Secondary Magazine

Issue 39

National Centre for Excellence in the Teaching of Mathematics

Welcome to Issue 39 of the Secondary Magazine. How is your holiday going? At this magical time of year when the routine of the school day is farthest from our thoughts, perhaps there is time to think about mathematics and enjoy our leisure. Enjoy the holiday.

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Up2d8 Maths will be back later in the summer

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From the editor – the fourth plinth

I expect you have heard about Antony Gormley's summer installation? He is asking people to occupy the empty fourth plinth in Trafalgar Square, London. There are 2 400 opportunities to spend an hour on the plinth doing whatever you want to do to between 6 July and 14 October 2009. The project is called One & Other and is open to everyone aged over 16 in the UK – places are allocated by draw.

At the time of writing, Heather, from the South West, is on the plinth singing under the shelter of an umbrella in torrential rain. Previous 'plinthers' have released white balloons every minute of the hour, made paper aeroplanes and thrown them to the crowd, publicised charities, dressed up as a giant pigeon, produced a panoramic collage with a camera etc. My favourite so far is a man who dressed up as a monster and stamped on a model of London – you can watch that on the One & Other website and on YouTube.

So what would you do on the plinth? If you had an hour, aloft in Trafalgar Square, to do something mathematical, what would it be? Here are some ideas:

- recite pi to as many decimal places as the time allows
- chant the seventeen times table
- take lots of paper and complete some massive mathematical origami
- talk your way through Euclid's Elements
- take a piece of A3 paper and cut it so that you can walk through the sheet?
- make increasingly complex loops of paper by cutting a Mobius strip
- sew a patchwork quilt
- calculate the area of the top of the plinth
- see if you can find examples of the golden ratio in the surrounding buildings
- estimate the number of people walking through Trafalgar Square
- build a Harmonograph, create some amazing pictures and give them to the crowd
- take up some blocks and challenge people in the crowd to games of Nim
- complete a giant sudoku (sorry – there's no mathematics there, just reasoning and logic).

So why do I feel it necessary to publicise mathematics? I'm sure you could think of many other interesting things to do for your hour on the plinth! Perhaps there is still a perception that mathematics is not a 'cool' subject? I keep returning, in my head, to the words of our interviewee in Issue 36, "I love knowing why things are the way they are. It makes me feel safe. And the more mathematics you know, the simpler the world gets."

How many of our pupils would feel that their classroom mathematics did that for them? That's why I want to promote mathematics – so that pupils can experience the excitement of solving a problem, or the awe and wonder generated by a neat solution. An understanding that mathematics is not only useful in their everyday lives but is inherent in so many aspects of life. Perhaps I will enter the draw for the plinth. Will you?

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The Interview

Name: a beekeeper.

About you: Sue has kept bees for several years. She has three hives in a field, which are separated from livestock by a barbed wire fence. To start with, honey was the main purpose of keeping bees but gradually the behaviour of the bees has also become a fascinating aspect of the hobby.

The most recent use of mathematics in your job was... Well, it depends what you think mathematics is. If you mean counting or arithmetic then there are plenty of calculations that you need to do to work out when the bees – in particular, a new queen – will hatch, from the time when you see the eggs or queen cell in the hive. If you don't get that right, the bees will swarm and you have lost them. Another aspect of mathematics for me is problem-solving and there is a huge amount of that! How do you perform an artificial swarm or a Bailey Comb change? You have to be a logical thinker.

Some mathematics that amazed you is... When I picked one of my own sunflowers and counted the spirals – they were Fibonacci numbers! I'd grown it from seed – that was amazing.

Why mathematics? The bees' natural behaviour is underpinned by a set of fundamental principles, like preservation of the colony, the queen pheromone and a strong sense of place. If you try and understand those principles then you can anticipate and work with some of their behaviours. Isn't mathematics a bit like that in that it underpins some of the structures in our world?

Your favourite/most significant mathematics-related anecdote is…
Why are the honeycomb cells hexagonal? It has been worked out that for shapes with a perimeter of one unit, the area of an equilateral triangle is 0.048, a square is 0.063 and a hexagon 0.075, so the hexagon encompasses the biggest area by using the least wax and is also a strong structure. Each cell can support 25 times its own weight.

A mathematics joke that makes you laugh is…
What did the bee say when it solved the problem? "Hive got it!"

Something else that makes you laugh is… I'm Sorry I Haven't a Clue.

Your favourite television programme is… Grey's Anatomy, The Apprentice, Gardeners' World…

Your favourite ice-cream flavour is… Honey.

Who inspired you? Brother Adam, a monk at Buckfast Abbey, who has worked intensively with bees at his apiaries in Devon, at a time when amateur beekeepers have encountered many problems with pests and diseases.

