Secondary Magazine Issue 25

National Centre for Excellence in the Teaching of Mathematics

Welcome to Issue 25 of the Secondary Magazine. With the new year underway it is time to stop making resolutions and get active! We hope this issue will give you some mathematical inspiration to turn some of those resolutions into a reality. Very best wishes for 2009 to you all.

Contents

From the editor – Is gender a barrier to achievement in mathematics?
In the week of the birthday of Sonya Kovalevsky, we consider whether gender stereotypes are barriers to success in 21st Century Britain and 19th Century Russia.

Up2d8 Maths
The fortnightly Up2d8 Maths resources explore a range of mathematical themes in a topical context. This week sees history made as Barack Obama is inaugurated as the President of the United States of America, so this Up2d8 Maths resource uses the context of the US election. Pupils are given the opportunity to explore the implications of the choice of electoral process on the outcome of the election, accessing the Key Processes from the mathematics Programme of Study.

The Interview – Bernd Eggen
We are told not to shoot the messenger! This week's interviewee works for the Met Office and belongs to a group of people who are investigating our ever-changing climate. Bernd himself is a Climate Change Consultant/Climate Science Advisor and tells us how mathematics impacts on his life and work.

Focus on…the sphere
There is something very satisfying about a perfect sphere; its symmetrical properties make it the focus of many sporting activities. Read on to discover some of the mathematical properties of the sphere.

An idea for the classroom – constructions
Do we put too much emphasis on the mechanical process of constructions and forget to talk about their uses? These resources encourage pupils to use the language of constructions as part of their revision.

5 things to do
As we put the holidays behind us, here are some mathematical and recreational things, to plan and do, to enrich 2009 for you and your pupils.

Diary of a subject leader – Real issues in the life of a fictional Subject Leader
As the implications of the introduction of Functional Skills begin to be considered in schools, our subject leader starts to share an understanding of the Functional Skills agenda with others in the department.

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Is gender a barrier to achievement in mathematics?

Do you think there are 'boys' subjects' and 'girls' subjects' in your school? Where does mathematics sit? Is your top set made up predominantly of boys or girls? When talking to a group of pupils recently, they told me that they liked mathematics because it was either right or wrong – do you think these were boys or girls that said this, or was it a mixed group? Our educational community tries to be inclusive in the broadest sense; it tries to provide equal opportunities for all to achieve.

Our data is presented and analysed to give us a picture of the achievement of different groups within the community to enable us to see if these different groups of pupils are performing in line with our inclusive expectations. How do we communicate our expectations to our pupils? Does society have gender-based expectations, and how do we avoid transferring any cultural gender bias to our pupils?

It is interesting to look at the composition of mathematics departments in secondary schools: is it important to get a mix of genders amongst the staff to provide positive mathematical male and female role models for pupils? Have you tried asking pupils to name a famous mathematician? Many pupils will cite Carol Vorderman or their own mathematics teacher; these are the people that pupils see 'doing mathematics' so it is vital that we are conscious of the mathematical example that we set to our pupils.

Is this an issue for you?
What will you do about it?

In 19th Century Russia, mathematics and all other forms of learning were certainly seen as male-dominated. Women were not allowed to attend universities nor could they travel alone. These difficult circumstances make the achievements of Sonya Kovalevsky (1850 – 1891) even more impressive.

Sonya was born into a middle class family and exposed to mathematics from an early age – her bedroom is said to have been papered with lecture notes from her father's calculus course. Sonya was self-taught – from her wallpaper! When she was 18, Sonya married Vladimir Kovalevsky so that she could travel with him to Heidelberg and attend the University. Having studied under Karl Weierstrass, she eventually received a doctorate from Göttingen in 1874 – the first woman to receive a doctorate from a modern university.

Her result, now known as the Cauchy-Kowalevski theorem, was published in 1875. Sonya never returned to Russia where her degree would not have been recognised. She had a daughter but continued working on mathematics even after the suicide of her husband in 1883. Sonia moved to Stockholm in Sweden where she remained until her death from pneumonia in 1891. In 1886, she won the French Prix Bordin for her work on the Kovalevsky top, which included analysis of the dynamics of Saturn's rings.

