

THE DYNAMIC COLLEGE CLASSROOM

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Introduction

Of all the academic subjects, Mathematics has possibly the broadest range of computer-related applications which can help with visualisation and greater understanding. For many teachers this is the great escape from the chalk, but for many though it represents a serious challenge to their well established and perfectly effective teaching styles, throwing up significant training issues.

Some classrooms are now being fitted with data projectors, and new techniques have to be established to make the best use of them. The key is variety, mixing regular teaching strategies with occasional computer-generated images.

This presentation will show great Java resources (that work 'off-line'), Excel files and a variety of dynamic software sources (including GSP and the new Autograph v.3) to create lively lesson plans which involve and motivate the students. There will also be some useful tips on making Word more mathematically friendly, including the use of hyperlinks to glue it all together.

Finally, with students the world over tending to find the subject dry and uninteresting, and teachers thinking they have discovered better things to do with their lives, this paper will try to make the point that technology can have a role to play here in rescuing this situation. Technology can help to make the subject appear more lively and relevant, and to add a sparkle to the lessons, thus making the process of teaching and learning the subject more fun, and more effective.

Hardware

First, to make the best use of technology in the classroom, the right classroom hardware needs to be in place. Ceiling mounted projectors are the best answer for the time being, but they are still too expensive for many education authorities to consider. We are about 3-4 years away from affordable large screens (using light-emitting polymers) – see this link to some research papers on this technology:

www.tsm-resources.com [‘Dynamic Classroom’ page]

The companies involved in developing these new ‘plastic’ screens will undoubtedly have a far reaching impact on education. If they can get the price down far enough it will enable all classrooms to have a large display screen, on which (importantly) the teachers can write with a white-board marker, thus combining their traditional methods with the occasional computer generated image. It will be connected (wireless) to a small portable computer, the local intranet and the internet. It seems a long wait, but we must be ready. Battery technology is also set to improve dramatically, making portable devices easily last a full day – this will remove the need for the final trip -wire, the mains cable! .

New Classroom Teaching Techniques

Many teachers are ill-prepared to make the best use of computer-driven images as part of their teaching. They are anxious about things going wrong which will compromise the effectiveness of the lesson. Interactive White Boards are also being installed in schools and colleges in some developed countries, giving teachers yet another technological layer to master.

So far as content is concerned, there are various sources of material for the dynamic classroom:

1. Java and Flash resources from the Web
2. Dynamic Software (eg Geometer’s Sketchpad, Autograph)
3. Standard Office tools, including Word/PowerPoint (with hyperlinks) and Excel

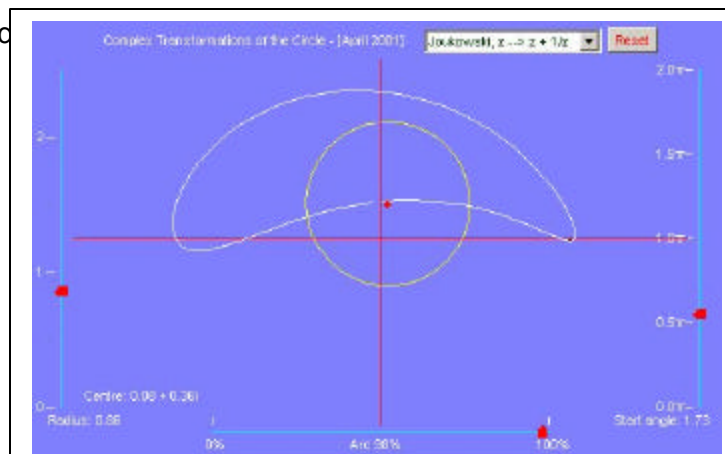
1. Java and Flash resources from the Web

A collection of good resources is maintained by the author in the Mathematics section on:

www.tsm-resources.com

and a number will be demonstrated during this talk, covering topics such as

Complex numbers – transformations of the circle illustrated here from “Waldo’s Maths Pages” (by Ron Barrow, UK), part of a suite of fully interactive Java pages for the secondary and college curriculum.



2. The use of Dynamic Software in mathematics teaching

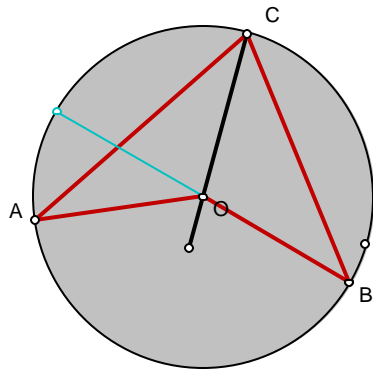
There are countless aspects of the secondary and college level mathematics curriculum for which this approach is effective. But the teachers need to practice making it effective, and training issues are a serious consideration. If the images proceed too quickly the learning can be lost. It is necessary to involve the class at each stage in the process, to get the students to anticipate what is about to happen, maybe to invite a student to draw on the screen first before the computer does it. This is a tried and tested technique, allowing the teacher to determine the pace, and if necessary to force errors from the class to help make good teaching points.

