Creating an inclusive culture in mathematics through subject-specific teacher professional development: A case study from England

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Introduction

In 2002, the UK government announced that there was to be an inquiry into Post-14 mathematics with a view to making recommendations that would revitalise mathematics education in the UK. Professor Adrian Smith, then Principal, Queen Mary, University of London, was invited by the Secretary of State for Education to lead the inquiry and the report was published in 2004 (*Making Mathematics Count*: see http://publications.teachernet.gov.uk). Professor Smith made many important recommendations, many of which were accepted by government. In addition, the inquiry was charged with drawing up plans for a new National Centre for Excellence in the Teaching of Mathematics (NCETM) and in June 2006 the new National Centre was launched.

I joined the organisation as Director in 2007 at a very exciting time in its development. I believe that the National Centre is having considerable impact on the teaching and learning of mathematics in UK schools and colleges and, most importantly, on the engagement and enjoyment of learners – so that mathematics is more inclusive, more meaningful to all learners in all their diversity.

Origins and aspirations

The NCETM was set up in England by the UK Government as a national infrastructure for the support of the teaching and learning of mathematics by providing expert advice, resources and information, and overseeing the funding for the development and dissemination of mathematics continuing professional development (CPD) provision at a strategic level and coordinating its
operation nationally. This is the first time such a national infrastructure has been put in place. The National Centre aims to raise the professional status of all those engaged in the teaching of mathematics in order that the mathematical potential of learners will be fully realised. It takes as its starting point the premise that effective CPD has three interrelated strands:

- broadening and deepening mathematics content knowledge;
- developing mathematics-specific pedagogy, which includes appreciating how learners engage with mathematics and likely obstacles to progression; and,
- embedding effective mathematics pedagogy in practice.

Thus we join with partners in the mathematics community to promote CPD opportunities for teachers that impinge on these strands in ways that are cumulative and sustained over the career of a teacher. Important among these partners are higher education institutions (HEIs), who are already offering CPD opportunities for teachers and who have expressed an interest in doing more with us. HEIs can provide expertise in mathematics and in mathematics education as well as bring new perspectives on the subject and effective pedagogies that will inform the work of the NCETM.

The key objectives of the NCETM are:

- To stimulate demand for mathematics-specific CPD contributing to strengthening the mathematical knowledge of teachers and improving school and college performance in mathematics
- To lead and improve the coordination, accessibility and availability of mathematics-specific CPD
- To enable all teachers of mathematics to identify and access high quality CPD that will best meet their needs and aspirations.

Most crucially, we set out to create a political climate where professional learning is both recognised and valued by all. So if there is a new initiative, for example to ensure certain groups
of learners engage with the subject, this is developed with teachers with time and resources committed to CPD.

And central to the Centre’s agenda are:

• its unerring focus on mathematics and developing excellence in teaching mathematics across all phases of education;

• its support for sharing successful practice within and across a range of didactical contexts from early years through to further education;

• its brokerage of a range of professional development opportunities while identifying and sharing evidence of their effectiveness;

• its commitment to placing teachers’ needs and goals at the core of its work by putting in place structures through which teachers are able to develop ownership of its provision;

• its offer of a single, unified point of contact for teachers of mathematics;

• its commitment to joining with partners to influence policy concerned with workforce development.

The National Centre has a virtual presence through its online web portal complemented by an on-the-ground presence through a network of Regional Coordinators that covers all of England. Each Regional Coordinator has been joined by a range of part-time ambassadors and associates who together work to create local networks around a topic of interest, build relationships with mathematics teachers and organisations, identify opportunities for high quality professional development and share examples of excellence across the region. What follows is a glimpse of the National Centre’s provision and its impact, with more information available at http://www.ncetm.org.uk.

Building the NCETM community through face-to-face meetings

The NCETM works with teachers face to face in a number of different ways. There are national events in which particular aspects of the work of the NCETM are disseminated. For example, The Potential of ICT in Mathematics Teaching and Learning conference showcased the work of
teachers using Information and Communication Technologies (ICT) in mathematics and explored the potential of ICT to motivate learners, widen access to mathematical ideas, expand opportunities and narrow the gap in achievement across mathematics.

