Teachers of mathematics to mathematics teachers: a TDA Mathematics Development Programme for Teachers

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To address the shortage of mathematics teachers in England, serving teachers, qualified in subjects other than mathematics yet teaching secondary mathematics, were eligible to participate in a Mathematics Development Programme for Teachers (MDPT) commissioned and funded by the Teacher Development Agency (TDA). A research project was set up to investigate how teachers in our 2010-11 cohort developed into mathematics teachers within this Programme. This report indicates how (1) learning new mathematics, (2) developing a view on the nature of mathematics and (3) teaching mathematics in different ways, contribute to a mathematics teacher identity, yet there was a discrepancy between the teachers' espoused confidence in being a mathematics teacher and their technical mathematical competence.

Keywords: mathematics teachers, community of practice, evolving identity

Background

The MDPT was commissioned in order to address the perceived lack of well-qualified teachers of mathematics in state schools in England. In particular, as there is a significant number of teachers teaching mathematics in the secondary age range (Y7-Y11) whose Qualified Teacher Status (QTS) was gained through their being teachers of another specialism a 'Mathematics Development Programme for Teachers' (MDPT) was specifically commissioned for such serving teachers. Participation on the MDPT course required that a teacher had completed their Newly Qualified Teacher (NQT) year and was employed in a maintained school and teaching at least some mathematics to pupils in the secondary age range, had no post 18 mathematics or any mathematics teaching qualification (although primary trained teachers were allowed to take the course), had the support of their head teacher and had a school-based mentor to support them. The structure of the course was: 30 days based at the university and 10 based in school with specific pedagogical tasks to complete. The participating teachers were offered a £5000 bursary on completion of the course where 'completion' included having at least 80% attendance and an assessment at a level of a final undergraduate of 40 CATS credits. Schools could claim for cover on the days where the teachers were in the university. On successful completion of the course, the teachers were considered to "have gained an additional specialism" (TDA 2009, 10) in mathematics.

Various providers in different regions of England offered these MDPT courses and had the freedom to design their own curriculum. The curriculum designed by the mathematics education team at the Institute of Education, University of London deliberately avoided mathematics National Curriculum classifications and arranged the MDPT curriculum to cover four broad mathematical content themes: Infinities, Uncertainties, Structures and Spaces. Mathematics pedagogical knowledge was taught by example, discussion and by setting school-based tasks that were supervised by the school-based mentor.

A natural question to ask about this TDA-promoted mathematics development programme for teachers is "Does this Programme offer a good way to provide more mathematics teachers?" Irrespective of the answer to this question, we note that the programme has since been decommissioned and a cheaper-to-run subject knowledge enhancement (SKE) course is now being piloted for 'returning' teachers (TDA 2011) that is also available for serving teachers of mathematics who do not have mathematics/mathematics teaching qualifications.

We orientated our research around a central research question that concerns itself with mathematics teacher identity in the sense of Grootenboer and Zvenberger who argue that "It is essential that teachers of mathematics (at all levels) have well-developed personal mathematical identities" (2008, 248). Our central question was: how do already qualified teachers come to see themselves as mathematics teachers?

Our MDPT research project

There were two cohorts, 2009-10 and 2010-11. In the first year tutors for the course were surprised both by many participating teachers' standard of mathematical competence and by their affective reaction to standard school mathematics such as solving two linear simultaneous equations or working with inverse proportion. We wondered how you can function as a mathematics teacher if the thought of solving simultaneous equations makes you cry. In algebra particularly there was a lack of meaningfulness in their work that we witnessed through their 'instrumental' application of methods and their displaying defence mechanisms like avoidance, talking or requesting explanations to them personally (hand-holding).

This brought up the very practical question: how can these participating teachers develop into mathematics teachers who are fit to teach the secondary age and ability (yes, 'ability') range? We had 30 days with them over a school year.

This is why we wanted to collect data more systematically in the second year to investigate teachers' journeys over the course. These journeys are rather individual - only one person cried at simultaneous equations - so our orientation was to look at a purposive sample of case studies to investigate transitions towards becoming a mathematics teacher.

Case studies

The 19 teachers participating in the MDPT course were recruited from the London area and regions from which it was possible to travel into the capital. The QTS specialisms of the ten women and nine men enrolled on the course included languages, science and business studies, with the most popular specialisms being primary (5) and Physical Education (PE) (5). Four of the participants were from overseas, one of whom did his training through an Overseas Trained Teacher (OTT) scheme in England and the others used their EU qualifications.