● The Circle Theorems illustrated (dynamically) in **Geometer's Sketchpad**

$$m\angle AOB = 141.6^\circ$$

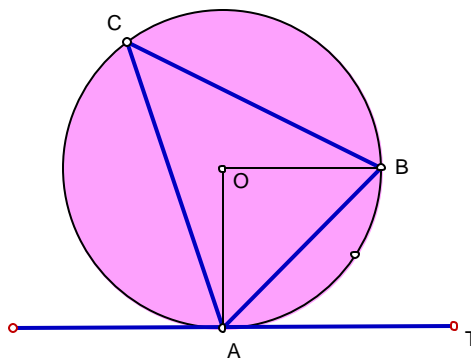
$$m\angle ACB = 70.8^\circ$$

$$\frac{m\angle AOB}{m\angle ACB} = 2.0$$



$$m\angle TAB = 45.3^\circ$$

$$m\angle ACB = 45.3^\circ$$

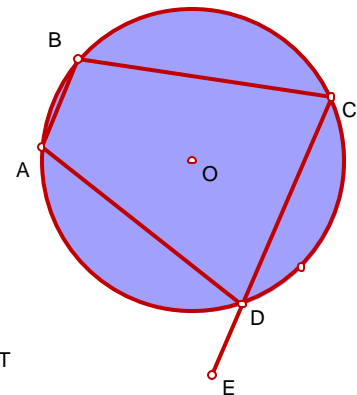


$$m\angle EDA = 104.9^\circ$$

$$m\angle ABC = 104.9^\circ$$

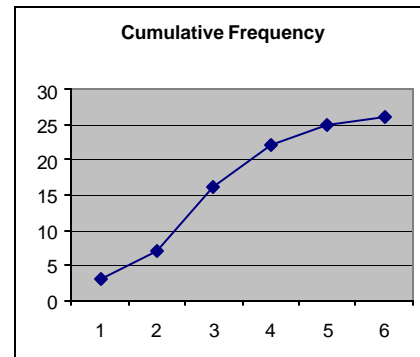
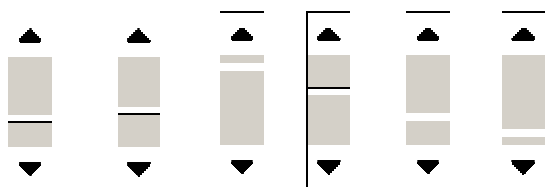
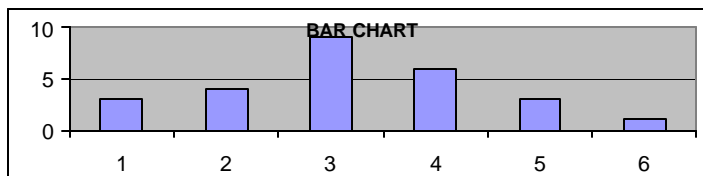
$$m\angle CDA = 75.1^\circ$$

$$m\angle ABC + m\angle CDA = 180.0^\circ$$



● Dynamic Cumulative Frequency, in **Excel**

(from Peter Mulkerrin)



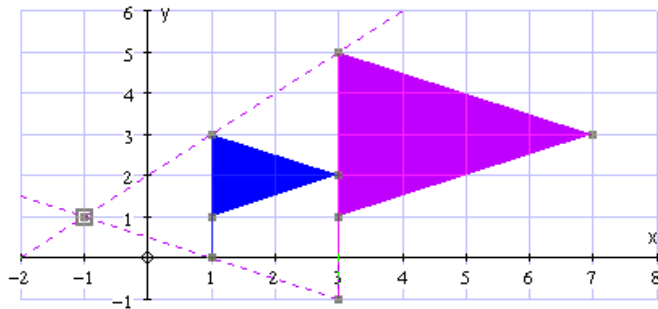
| Slider | 7 | 6 | 1 | 4 | 7 | 9 | 34 |
|-----------|---|---|----|----|----|----|----|
| <i>f</i> | 3 | 4 | 9 | 6 | 3 | 1 | 26 |
| <i>cf</i> | 3 | 7 | 16 | 22 | 25 | 26 | |