The Teachers Talking About Teaching Mathematics conference brought together teachers who had received NCETM grants to celebrate what they had achieved and to give them the opportunity to share their findings and their experiences.

One teacher who attended the day said:

“I attended the conference and it ‘did what it said on the tin’! Lots of teachers were talking about maths! It’s great to be given the opportunity to see what colleagues around the country are up to. The day confirmed my belief that we all live in hope of that spark of real understanding from a child - will today be the day?”

In autumn 2008, the NCETM also held national Influential Mathematics Teachers (IMT) conferences in Birmingham, Leeds, and London. IMTs are those who have the potential to be a major force in improving mathematics education beyond their own schools. The National Centre is establishing a national IMT network so that IMTs can share their experiences, feel supported, have a national voice in the mathematics community and, crucially, support more teachers in making a difference in the classroom.

To initiate this network, more than 250 teachers took part in talks, workshops and ‘speed-dating’, a fast and effective medium for the exchange of ideas. Evaluations showed an overall satisfaction level of 100%. One teacher in a secondary school in Devon said:

“When working in education it is all too easy to lose one's sense of perspective as you become embroiled in the day-to-day... The IMT conference gave a unique opportunity to recalibrate, to understand one's place in the mathematical community, to experience practice across the country and to forge links with other teachers of mathematics. The whole event was brilliantly organised and vital to the well-being of the nation's mathematical community.”
The NCETM sets up teacher networks and supports them, and works for their sustainability whereby teachers take the lead in developing their own communities, thus not only spreading the ideas further, but also developing the capacity among teacher-leaders. One teacher commented:

“The networks allow an up-to-date discussion of current issues in mathematics, and include an opportunity to see and try something new. Regular team meetings at school focus on teaching and learning and I am then able to share the network content with other staff. Focusing on teaching and learning in this way has increased motivation amongst staff and encouraged them to ‘try something new’. It has also allowed me the time to be imaginative and discuss, try and evaluate new ideas. It has also proved to be effective CPD for me as I am now much more confident and competent at planning and delivering more worthwhile teacher network meetings.”

Teacher enquiry and research

NCETM funding offers teachers time, space and support to try out something new. Many have taken up this valuable opportunity to develop the way they teach mathematics by working collaboratively: more than 80 projects have been funded to date. Through this often career-transforming experience, teachers have adopted new approaches and improved the experience of their learners. One teacher who received funding to support her research in early years mathematics said:

“My practice is now more reflective and responsive. As an experienced teacher this project has taken me on a fascinating learning journey, which has demonstrated that small alterations in my practice can have a profound effect on children’s thinking.”

The NCETM-funded project Maths Talk in Bilingual Children's Classrooms involved 17 Walsall primary maths teachers, most of whom are leading mathematics in their schools, embarking on an action research project in mainstream classrooms to find out how improving the ability of Pakistani and Bangladeshi children to use mathematical language will contribute to their success as developing mathematicians, increasing their capacity, understanding and
confidence. The teachers worked in small research groups for planning and discussion, each supported by a consultant, while they were paired to make visits to their partner’s school, undertaking some research together. The final report is available at http://www.ncetm.org.uk/bilingualclassrooms.

Another funded project, entitled Work-Related Learning in the Mathematics Curriculum, aimed to increase the number of teachers who are able to engage effectively with applied and work-related learning in the mathematics curriculum, especially in Years 9 to 11 (ages 13-15). Research into enhancement and enrichment of mathematics provision indicates that work-related learning (WRL) is not a significant element in current practice nationally, even though there is strong evidence for the benefits of WRL. A survey conducted in 26 schools in western England, in 2003-2005, showed that young people enjoy and value work-related learning opportunities and want more of them. They also want the relevance of subjects and courses made explicit.

The funded project was based on collaboration between teachers at different schools, and enabled the production of learning materials which applied mathematical concepts in ‘real world’ contexts. Partnerships were set up between schools and local employers or work-based training providers. Participating teachers visited workplaces in pairs, investigated opportunities for mathematical learning, and collaborated on putting into practice the new approaches that they encountered. This included devising work-related learning activities and trialing them in the classroom. A report will be published shortly at www.ncetm.org.uk/teacherenquiry.