From the volunteers, we chose a purposive sample of five case study teachers each of whom had come via a different training route. It was not possible, given that there were fewer than twenty teachers, to get a sample of teachers with variation over all the key parameters of their prior training or experience. Variation of the Initial Teacher Training (ITT) route was used as sample-defining; this was a judgement based on a sense that these different routes represented allegiance to different communities of practice within secondary teaching, though other choices of samples could have been used (e.g. QTS subject). Some of the biographical details of the case study teachers are presented in the table below under their pseudonyms:

	Jessie	**Madeleine**	**William**	**Nas**	**Lech**
ITT route	BA/QTS	PGCE	Bed	Teach First	EU QTS
Subject specialism	Primary (PE)	Primary (mathematics)	PE	Citizenship	PE
School phase training	Primary	Primary	Secondary	Secondary	Secondary
Prior to course taught some mathematics for	10 years	6 months	2 years: 1 lesson a week	2 years: 1 or 2 lessons a week	9 years
% of maths teaching during the course	100%	100%	90%	100%	100% science and maths

Table 1

The research took place alongside the course and was subordinate to the course. Data of the following types were collected as part of teaching: autobiographical data; a 'needs analysis' (of their mathematics subject knowledge and capacity to diagnose pupils' errors/misconceptions); collection of their: maths work; school-based work; mentor feedback; assignments; reflections; observations in university sessions. The only purely research-focussed type of data that the teachers were invited to participate in was to be interviewed. We had more volunteers to be interviewed than we needed and not every course member volunteered. The first interviews carried out at the beginning of the course (during the Autumn term) were conducted 'narrative style' (Hollway and Jefferson 2000) where the teacher was invited to tell his/her story and the second interview carried out in July was of semi-structured design (e.g. Brown and Dowling 1998) using an interview schedule.

Theoretical framework

This research arose from queries about teachers of specialisms other than mathematics becoming specialist mathematics teachers through doing a course commissioned by the TDA. Hence there was no a priori theoretical framework and part of the research work was to choose a theoretical framework in order to address the research questions and to explain the suitability of that framework for this context. The MDPT teachers were positioned by the job they were doing (secondary school mathematics teaching) and they were on the course because (from the 'outside') (1) they did not have mathematics teacher certification and (2) their headteacher felt that this lack was worth rectifying. In an alternative expression, they were on the course because (from the 'inside') (A) they wanted to learn more mathematics, and (B) they wanted to find out about ways of teaching mathematics and incorporate these into their teaching repertoire. Because of this dual aspect of why these teachers came to be on the course, we sought a theoretical framework that embraced the yin-yang nature of learning and participation and theorised such dualities. Such a framework is provided in Etienne Wenger's (1998) *Communities of Practice* which addresses identity ('inside') as an outcome of learning within social practices. And social practices are found in communities which collectively 'reify' aspects of the practices like mathematical content and standards. Learning – or developing a meaningful practice - occurs within the to and fro of participation and reification. We used the 'communities of practice' framework to analyse and interpret participating teachers' reifications and episodes of participation. In conclusion we have some remarks about these teachers' evolving

'mathematics teacher identities' which arise from their participation in a web of communities that relate to their mathematics teaching.

In the next section, we present a selection of our findings. These are organised under themes that came from analysis of the data overall using the communities of practice lens. We report 'horizontally' across the cases studies, using quotations from case study teachers, findings concerning:

1. participation in learning mathematics: e.g., their approaches to learning mathematics;
2. reification: e.g., views on mathematics as a discipline;
3. practice: e.g., their reported changes in their teaching practice.

A selection of findings

Participation in learning mathematics

Teachers had different ways of approaching their mathematics learning and thinking about mathematical knowledge. For instance, in Jessie's telling of her learning she expresses a view of mathematics knowledge as reified items: "all of a sudden and everything that I've got from pockets of knowledge here and pockets of knowledge there, just all falls into place" (Jessie, interview 1). This contrasts with Nas who expresses perceived limitations in terms of his feelings: "I mean I don't think maths has ever come naturally to me; it was probably my worst subject in school actually. I mean in my A levels, it was my lowest A level grade." (Nas, interview 1). Madeleine, daughter and sister of mathematics teachers now in her 40s, gives a stronger expression to her feelings about mathematics "A vile, awful subject […] And I just never connected – I never connected with maths at all" (Madeleine, interview 1). However, William, who like Jessie, was prevented from doing A-level mathematics by his school because he got a C rather than a B at GCSE, says "maths I found relatively easy" (William, interview 1).

Indicator of developing mathematics teacher identity 1: Participation in learning was motivated by potential application in teaching

Indeed, 'understanding a topic' was typically construed as understanding at the same depth their students are expected to attain at a particular grade/level. As Jessie explains: "So whereas now I'm using like the Edexcel higher plus book; and I look in there and I'm thinking right, I'm doing curved graphs – so I need to go home, I need to look at all those equations and then also look at what point a line would intercept that curved graph. And I can understand what I have to do, but physically sitting down and getting myself to a level where I feel that I can look at a question – and it doesn't matter which question it is - then I could help someone -. " (interview 1).