● The use of Dynamic Coordinate Geometry and Statistics

The presentation will include examples from secondary and college programs, where the use of dynamic images can greatly enhance the learning. The software Autograph will be used, but many of these images can equally well be achieved with other packages,

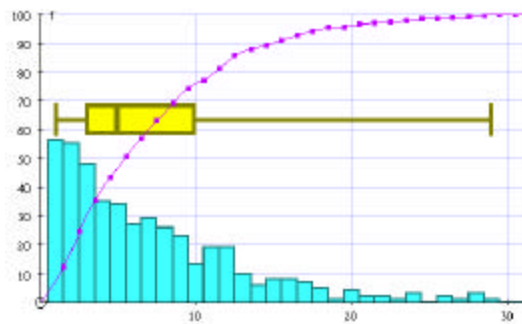
TRANSFORMATIONS

A perfect dynamic situation: the original objects can be moved around, and the parameter that created the second object can be animated. Write on top of the images on the white board to get the students to anticipate the results before the computer.



DATA OFF THE NET

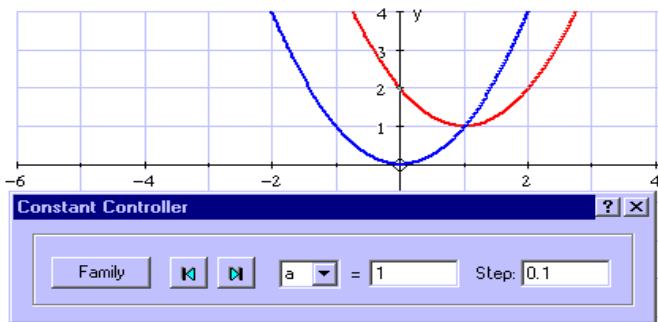
The UK Lottery data (6 balls from 49) is collected from all previous results and downloaded to Excel. The distribution of the first ball (in order) copied to *Autograph* offers an unusual bar chart, box and whisker and cumulative frequency diagram.



TRANSFORMING CURVES

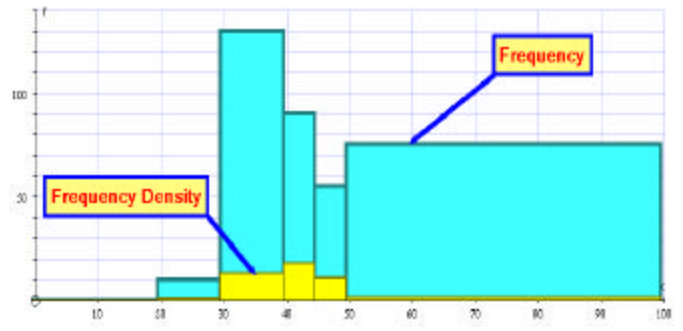
Several approaches are possible here. Illustrated here is:

$y = x^2$, and $y - b = (x - b)^2$
and then vary a and b
Using function definitions works well too, eg plot $f(x) = x^2$,
then $y = f(ax + b) + c$; vary a , b , c
Then redefine $f(x)$ as $\sin x$.



FREQUENCY DENSITY

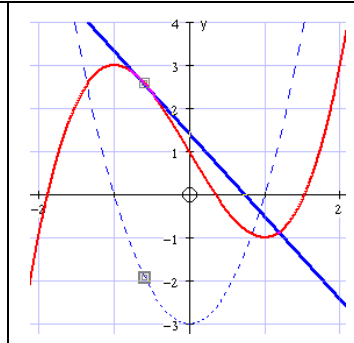
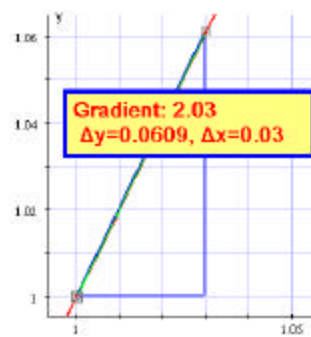
It is useful to be able to plot a set of grouped data so that students can see the difference between representing the data as **discrete** (displace to the left) or **continuous**, and by **frequency** or **frequency density**.



THE CONCEPT OF GRADIENT

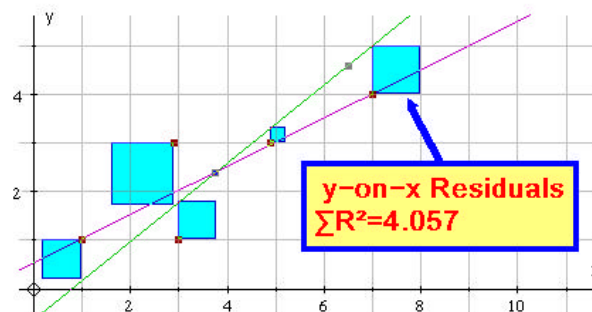
(a) zooming in on the gradient of a chord as $x_2 \Rightarrow x_1$, observing $\Delta y \Rightarrow 0$, $\Delta x \Rightarrow 0$ yet $\Delta y / \Delta x \Rightarrow 2$.