Large collaborative projects

As well as funding teacher research, the National Centre has also undertaken two large-scale projects, Mathematics Matters and the Researching Effective CPD in Mathematics Education (RECME) project:
In the Mathematics Matters project, following national and regional events and portal engagement with teachers and all major stakeholders in mathematics education in the country, the National Centre drew together key findings concerning what was generally agreed to be effective learning in mathematics, and what it looks like in practice. The project demonstrated widespread agreement on the values and principles that underpin effective practice and the Centre is working with key stakeholders to ensure these are embedded in all mathematics initiatives. The *Mathematics Matters Final Report* was published in 2008 at http://www.ncetm.org.uk/mathematicsmattersreport, supported on the portal by a searchable database of accounts of actual lessons to exemplify the findings.

The National Centre also commissioned research into CPD itself, which will inform its work supporting the development of CPD across the country. The Researching Effective CPD in Mathematics Education (RECME) project was developed in consultation with the NCETM Research Advisory Group and was carried out by a team of NCETM researchers. They examined a range of professional development activities, including networks, courses, and funded teacher enquiry projects. They asked teachers about their direct experience of CPD courses and examined how this was informing their practice and their students’ learning. The final report *Researching Effective CPD in Mathematics Education* was launched at an NCETM national conference in 2009 and is available at http://www.ncetm.org.uk/recme.

**Building a virtual community through the NCETM portal**

As well as working with teachers directly, a crucial way that the Centre is extending its reach is by exploiting technology and social networks on the web. The NCETM portal is increasingly regarded as the first port of call for the support of mathematics teachers. It transcends locality and phase, signposts a wealth of excellent resources, and hosts communities
of all types. It is a dynamic site: strategies for teaching mathematics can be shared, and resources grow with use as teachers offer feedback, examples and ideas for improvement. The portal can also be used to chart individual CPD progress through the Personal Learning Space (see Figure 1 below). It also supplies the latest news and information about developments at the National Centre and in the wider world of mathematics education.

In brief, the NCETM portal includes:

- Courses and Events directory through which teachers can find details of upcoming mathematics-specific CPD events;
- Resources section that provides a collection of stimulating CPD materials, including materials and case studies from practitioners that describe how they have been used and what effect they can have had on teaching and learning;
- Teacher Enquiry section where you can gain access to research developments and findings relevant to mathematics education and find out how to apply for NCETM funding for your own enquiry project;
- News on issues in mathematics education;
- Communities and Blogs, where teachers can share their ideas about teaching, professional development and current issues, and read what other teachers have to say;
- Mathemapedia, a wikipedia for mathematics education, where teachers can explore classic themes in mathematics education, read about useful pedagogical strategies, and be prompted to take such ideas and strategies into the classroom as a way of developing practice.

Other key portal features include the increasingly popular Secondary and Primary Magazines, with their accompanying Up2d8 Maths resources which explore a range of mathematical themes in a topical context. There is also an Early Years Focus, with news, tips and suggestions for work with this age group, and an FE magazine for post-16 and adult numeracy educators looking for ideas and resources.
At the heart of the Professional Learning Framework lies the Personal Learning Space (PLS). The framework has Personal Learning at its core and covers: News, Mathemapedia, Resources, Community, Teacher Enquiry, and Courses and Training. The PLS is an area of the portal dedicated to the individual user, which they can enter as they log in to the portal. It allows teachers to personalise their journey on the National Centre portal through linking to their favourite items (activities, communities etc.), easily accessing their contributions and sharing with chosen colleagues, and making notes and reflections on resources and materials. All the different elements can be connected, linked and referenced. Through the PLS, teachers can also evaluate their current strengths and weaknesses in mathematics topics and follow recommended next steps for their own learning. The PLS can be used to support their professional journey, as well as allowing them to collect evidence for use in their career progression.
There has been a consistent upward trend in registrations on our NCETM portal which reflects, in the author’s view, the increasing richness of its provision as well as a growing awareness as to how it can be used effectively in schools, colleges and HEIs.

