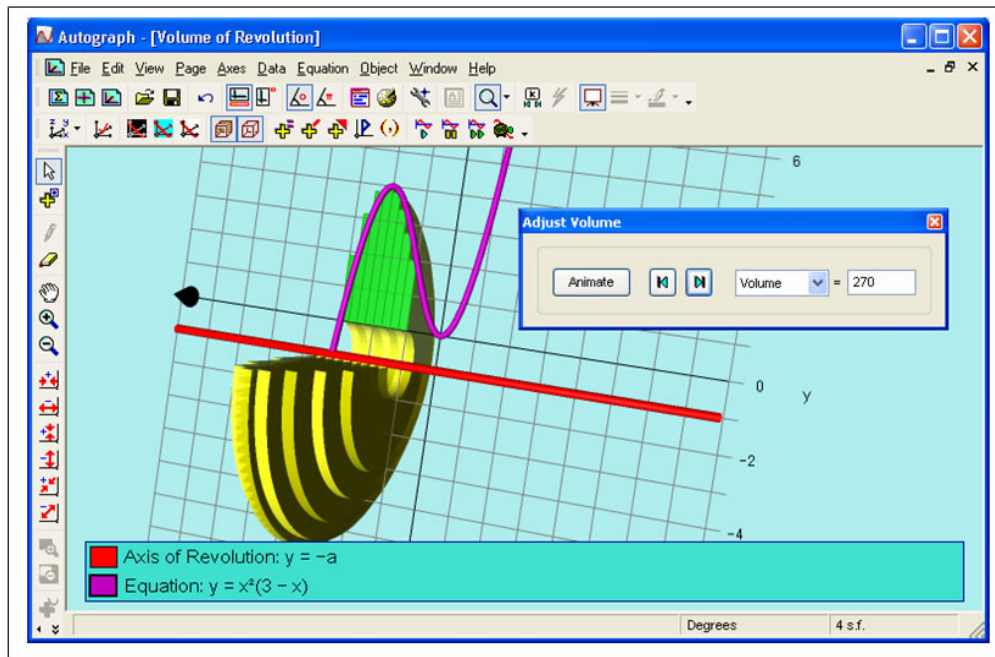


Here 'Completing the Square', which is usually exclusively an algebraic topic, is given a coordinate geometry treatment, showing dynamically that the process is equivalent to a translation of  $y = x^2$  by the vector  $[a, b]$ .

Note the Autograph<sup>(9)</sup> **on-screen keyboard** designed with its own Unicode font for mathematical use on an IWB.



While studying enlargement in 2D, why not extend to 3D? Here is a simplification of the image used at the start of most sci-fi movies where a space station moves towards, and past the camera.



*Many mathematics topics have been dropped from main-stream post 16 teaching because they were hard to visualise, and just at a time when technology is enabling students to make sense of them. 'Volume of Revolution' is a good example of this, along with most of the 3D coordinate geometry syllabus.*

## Conclusion

The TSM training programme has evolved over that last 10 years to address the needs of the mathematics teacher who is intrigued by all the technology and wants to gain the confidence to put it into practice. Feedback from teachers has been very positive, particularly from those who are using ICT methods in their teaching for the first time.

This can only really be achieved by hands-on workshops that last more than one or two days. This of course has important and far-reaching consequences on the funding available for regular and on-going INSET time for teachers.

Douglas Butler,  
Oundle, July 2005

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## References:

- (1) TSM Workshop: <http://www.tsm-resources.com/July05.html>
- (2) MathType: <http://www.mathtype.com/>
- (3) Conics website: <http://ccins.camosun.bc.ca/%7Ejbritton/jbconics.htm>
- (4) Who Drives on the Left: [http://www.tsm-resources.com/left/Which side of the road do they drive on.htm](http://www.tsm-resources.com/left/Which%20side%20of%20the%20road%20do%20they%20drive%20on.htm)
- (5) NRICH PLUS Magazine: <http://pass.maths.org.uk/>
- (6) Waldo's Java Applets: <http://www.waldomaths.com/>
- (7) Java Slide Rule: <http://www.taswegian.com/SRTP/javaslide/javaslide.html>
- (8) Turbo Demo Tutorials: <http://www.turbodemo.com>
- (9) Autograph software: <http://www.autograph-maths.com>