Changing attitudes to mathematics in primary school teachers in England

Mary McAteer\textsuperscript{a,b} and Victoria Grinyer\textsuperscript{c}

\textsuperscript{a}Edge Hill University, Ormskirk, UK; \textsuperscript{b}North-West University, Potchefstroom, South Africa

\begin{abstract}
Concern about attitudes to mathematics and mathematics education is not unique to England. Studies across the world, including the USA, Canada and Australia, indicate similar concerns. This research aimed to identify the factors that impacted on the formation of teachers’ attitudes to mathematics in primary schools in England and to discover how these have been shaped and/or changed during an in-service professional development programme, The Mathematics Specialist Teacher Programme (MaST). We thus take a unique position in attempting to develop a possible model for reducing teacher mathematics anxiety, and its consequences in classrooms. Findings were analysed using key typologies of professional learning and reveal that teachers who undertook the programme made strong, explicit links between previous experiences of being taught mathematics, their own feelings of mathematics confidence and competence, and levels of mathematics anxiety. High-level collaboration with colleagues and expert facilitators were evident as significant factors in overcoming this anxiety.
\end{abstract}

\begin{keywords}
Mathematics anxiety; primary mathematics teaching; continuing professional development; England; collaboration; attitudes
\end{keywords}

\section{Introduction and context}

There is a concern in England about the attainment of primary pupils in mathematics. Most primary schools currently follow the 2014 mathematics curriculum which emphasises ‘procedural fluency’, and brings changes including the teaching of the 12 times multiplication table (at age 9), earlier (and more challenging) work with fractions and decimals, the use of formulae in calculations such as area and volume, the development of proportional reasoning, and fluency in calculation without the aid of electronic calculators.

Juxtaposed with these curriculum changes there remains ongoing concern about primary teachers’ own mathematics subject knowledge and opportunities for relevant, high-quality professional development. The National Centre for Excellence in the Teaching of Mathematics (NCETM) has been providing training and support for mathematics teachers in all sectors, while mathematics consultants report increased requests for professional development for primary teachers. The Maths Hubs initiative aims to harness mathematics expertise and leadership in regional ‘hubs’, each led by an outstanding local school or college. The Mastery Specialists’ Training Programme, run...
by the NCETM aims to train 140 teachers in Mastery teaching, as part of a cascade model of professional development. While acknowledging the need for and worth of these provisions, the Advisory Committee on Mathematics Education (ACME) is concerned about the lack of a national coherent strategy. It convened an Expert Panel which will report on ‘guidance on the professional learning journey of all teachers of mathematics’ in July 2016.

Coupled with concerns about mathematics subject knowledge and pedagogy, it is also reported, that in England, attitudes to mathematics are often negative. Studies on school pupils, trainee teachers, practising teachers (Matthews and Pepper 2005, Brown et al. 2008, Jackson 2008, Hodgen et al. 2009), found that there are widely held perceptions of mathematics as dull and difficult, and even those students who achieve well in mathematics, demonstrate low self-efficacy. Findings such as these are replicated in other countries.

These issues sit alongside our societal recognition that mathematics is an essential life skill; lack of mathematical competence can have significant and negative impacts on life chances. Our relationship with mathematics is thus complex. While we recognise its significance in our lives, our attitudes towards it tend to be negative. For some, this negativity is manifest as a form of what has been called mathematics anxiety, leading to behaviours including avoidance of mathematics, or ‘celebrating’ lack of competence. For others, the negative relationship is less pronounced, but, as we argue, still present and potentially significant. In particular, we explore the attitudes of practising primary teachers.

The Mathematics Specialist Programme (MaST) was developed in response to the Williams (2008) Independent Review of Mathematics Teaching in Early Years Settings and Primary Schools. The programme design, which was centrally determined during the tender-to-deliver process, incorporated a number of features which made it different to other postgraduate, professional learning and development programmes, and also different to other in-service professional development programmes. Specific innovative features included the 2-year delivery period for the 60-credit postgraduate certificate programme, rather than the more usual 1-year period, and the partnership between Universities and Local Authority Mathematics Consultants. This design element meant that teachers on the programme had an opportunity to couple practice-development work with consultants, with theoretical underpinnings from university staff. Delivered through a mixture of University-based teaching days, small group meetings led by mathematics consultants, and in-school gap-tasks with follow-up reflections, all supported through an online learning platform, core programme aims were three-fold:

1. To improve primary teachers’ mathematics subject knowledge
2. To improve primary teachers’ mathematics pedagogy
3. To develop leadership capacity so that these teachers could become ‘champions of mathematics’ in their schools and settings.

The unique combination of consultant-led practice development and university academic input, delivered over an extended time period, allowed a deep and meaningful exploration of mathematics subject-knowledge and pedagogy, and an explicit mapping of their theoretical underpinning. The in-school gap-tasks and the structured reflections, enabled participants to put their new knowledge and skills into practice in staged,
manageable chunks, consolidating and embedding learning. Participants were required
to engage in school-based research and enquiry activities, and work collaboratively with
colleagues in a supportive or leadership role. Reports of these activities, combining
practical work with theoretical analysis, formed the basis of the assessment for the post-
graduate award.

Despite the withdrawal of central funding for the MaST programme, it has continued
to flourish, albeit in a slightly changed form, in some areas. While the underlying
principles of the programme remain, the timescale has been reduced to bring it into line
with other postgraduate provision of a similar credit level. Face-to-face delivery days are
now structured to include the consultant-led practical pedagogy workshops, whereas in
the original programme, this was provided during separate out of school meetings.
Tutors report that this new format works well and indeed allows a fuller integration of
all aspects of the programme as academic and theoretical input by university staff is
more explicitly and immediately linked to practice. This university continues to recruit
more than 20 applicants each year to the new version of the programme. This study
seeks to identify the nature of relationships with mathematics, both historically, and on
completion of the programme, in a group of 43 primary school teachers who have
completed MaST.