If you weren't doing this job you would…not get stung so often.

Focus on...Prime numbers

- Wolfram MathWorld defines a prime number as *a positive integer having exactly one positive divisor other than 1*. A number which has more than two factors is called a composite number. The number 1 is a special case and is neither prime nor composite. The first 10 000 prime numbers are listed on the University of Tennessee at Martin website.

- Euclid proved that there is an infinite number of primes in The Elements. His proof is summarised in Wikipedia:
  Consider any finite set of primes. Multiply all of them together and add 1. The resulting number is not divisible by any of the primes in the finite set we considered, because dividing by any of these would give a remainder of 1. Because all non-prime numbers can be decomposed into a product of underlying primes, then either this resultant number is prime itself, or there is a prime number or prime numbers which the resultant number could be decomposed into but are not in the original finite set of primes. Either way, there is at least one more prime that was not in the finite set we started with. This argument applies no matter what finite set we began with. So there are more primes than any given finite number.

- A Fermat prime is any prime number of the form 2^{2^n} and has a surprising link with geometry. A regular polygon with n sides is able to be constructed only if n is of the form $2^m \times p$ where p is a Fermat prime and m is any positive integer. There are only five known Fermat primes: 3, 5, 17, 257, and 65 537.

- A Mersenne prime is any prime number of the form $2^n - 1$. The largest known prime number, which was found in August 2008 is a Mersenne prime. It contains 12 978 189 digits and is equal to $2^{43\,112\,609} - 1$. A complete list of the largest known primes can be found on the University of Tennessee at Martin website.

- Three is the only prime number that is one less than a square number and is also the only prime number that is also a triangular number.

- GIMPS, the Great Internet Mersenne Prime Search, has so far found 13 Mersenne primes in its 13-year history. The most recent of these was in April 2009 when Odd Magnar Strindmo discovered the 47th known Mersenne prime, $2^{42\,643\,801} - 1$. You can join GIMPS via their website.

- In 1984, Samuel Yates defined Titanic Primes. These are any prime number with at least 1 000 digits. When he introduced this term, there were only 110 known Titanic Primes, but there are over 1 000 times that many.

- Twin primes are prime numbers that differ by two, such as 3 and 5 or 17 and 19. It is thought that there are an infinite number of twin primes although this hasn't yet been proved. The largest known twin primes were found in 2007 and are $2\,003\,663\,613 \times 2^{195\,000} \pm 1$ which both contain 58 711 digits.

- The RSA Cipher is the security algorithm on which much of our internet security is based. It relies on the relative simplicity of being able to create a composite number from two large prime numbers and the complexity of being able to find the two primes given the composite number.

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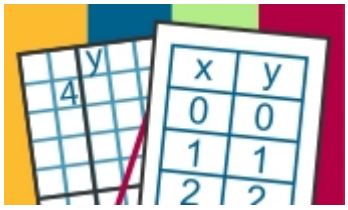

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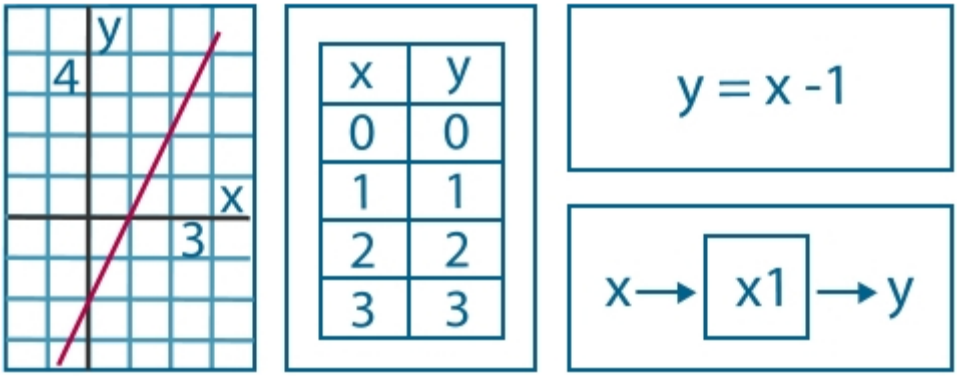
An idea for the classroom – functions multiple representation

We have mentioned some of the excellent resources from the Standards Unit Improving Learning in Mathematics. I have been thinking a lot about the 'Interpreting Multiple representations' activities and was delighted when a colleague devised this activity which focuses on functions.



Pupils are given a set of cards which include:

- a graph
- a table of co-ordinates
- a function machine
- a function.

