The Primary Mathematics Specialists – What Do They Think About Teaching and Learning Mathematics?

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Abstract

One recommendation of the Williams Review (2008) was that there should be a Primary Mathematics Specialist in every primary school within the next ten years. Research with one group of over 100 primary teachers following an Open University course suggests that the teachers who will be following the Primary Mathematics Specialists Programme will face a number of challenges including changes to their beliefs about the importance of subject knowledge and their pedagogic practices.

Introduction

In January 2010 the first cohort of primary teachers start on a programme of study that will result in them becoming Primary Mathematics Specialists. This national programme was one of the recommendations in the Williams Review (2008). These teachers are expected to emerge from the programme of study with "deep mathematical subject and pedagogical knowledge" (Williams 2008, 7). The review summarises the aims of the programme as including:

- subject knowledge in all aspects of the mathematics curriculum;
- solving problems and thinking mathematically;
- mathematics pedagogy; and
- working with colleagues to develop practice. (Williams 2008, 18).

The Williams Review criticised the National Strategies and Local Authorities for becoming more general in the approach to CPD with 'subject speciality becoming de-emphasised' (Williams 2008, para. 54). This new programme is an attempt to redress this balance by putting mathematics at the centre of teachers' professional development and is being led by universities in association with local authorities.

The work of Ernest (1989) suggests that in order for teachers to make a shift to problem solving in mathematics lessons they need to change their beliefs about mathematics, its teaching and its learning. Ernest describes three views of mathematics; problem solving, Platonist and instrumentalist. The problem solving view includes teachers who see mathematics as dynamic with content continually growing. A teacher with a Platonist view see mathematics as a static body of knowledge. The instrumentalist view of mathematics is as a collection of facts, skills and rules which often have no connections.

The significance of these views to teaching is that a teacher with a problem solving view is more likely to accept pupils' own methods of solving a problem. Whereas someone with a Platonist or instrumentalist perspective would expect pupils to find the single 'correct' answer to a problem. It is possible that the emphasis on numeracy (rather than mathematics) over the last ten years will have encouraged teachers with an instrumentalist perspective to be dominant in primary classrooms.

This paper is concerned with the beliefs of primary teachers of mathematics. In particular, it describes the way that a group of primary teachers view mathematics at the beginning of a CPD course.

Open University CPD provision

In recent years, the Open University's Centre for Mathematics Education has been running a mathematics course for primary teachers. The course, *Developing Mathematical Thinking*, which predated the Williams Review, is underpinned by a philosophy that professional development for teachers needs three interlinking strands:

- subject knowledge;
- subject related pedagogy; and
- embedding in practice.

These three strands are influenced by the work of Shulman (1986) and his notion of Pedagogical Content Knowledge (PCK) which is at the intersection of mathematics content knowledge and pedagogy. The three elements of the OU course are interwoven into the mathematical tasks that the teachers work on collaboratively.

The Open University course has proved to be highly successful in terms of supporting teachers as they improve their subject knowledge and develop their pedagogic practices. Anecdotal evidence from the teachers also suggests an increase in the attainment of their pupils.

As part of the *Developing Mathematical Thinking* course the Open University has carried out some research with these primary teachers in order to find out their beliefs about mathematics, its learning and teaching.

Method and analysis

Data were collected near the start of the course in a written questionnaire. There were two forms of items on the questionnaire: quantitative and qualitative. There were 15 quantitative items with multiple responses based on a Likert scale. For example, Item 1/9 *When I am successful in mathematics, it is because* .. had four possible responses on a five-point Likert scale: agree mostly; agree a bit; no feeling; disagree a bit; disagree mostly. These items were developed by Barbara Allen and John Mason (The Open University, 1994) as a means for OU students to profile their own beliefs about, and attitudes to, learning and teaching mathematics. The possible responses to the items relating to beliefs were designed to extract the teachers' perspectives in line with Ernest's model: problem solving, Platonist and instrumentalist. The wording of the items that were concerned with attitudes had been influenced by previous OU work with teachers and learners of mathematics (Ruffell, Mason and Allen 1998; Allen and Shiu, 1997).

The first four quantitative items asked about when the teachers felt they were successful at mathematics and how they knew when they understood a topic. The next four were the qualitative items and included statements about the teachers' perceptions of mathematics and its learning. The final eleven quantitative items were designed to highlight the teaching of mathematics including the role of the teacher, how learning happens and perceptions of themselves as effective teachers. This paper reports on four of the quantitative items and one of the qualitative statements.

The analysis of the quantitative items was a simple tally and percentage of the total responses. Not all of the teachers completed all the items. The qualitative items were sorted into general categories in line with grounded theory approaches.