This paper reports on the findings in an attempt to:

1. elicit and describe the relationships the teachers have and had with mathematics
2. identify possible factors involved in the formation of their attitudes to
calculating
3. uncover how their attitudes to mathematics have been shaped and/or changed
during the programme.

**Attitudes to mathematics: why they matter**

Concern about attitudes to mathematics is not unique to the United Kingdom. These
attitudes are often negative and can be located within historical and cultural contexts.
The term ‘mathematics anxiety’ has been variously described and defined in discussions
about pupil engagement with and performance in mathematics. Widely accepted as
a key factor in the low uptake of mathematics by students post-16 (and particularly
amongst girls) (Brown et al. 2008), and the low achievement of school pupils, both in
the UK and elsewhere, it is understood as ‘a feeling of tension, apprehension, or fear
that interferes with math performance’ (Ashcraft, 2002: 1). Its effects, which include
avoidance strategies, lack of confidence and competence, and negative attitudes, persist
into adult life and significantly impair creativity and problem-solving activities
(Ashcraft and Moore 2009). Hodgen et al. (2009) found that even pupils who have
achieved well in mathematics may exhibit low confidence and self-efficacy.

It is not only school-pupils who demonstrate negative attitudes towards mathe-
ematics. Studies conducted across populations of trainee and practising teachers show
that they also are insecure in relation to mathematics. In 2010, Shectman identified that
the majority of the middle-school teachers they surveyed (n = 33) in a disadvantaged
urban district in the United States of America reported mathematics anxiety, which had
the potential for negative impact on their practice. Swars et al. (2006) note a significant negative correlation between mathematics anxiety and teacher efficacy in their study of 28 pre-service elementary school teachers in the United States. Similarly, studies in Australia, such as that of Uuismaki and Nason (2004), document significant levels of mathematics anxiety in pre-service teachers. Copley’s (2004) study of early childhood educators in Canada found they were confident in literacy and language teaching, but considered mathematics difficult to teach.

Studies in the United Kingdom suggest similar issues. Jackson’s (2008) findings suggest that 71% of student teachers in her sample (n = 31) reported a negative emotional and/or physical response to mathematics, with 61% of those reporting both emotional and physical responses. Many studies make connections between early experiences of mathematics teaching and cultural norms. Public concern about low mathematics attainment, poor teaching and mathematics anxiety can also be seen in headlines such as ‘Poor numeracy is blighting Britain’s economic performance and ruining lives, says a new charity launched to champion better maths skills’ (Burns 2012). In preparation for the 2015 World Maths Day, The Independent ran an article by Marsden, headlined: ‘Why are Britons so hopeless at maths?’

The impact of children leaving school with poor mathematical skills is significant and far-reaching. Analysis of the 2003 DBIS, UK Skills for Life Survey identifies the following key findings:

- Almost 15 million adults in the UK have very poor numeracy skills, achieving below entry level 3, i.e. equivalent to the skills expected of an 11-year-old. 6.8 million of them had skills at or below entry level 2, the standard expected for a 9-year-old.
- One in six companies currently provides remedial mathematics classes for their employees.
- Each year over 30,000 11-year-old (over 5% of their age group) leave primary school with numeracy skills at or below the level expected of the average 7-year-old.
- Numeracy failure carries high social costs; the proportion of the prison population with very poor numeracy skills, for example, is even greater than the proportion with poor literacy skills.

Comparison with the more recent 2011 survey suggests little change: the issues relating to poor levels of numeracy still pertain, and are of a relatively unchanged scale.

Both surveys show a strongly correlated link between low levels of numeracy and low-wage occupations. Hastings (2006) suggests that low levels of numeracy are more significant than low levels of literacy in relation to future earning capacity. The provision of high-quality mathematics education would thus seem an important national priority.

**Improving the teaching of mathematics**

In 2008, the Independent Review of Mathematics Teaching in Early Years Settings and Primary Schools was conducted by a review panel, led by Sir Peter Williams, Fellow of the Royal Society. The panel comprised academics, practitioners, early years and curriculum experts, and the director of the National Centre for Excellence in the
Teaching of Mathematics, reflecting the diverse nature of early years and primary mathematics teaching, and their place within the wider curriculum. The final report was designed with the key aim of improving the quality of mathematics teaching for children. Identifying mathematics as ‘a discipline which is not always embraced with enthusiasm and confidence’, Williams focused his recommendations on ‘the teaching force rather than the content of the programme of learning in primary and early years’ (p1). By developing the teaching force, he hoped to provide experiences for school children enabling high-quality mathematical learning, promoting deep learning and positive attitudes to mathematics. He suggested that ‘too little attention is paid to building good attitudes to mathematics.’ (p62)

His key recommendation was the development of teachers to ‘champion this challenging subject and act as the nucleus for achieving best pedagogical practice’, he further clarified this in recommendation three:

There should be at least one Mathematics Specialist in each primary school, in post within 10 years, with deep mathematical subject and pedagogical knowledge.

Williams (2008: 7)

MaST was set up in direct response to this report, providing postgraduate level professional development for serving teachers. This innovative programme (funded by the Department for Education) which started in January 2010, was delivered by eight university or university consortia in partnership with Local Authorities.

The programme aims were supported by three objectives:

- to develop mathematical subject knowledge of teachers, providing deep knowledge of mathematics within the Early Years Foundation Stage (EYFS) and primary curriculum
- to promote good understanding of fit-for-purpose pedagogies to support teachers in utilising a wide repertoire of teaching approaches
- to develop expertise of the mathematics specialist in working with and providing effective professional development for colleagues through classroom-based collaborative professional activity.

