How to motivate teachers to want to use technology

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Abstract: 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.

Introduction

TSM Workshops[(1)] 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 workshops 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*, even more so now that the interface for MS Office 2007 is so different.

2. have little idea how to use Word's *Drawing* facilities to create accurate and realistic 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 was born, and it is now in its seventh sell-out year!

This paper will outline the contents of the workshops, and touch on some evidence which supports the need for the workshops to last for more than a day.

1. Mathematical expressions in Word

Making *Word* mathematically friendly is a popular strand in the TSM workshops. The sessions often starts with asking the teachers to put 'π' into a document. 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:

eg: $\mathbf{y = x\sqrt{(1 - x^2)}}$ $\mathbf{y = \pi \pm \sin^{-1}(\frac{1}{2}x)}$

$\mathbf{y = e^{\sin^2 x}}$ $\mathbf{\int \sin^2\theta d\theta = \int \frac{1}{2}(1 - \cos 2\theta)d\theta = \frac{1}{2}\theta - \frac{1}{4}\sin 2\theta + c}$

$\mathbf{\chi^2 \sim N(\mu, \sigma^2)}$ $\mathbf{\int \sin^2\theta\cos\theta d\theta = \frac{1}{3}\sin^3\theta + c}$

Teachers are also shown how to make use of the on-screen keyboard that is supplied with Autograph[(2)], which allows users to enter a wide variety of mathematical symbols as text.

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, not only in Word but in any other environment, including HTML:

eg: $y = x^3 - 2x^2 + 1$

and teachers are shown how to use the ALT-0xxx shortcuts on the keyboard keypad for characters:

eg: °, ±, ², ³, –, €, •, ½ and ÷.

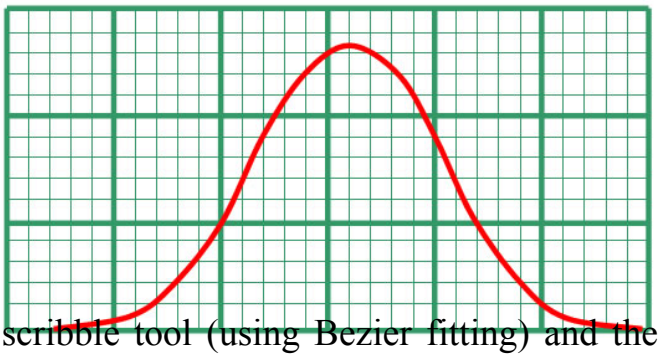
The *Equation Editor,* produces graphics, not text, and is best used when one-line expressions fail,

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 "Autocorrect" feature in Word (eg 'var' to enter the variance formula above, or '2/3' to enter $\frac{2}{3}$).

2. Mathematical Diagrams in Word



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

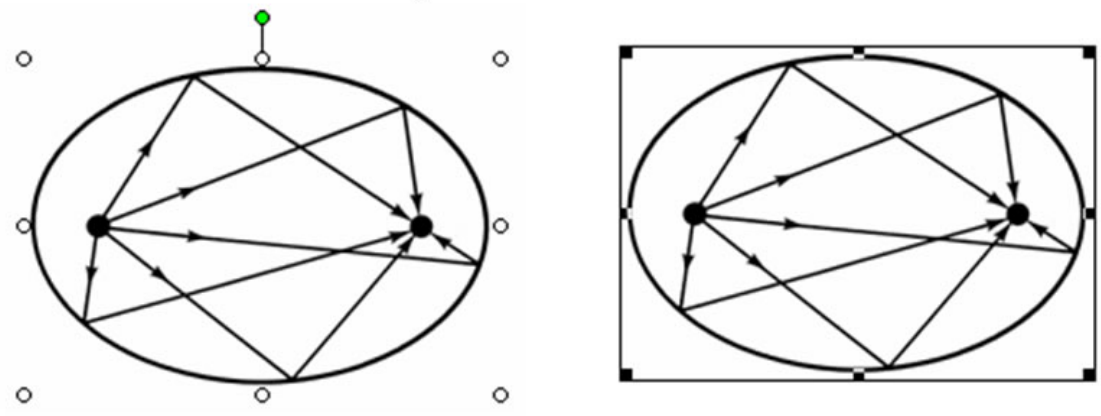
A few special tricks are popular, and are quickly picked up, including the judicious use of Shift and Ctrl. The scribble tool (using Bezier fitting) and the undocumented Ctrl-D which performs intelligent duplication (eg to create the graph paper) always give pleasure to most teachers.

