Enriching school maths: the Millennium Mathematics Project

In November 2005 it was announced that the Millennium Mathematics Project, which aims to support and enrich maths education for ages 5 to 19 and promote the public understanding and awareness of mathematics, had won the University of Cambridge its third Queen’s Anniversary Prize for Higher and Further Education.

The Queen’s Anniversary Prizes, which sit within the national honours system, recognise and honour outstanding achievement and excellence at world-class level in UK universities and colleges, with all universities and colleges across the UK invited to make a single entry in each biennial round. Entries must demonstrate outstanding achievement and benefit brought to the institution and the wider community, and the Awards Council look in particular for signs of initiative, innovation and originality. Cambridge chose to enter the Millennium Mathematics Project for the 2005 round, reflecting the University’s view that “The Millennium Mathematics Project is an outstanding initiative which has made a significant contribution to education and to society as a whole, addressing an issue of great national concern: ... it amply deserves recognition at the highest level”.

The prize is the culmination of six years of growing success for the Millennium Mathematics Project (MMP), which was launched in 1999 as a joint initiative between the Faculties of Mathematics and Education at the University of Cambridge, and is headed by Professor John D Barrow. The MMP now encompasses a range of complementary programmes, which have a national (and in some cases international) impact. We are active across the whole of the UK through web resources and our video-conferencing programme and through face-to-face school visits to run pupil workshops and teacher professional development courses. Since 1999 take-up of our various activities has grown significantly: over the course of the academic year 2004/2005 our websites attracted over 4 million site visits in total, or more than 100 million hits.

The number of people working on the MMP has also increased: in addition to Professor Barrow there are now 10 full-time and 11 part-time staff employed specifically to work on the project, which is funded from a variety of sources including corporate philanthropy, charitable trusts, sources within the University of Cambridge, particularly generous support from Cambridge University Press and Cambridge Assessment, and part-funding from the Department for Education. The MMP was cited in the Smith report on Post-14 Maths Education and singled out for mention in the DfES’s response, Making Mathematics Count (June 2004). The MMP’s activities were also specifically cited as a means of improving and supporting teachers’ subject knowledge in the Transforming Secondary Education paper circulated to all secondary schools in February 2003, while our resources were also recommended in the 1998 DfEE report on the National Numeracy Strategy.

Our largest programme is the NRICH website (www.nrich.maths.org), which publishes free mathematics education enrichment material for ages 5 to 19. NRICH material focuses on developing mathematical skills through problem solving, and encourages creative, confident approaches to mathematical thinking. Although NRICH initially focused on gifted and talented pupils, its remit has since broadened and the material is now aimed at all ability ranges: there is a growing body of evidence from educational research that problem
solving approaches can benefit all pupils, including low-attaining students.

A new ‘issue’ of the NRICH website is published every month in school term time, containing mathematics enrichment problems for Key Stage 1 to 5 (ages 5-19). Each monthly ‘issue’ contains content arranged in ‘stages’ corresponding to the level of pre-assumed mathematical knowledge assumed at each key stage, with problems in each given a star rating according to difficulty, as well as other material including games and articles. All past material is archived and freely accessible, and the site therefore provides an enormous resource bank of mathematics teaching and learning material: the archive contains the equivalent of one problem for every single day of a child’s school career from the age of 5 until they leave at 19. NRICH is enormously popular - in 2004/5 the website attracted over 1.7 million site visits (more than 49 million hits), and usage continues to grow.

NRICH also offers an online discussion and mentoring service, AskNRICH, staffed by Cambridge University student volunteers, which helps enquirers of all ages with their mathematical queries (our youngest users are around 8, the oldest at university, and over 1,700 new users registered last year) and provides a forum for an online mathematics community. The discussion boards are not designed to “give the answer” – the volunteer mentors and other peer users engage in mathematical conversations which help AskNRICHers, as they call themselves, to develop their own understanding of the topics raised.

MMP staff working on NRICH also run pupil workshops and master classes and continuing professional development courses for teachers in schools all over the UK from Aberdeen to Newquay. These face to face activities help to reinforce and enhance the impact of the website, and also help to provide feedback on the needs and reactions of teachers and pupils which can inform future developments. Over the course of 2004/5 NRICH staff worked face to face, through small-group continuing professional development courses and hands-on sessions at teacher conferences, with more than 1500 teachers from 1200 schools, went into a further 45 schools to run pupil workshops, and ran a year-long programme of after-school workshops for 80 Year 10 pupils in Hackney and Tower Hamlets.

Our extremely popular Hands-On Maths Roadshow is aimed at children from 4 to 13, and is taken to primary and secondary schools all over the country by the MMP’s Schools Liaison Officer, Susan Hickman Pinder. The Roadshow consists of a collection of mathematical games, puzzles and challenges – taking the form of everything from a giant foam-filled deconstructed cube to a collection of coloured plastic teacups – which aim to develop mathematical reasoning skills, strategic thinking and problem solving while also challenging pupils’ preconceptions about what ‘maths’ is and stimulating mathematical curiosity. Many of the Roadshow activities are physical translations of problems on the NRICH website, which also allows teachers to follow up activities after the school visit, creating a more sustained impact.