(b) The gradient function can be drawn slowly, and the tangent can be moved dynamically along the parent curve



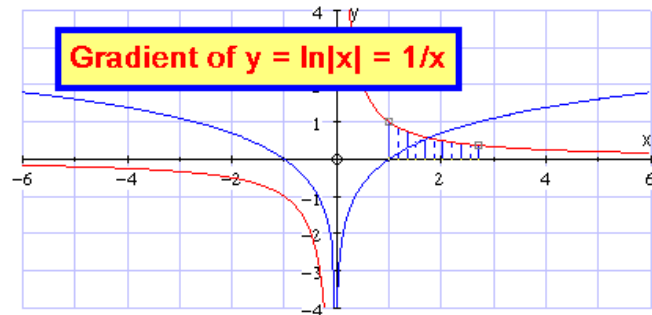
ILLUSTRATING RESIDUALS

Here a variable line is constructed through the centroid and another random point. This line and the data set (which is an object) are selected and the y-on-x residuals illustrated as square. Vary the second point to watch the squares minimize.



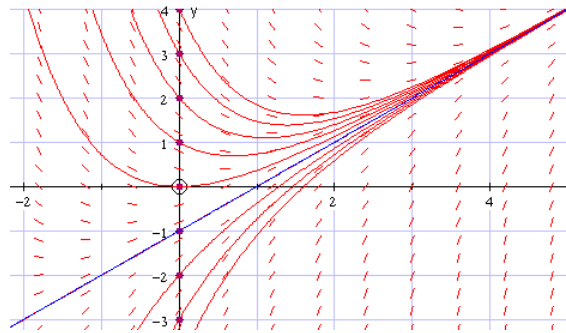
$y = 1/x$ and e and $y = \ln x$

This lesson first shows, by varying the right limit of the area under $y = 1/x$ to find e . Then plot $y = \ln x$, and show that its gradient is the right branch of $y = 1/x$. Then develop an argument for $y = \ln(-x)$ and finally $y = \ln|x|$



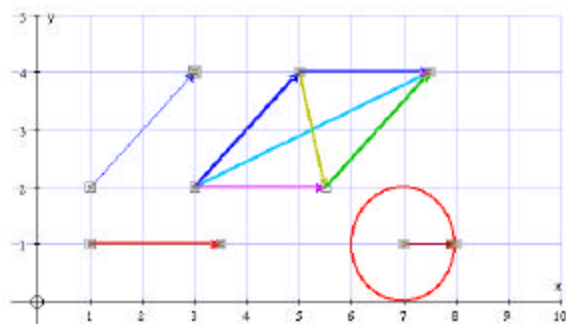
DIFFERENTIAL EQUATIONS

Here is a lesson showing the principle of the complimentary function and particular integral. The implicit form of the entry allows the RHS to be changed, say, to $\sin x$. Also, the original equation can have a variable parameter, eg $y' + ky = x$.



FUN WITH VECTORS

The principle of copying, adding and subtracting vectors can be explored dynamically. Also scalar multiples (vector equation of a line). The difficult concept of a unit vector can be explored by constructing a unit circle over it and varying the parent vector.



3. The use of standard office tools.

Standard tools, such as MS Office, can be used to help add a sparkle to lesson plans and hand-outs. In particular, Word can be the common denominator of all electronically stored lesson plans and teaching resources for mathematics.

● **WORD documents can contain equations as text**

The UNICODE font system enables each of the major fonts to have its own set of symbols. (though unfortunately a MAC or a PC system prior to W-98 will not display these characters). Using "Insert" => "Symbol" => "Font" => "Normal Text" you can set up short-cut keys as required so that the current font can use its own symbols. The *suggested* ALT keys to set up are:

| | | | | | | | | | | | | | | |
|-------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---|---|
| ALT Symbol | 2 ² | 3 ³ | 4 ¼ | H ½ | R v | I ò | O ° | 0 ¥ | < £ | > ³ | + | / | ? | ? |
| ALT Symbol | A a | B ß | D D | E S | F f | L l | M µ | N n | P p | S s | T ? | X ? | ? | ? |

Examples: $y = xv(1 - x^2)$
 $y = e^{\sin^2 x}$
 $?^2 \sim N(\mu, s^2)$
 $3x - 2y = 2$