Sonia Kovalevsky was born on January 15, 1850. Would this be a good week to celebrate the achievements of a great female mathematician?

A Department for Children, Schools and Families initiative to enhance professional development across mathematics teaching

Up2d8 Maths

The fortnightly Up2d8 maths resources explore a range of mathematical themes in a topical context. The resource is not intended to be a set of instructions but rather a framework which you can personalise to fit your classroom and your learners.

The inauguration of Barack Obama as 44th President of the USA will be a memorable event. Here is an opportunity to use the context of this high profile event to understand the role of mathematics in the foundations of a democratic society. This Up2d8 Maths resource, set in the context of the US Election 2008, explores the mathematics involved in the electoral process of the USA and to contrast this with the 'first past the post' system used in British General Elections. Students will have the opportunity to consider the role of the individual within the democratic process and how their vote contributes to the overall result. (Pupils will have an opportunity to consider a different electoral system with an Up2d8 maths resource to be published to coincide with the European Elections in June 2009).

This resource is not year group specific and so will need to be read through and possibly adapted before use. The way in which you choose to use the resource will enable your learners to access some of the Key Processes from the Key Stage 3 Programme of Study.

Click here to download the Up2d8 maths resource - in PowerPoint format.

The Interview

Name: Bernd Eggen (for ease of pronunciation, that's 'Bernd' as in toast)

About you: I am a Senior Climate Change Consultant/Climate Science Advisor at the Met Office Hadley Centre. I studied Chemistry and Mathematics many years ago (some ¾ billion seconds) in Freiburg (Germany), came to the UK as an exchange student before the Berlin Wall came down and stayed ever since, acquiring a house, a wife, three children and five chickens along the way. I've worked in academia, industry and a non-profit foundation before joining the Met Office (in the internet age, I've made a progression from .ac.uk → .com → .org → .gov.uk…who knows if that's it or what will be next).

The most recent use of mathematics in your job was... a climate change consulting project, where I looked at the behaviour of soils under a changing climate. I ran complex computer models on thousands of different soils/climate scenarios, producing gigabytes worth of data. Mathematical interpretation, visualisation of the data, and statistical analysis are absolutely essential to see patterns and trends. I've also given some climate change workshops at local schools, e.g. getting the students to analyse time series of temperature using spreadsheets – the **C**entral **E**ngland **T**emperature record, which represents the longest accurate series of monthly temperature observations in existence, with daily data from 1722 onwards – can you guess how many data points that is: 1 000, 10 000, 100 000, a million, or more?

Some mathematics that amazed you is... Complex Systems, Chaos and Fractals – an area that started in earnest in the 1960s with the advent of digital computers – Edward Lorenz famously investigated a very simple weather system model, with only three differential equations in three variables. However, it contained a non-linear term that resulted in a surprisingly complex behaviour (chaos) when he tried to solve the equations numerically. He also found that the system is very sensitive to small changes of initial conditions, and he popularised the term "butterfly effect" – the effect of the flap of the wings of a single butterfly in the Amazon would eventually influence the path of a tornado. Some of these systems also generate beautiful self-similar patterns, known as fractals (e.g. the Mandelbrot set).

What also amazes me is Number Theory (a branch of pure mathematics concerned with the properties of numbers in general, and integers in particular), which is also probably one of the areas that is least applied…apart from cryptography. There are still many unsolved problems in Number Theory.

Why mathematics? I love the beauty of it, the patterns, the symmetry. Personally, I like a symbiotic approach with computers, although some areas only require a pen, paper & brains. Often seemingly simple questions can lead to very complex answers and profound insight – e.g. Are there integer solutions to x^n+y^n = z^n for n>2 ?, famously known as Fermat's Last Theorem, which generated a fantastic wealth of mathematical knowledge for several centuries until it was solved in 1994. The proof brought together a wide range of different mathematical methods and generated some deep understanding, before arriving at the answer to the above question: "No".

