Secondary Magazine Issue 26

National Centre for Excellence in the Teaching of Mathematics

Welcome to Issue 26 of the Secondary Magazine. Have you noticed that the hours of daylight are starting to increase? Although I'm still leaving home in the dark each morning and getting home in the dark at night, there is more light creeping into each day which inspires me to shake myself into shape and tackle 2009. We hope this Issue will give you some inspiration and shed some light on mathematical developments.

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What is Functional Mathematics?

There can be very few secondary mathematics, English or ICT teachers in the country who haven't heard of Functional Skills! Even if all they've done is caught it in their peripheral vision and know nothing more than the fact that all students from the current Year 8 onwards will have to achieve Level 2 in the relevant functional skill in order to gain a C or higher in that GCSE. Staffrooms up and down the country are rumbling with predictions and thoughts about what the impact might be and how the skills will be assessed.

Functional Skills could be thought of as a natural extension to the new KS3 curriculum (which started with Year 7 in summer 2008) and the process skills introduced in this curriculum lay at the heart of Functional Skills.

Although the QCA states that functional skills 'have been developed to strengthen and bring consistency to learning routes for young people to ensure that they achieve a firm grounding in the basics of English, mathematics and ICT' (Developing Functional Skills Qualifications, 2006) Functional Maths is not just about basic numeracy skills. In fact, when looking at the Functional Maths Standards (which detail what students must achieve in order to pass Functional Maths) there appears to be little or no mathematical content to be taught. The then QIA (now known as LSIS) sum this up in the useful Teaching and Learning Functional Maths folder which states:

> *Clearly, teachers cannot know what English/mathematics/ICT their learners will use as they move through their lives. This means that we cannot identify a curriculum core that every learner will use. Instead, and much more powerfully, learners should be taught to use and apply the English/mathematics/ICT that they know, and to ask for help with the areas with which they are less confident.*
> *It is essential to think of learners becoming functional in their English/mathematics/ICT, rather than thinking that there is a vital body of knowledge, known as functional English/mathematics/ICT.*

So if there isn't a curriculum core, there isn't any 'stuff' to be taught, what will Functional Maths look like in the classroom and how will we know whether our students are 'functional'?

It's often been said that Functional Skills are about the *how* rather than the *what*. If you were to be a fly on a wall in your classroom on a day in which you (improbably) had Year 7 class for lesson one, Year 8 for lesson two and so on, all the way up to Year 11 at the end of the day, you'd probably notice that the *stuff* that the class was working on would be getting progressively more difficult. It's likely that you'd also notice that the *way* in which they were working on it was similar if not exactly the same. Functional Maths might be thought of as the progression of *how* students learn alongside the traditional approach which focuses on progression in *what* they learn.

Progression in the way that students work is explicit in the way that the Functional Skills Standards develop and is common to all three subject areas. The Functional Skills Standards identify four ways in which the way that students work can develop; familiarity, complexity, technical demand and independence. In mathematics this progression is expanded to:

> ***Complexity***
> *Real-life situations, as they arise, are often quite complex. Identifying the separate areas of knowledge needed to tackle a situation, the steps needed to solve the problem and the accessibility of the problem itself (routine or non-routine) determines the level of complexity.*
> ***Familiarity***
> *This reflects the extent to which a problem or situation requires an individual to relate skills and*

understanding developed in other contexts to make sense of a new situation. In transferring skills and understanding, the individual may need to adapt or extend their knowledge in order to tackle the problem effectively.

Technical demand

This reflects the range of knowledge, skills and techniques that an individual is required to draw on in order to tackle a problem. These are defined in various ways, for example in the national curriculum levels. Demand may vary from a simple calculation to a thorough analysis of a practical situation.

Independence

This relates to the level of autonomy that learners apply to tackling a problem at each stage. It is closely related to the ability to apply problem-solving skills, so that at higher levels learners can demonstrate the ability to select and apply mathematical skills independently.

Again, what does this mean? How will the mathematics classroom in which Functional Skills are being learnt look different to any other mathematics classroom? For many of us who feel that we've maybe become a little too XXX (have a look back at this article from the Secondary Magazine Issue 23) this gives a welcome opportunity to try new things (or to bring back some old favourites). There are some really nice strategies and activities to get your classes (and maybe you!) used to this way of working in the second half of the QIA document, which will feel familiar to anyone who's used either the Improving Learning in Mathematics or the Thinking Through Mathematics resources. You might like to have a look at some of the exam board sample assessment materials – the OCR sample assessments for level 2 can be a good starting point for a short project.

As 2009 begins, 2010 and 2012 start to feel closer and the challenge of preparing our students not only to be able to do mathematics, but to be able to function mathematically and to become mathematical problem solvers, is one that many of us will begin chipping away at – not just at KS4, but through the whole of the secondary curriculum.

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.

On 7 February 2009, the RBS Six Nations rugby tournament kicks off with England playing Italy at Twickenham. This is the first of two Up2d8 Maths resources which use this competition as the starting point for mathematical exploration. Try, Try and Try Again uses the scoring system of Rugby Union (in which either 3, 5 or 7 points are awarded) as the context to launch an investigation into partitioning integers. Students explore which total scores are possible and might then go on to investigate which scores can be constructed in one, two or three ways.