MaST provided practical and theoretical mathematics activities to develop key skills in these areas. Williams (2008) suggests that ‘confidence stems from deep mathematical subject and pedagogical knowledge’ (p3). This confidence enables teachers to teach effectively, successfully choose pedagogies in varying situations, while also conveying enthusiasm towards mathematics. This is an important factor in improving attitudes to mathematics in children. Haylock’s 2010 work would support this, suggesting that there is evidence that teachers can be helped develop pedagogies to ameliorate anxiety and raise mathematical confidence in children.

**Reducing mathematics anxiety in teachers**

Studies of mathematics anxiety relate mainly to anxiety in school, college or university students, or trainee teachers (see, for example, Uuismaki and Nason 2004, Swars et al. 2006,
Gresham 2007, Jackson 2008, Brown et al. 2008, Finlayson 2014). Fewer such studies have been conducted with practising teachers. Of those that have been, there is little focus on the ways in which such anxiety may be reduced, or the potential for teacher professional development to reduce that anxiety. Beswick’s et al.’s (2006) study suggests that as content becomes more difficult in higher grades, teachers experience increasing anxiety, and this, coupled with uncertainty in relation to appropriate subject-pedagogical knowledge, makes them tend to offer reduced experiences for their pupils. Their study, however, does not address ways in which teacher anxiety and its impact on pupils may be reduced. Shectman (2010) suggests that teachers also transmit their anxieties to their pupils, further perpetuating the issue. She suggests the adaptations of known anxiety-management interventions including cognitive restructuring, could be adapted from their normal use with young people, to be incorporated into pre-service and in-service programmes for teachers. The study falls short, however, of explaining what such interventions might look like.

The positive correlation between teacher lack of competence, and anxiety demonstrated by Beswick et al. (2006), Swars et al. (2006) and Copley (2004) among others, suggest that improving teacher subject and subject-pedagogical knowledge would, as Williams (2008) suggests, improve teacher confidence. The programme which this study explores was designed to provide improvement in subject and subject-pedagogical knowledge. This paper seeks to articulate the attitude changes which happened alongside practice development. In identifying, and exploring the ways in which teacher anxiety was reduced during the programme, we take a unique position in attempting to provide a possible model for reducing teacher mathematics anxiety, and its consequences in classrooms.

Study design

The research was conducted as an exploratory case study (Yin 2014) using a mixed-mode questionnaire as its data collection instrument. As well as answering closed-response and multi-choice responses, teachers were given the opportunity to provide a free response to the prompt ‘write an emotional response to mathematics’.

Forty-three participants took part in the study, which surveyed their experiences of and attitudes to mathematics and how they perceived they had changed while undertaking the MaST. All participants were recruited on a voluntary basis towards the end stage of the programme. The research itself took place after course completion, to ensure that participants neither felt potential risk, or benefit from participation. Five of those who completed the questionnaire volunteering (in response to a field on the questionnaire) to complete reflective narratives. The project was undertaken in accordance to BERA (2011) Ethical Guidelines, and relevant Faculty processes. Questions were designed to elicit some possible factors involved in attitude formation and change, specifically:

(i) Current attitudes to mathematics, both personally and professionally
(ii) Early experiences of and attitudes towards mathematics;
(iii) Factors (if any), such as family, teachers, or peer group which they felt had been important in their experiences and attitudes.
Questions also addressed possible attitude change experienced during the programme, exploring factors which may have been contributory, and invited consent for further participation. It is important to note at this stage that there was no pre-programme investigation of mathematics anxiety or attitude to mathematics. Indeed, the project itself arose from the numerous self-reports of changed attitude, or reduction in mathematics anxiety during the programme. Hence, all changes identified are self-reported perceptions of the teachers involved.

Of those who agreed to further participation, five volunteered to complete prompted, self-reflective narratives, enabling deeper articulation of the ways in which their attitudes had been shaped and formed, and changed. Data from these narratives added richness and depth to the findings, through further exemplification and illustration, taking account of individual experiences within a specific cultural context (Clandinin and Connelly 2000).

Responses to closed-response items were analysed through axial coding, identifying connections and contradictions between response categories. Contradictions provided sources of insight, uncovering the often complex and paradoxical nature of attitude and its explication. Tensions between personal and professional identities were also evident.

Thematic analysis of free-response questions and reflective narratives enhanced the development of explanatory categories and themes.

**Findings and analysis**

**Demographics**

Forty-three questionnaires were completed. The majority of respondents were female (90.7%, n = 39) and were aged between 25 and 44 years (67.5%, n = 29). Nearly three quarters (72%, n = 31) had been teaching for at least 6 years; 44.2% (n = 19) having 10 years or more teaching experience. Only 2% of respondents had taught less than 2 years. Most were Subject Leaders (48.8%, n = 21) or Class Teachers (37.2%, n = 16).

**Analysis of fixed response items**

The questionnaire comprised 22 closed, and one open-response question. The first 12 items explored the teachers’ mathematics confidence and ability in a personal capacity, while the following 10 related to their mathematics teaching. In each section, some questions were deliberately worded to cross-check responses, and identify possibly areas of ambiguity or data conflict, which would warrant further investigation. One such pair was ‘I find unfamiliar mathematical problems interesting and challenging’ and ‘I tend to panic when faced with mathematics problems of a type that I have not met before’.

The final question invited ‘a personal emotional response to mathematics’.

**Outcomes**

**Relationships the teachers have and had with mathematics**

This was analysed separately in relation to their responses to personal and professional attitudes to mathematics. Firstly, responses to personal attitudes to mathematics were
collated and cross-checked (presented in Table 1). For these questions, participants were instructed that they ‘relate to your own, personal perceptions and feelings, and not to your teaching of mathematics’ and were constructed as a set of statements prefixed by ‘On a personal level...’