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

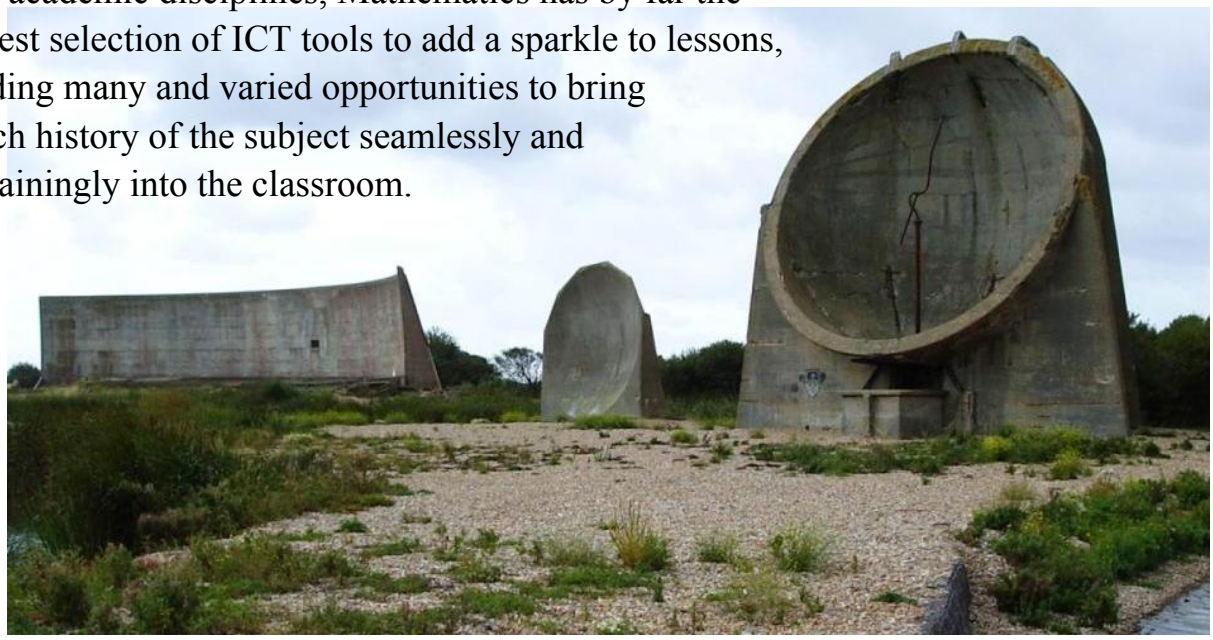
To accompany the TSM workshops, an extensive site of carefully researched web resources has been assembled at the TSM-Resources web site [(3).]

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 emphasise the importance of how to manipulate images, using the "Picture" controls, together with the concept of "in-line with text" and other wrapping options.



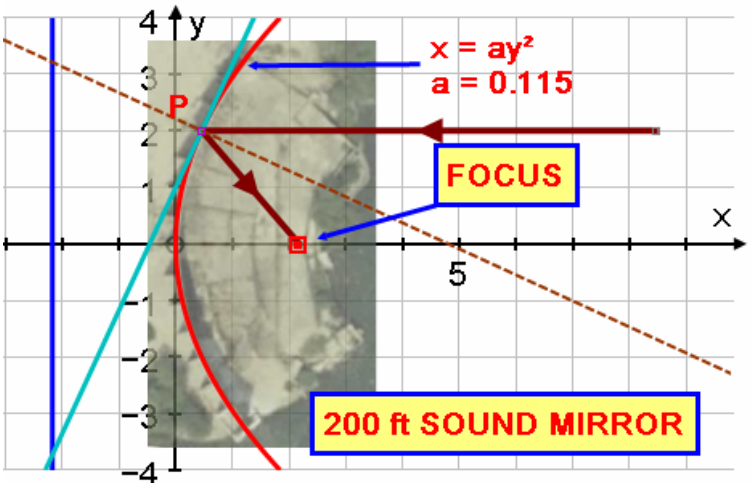
Two selected graphics in Word: 'floating', allowing wrapping (left) and 'in-line-with- text' (right). This, incidentally, is a good example of a web resource that can show how mathematics is applied to different areas: here the properties of the ellipse can be used in non-invasive surgery, using an elliptical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

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.