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.

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The Interview

Name: Celia Hoyles

About you: Celia Hoyles was awarded a first class honours degree in mathematics from the University of Manchester and holds a masters and doctorate in mathematics education. She has been Professor of Mathematics Education at the Institute of Education, University of London, since 1984.
Her major research interests are: secondary students' conceptions of proof and strategies for teaching proof; the mathematical skills needed in modern workplaces; the design and implementation of computational environments for learning and sharing mathematics; and systemic change in the professional development of teachers of mathematics.
Professor Hoyles was awarded an OBE in January 2004 for services to mathematics education. From December 2004 to November 2007 she was the Government's Chief Adviser for Mathematics. She became Director of the NCETM in June 2007.

The most recent use of mathematics in your job was... Mainly as I design and share activities for learning mathematics and analyse teacher input and student responses. I am working on a project that is building a system to support students to express patterns in ways that are general – that is, relate to structural invariants rather than 'pattern spotting' in the numbers. Working in an interdisciplinary team on this is challenging. I am also constantly using mathematics as part of my job as Director of the NCETM – we always try to be active mathematically, even in management meetings!

Some mathematics that amazed you is... I still get amazed at the simple outcomes and regularities that 'pop up' in mathematics in surprising ways: $e^{i\pi} = -1$. How sometimes the limit of a sequence tending to 0 divided by another such sequence can be something simple like 1. And the sheer pleasure in the invariants you can find in simple Euclidean geometry. Plus, of course, alongside all this 'beauty', mathematics is also useful just as part of everyday life, and valued in your career. What continues to amaze me is that so many people boast about being 'no good at mathematics'.

Why mathematics? I just have always enjoyed the pleasure of working things through in a logical way - looking for reasons and structures and seeking to be able to justify my actions and solutions. I have also had such stimulation in exploring mathematics in so many different ways (for example in games and puzzles, how mathematics is used in the workplace, how better to teach mathematics at all phases, how to communicate mathematically to diverse groups) – and in so doing, have met such a range of people from all walks of life.

Your favourite/most significant mathematics-related anecdote is… a teacher in a primary school had split up the class in groups, each with an even number of pupils. Unfortunately Johnnie was left out – and he found much to his anxiety that wherever he went he made the group odd..

A mathematics joke that makes you laugh is… there are 3 types of mathematician: those that can count and those that can't…

Something else that makes you laugh is… I loved *Fawlty Towers*.

Your favourite television programme is… I only really watch the *News* and *Newsnight* – oh, and the tennis when it is on.

Your favourite ice-cream flavour is… I don't like ice cram at all I am afraid.

Who inspired you? Seymour Papert, the brilliant mathematician, psychologist and computer scientist. His vision of how to make mathematics more accessible and engaging for all – through technology (he invented *Logo* and the turtle all those years ago) continues to be my inspiration.

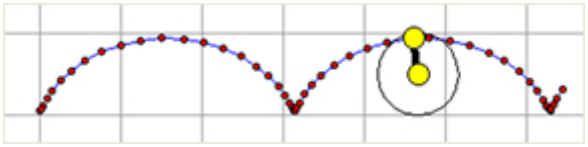
If you weren't doing this job you would… be back to full time as an academic – teaching, reading more than I can find time to do and writing more too…oh and engaging with mathematics, mathematics teachers and mathematicians.

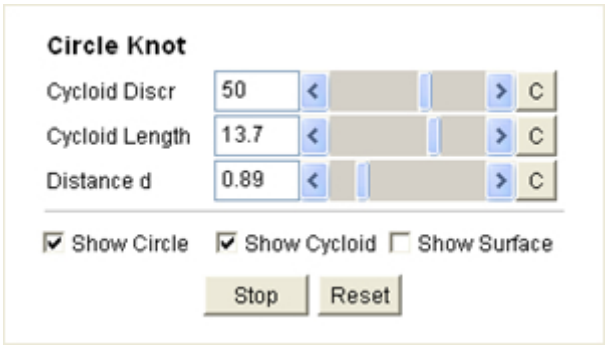
Focus on...the cycloid

One arch of a cycloid of radius *r* is given by the parametric equations teachers and mathematicians.

$$x = r(t - \sin t)$$
$$y = r(1 - \cos t)$$

What happens if the radius of the cycloid changes? Make your prediction then test it using this animation:



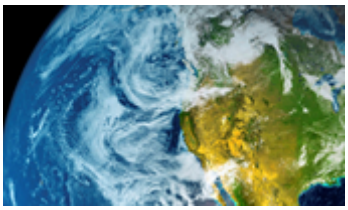


The cycloid has generated fierce competition among even the most distinguished of mathematicians. It has been called 'Helen of Geometers' – the most beautiful curve in the world.

The name Cycloid is attributed to Galileo who attempted to find its area by weighing various pieces of metal slices representing the rolling disc. Many other very famous mathematicians worked on ways to calculate the exact area under the curve – those who were successful include Fermat and Descartes. Roberval and Sir Christopher Wren succeeded in calculating the length of the arc.