There are now several other "big questions" that are waiting to be solved (the Clay Mathematics Institute of Cambridge, Massachusetts has compiled a list of seven Millennium Prize Problems), including one with relevance to weather and climate modelling: "*Existence and smoothness of the Navier-Stokes equation*".

Your favourite/most significant mathematics-related anecdote is… A) I worked on an abstract 3-D puzzle of arranging 27 water molecules into a cubic cluster with some special conditions. The first question was whether this was possible at all and the second question was, if it was possible, then how many solutions would there be? The whole team I was working in was trying to solve this puzzle in a variety of ways – a "brute force" approach (i.e. looking at all possibilities) was out of the question – there were too many arrangements (of order 24^27 ≈ 1.8E37 – some 20 undecillion). After some unsuccessful drawings, I decided to build a real 3-D model out of a small molecular building set which I "modified" using Tipp-Ex. By starting on the first layer (reducing the problem to 2-D) I found a way to construct the whole cube and after some trial-and-error I found a solution, which I proudly presented to my supervisor the next morning. The way I had arrived at this first solution opened an avenue to how to find other solutions – there would be still several hundred million candidates to sift through, manageable with a powerful computer. After some days of writing the programme and some testing/validation, I was ready for the "big run" – I started the computer on the task and after several hours (and me being concerned it would run out of memory space) it came back with the answer – some 456 possibilities. One of my colleagues used a different approach and arrived at the same number shortly afterwards. We published the results together in a scientific journal.

Sometimes a mathematical problem gets easier when the complexity (e.g. the number of dimensions) is reduced, however, quite often the reverse can be the case, at least in mathematics, and a problem becomes more tractable in higher dimensions.

A mathematics joke that makes you laugh is… Q: What does the zero say to the eight? A: Nice belt! Also: There are 10 kinds of mathematicians. Those who can think binarily and those who can't...

Something else that makes you laugh is… Radio 4's *Just a Minute* (which is almost as mature(d) as I am) and (to cater for my more cynical side) *The News Quiz*.

Your favourite television programme is… *Gavin and Stacey, Green Wing, Smack the Pony, Rough Science*, to name but a few.

Your favourite ice-cream flavour is… chocolate and lemon, Italian-style (and eaten there on a warm summer's evening).

Who inspired you? One of my heroes is Alexander von Humboldt, a German researcher, who in the early 19th century travelled South America extensively and in his observations was well ahead of his time. He is thought of as one of the last people who was universally knowledgeable – an erudite (one who has a thorough comprehension of all the knowledge of his time).

If you weren't doing this job you would… work as a science/maths/environmental educator in developing countries.

Focus on...the sphere

A sphere can be defined as the locus of all points in three-dimensional space which are at distance *r* from a fixed point. This means that a sphere is the two-dimensional spherical surface, rather than the volume contained within it.

The equation of a sphere of radius *r* with its centre at (*a*, *b*, *c*) is

$$(x-a)^2+(y-b)^2+(z-c)^2=r^2$$

The surface area of a sphere is given by the equation $A=4\pi r^2$ and the volume, $V=\frac{4}{3}\pi r^3$

A sphere contains the greatest volume within a given surface area and, therefore, has the smallest surface area for a given volume. This can be seen in soap bubbles whose spherical shape is caused by surface tension.

Can you turn a sphere inside out? Find out in this video.

The most efficient way of packing spheres together in an enclosed space is to have each sphere surrounded by 12 other spheres. This gives an average density of $\frac{\pi}{\sqrt{18}}\approx 0.7404$

Kepler conjectured that this was the optimum density in 1611 but it wasn't proved until 1998 by Thomas Hales from the University of Michigan.

In the 1998 movie *Sphere* starring Dustin Hoffman and Sharon Stone, the sea snake was designed by Joseph Hahn who later found fame as the DJ for Linkin Park.