The teachers

The cohort reported here is from one local authority with over 100 teachers. The vast majority of the teachers were female (84%) and most of them were in their twenties (42%) or thirties (24%). Their highest educational qualifications were mainly at first degree level with 6% having a Masters degree – not necessarily in education. The highest mathematics qualification was generally at GCSE (64%) or O level (29%) with 7% having an A level.

We do not have information about why the teachers attended the course: for example, whether they were volunteers or were selected by their Headteacher.

Quantitative Findings

Data from four quantitative items are reported here and are concerned with the teachers' own experiences of learning and teaching mathematics.

Teachers' view of success in mathematics

We were interested to find out how the teachers viewed their own experiences of learning mathematics. For some this would have been many years ago but for many it was relatively recent – within 10 years.

Item 1/9	When I am successful in mathematics, it is because …	
%	Agree mostly	Agree a bit
I persevere.	56	48
I am clever.	6	39
I follow an example.	45	63
I am fortunate	3	20

Fig 1: Teachers own experiences of learning mathematics.

The teachers were universal in their agreement that they were successful at mathematics if they persevered. But 39% thought that they were also successful because they were clever. Does this imply that some of the teachers thought that only 'clever' children could do mathematics? If so, how are these clever children identified? How do the teachers work with children who are not clever and do they assume they can not be expected to be successful at mathematics? And what do the teachers mean by clever? Are the clever children the ones who get the answers correct?

Most of the teachers also thought they were successful if they followed an example. This suggests that their experiences of learning mathematics were in a 'traditional' setting where the teacher demonstrates a mathematics technique to the class who then complete a series of similar questions. Does this mean that these teachers teach in a similar way? If this has been a successful learning experience for them then one might assume that they believe that this traditional form of teaching would be effective in current primary classrooms. This suggests that a majority of the teachers may have an instrumentalist perspective on mathematics.

Some additional information came from item 8/11 when the teachers were asked to what they attributed their pupils' success.

Item 8/11	When teaching I assume that pupils' success is primarily due to ...	
%	Agree mostly	Agree a bit
their hard work.	35	61
luck	0	9
their natural ability.	14	73
them being set suitable work.	74	27
good teaching.	75	29

Fig 2: Teachers' attributions of pupils' success

Most of the teachers appeared to attribute some of their pupils' success to hard work and natural ability. But they were more strongly in agreement that success was attributable to them being given the appropriate work with quality teaching. It appeared, then, that the teachers felt that their pupils' success depended mainly on their skill as an effective teacher.

There seemed to be conflicting information here. Whereas the teachers attributed their own success in mathematics to perseverance (a personal quality) and following an example (a personal strategy) it is not these personal qualities or strategies they felt made pupils successful. This appears to be evidence for an emphasis on teaching rather than learning. The Primary Mathematics Specialist Programme includes an understanding of the ways people learn mathematics which suggests it is possible that this shift from teaching to learning could be a challenge for some teachers.

Teachers' view of teaching mathematics

The teachers were also asked about their expertise as a teacher and how they approached their teaching. These two items produced responses that contradicted those described above. The first concerned the teachers' beliefs about learning mathematics and how this impacted on their teaching.

Item 10/11	My approach to teaching is mainly based on a firm belief that ….	
%	Agree mostly	Agree a bit
everyone can learn maths if only they'd work at it.	15	47
some people are naturally good at maths and some are not.	25	57
I can accelerate learning by stimulating and challenging pupils.	76	25
my job is to get pupils through the assessments and SATs.	7	33
everyone can learn maths if I support and encourage them.	71	31

Fig 3: Approach to teaching

Item 8/11 the teachers attributed their pupils' success in part to hard work (35% and 61%) and natural ability (14% and 73%). Item 10/11 gave a different perspective with the majority of teachers feeling that some people are naturally good at mathematics (25% and 57%) but also that anyone can learn if they have the support

of a teacher (71% and 31%). This seems to suggest that the teachers feel that although some pupils have natural ability in mathematics anyone can learn mathematics provided they work hard and have effective teaching.

It is, of course, possible that the teachers were giving the answers that they imagined the researchers wanted to see. It is also possible that the teachers have never before been asked for their perspective on teaching and learning mathematics and therefore have not thought through possible answers.

We also do not know how the teachers interpreted the word 'maths'. Do they see maths as just number or numeracy? Or do they see maths as a larger subject?

If these teachers believe that their teaching is a major influence on whether or not pupils learn then it suggests that they will be supportive of the Primary Specialist Programme which aims to improve pedagogical subject knowledge.

An effective teacher of mathematics

It seems from previous answers that the teachers felt that one of the keys to success was quality teaching but what did they think made an effective teacher? Item 7/11 was designed to establish their opinions about how they could be more effective as a teacher of mathematics.