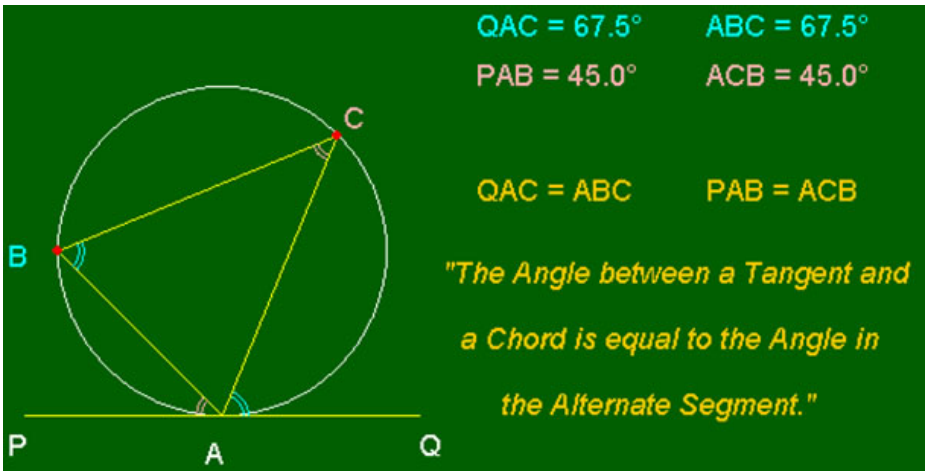


New tools such as Flash Earth[4] enable large, mathematically interesting objects to be studied easily.

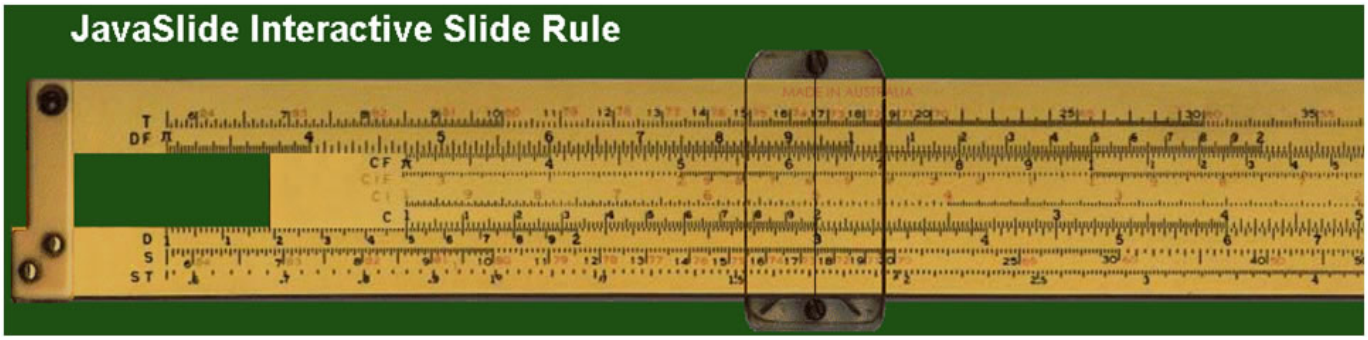
Illustrated here is one of the two remaining giant concrete mirrors (used as pre-radar aircraft detection), which can be shown to have a parabolic surface, and its focus found.



There are two main types of web site: 'passive' (like the example above, and the NRICH's amazing PLUS Mathematics magazine [5]) 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. 'YouTube' videos[6] are also a great source of material, and even a place where pupil's serious work can be lodged.



One of the suite of "Waldo" Java Applets from Ron Barrow [7]
Here the Alternate Segment Theorem can be animated by moving 'B' or 'C'

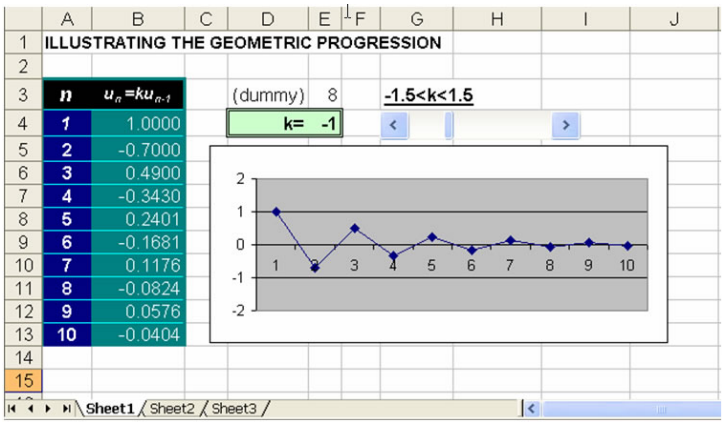


A lesson on logarithms can be brought to life with a Java-based slide rule [8].