**Figure 2 - Change in portal registrations between June 2008 and June 2009**

One numeracy and literacy tutor said: “*It [The NCETM] feels a bit like a security blanket – when I feel I'm out of my depth, it's one place I can go find out about something to do with numeracy or maths.*” Just this sentiment was echoed by a teacher from a very different institution, a sixth form college catering for post-16 learners studying Advanced level mathematics, who simply said: “*I plug myself into the NCETM to recharge.*”

**Self-Evaluation tools**

The Self-Evaluation Tools (SETs) are at the heart of the PLS. Teachers can assess their own mathematical knowledge and pedagogy (either on their own or in groups) then explore hundreds of 'next steps' targeted on areas where they have expressed low confidence. The SETs are proving effective for departmental use, as well as for the individual, and they thus stimulate collaboration and sharing within a school as well as at cross-school levels.

Teachers first select the strand in which they are interested: mathematics content
knowledge or mathematics-specific pedagogy. They then select the stage: early years, Key Stage (KS)1, KS2, KS3, KS4, KS5 and adult learners, and then the topic that they wish to self-evaluate. Following this choice, teachers assess their level of confidence on a four-point scale and are provided (if they wish) with an exemplar of the topic to assist in their self-evaluation. Figure 1 shows an example from the mathematics content for Key Stage 3 and Fig 2 shows Assessing confidence in mathematics content knowledge for Key Stage 5 – Algebra and Functions.

Figure 3 - Assessing confidence in understanding the mathematics (Key Stage 3 - Geometry)

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1 A Key Stage is a stage of the state education system in the UK setting the educational knowledge expected of students at various ages.
The SET then produces a bar chart showing how confident the user is in the topics evaluated. Finally – and crucially – as mentioned above, the tool offers recommended next steps to develop practice and to support teachers in planning their own professional development. The key point is that there are a range of next steps from which the teacher can choose depending on their needs and interests, but all are assessed as useful and potentially effective.

Our feedback to date on the use of the tool has been very positive as illustrated in the quote below from a teacher:

“The self-evaluation resources provide a facility for me to reflect on my own strengths and weaknesses, and we plan to use the materials as a team to evaluate the strengths and weaknesses in our mathematics department. This is useful in itself, but most importantly, the site provides the information on the courses and

Figure 4- Assessing confidence in mathematics content knowledge  
(Key Stage 5 - Algebra & Functions)
further reading that are most suited to developing the skills and plugging any gaps in subject knowledge."

We have noted that the SETs are increasingly being used as part of regular performance review in schools, a trend we applaud. It puts review in the hands of the teachers rather than an external agency, and provides a robust template against which this review can be assessed. This process is described in the quotes from heads of mathematics and team leaders below:

“The benefits in incorporating the tool into Performance Management were abundantly clear to the department as was its use in providing evidence-based support for internal and external CPD applications."

“Using the SET has been both an encouragement and an eye-opener for my colleagues in the Maths Dept and for me. The tool provides quick and valuable feedback by summarising self-measured confidence across the spectrum of skills within mathematics, and the interface makes the whole data-gathering procedure very straightforward.”

The SETs are also proving very useful in Higher Education Institutions, both as a way for teacher trainees to self-evaluate and be pointed to appropriate resources and to discuss the examples to see if they can be challenged or improved. At Hertfordshire University, students have been doing an assignment with the SETs, working through the subject knowledge module and preparing an ‘action plan’ based on the results. The primary mathematics leader in the School of Education, said:

“[The SETs] have proved valuable as a way of enabling them to take ownership of their own professional development as they start their careers as qualified teachers. The focus on teaching the subject matter is very good, as many subject knowledge audits only focus on the students’ mathematical understanding. The visual explanations are a good professional development tool in themselves.”
On-line courses for professional development