Pupils have to match the cards into equivalent groups. These activities are fairly easy to make up, but it can take time to capture the graphs etc. so it is nice when one is done for you. This activity has been arranged on the page so that pupils can cut up the cards themselves, saving the teacher time. It has also been devised to add an element of potential confusion so that the connections are not immediately obvious.

I usually give out a sheet like this with the minimum of instructions to the pupils. Working in pairs they cut them out and start to group them. While they are doing this, I am getting some valuable information about their understanding. With some pairs, I will need to encourage them to join their pairs of cards into fours, other pupils manage this on their own. My role in this task is to question and encourage rather than give direct instructions.

Why do I like these activities so much? Well, I like to give pupils the opportunity to make connections between different areas of mathematics – it is not always intuitive for pupils to be able to represent a function in these different ways. I like the kinaesthetic nature of the activity – it allows pupils to experiment and make mistakes while they are thinking.

For me, the best part of the activity - and certainly the hardest bit for the pupils - is to make up a group of cards of their own. So for this activity, I would ask them to write down a function, illustrate it using a function machine, work out an appropriate set of co-ordinates and plot them on a graph. Working through this linked set of tasks shows me that they have some understanding of the concept of functions.

Have you used some good multiple representation activities?
What have they allowed you to do? How have your pupils responded to the activities? Why not tell us about this?

5 things to do this fortnight

- Could a young man really run away with £5 000 in £1 coins? Are the Bowland resources integrated into your scheme of work? Maybe You Reckon is a good place to start. Unlike many of the Bowland resources, You Reckon doesn't require any ICT resources but rather contains a set of activities designed to help develop students' questioning and reasoning skills – perfect for developing process skills. Why not make a start with this in September?

- In June, the QCA [now QCDA] launched a consultation exercise looking at the proposed regulatory criteria documents which will form the basis of the next generation of functional skills qualifications. The consultation on the draft regulatory criteria is a vital stage in the development and introduction of functional skills. The results of this consultation, together with the lessons learnt from the functional skills pilot, will go on to form the new regulations. These regulations will in turn be used by awarding organisations when they develop the functional skills qualifications being introduced as part of national roll out in September 2010.

- What images help students access mathematical ideas? Helping students develop multiple images of concepts, such as fractions, is a key part of the Improving learning in mathematics resource from the Standards Unit. In this article from 2007, Dave Hewitt considers two images which he considers to contain within them "the essence of a particular topic of mathematics".

- Are you missing talking mathematics during the holidays? Have you contributed to any of the NCETM communities? Maths Café offers a place to talk about anything you wish, while the Secondary Forum provides an opportunity to post questions and join discussions about all things Secondary – it's a bit like a mathematics department office that spans the entire country! Why not verbalise what's on your mind?!

- Relax! The holiday's here! It's time for everyone you know who's not a teacher to be glaring at you as you kick back and take a well-earned break.

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Diary of a subject leader

Real issues in the life of a fictional Subject Leader

My second in department and I have been busy rewriting our Key Stage 3 scheme of work. With the loss of SATS, inclusion of process skills and the continuing implementation of APP, a curriculum review had been long overdue.

Our previous scheme of work was based upon the National Strategies' Sample Medium Term Plan. It proved adequate for a number of years, providing a balanced range of topics pitched at an appropriate level of challenge. Our textbooks also followed the same format, which was somewhat convenient as it saved time with the referencing of chapters to learning objectives. Nevertheless, we believed it had become outdated and no longer reflected the drive and ambition of the department to promote process skills and effective day-to-day teacher assessment. So can a document be a useful point of reference while reflecting the philosophy and ambitions of a department?

The last thing we wanted to do was start from scratch. The previous scheme of work was limited yet worked and it would have been nonsensical to throw the baby out with the bath water. Consequently, the content objectives, order of topics and time allocations remained unchanged. We knew what we were to teach but were still scratching our heads as to how to teach it. How were we going to encapsulate the essence of the key processes?

We started by referencing rich tasks within the scheme of work, including examples of investigative, problem-solving activities that may provide stimulus and engagement when teaching a specific topic. However, the style in which I delivered an activity may vary to the way a colleague delivered it. Therefore, the learning experiences and processes undertaken by students in opposing classes would inevitably vary to some extent. Moreover, how could this diversity be encapsulated within a scheme of work?

After much discussion, we included regular reminders of the key processes with the aim of encouraging teachers to consider how the learning objectives were to be delivered and the experiences gained by the students through a variety of teaching activities. In addition, subtle reminders of basic AfL techniques were placed on every page to promote the day-to-day assessment of students' understanding.

Will these small additions have much effect on developing the pedagogy within my department? Well, not on their own. However, they do reinforce the ethos I am trying to promote within the department: that how we teach is as important as what we teach.