Similarly, Madeleine thinks that if she is secure in a certain piece of work or the way that something works, then she can pass that on to her students in a way that they feel secure, too. However, Madeleine is concerned that despite working hard since she started the course, covering an enormous amount of mathematical knowledge, she will not be "[...] ever going to cover it all. But within what I teach – and perhaps a bit further." (interview 2) she has the inner confidence in the classroom.

Reification of mathematics

In interviews, in their assignments and in class presentations, the teachers talked about their changing of views of mathematics towards that of more useful or more real: for

example, "Through completing this course I feel I've moved on from viewing maths as a pure subject that is learnt in classrooms to seeing mathematics as something that has endless applications." (Nas, final assignment).

Indicator of developing mathematics teacher identity 2: Experience of reification of mathematics was conceptualized as contributing to teaching

'Pascal's triangle' came up several times during the course and the teachers increasingly welcomed unexpected appearances of this 'triangle' with delight and humour; they also remarked about uses of this piece of mathematics for teaching. Similarly, Lech's change in view is expressed in a mathematical metaphor "[previously I was] only looking at maths in 2D, very flat." (interview 1). Several months later he says "And knowing about different learning styles, and having to have to read and research … gave me a completely different perspective on just, on what I previously thought maths was - as being two plus two equals four. So that's the third dimension I've got now." (Lech, interview 2)

Practice of mathematics teaching

During interviews, oral presentations and informal conversations, the teachers were able to exemplify 'new' pedagogical approaches (i.e. approaches other than teaching by showing worked examples) that they had used in their own classrooms.

Indicator of developing mathematics teacher identity 3: Nexus of communities (Wenger, op. cit. 158) was considered beneficial in teaching mathematics

Coming from a humanities background, Nas considered his strength was "[in removing] the language barriers and being able to represent it [maths] in other ways, which would mean students will understand it." (Nas, interview 2) Nas liked teaching citizenship lessons because he could make those lessons very engaging about real life issues that directly affected the students "I felt much more kind of comfortable teaching more humanities subjects than maths and doing those kind of interesting, engaged-in discussion and investigation based things in humanities subjects. But I mean that's changing; I'm definitely changing and I think NRich is like brilliant in providing those sort of resources." (Nas, interview 2). In Wenger's terms, Nas is reconciling different forms of memberships (to the subject specific teaching community, and now to the maths teaching community). Nas's knowledge of pedagogical approaches developed and acquired before starting to teach mathematics are 'brought' into the mathematics classroom. This helps him to maintain his citizenship teacher identity, while also entering the mathematics teaching community.

Conclusion: towards a mathematics teacher identity

In the second interview one of the questions was "to what extent do you now see yourself as a maths teacher?" While every interviewee responded positively, their replies were nuanced differently, for example: "So I actually feel that I can say that I am a maths teacher, rather than PE playing at maths. Feels good." (Jessie), whereas William proudly told us that "[…] my first subject as of the 1st of September when the qualification comes through will be the first subject as maths." And Lech says "Yes, definitely; I couldn't go back to teaching PE definitely. I am a maths teacher, yes; that's how I see myself." The issue of 'the qualification' was significant to several others in the class; the actual phrase "desperate to get it" was used by (at least) three of the teachers in the whole group. This certification gave them formal membership of a community of mathematics teachers in England. This offered career benefits, since mathematics will always be on the curriculum, whereas, for example,

citizenship might not: "So I thought it was quite important that I actually had another subject that I could teach, and maths is obviously a very stable subject. So almost as if in an insurance kind of way I wanted to move into maths as well." (Nas, interview 1).

This gift of membership with completion of their MDPT course gives rise to the questions about the quality of this membership. They have the badge and they are pleased to wear it but is that enough? Analysis of their mathematical and math-pedagogical work and the mock GCSE paper they sat in June showed that these teachers still lacked fluency with mathematics and were far from having secure subject knowledge. In particular, bar one or two of the 19, their algebraic manipulations skills were no better than GCSE grade B, and in some cases this is an optimistic appraisal. However, such teachers claimed that their experiences of finding mathematics difficult to learn was helpful with respect to the practice of teaching as they were in a better position to relate to pupils' difficulties than those teachers for whom maths learning came easily: "But I think being of a decent enough standard to teach maths, and sharing those frustrations, or understanding where those difficulties arise, helps me to relate to the students and get over those problems." (Nas, interview1)

In Wenger's terms, these teachers negotiate their contribution to the practice of mathematics teaching community. They are aware of their limitations and instead of positioning themselves as outsiders (as they do not have a strong mathematical background), they focus their attention on the meanings that really matter to them: their struggle with mathematics gives them a special insight into understanding pupils' difficulties with mathematics and this privileged viewpoint offers them access to participating and contributing to the mathematics teaching profession.

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