Examples of Roadshow activities include ‘Auntie’s Teacups’ – with four cups and four saucers of each of four colours, arrange the cups and saucers on a 4x4 grid so that in any row no two cups and no two saucers are the same colour; or the very popular Soma cube - a giant, foam filled cube constructed out of seven pieces, all different, which need to be reassembled. There are 240 essentially distinct ways of assembling the seven Soma pieces into a cube, and mathematicians as eminent as John Conway have spent time examining the Soma cube combinations.

Susan explains:

“The Roadshow activities are designed to get children to develop their strategic thinking and reasoning skills, and they can be taken to different levels depending on the ages of the children and how able they are. The ‘Aunties Teacups’ activity, for example, is based on Latin squares – the underlying mathematical idea is linked to group theory that pupils might study if they continue mathematics at A-level, but for most age groups involved in the Roadshow the pupils will be finding different combinations through experiment and looking for patterns.”

In October 2004 we took on the running of the Enigma Schools programme originally devised by Simon Singh, which runs workshops on codes and code-breaking for pupils from Key Stage 2 up to A-level, enhanced by a genuine Enigma cipher machine loaned to the MMP by Dr Singh. Claire Ellis, formerly the Education Manager at Bletchley Park, has developed the programme to include a circus of hands-on code-breaking activities, and, like the Roadshow, the Enigma workshops are enormously popular with schools.

Plus (www.plus.maths.org), the sister-site to NRICH, is an online maths magazine aimed at non-specialists interested in mathematics among the general public and school maths and physics students aged 15 and upwards. It contains lively, informative, accessible
articles and features on a huge range of different aspects of maths and its applications. Recent article topics for example have ranged from airline seat pricing to Boolean algebra and astrobiology. Contributors to Plus have come from many universities both within the UK and overseas, and include both current research students and some of the world’s most eminent mathematicians and physicists – Freeman Dyson, Sir Roger Penrose, John Conway and Gerardus ’t Hooft have all been interviewed or have written for Plus.

Plus also includes a large digital careers library encouraging the further study of maths at A-level or as a degree through showcasing the huge range of opportunities which the study of maths can open up. The careers section features interviews with mathematicians in a range of different fields ranging from computer games design to defence analysis, medical statistics, financial modelling or architecture. Posters based on the careers information on the website were produced in 2004 and sent to UK secondary schools and Connexions offices – following a request from the BBC, the careers posters are also due to feature in the background set of an episode in the new series of Dr Who!

Again, the usage of the site has grown dramatically since 1999: in 2004/5 Plus attracted over 1.3 million site visits (more than 31 million hits) during the year. The site also won the prestigious international Webby award in 2001 for the best Science site on the Internet, joining winners in other categories such as CNN, the BBC and National Geographic. Readers of Plus can also sign up for a free fortnightly email newsletter highlighting items from the site and including extra information, events listings and news items: there are currently over 2,000 subscribers to this service.

In addition to working via the internet and through school visits, the MMP has also developed a programme which uses live video-conferencing to teach and enrich mathematics for ages 6 to 19. The Motivate video-conferencing project (see www.motivate.maths.org) links university mathematicians and scientists (from several different UK institutions) to primary and secondary schools in areas of the UK from Jersey and Belfast to Glasgow and inner-city London, with international links to Pakistan, South Africa, India and Singapore. We organise a set programme of video-conferences throughout the year on different topics for different age groups – for instance ‘The Transit of Venus’, ‘Einstein and Relativity’, ‘Are You Convinced?’ [geometric proof] and ‘Flipping Beermats’ [mathematical modelling and aerodynamics]. For pre-16 groups the format is usually two videoconferences a few weeks apart, and for post-16 students the format is condensed into a one-day master class, with several schools participating in each video-conference. In the first video-conference the speaker introduces and explains the topic, and then presents the participating students with project work, which the MMP co-ordinator, Dr Jenny Gage, devises in consultation with the presenter. Pupils work on the project tasks between the two video-conferences before presenting the results of their work to the speakers and their peer students at the other participating schools in the second session.

Feedback from teachers has been overwhelmingly enthusiastic. As a maths teacher from a school in Cumbria commented of her Year 8 group:

“Students’ confidence has been affected in a positive way. Many of the students who had seemed thus far ‘less able’ within the group were realising that they were capable of doing ‘difficult’ maths and so their overall confidence has increased. The more able students have relished the opportunity to really stretch themselves. … Students have gained a sense of where school maths fits into the ‘real world’…”

Around 3,000 children from 80-90 schools each year participate in our video-conferences, at Key Stage 2, 3, 4 and 5.

As well as our national programmes, the MMP is also involved in local activities, which have proved very successful. STIMULUS is a student volunteer programme placing Cambridge maths and science undergraduates in local primary and secondary schools as classroom assistants. 175 Cambridge students were involved in 2004/5, each spending at least one afternoon each week for a full term in schools – one undergraduate described her STIMULUS placement as “the highlight of my week!” We have recently been asked by the Ogden Trust for advice on how other HE institutions might replicate the volunteer programme.

We also organise a programme of popular lectures, held in Cambridge, for local primary or secondary schools and the general public. Past lectures have included topics ranging from mathematical models of climate change, string theory or the maths of sport to Ramsey Theory and the Riemann Hypothesis. Lectures are consistently over-subscribed, with the lecture theatre full to capacity with audiences of nearly 200, and we aim to organise 9 or 10 lectures each year.

For more information about all of the MMP’s activities, visit: www.mmp.maths.org