Key findings from the 12 items assessing personal attitude to mathematics suggested that at least 75% of respondents were confident in their mathematics knowledge, understanding and ability, found unfamiliar problems in mathematics challenging and interesting, and felt confident to problem-solve. However, less positive responses represented significant minorities. On occasion, there appeared to be self-contradiction in the responses, with, for example, 79% feeling confident in their ability, but 44% worrying about getting things wrong in mathematics. Clearly, 23% had agreed with both statements. Likewise, 12% agreed with ‘I find unfamiliar mathematical problems interesting and challenging’ and ‘I tend to panic when faced with mathematics problems of a type that I have not met before’.

Responses to items 7 and 8 on the table suggest that a significant minority (35%) of respondents displays some of the features of Mathematics Anxiety, yet items 9 and 12 which asked directly about mathematics anxiety are scored lower, each at 21%. This suggests that while these teachers did have some degree of mathematics anxiety, it was not something they felt comfortable openly admitting.

Table 2 presents responses for those questions relating specifically to the second set of items that ‘relate to you as a teacher’ and were constructed as statements prefixed by ‘As a primary school teacher...’

Analysis of findings from the participants’ professional attitude indicates that the majority of teachers felt confident in, and enjoyed their mathematics teaching. Responses to items 13 and 14 (11% higher response to the item asking how ‘good’ they were, than to that asking how ‘secure’ they were) might suggest not so much disparity, but a sense that being a ‘good’ teacher brings with it some insecurity during reflection on practice. Comparing items 17 and 18 suggests that while only 33% feel safer using standard teaching approaches, 77% enjoy the opportunity to think creatively in mathematics teaching. Clearly, 10% answered ‘yes’ to both items.

**Table 1.** Personal experiences of and attitudes to mathematics.

| Item                                                                 | % agree/strongly agree |
|----------------------------------------------------------------------|------------------------|
| 1. I feel confident in my own mathematics understanding and ability. | 79                     |
| 2. I worry about getting things wrong in mathematics.               | 44                     |
| 3. I would try to avoid getting into a situation where I might find the mathematics challenging or unfamiliar. | 41                     |
| 4. My own tendency is to learn mathematics by rote rather than expecting to understand it. | 12                     |
| 5. I feel inadequate when I am with people who I consider to be good at mathematics. | 36                     |
| 6. I find unfamiliar mathematical problems interesting and challenging. | 77                     |
| 7. I tend to panic when faced with mathematics problems of a type that I have not met before. | 35                     |
| 8. I dread being asked mathematics questions that I might not know the answer to. | 35                     |
| 9. I have a level of anxiety about mathematics that affects my ability to solve mathematics problems. | 21                     |
| 10. I am confident in my ability to solve everyday mathematics problems | 86                     |
| 11. I have clear memories of anxiety about mathematics lessons when I was at school that still interfere with my confidence in mathematics. | 35                     |
| 12. When I am faced with some unfamiliar mathematics I find I am often unable to think clearly and recall things that I know. | 21                     |
Table 2. Professional experiences of and attitudes to mathematics.

| Item                                                                 | % agree/strongly agree |
|----------------------------------------------------------------------|------------------------|
| 13. I am generally very secure about teaching mathematics at primary school level. | 77                     |
| 14. I am a good teacher of mathematics at primary school level.       | 88                     |
| 15. I enjoy teaching mathematics.                                     | 98                     |
| 16. I am confident when talking to parents about teaching and learning of mathematics. | 86                     |
| 17. I feel safer using standard, routine written methods for teaching mathematics than doing problem-solving activities or other informal approaches. | 33                     |
| 18. I enjoy the opportunity to think creatively in mathematical situations. | 77                     |
| 19. I feel that mathematics in primary schools should be mainly about the number and learning standard ways of doing calculations. | 7                      |
| 20. I emphasise to the children in my class that getting correct answers in mathematics is the most important thing. | 16                     |
| 21. I worry more about having my mathematics lessons observed by colleagues or inspectors than having other lessons observed. | 37                     |
| 22. If I am in a mathematics training session, having to answer a mathematics question in front of others would make me feel very anxious. | 33                     |

Of more interest however was the small, but arguably significant, minority who worried more about having mathematics teaching observed than observations in other subject areas, and those for whom answering a mathematical question in front of colleagues would produce anxiety (37% and 33%, respectively).

A further, numerically smaller group also identified that their concept of primary mathematics was primarily ‘number and learning standard ways of doing calculations’ (7%), while 16% emphasised the importance of ‘getting correct answers’. The possible significance of these responses will be discussed later.

**Analysis of free-response item and reflective narratives**

Analysis of the 22 closed-response items gave the scope of the issue; deeper insight was obtained through thematic analysis (using Braun and Clarke 2006 framework) of the free-response item. Two key issues emerged:

(1) The impact of school experiences on feelings of mathematics confidence and competence

(2) The impact of school experiences in the development of mathematics anxiety and classroom practice

These will each be discussed in turn.

**The impact of school experiences on mathematics confidence and competence**

Many teachers described their confidence or competence in mathematics in relation to their school experiences. The words and behaviours of their childhood teachers remained vivid for them, whether negative or positive experiences. For one teacher, memories of being required to answer quickly and accurately in her own year 6 had left her still nervous about mathematics, and worried about being wrong. On the other hand, a teacher who was always labelled as ‘good at maths’, believed this message gave them lasting confidence as a mathematician.
For many, however, the experiences of school undermined any feelings of mathematics confidence or competence. One participant described how, when asking for help, the teacher ‘went through something once, then left me to my own devices’, and seemed ‘only interested in teaching brighter children in the class’. She described dreading each new topic, and vowing never to open a mathematics book after her O-Level examination. Another described how one of her teachers instilled a lack of confidence in her, advising her to discontinue with the subject at the earliest opportunity. One respondent described being ‘targeted to do tables almost every lesson with the teacher knowing full well that I didn’t know them and she was just embarrassing me’. She still describes herself as ‘rubbish at tables’.