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 π!)
- Formula results can be truncated, eg in the next example, 'k' should be –0.7!



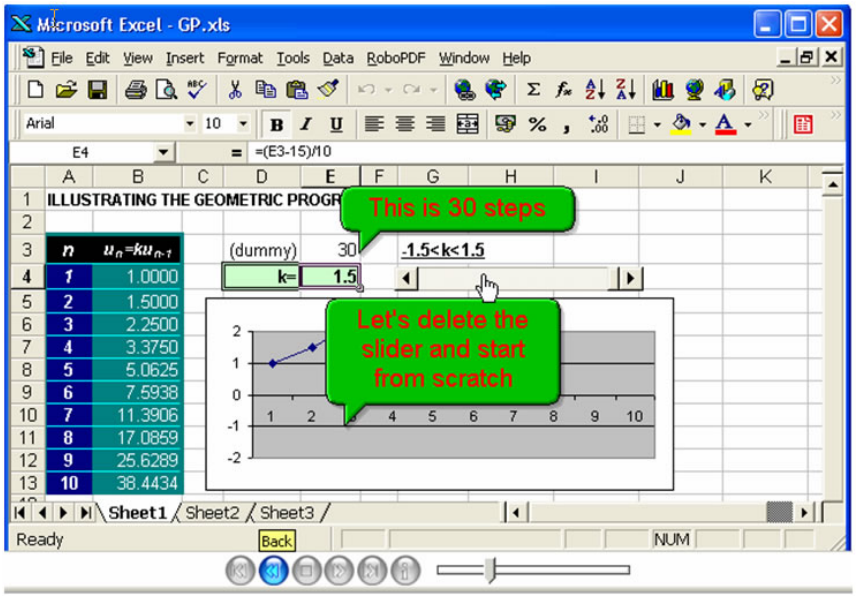
TSM Courses usually include *Excel* topics at different levels, but for the beginners the following are often included:

- creating series
- elementary statistics (including random sorting)
- how to set up a Slider Bar in Excel (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*[10], and placed on the associated TSM page "Useful Files for Mathematics Teaching" [11].

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 is "authored once" for "learning anywhere".



5. Hardware considerations for ICT-driven teaching

TSM courses also discuss which technology works best, and the benefits of using ICT in a whole-class situation. For example teachers are invited to discuss the relative merits of:

- 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 PC laptop and also the Bluetooth Tablet slate: either of these could supplant the IWB as they solve the problem of the awkward shadow, the teacher being 'in the way' and also in some sense 'trapped' at the front.

With the Tablet or slate the ICT elements of a lesson can be run from anywhere in the room. However with the Tablet PC the essential wireless link to the projector is still rather slow, preventing videos and fast animations from working.

6. Procedural considerations for ICT-driven teaching

Teachers also need to consider how to conduct the lessons including ICT in a way that excites and motivates the students.

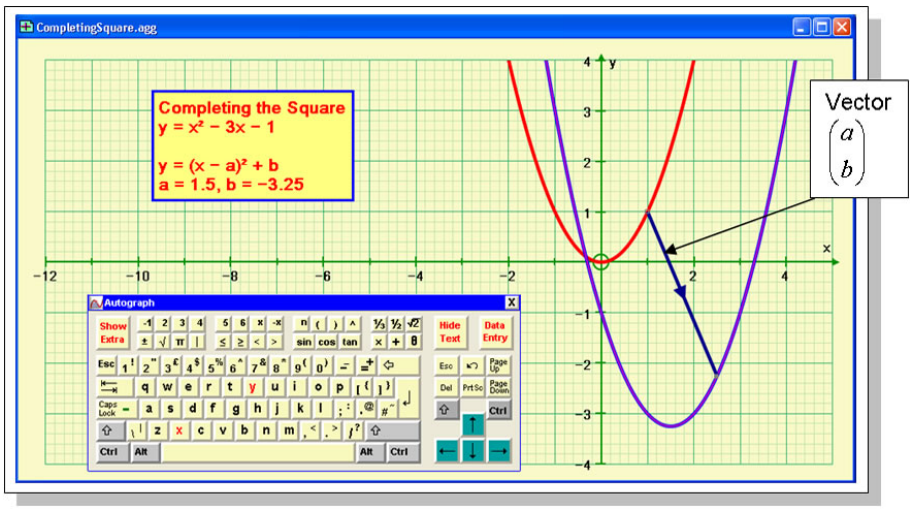
(a) There a need to ensure that the pupils are fully engaged and not in any sense just watching a 'show'