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An idea for the classroom - Constructions

I have spent some time over the last term, using the GCSE exam board's on-line analysis tool to find some strengths and weaknesses from last summer's examinations. I was particularly looking at those pupils who achieved a level 6 in their Key Stage 3 SATs and did not go on to achieve a C+ grade at GCSE.

I was initially quite surprised to see that 'constructions' was a weakness for these pupils. On looking at the question paper, I decided that perhaps it wasn't just the construction itself that caused the problems, but some of the vocabulary and language used in the question that made it seem inaccessible? I felt that I needed to do something about this, so I have prepared two resources to use with pupils this term as part of their revision.

The first resource is a 'constructions card sort' which takes the form of a multiple representations activity. Pupils are given a set of cards to sort into the appropriate groups.

Here are some of the cards which have a mixture of formal language, a diagram and a contextual question:

Pupils will have the opportunity to explore the cards and make sense of the connections between them. They can then look at some GCSE constructions questions and relate them to the activity they have done.

The second resource is a set of Powerpoints which have been designed to encourage pupils to explore the sorts of answers that they might give to constructions questions. On each slide there are a set of possible replies to a question. Pupils need to select the correct responses.

What sort of things do you do to tackle pupils' known weaknesses?

5 things to do this fortnight

Put the ACME Conference in your diary.
Each year the Advisory Committee for Maths Education (ACME) hosts a conference at the Royal Society in London. This year's will be held on the 3 March – further details are available here.

Teachers Talking Theory: In Action
Have you had a look at this resource yet? If your New Year's Resolution is to try something different in your classroom, then why not start by having a look at these teachers and the theory behind their classroom practice?

Have you met Marcus du Sautoy?
Rumour has it that he'll be presenting a plenary session at BCME-7, a conference which aims to have all sections of mathematics and mathematical education coming together in a single conference to celebrate, enrich, refresh and build mathematical and pedagogical confidence and expertise. Hosted by the British Congress of Mathematics Education (BCME) – find out more here.

The constraints on the local provider include the limited time they have available for this support – so early contact of the named person is recommended. Also, of course, the ICT skills of these local leaders differ from person to person – please contact them direct to see whether their skills and your needs match!

Focus on Year 11
Now that the mocks are out of the way, how did your students do? A quick analysis of your class' papers can really help you (and them) to focus in on key curricular areas in their last full term at school.

Mimefest 2009
Feel like a bit of peace and quiet? The London International Mime Festival runs from the 10 – 25 January. Find out more here.

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Diary of a subject leader

Real issues in the life of a fictional Subject Leader

I recently received a wake-up call from my curriculum deputy regarding Functional Skills. She quizzed me on my understanding of this latest initiative and my intentions on its implementation within our scheme of work. She had just returned from a course on which it had been discussed and in true managerial fashion, she was disseminating the responsibility onto her middle leaders. Luckily, I felt I was up to speed on the matter and although I was yet to 'disseminate' to my department, I had already given it some thought.

Functional Skills and its implications on the teaching of mathematics became the main item on the agenda at our next department meeting. The facts were discussed, including the difference between level 1 and 2, the requirements for GCSE/diplomas and the general philosophy behind it. As anticipated, the response of my staff was mixed. Some listened and debated with interest but a degree of apprehension was evident from those perceiving it as an additional and unnecessary change to the curriculum. Nevertheless, on scrutiny of the four 'measurable' skills (complexity, familiarity, technical demand and independence), all agreed that if implemented well it should improve the quality of teaching and learning within our maths lessons and if nothing else, its aims were honourable.

I posed the question, 'so what will a Functional Maths lesson look like?', desperately trying to avoid the questions relating to assessment which at present appear somewhat of an unknown. Using and Applying, group/paired work, discussion, real-life and questioning all came up within the debate, providing me a sense of optimism. Towards the end of the meeting, I left them to contemplate whether the department should teach stand-alone Functional Skills lessons or integrate it within everyday teaching (or even both).

Without sounding too profound, I felt we had at least started a long journey and that we shared an understanding of what was required. Nevertheless, we are aware that the hard work lies with its implementation within the classroom, a topic for further debate when we next meet.