The brachistochrone problem, posed by Johann Bernoulli in 1696, which asks: *Given two points A and B in a vertical plane, what is the curve traced out by a point acted on only by gravity, which starts at A and reaches B in the shortest time?* can be solved using a cycloid. It is thought that Bernoulli knew the solution but challenged others to solve it. He received four further solutions from Newton (who is said to have solved it in an evening after returning home from the Royal Mint), Jacob Bernoulli, Leibniz and de L'Hôpital.

If the cycloid is turned upside down it forms a tautochrone curve, that is a bead dropped anywhere on the curve will always take the same time to reach the lowest point of the curve, $T = \pi\sqrt{\frac{r}{g}}$ as illustrated here



An idea for the classroom – World Class arena

The World Class Arena website is the home of the World Class Tests which are available three times a year for pupils aged 8-14. The website states that they are intended for the top 10% of pupils.

When taking World Class Tests you should be able to:

- *think creatively and logically*
- *use your thinking skills to solve problems and answer questions on subjects that you may not have studied previously*
- *work out and respond to unfamiliar information*
- *demonstrate clearly how you think through and solve questions.*

For our pupils to function mathematically and improve their problem-solving abilities, there is no doubt that these are desirable skills and it may be worth considering if the World Class Tests would provide a suitable challenge for some of your pupils.

Whether or not you decide to sit the World Class Tests (which are available on 9-27 March, 22 June–10 July, and 9–27 November in 2009) there are some On-line Interactive Challenges which are good resources for the mathematics classroom.

There are four different challenges you can try:

- Mathematics ages 8-11
- Mathematics ages 12-14
- Problem solving ages 8-11
- Problem solving ages 12-14

If you look at *Problem solving ages 12-14*, there are five problems:

Moongazing
You are asked to order a set of images to show how someone standing on the earth might see the moon as it orbits the earth. There is a nice simulation to assist your visualisation.
Pyramid
You are invited to explore the patterns and connections within an addition pyramid
Game of 20. This is a board game where players take turns covering a number on the board with the aim of being the first to reach a target of 20.
Machines
Using cogs and gears, pupils explore ratios in a practical setting.
Oxygen
Pupils use interactive graphs to decide on the best conditions for plants to generate oxygen.

Each problem has an interactive element and comes with a set of solutions and could be worked on individually or in pairs within the mathematics lesson.

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5 things to do this fortnight

1. If you're in Yorkshire, book your place on the MA one-day event for secondary mathematics teachers. Following the success of last year's event, delegates will have the opportunity to hear opening and closing plenaries from Paul Andrews of University of Cambridge and Jane Imrie of the NCETM (and President-designate of the MA). A diverse choice of talks, workshops and discussion groups will be offered which aim to invigorate secondary mathematics teaching around the central theme *Exciting Ideas for Teaching Secondary Mathematics*. The event is on 6 March in Garforth.

2. As England's first test match of the West Indies tour approaches, what better way is there to enjoy the cricket than through the statistical analysis in this article from the Plus website.

3. Have you considered assessment for KS3 now that the SATs have gone? The secondary maths APP has been re-written and relaunched – why not have a look at it here.

4. Try using an always, sometimes, never question as a way to get students talking in your class.

5. 12 February would have been Charles Darwin's 200th birthday. Celebrate with a visit to the Natural History Museum's Darwin exhibition.

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Diary of a subject leader

Real issues in the life of a fictional Subject Leader

Our Gifted and Talented school coordinator is auditing again. I've just received a form asking me to state what provision the department makes for the G&T students within mathematics.

As always, my first step is to dig out what I wrote the year before and check whether we are still running the 'one-off' events for the brighter students. These include the usual UKMT maths challenge, maths clubs, workshops at the local college/university, the odd trip to a maths-related exhibition and the occasional visit from guest speakers to the school. Needless to say, these are all to be included again this year.

Feeling somewhat unsatisfied by my flippant attitude in the past to completing this form, I began contemplating what it actually meant to be a G&T student. Did the students on the school's G&T register qualify across all subject areas, within maths alone, or should they even be there to begin with? The term 'Gifted and Talented' conjures up images of Nobel Prize winners, pioneers in industry and revolutionary artists. If they are at my school, many are particularly gifted and talented at hiding their potential.

So what criteria make a student G&T in maths? Is a potential A* student G&T by default? Are there unique, imaginative and creative thinkers within the lower sets? Is it merely a statistical measure or is it based upon individual skills and attributes?

Every student within the top sets receives some extra-curricular provision. All will, at some time during the year, have the opportunity to participate in some kind of higher level 'bolt-on' activity. But is this really fulfilling the brief of catering for these exceptional students? Were we providing provision for them to expand and apply their talents?

We, as a department, have now agreed to develop enriching, open-ended activities within lessons in addition to the extra curricular one-offs which would continue as normal. Catering for the G&T students would no longer mean giving them larger numbers or questions from lower down the page. In our eyes, G&T students should be given the opportunity to apply their skills within the context of problem solving rather than through an accelerated curriculum.

This now leaves me contemplating how we can put this into practice?