The NCETM has developed a small number of Professional Development Modules for teachers of mathematics, with each module focusing on a current theme of relevance to the particular sector. It takes teachers through a number of guided online activities to develop their thinking and encourage reflection on the theme. As a teacher proceeds through a module they can store their ideas and reflections in their Personal Learning Space. Teachers can work through modules on their own but they are encouraged to work alongside a colleague so that they can share ideas. An example from a module designed for teachers of post-16 learners appears in Figure 6 below:
Figure 6 – Screenshot from online post-16 Professional Development Module
Departmental workshops

A number of CPD activities are aimed at whole teams, rather than individuals, and have been written to provide groups of mathematics teachers with structured professional development that can be discussed in-house, utilising all members' expertise and knowledge in, for example, a secondary school mathematics department. To date, there are 27 modules in the collection. Each workshop module has an overview and a number of resource sheets. The range of topics covered in the modules is shown below:

Figure 7 - The online departmental workshops
Pedagogical approaches for inclusivity

The NCETM promotes CPD activities based on pedagogical approaches that strive to include all learners, whatever their background, culturally or socially. These approaches are based on a belief that all learners can actively participate in mathematical enquiry. Learning mathematics is a collaborative activity in which learners are challenged and arrive at understanding through discussion. Meaning is explored and connections made through non-linear dialogue between the teacher and the learners, problems are presented before offering explanations and misunderstandings are made explicit and learnt from. In this way, constructive use is made of learners’ prior knowledge and experience and the ‘fear of failure’ is removed. The teacher does not set up expectations, all contributions and methods are equally valued and therefore learners are less likely to feel alienated. Enjoyable rich collaborative tasks are used which are accessible to all learners, allow them to make their own decisions, promote discussion and communication, help overcome the barriers of mathematical language, encourage ‘what if?’ and ‘what if not?’ questions and contain the opportunity for surprise. These approaches are exemplified in a resource, Improving Learning in Mathematics. This resource was originally trialed and then piloted in post-16 organisations prior to distribution and was very well received. One teacher working in a prison said: “In the prison service this approach has taken the demon out of mathematics. They come hating mathematics and now enjoy it.”

Since then, the principles have been widely accepted and are used in other phases. A teacher from a secondary school reported that: “During the lessons, the students have been motivated and have been eager to participate. There were loads of discussions. Even the students who were quiet and shy came out of their shells and discussed.”

The same pedagogical principles are applied at NCETM network events where we
endeavor to ‘practice what we preach’ in the running of workshops for teachers. After one such meeting, a teacher wrote: “I get a real buzz of inspiration after these. I don't think that any other training courses I've been on in teaching have ever made me feel so inspired that I really want to learn more and do more.”

**Conclusion**

There is still much to do and many challenges to face before CPD for all teachers of mathematics in the UK is recognised and demanded. We continue to seek to engage more teachers and find more ways to work with our partners across the mathematics education spectrum. We are actively working to engage school leaders to support our work as we rely on them to help us to support and value their mathematics teachers and spread the important message articulated by one London headteacher: “Projects and outreach work takes energy and costs but what you get back in the way of staff involvement and development is priceless.” (The case study of a sample of secondary schools in London, entitled Developing mathematics in London Secondary School: Headteachers talk about creating and sustaining excellent mathematics departments [www.ncetm.org.uk/headteachersreport] had a major political impact and the work is being extended to other regions and to the primary phase.)

Effective professional development offers teachers the chance to realise their full potential – enhancing their skills and aspirations, enabling them, in turn, to help all learners realise their own potential. This is so important for us all as individuals, as well as for the UK as a whole. Recent reports have underlined the crucial role of mathematics in the UK’s economic future and also in personal and professional confidence, as mathematics forms a key part of people’s lives – at work and at home.

The National Centre is helping to bring about a shift in our culture where no longer will it
be socially acceptable to say, “I can’t do mathematics – and I am even proud of it.” We are passionate about our role in ensuring that we have enough well-qualified and confident teachers of mathematics in all our schools and colleges. We have to continue our political pressure to emphasise that high quality CPD is something we simply cannot afford to do without.

References


NCETM (2009b). *Final Report: Researching Effective CPD in Mathematics Education*