$y = p \pm \sin^{-1}(1/2x)$
 $s^2 = (1/n)S(fx^2) - \mu^2$
 $\int \sin^2? \cos? d? = ? \sin^3? + c$
 $\int \sin^2? d? = ?/2(1 - \cos 2?)d?$

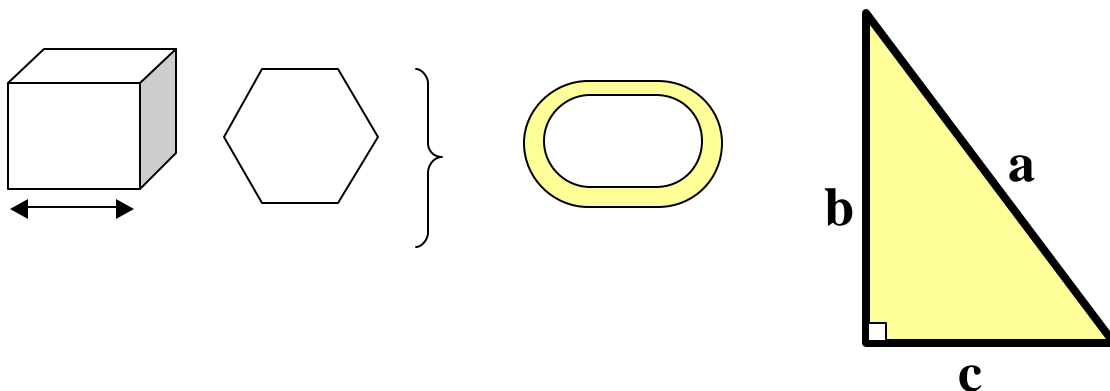
● **WORD documents can contain equations as graphics**

These can be edited only using the Equation editor. Equations created this way are graphics and require format and layout control, Short-cuts can be placed in the "Auto-correct" list when selected in 'move with text' mode.

eg type "qf <ENTER>" for the quadratic formula: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

● **WORD documents can contain object-based diagrams**

The drawing toolbar has many more mathematical tools than many realize:



● **WORD documents can contain HYPERLINKS, using** 

linking to bookmarks in the same document, eg [back to the start](#)
linking to files on the hard drive (eg an [Excel](#) file)

linking to web pages (URLs), eg www.tsm-resources.com

eg, some useful web links from the Oundle site with dynamic images for the classroom:

MATHEMATICAL RESOURCES

UK [PLUS - Maths magazine](#)
[NRICH - Online Maths Club](#)
[Counton](#) (MathsYear 2000)

AUSTRALIA [Maths300 \(Lessons on the Web\)](#)
JAPAN [Mathematical JAVA applets](#)

MATHEMATICAL ENTERTAINMENT

[Ron Knott's Fibonacci pages](#)
[Integer Lists to full accuracy](#)
[History of Mathematics \(St Andrews\)](#)

STATISTICAL RESOURCES

DATA SETS

[DASL: USA Data and Story Library](#)
[The UK Lottery - Data from UN, by country](#)
[Statistical web resources from Sidney Tyrrell](#), Coventry University, UK

● **WORD documents can contain items pasted from other applications**

eg a graph or text from Autograph, Excel or the Web – these are often best placed in a text box for greater layout control.

Conclusions:

Mathematicians have been teaching the subject with nothing more than a writing surface and a piece of chalk for centuries, and to good effect, certainly with the more able – these are pupils who can, by and large, visualise the subject for themselves. The real beneficiaries in the new, visual approach are the next ability level down. The rewards to them can be considerable, and there is every chance that this approach can help numbers who want to take the subject further to rise.

Douglas Butler,
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November 2003

Douglas Butler: BIOGRAPHY (November 2003)

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After graduating in Mathematics and Electrical Sciences at Cambridge University, and a spell with EMI Records, Douglas has specialised in secondary Mathematics. He has served as Head of Mathematics and then Head of Careers Education at Oundle School (Peterborough, UK), and was Chairman of the MEI Schools project, a leading UK curriculum development project, for 6 years.

A keen pianist and dinghy sailor, he is also one of the co-authors of Autograph (v.3 2003), and author of "Using the Internet - Mathematics" (revised July 2000). He maintains a large web site of educational resources in many subject areas.

In 2000 he founded the innovative iCT Training Centre, based at Oundle School, which is now creating new resources for the educational use of computers in mathematics, and running the TSM (Technology in Secondary/College Mathematics) teacher training events all over the UK and overseas. He has recently launched a new series of conferences on Technology for Teaching Music, and for Science.

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