There were, however, some positive experiences of mathematics at school. Five of the 43 participants referred to positive mathematical experiences at school. Associated with positive experiences, and in contrast to those reporting more negative experiences, they also reported more confidence in their ability to do mathematics and to teach it. Many attributed their confidence to constructive, encouraging responses of both primary and secondary educators. A ‘good grounding in both primary and secondary’ was cited by one participant as the reason for their ‘very positive response to mathematics’.

I feel very confident in my own mathematical ability and when teaching mathematics to children. As a child my experiences of mathematics teaching and learning were largely very positive.

The importance of teachers in forging good attitudes to mathematics was clearly expressed by one participant suggesting ‘I must have had good maths teaching at school as I never felt anxious’. Another suggested that a teacher could help pupils overcome worries and anxiety about mathematics, as had happened in her own experience. ‘I remember being very anxious . . . about maths . . . but I also remember my maths teacher at secondary school and how much of a difference he made to my learning and progress’.

Clearly, the participants made strong and explicit links between their experiences of having been taught mathematics and their own feelings of confidence and competence in the subject.

The impact of school experiences on mathematics anxiety and classroom practice

In discussing the nature and significance of school experience in relation to feelings of confidence and competence, some of the teachers framed their responses in the language of mathematics anxiety. Twelve of the 43 (28%) reported mathematical anxiety as a child which many believed resulted in subsequent decreased mathematics confidence. Experiences of mathematical anxiety were often due to behaviours of certain teachers who caused embarrassment and humiliation, when asked for support in areas of difficulty.

Feelings of lack of competence, and/or confidence in mathematics often led to manifestations of mathematics anxiety. One teacher recalled ‘...having been humiliated many times at secondary school by a teacher for not being able to respond quickly to questions or not understanding the concepts taught, I started to panic about maths, lost my confidence and avoided it all I could’.

Mathematics anxiety was evident, through words such as ‘fear’ and ‘panic’ used to describe being ‘rushed’ in mathematics, or taken outside the ‘comfort zone’. For many,
the anxiety persisted beyond school. Teachers talked of continued lack of mathematics confidence and/or competence, feelings of mathematical inadequacy, of dread when faced with unfamiliar situations, or when with people they perceived to be better mathematicians. One teacher explained how insecurities and anxieties about mathematics knowledge meant that she spent many hours planning lessons, so that she can ‘get it right’.

In one case, the anxiety had become a generalised response to other stressful situations.

At primary school I . . . grasped most concepts apart from the written method for long division . . . I have a vivid recollection of pages of long division calculations with red crosses at the bottom and the words “see me” written next to them..the “long division” experience still resonates with me and, I am slightly embarrassed to say, is revisited every time I am stressed. I have what I refer to as “the long division dream”

Other researchers, for example, Brown et al. (2008) have found resonances with this level of anxiety. While this study did not focus on gender issues, it is of some interest to note that this comment was from a female participant. Studies such as that of Elwood and Comber (1995), and Hannula (2002) among others indicates a greater tendency for girls at school to suffer from lack of confidence in mathematics and mathematics-related anxiety.

For many respondents, these experiences had been influential in their initial decision to undertake MaST. Their experiences as children made them sympathetic to children’s anxieties, and want to ensure that their pupils should not feel as they had done while at school. They explained that they were careful to ensure that they did not treat children in their classes in the same manner as they had been.

‘As a child I suffered severe maths anxiety and this affected my confidence..part of my reason for being so enthusiastic about maths is because I don’t want children to feel as I did as a child’ Participant 1.

‘I now feel happier about maths and believe that my experiences have made me a better teacher as I can help children overcome mathematical anxieties’ Participant 13.

**How attitudes change**

Having explored ways in which teachers related to mathematics, and how their attitudes had formed and were manifest in practice, we now address the third of the research questions, namely ‘how attitudes to mathematics have been shaped and/or changed during the programme’.

A number of issues arose from the free-response responses and narratives. All teachers indicated a change in attitude, with some more explicit in perceived causes than others. For many, the reason they cited was the opportunity in the programme for dialogue, discussion and collaboration. As one teacher said, ‘one of the most useful parts was . . . the dialogue it afforded me with other teachers and experts in the field’. Others mentioned the opportunity to work collaboratively in their schools, or with other course participants. All mentioned aspects of deeper mathematics knowledge and pedagogy as significant in their changed attitudes. For some, this meant learning things
which had not previously been clear to them ‘I learnt the processes and strategies that had never been explained fully to me before.’

It was clear that for all participants, improved subject and subject-pedagogical knowledge was a key factor in improving confidence, and as a consequence, attitudes to mathematics. The depths of explanations provided, and the explicit theory accompanying teaching and learning experiences helped provide a security in knowledge that a ‘training’ model would not have helped. One participated noted that ‘the fact that I understood why it’s helpful to structure and sequence my teaching in a particular way, really gave me confidence in the classroom, and also when talking to colleagues.’

**Discussion/conclusions**

The aims of this research were to identify the factors that impacted on the formation of teachers’ attitudes to mathematics, and to discover how these have been shaped and/or changed during MaST. We discuss each area below.

**The impact of school experience on feelings of competence, confidence and anxiety in relation to mathematics and classroom practice**

Reflecting on the factors that influenced the development of their attitudes towards mathematics, teachers made strong and explicit links between their previous experiences of being taught mathematics, their own feelings of mathematics confidence and competence, and their levels of mathematics anxiety. This was the case both in terms of reported negative and positive previous school experiences.