(b) Ideally for every step in which ICT is involved, the teacher needs to try to get the students to PREDICTED what is about to happen. This way they are involved at each stage, and become curious to see what the outcome will be.

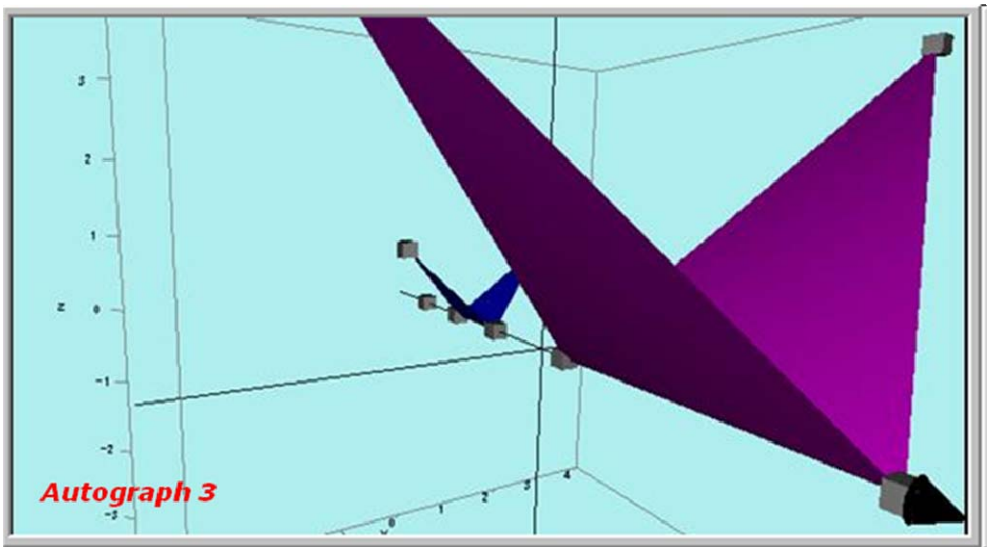
To help with planning lessons which incorporate dynamic images, TSM offers courses on *Sketchpad*, *Cabri* and *Autograph* to show how basic concepts can be covered more effectively. It is not easy to represent this dynamic approach in a static paper, so readers are invited to look at the Turbo Demo tutorials given on the TSM "Useful Files" page [(11)].

It is also important to ensure that a variety of approaches is adopted, and to be absolutely sure that what excites *you* as the teacher also excites the pupils.

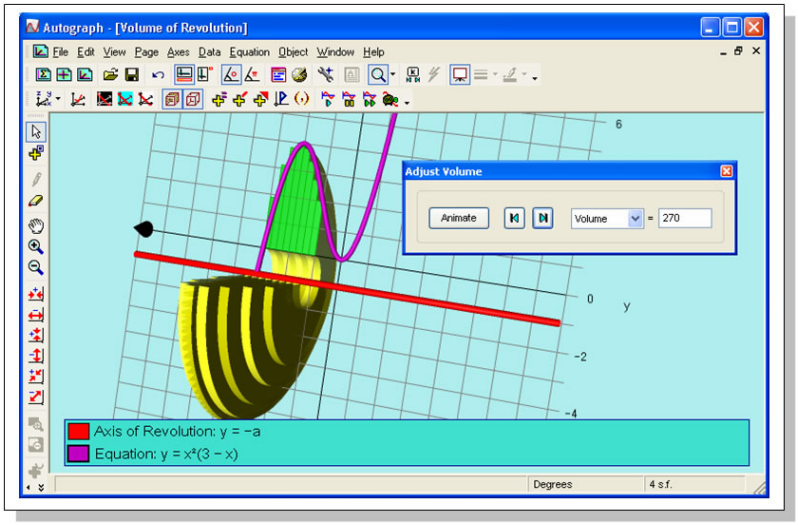
7. Some examples of lesson ideas using dynamic software



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



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.

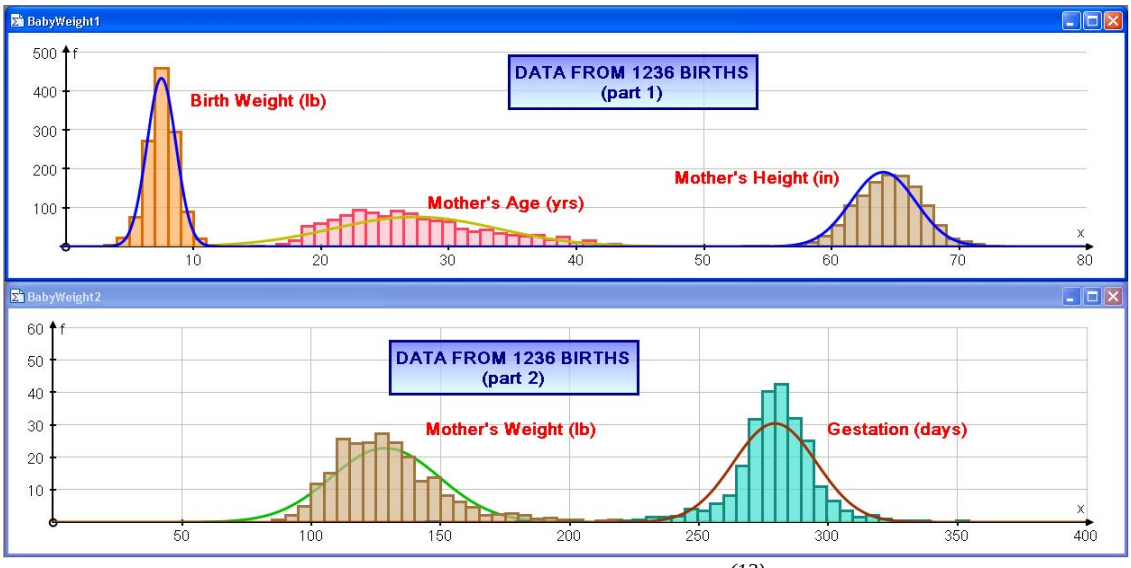


Many mathematics topics have been dropped from main-stream post 16 teaching because they were hard to visualise, and just at a time when technology is enabling students to make sense of them. 'Volume of Revolution' is a good example of this, along with most of the 3D coordinate geometry syllabus.

8. The visualisation of Probability and Statistics

Another area particularly suited to the dynamic approach is data handling. Several countries are in the process of enlarging the statistical content of their secondary curriculum, including South Africa and Australia (New South Wales). Many teachers did not learn this subject themselves at school, so are still learning the mathematics, as well as the ICT!

Here, teachers can be really motivated to use ICT: they can enjoy the way large amounts of data can be seamlessly analysed, and presented visually on screen.



Using a large data set of baby births from Stanford University [12], analysed by Autograph

9. Conclusion

The TSM training programme has evolved over that last 15 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, both in and out of the classroom. Feedback has been very positive, particularly from those teachers using ICT-based methods in their teaching for the first time.

The evidence suggests that this success can only really be achieved by hands-on workshops that last more than one or two days. This of course raises important and far-reaching issues concerning the funding of regular INSET time for teachers.

References

[1] TSM Workshop: www.tsm-resources.com/July08.html
[2] Autograph: www.autograph-math.com
[3] TSM Resources www.tsm-resources.com
[4] Flash Earth www.flashearth.com
[5] YouTobe videos www.youtube.com
[6] NRICH PLUS Magazine: http://pass.maths.org.uk/
[7] Waldo's Java Applets: www.waldomaths.com/
[8] Java Slide Rule: www.taswegian.com/SRTP/javaslide/javaslide.html
[9] You Tube videos: www.youtube.com
[10] Turbo Demo Tutorials: www.turbodemo.com
[11] TSM Useful Files www.tsm-resources.com/useful-files.html
[12] Baby data from Stanford University www-stat.stanford.edu/~rag/stat141/exs/babies.dat
www-stat.stanford.edu/~rag/stat141/06Lab4.pdf