These findings support other studies which suggest that teachers’ previous school experiences of being taught maths affect the development of their attitudes to maths and their levels of anxiety (Brady and Bowd 2005, Bekdemir 2010, Barrett 2013, Finlayson 2014). Bekdemir’s (2010) study revealed that in the majority of instances of trainee teachers having maths anxiety, their own most upsetting mathematics classroom experiences had been significant. Furthermore, these negative experiences were mostly caused by behaviours of their teachers.

Likewise, Brady and Bowd (2005) found that trainee teachers reported feelings of inadequacy if they voiced difficulty in understanding course material. Similarly, this study reports teachers feeling humiliated and embarrassed by their own teachers ‘for not being able to respond quickly to questions or not understanding the concepts taught’. They associated this with their lack of self-confidence in mathematics. Furthermore, teachers reported that their negative memories have led to a lasting lack of confidence in maths even when they know they can achieve highly in the subject, which echoes Hodgen et al.’s (2009) findings that pupils who have achieved well in mathematics can still lack confidence and have low self-efficacy.

For teachers indicating confidence in their own ability, and in their mathematics teaching, this was related to previous experiences of being taught mathematics. They explained how anxiety around mathematics had been alleviated by the encouragement and support of their maths teachers. The importance of mathematics teachers being motivational to pupils has been highlighted by Finlayson (2014) who found that many trainee teachers attributed their success in mathematics to their teachers. In Finlayson’s
study, teachers recalled positive memories of being taught mathematics with teachers encouraging self-confidence through believing in them and telling them ‘that they could do the mathematics’ (2014: 111).

It would seem, therefore, that teachers’ attitudes and behaviours towards their pupils when teaching mathematics can either positively or negatively impact on the development of pupil attitudes and mathematics confidence. Additionally, pupils’ experiences in this regard can have a lasting impact on their attitudes towards maths, suggesting teachers have a greater influence on their pupils’ future success in mathematics than they might realise. Although most participants felt confident in their ability in maths on completion of the programme, a minority (35%) mentioned some level of maths anxiety, though it would appear they did not feel entirely comfortable admitting this. Most teachers said they enjoy teaching maths and feel confident in their teaching ability; however, again, a minority reported more worry about being observed by others in their mathematics teaching than in other subjects. This suggests that even if teachers are confident and secure in their teaching ability, for some, there is still persisting anxiety around their mathematics practice, thus supporting the findings of other similar studies (Uuismaki and Nason 2004, Swars *et al.* 2006, Shectman 2010).

An important outcome of engaging on MaST was that teachers reported enhanced awareness of their pupils’ needs when learning mathematics. They took measures to ensure the children did not feel the way they had been made to feel about mathematics, making maths more fun than they can recall it being, and taking time to explain maths properly to children. This concurs with Haylock’s (2010) work which suggests that teachers can be supported to develop pedagogies which reduce anxiety and raise mathematical confidence in children. Many cited the practical pedagogy workshops as key in this, giving them both high-quality input, and a safe space in which to ask questions.

These findings suggest that professional learning and development programmes such as MaST can positively impact on teachers’ own attitudes and mathematics teaching practice. This, in turn, impacts on the experiences and attitudes of their pupils, improving chances of their success in mathematics. These findings have important implications for teacher educators delivering training and professional development courses to existing teachers.

**How teachers’ attitudes to mathematics have been shaped or changed during the programme**

Our findings suggest that teachers who completed MaST changed their own attitudes and practices. Specific reasons attributable to the changes included increases in confidence and competence in mathematics subject knowledge during the programme. Alongside this, a greater understanding of mathematics pedagogy meant that teachers felt more creative and engaged in their teaching, providing richer learning opportunities for the pupil. The programme also gave them a new enthusiasm for teaching mathematics.

These results also support the core aims of MaST: to improve primary teachers’ practice through developing mathematics subject knowledge and pedagogy. Teachers in our sample reported that the improvement in their attitude and confidence was as
a direct result of improved pedagogical knowledge, better understanding of mathematics concepts, and the opportunity to access high-quality theoretical resources, which helped underpin the development of their competence and confidence. Other studies (Gresham 2007, Barrett 2013) also note improved attitudes in teachers who undertook mathematics pedagogy courses, suggesting that one important factor in supporting such practice change was having opportunities for collaboration with colleagues.

Teachers in our study also reported the benefits of collaboration. Teachers valued ‘dialogue, discussion and collaboration’ with other teachers and experts; this impacted positively on feelings of confidence, mathematics competence, and practice. Similar studies report collaboration with other teachers to be a key factor in developing teacher attitudes towards their teaching of maths and importantly, towards themselves as maths teachers (Bonner 2006, Bobis et. al., 2014) as well as helping reduce levels of mathematics anxiety through discussion with others (Liu 2007).

The importance of encouraging collaboration with colleagues and mutual feedback and support to critically reflect on their practice has been articulated by many writers (Lieberman 1994, Clement and Vandenberghe 2001); it has been argued that this experience, in itself, can lead to a genuine advancement of knowledge and beliefs. This also resonates with Boreham’s (2000) argument that ‘when the professional activity is collective...A more appropriate measure [of knowledge] would be the knowledge generated by the richness of the connections between individuals’. (p505). Furthermore, providing teachers with professional development programmes that encourage high levels of collaboration amongst teachers, can positively impact on teachers’ beliefs about themselves as successful teachers of mathematics (Bruce and Flynn 2013) and importantly, can positively impact on student achievement in mathematics (Goddard and Goddard 2007). Evaluation of MaST by the National Foundation for Educational Research (Walker et. al., 2013) suggested ‘that teachers were now emphasising that learning new skills is what mattered, [...] pupils’ enjoyment of, and confidence in, mathematics had increased as a result of the MaST Programme.’ (p134)

Kennedy’s (2005) typology of Continuing Professional Development outlines nine key categories of professional development activities:

- training;
- award-bearing;
- deficit;
- cascade;
- standards-based;
- coaching/mentoring;
- community of practice;
- action research;
- transformative.

She sees these models belonging in three key categories, transmission, transitional, and transformative, with the last two being in the ‘transformative’ category. ‘Transformative’ aligns with the capacity for professional autonomy and changed practice. Of particular significance here is her definition of professional autonomy suggesting that the activity requires ‘teachers to be able to articulate their own
conceptions of teaching and be able to select and justify appropriate modes of practice.’ (p236). We would argue that the design, delivery and assessment model of the MaST programme, as outlined earlier means that the programme fits into a number of the nine categories, namely, award-bearing, coaching/mentoring (where appropriate to participant professional circumstance), community of practice, action research and transformative.

She uses the term ‘transformative’ as an overview one, recognising that transformative activities have a range of features, but will normally have an enquiry focus, an awareness of issues of power, and a consciously proactive approach. We suggest here that the MaST programme enabled participants to undertake a meaningful, context-specific enquiry, in a practice-theory rich environment. The opportunity to work collectively, to generate new, theory-rich practice-based knowledge through systematic enquiry, is, we suggest a powerful transformative model.

Hill’s (2004) Standards for elementary school mathematics provide a further insight and analysis of our findings. In her exploration of Professional Development Standards and Practices in Elementary School Mathematics (2004) she identifies eight core standards in effective professional learning (PL), paraphrased below.

(i) analysing examples of classroom practice;
(ii) collaboration during the PL programme;
(iii) active enquiry focused on exploring mathematical concepts;
(iv) opportunities to see excellent practice modelled;
(v) in-school trialling of ideas, with shared feedback and reflection;
(vi) mathematics subject content and associated pedagogy;
(vii) opportunities for teachers to identify their own learning needs; and
(viii) focus on student learning, student misconceptions and teaching strategies to develop mathematical thinking.

Our findings suggest that all of these features were present to carrying extents in the programme, and were significant to teachers; some more significant than others. It was clear from the teacher data, for example, that collaboration, the opportunity to learn from experts, and a deeper understanding of the process, and hence pedagogy of mathematics were of central importance in helping them overcome their own anxiety. This is congruent with other findings, such as that of (Bonner 2006, Buck et al. 2007, Ross and Bruce 2012), which show the potential for collaborative enquiry based professional learning activities to improve mathematics subject knowledge, mathematics pedagogical knowledge, and, significantly in the context of this study, attitudes to mathematics. Bruce and Flynn’s 2013 study, further affirms this. As part of their analysis, they present a ‘Program Process Theory’ (p699), indicating the efficacy of collaborative enquiry alongside transformation leadership practice, in increasing teacher efficacy, and the development of positive self-belief.

In conclusion, our study clearly points to the benefits of providing teachers with opportunities to undertake sustained professional learning and development activities which have certain key features. The enquiry-based, theory-rich nature of the programme was significant in helping teachers develop the deeper insights into both their own mathematics understanding and also, into children’s learning. Being able to do so,
in a collaborative way which was guided by expert practitioners, with opportunities to undertake school-based practice of their new learning enabled the development of enhanced confidence, feelings of competence, and reduction in anxiety.

**Notes on contributors**

Dr Mary McAteer is Programme Lead for the MA Educational Enquiry and Professional Learning, Edge Hill University, and has worked a teacher and teacher educator for more than 40 years. Her main research interests include primary mathematics education, practitioner research, and participatory action research in school, community and international contexts.

Victoria Grinyer has worked with the Specialist Primary Mathematics Practice Programme at Edge Hill University, England since 2010. She is an experienced primary school teacher and she is currently undertaking research for an EdD. Her study explores ways of supporting teachers to build, support and sustain effective communities of learners, particularly in relation to building on line learning communities.

**ORCID**

Victoria Grinyer [http://orcid.org/0000-0001-5092-0129](http://orcid.org/0000-0001-5092-0129)

**References**

Ashcraft, M. and Moore, A., 2009. Mathematics Anxiety and the Affective Drop in Performance. *Journal of psychoeducational assessment*, 27 (3), 197–205. doi:10.1177/0734282908330580

Ashcraft, M.H., 2002. Math Anxiety: Personal, Educational, And Cognitive Consequences. *Directions in Psychological Science*, 11, 181–185. doi:10.1111/1467-8721.00196

Barrett, D., 2013. Preservice Elementary Teachers’ Attitudes Improve and Math Anxiety Decreases with Focus upon Manipulatives Use. *National Teacher Education Journal*, 6 (2), 5–10.

Bekdemir, M., 2010. The Pre-Service Teachers’ Mathematics Anxiety Related To Depth Of Negative Experiences In Mathematics Classroom While They Were Students. *Education Studies in Mathematics*, 75, 311–328. doi:10.1007/s10649-010-9260-7

BERA, 2011. *Ethical Guidelines for Educational Research*. London: BERA.

Beswick, et al., 2006. Teachers’ Confidence and Beliefs and their Students’ Attitudes to Mathematics. In: P. Grootenboer, et al., ed. *Identities, Cultures and Learning Spaces* (Proceedings from the 29 Annual Conference of Mathematics Education Research Group of Australasia, Canberra. Adelaide, SA: MERGA, 68–75.

Bobis, J, Bruce, C, and McAteer, M, 2014. Professional learning through collaborative action research in mathematics: canadian, australian and uk perspectives. In: Polush, E., Flynn, T., Hill, J., Leaman, H., & Martinez, J. (Eds, Eds. 2014). *Proceedings of the 2014 Conference of the Action Research Network of the Americas (ARNA)*. USA: ARNA: Bethlehem.

Bonner, P., 2006. Transformation of Teacher Attitude and Approach to Math Instruction through Collaborative Action Research. *Teacher Educator Quarterly*, 33 (3), 27–44.

Boreham, N., 2000. Collective Professional Knowledge. *Medical education*, 34, 505–506.

Brady, P, and Bowd, A., 2005. Mathematics Anxiety, Prior Experience And Confidence To Teach Mathematics Among Pre-Service Education Students. *Teachers and Teaching*, 11 (1), 37–46. doi:10.1080/1354060042000337084

Braun, V. and Clarke, V., 2006. Using TA in psychology. *Qualitative research in psychology*, 3 (2), 77–101. doi:10.1191/1478088706qp063oa

Brown, M., Brown, P., and Bibby, T., 2008. ‘I Would Rather Die’: Reasons Given By 16-Year-Olds For Not Continuing Their Study Of Mathematics. *Research in Mathematics Education*, 10 (1), 3–18. doi:10.1080/14794800801915814
Bruce, C.D. and Flynn, T., 2013. Assessing the Effects of Collaborative Professional Learning: Efficacy Shifts in a Three-Year Mathematics Study. *Alberta Journal of Educational Research*, 58 (4), 691–709.

Buck, G.A., Latta, M.A., and Leslie-Pelecky, D.L., 2007. Learning how to make inquiry into electricity and magnetism discernible to middle level teachers. *Journal of science teacher education*, 18 (3), 377–397. doi:10.1007/s10972-007-9053-8

Burns, J. 2012. “Poor Numeracy ‘Blights The Economy And Ruins Lives”. BBC News, 2 March. Accessed 15 April 2016. www.bbc.co.uk/news/education-17224600

Clandinin, D.J. and Connelly, F.M., 2000. *Narrative Inquiry: Experience And Story In Qualitative Research*. San Francisco: Jossey-Bass.

Clement, M. and Vandenberghe, R., 2001. How School Leaders can Promote Teachers’ Professional Development: An Account from the Field. *School Leadership and Management*, 21 (1), 43–57. doi:10.1080/13632430120033036

Copley, J.V., 2004. The Early Childhood Collaborative: A Professional Development Model To Communicate And Implement The Standards. In: D.H. Clements and J. Sarama, eds. *Engaging Young Children In Mathematics: Standards For Early Childhood Mathematics Education*. Mahwah, NJ: Lawrence Erlbaum Associates, 401–414.

DFES, 2003. *The 2003 Skills for Life Survey: A Survey of Literacy, Numeracy and ICT Levels in England*. London, DBIS.

Elwood, J. and Comber, C., 1995. Gender differences in ‘A’ level examinations: The reinforcement of stereotypes. Paper presented as part of the symposium A new ERA? New contexts for gender equality: BERA conference, September, in the University of Bath

Finlayson, M., 2014. Addressing Math Anxiety In The Classroom. *Improving Schools*, 17 (1), 99–115. doi:10.1177/1365480214521457

Goddard, Y.L. and Goddard, R.D., 2007. A Theoretical and Empirical Investigation of Teacher Collaboration for School Improvement and Student Achievement in Public Elementary Schools. *Teachers College record*, 109 (4), 877–896.

Hannula, M., 2002. Attitude towards mathematics: Emotions, expectations and values. *Educational Studies in Mathematics*, 49, 25–46. doi:10.1023/A:1016048823497

Hastings, S. 2006. Numeracy. [Accessed 6 May 2017].

Jackson, A., 2008. Mathematics Anxiety In Student Teachers. *Practitioner Research in Higher Education*, 2 (1), 36–42.

Kennedy, A., 2005. Models of continuing professional development: A framework for analysis. *Journal of In-service Education*, 31 (2), 235–250. doi:10.1080/13674580500200277

Lieberman, A., 1994. Teacher Development: Commitment And Challenge. In: P.P. Grimmett and J. Neufeld, eds. *Teacher Development and the Struggle for Authenticity*. New York: Teachers College, 15–30.

Liu, F., 2007. Impact of Online Discussion on Elementary Candidates’ Anxiety Towards Teaching Mathematics. *Education*, 128 (4), 614–629.

Marsden, T. 2015. World Maths Day: Why Are Britons So Hopeless At Maths? Independent, October 12. http://www.independent.co.uk/news/education/education-news/world-maths-day-why-are-britons-so-hopeless-at-maths-a6691411.html

Matthews, A. and Pepper, D., 2005. *Evaluation Of Participation In A Level Mathematics: Interim Report*. London: Qualifications and Curriculum Agency.

Ross, J.A. and Bruce, C., 2012. Quantitative inquiry into collaborative action research: Measuring teacher benefits. *Teacher Development*, 16 (4), 537–561. doi:10.1080/13664530.2012.734746
Shectman, N., 2010. Math Anxiety in Middle School Math Teachers: Implications for Teacher Practice and Professional Development. *Proceedings of the International Conference of the Learning Sciences*, 2, 409–410.

Swarz, S.L., Daane, C.J., and Giesen, J., 2006. Mathematics Anxiety and Mathematics Teacher Efficacy: What is the Relationship in Elementary Preservice Teachers? *School science and mathematics*, 106 (7), 306–315. doi:10.1111/ssm.2006.106.issue-7

Uusimaki, L. and Nason, R., 2004. Causes Underlying Pre-service Teachers’ Negative Beliefs and Anxieties about Mathematics. *Proceedings from the 28th Conference of the International Group for the Psychology of Mathematics Education*, 4, 369–376.

Walker, M., *et al.*, 2013. *Evaluation of the Mathematics Specialist Teacher (MaST) programme*. National Foundation for Educational Research & SQW. London: DFE.

Williams, P., 2008. *Independent Review of Mathematics Teaching in Early Years Settings and Primary Schools*. London: DCSF.

Yin, R., 2014. *Case Study Research: Design and Methods*. London: Sage.