Item 7/11	I think I would be a more effective teacher if only ….	
%	Agree mostly	Agree a bit
I had more preparation time.	57	40
pupils were motivated to learn.	26	33
I had more support.	23	42
I could spend more time on professional development.	23	51
I knew more mathematics.	12	46

Fig 5: More effective teacher

It appears that the teachers believe that they would be more effective teachers if they had more preparation time. We do not have any information on how much preparation time they currently get or would want. One feature of the Primary Specialist Programme is Lesson Study which will involve teachers planning, teaching and reflecting on lessons together. This is going to involve a change in the way many teachers plan a programme of work for their pupils.

Time spent on professional development appears to be important to the teachers which suggests that they might be supportive of the Primary Mathematics Specialist programme.

The teachers do not see increased subject knowledge as the highest priority. This is of some concern since one of the main thrusts of the Primary Specialist Programme is the raising of teachers mathematics knowledge. This could be a concern to the university providers who will be required to work on mathematics with the teachers and increase their subject knowledge.

Although the quantitative date gave some information about the way the teachers viewed the teaching and learning of mathematics, it was the qualitative data that added some detail.

Qualitative findings

The open-ended item being reported here asked the teachers to complete the following sentence.

> **Mathematics is** ... …

It was intended that the responses be analysed in terms of Ernest's three views of mathematics; problem solving, Platonist and instrumentalist. On reading the responses it was clear that they could not be sorted into these three groups, instead they fell into 4 different categories that were named: affective (38%); real world (26%); subject content (24%); and mathematical relationships (12%). Clearly some of these categories have links with Ernest's model and these will be discussed later.

Affective responses

A large number of the affective responses were single words like; creative, challenging, hard, great, enjoyable, daunting. A few expanded on the single word with

> **Mathematics is** fun when I get it!
>
> **Mathematics is** fun when it is understood.
>
> **Mathematics is** good when you understand it.
>
> **Mathematics is** difficult when I am expected to provide answers to others.

The longer responses in this category gave more information.

> **Mathematics is** finding a way which works for you and working with it to succeed.
>
> **Mathematics is** fun when I have success and frustrating when I fail.
>
> **Mathematics is** taxing because it makes me think and takes me out of my comfort zone.
>
> **Mathematics is** very challenging for me. I have struggled with maths since being in school and that puts up barriers against extending my mathematical understanding.
>
> **Mathematics is** motivating because there are answers to be found out and the possibility of getting it right which feels good.

Some of the teachers seemed to feel that understanding mathematics was important while others linked feelings of success with getting the answers right. These affective responses were not part of Ernest's model but it is possible that getting the answers right indicates an instrumentalist view. These responses do not really give any indication of how the teachers view mathematics. It seems that the word mathematics engendered only an emotional response for 38% of the teachers.

Real world

The 26% of responses in this category split into three different sub-groups: those that referred to mathematics being everywhere; those that related to needing mathematics to understand the real world; and some that regarded mathematics as a skill.

The responses that were concerned with mathematics being everywhere generally consisted of single word responses; essential, everything, everywhere, a subject.

A number of teachers made comment about needing mathematics in order to make sense of the real world.

> **Mathematics is** making sense of the world through generalising patterns to solve problems.
>
> **Mathematics is** using numbers to explain the world.
>
> **Mathematics is** learning skills, knowledge and concepts to help you undertake tasks in the real world.
>
> **Mathematics is** an important life skill.

These responses suggest an awareness of the uses of mathematics outside the classroom. They do not however give any indication that the teachers can see connections between the topics in mathematics. The teachers giving real life responses did not seem to be displaying an instrumentalist view of mathematics.

Subject content

The responses in this category mentioned the content of mathematics.

> **Mathematics is** working with numbers and patterns.
>
> **Mathematics is** the knowledge, understanding and application of number, shape and concepts to do with these.
>
> **Mathematics is** a combination of facts and figures.
>
> **Mathematics is** an understanding of number.
>
> **Mathematics is** the ability to calculate values.
>
> **Mathematics is** problem solving, number concepts, patterns, collecting data, understanding measures.

Some of the statements overlapped with those in previous categories. These were placed in the subject content group because that was the overriding issue.

> **Mathematics is** learning rules, patterns and examples about numbers, shape, space, measures and using them to solve problems that will help in our everyday lives.

The responses in this category suggest that these teachers see mathematics consisting only of school mathematics. Only a few made links to the use of school mathematics in everyday life. Schoenfeld (1988) criticised the school curriculum for only introducing learners to a subset of mathematics, namely school mathematics. It seems from these findings that some of the teachers were only aware of this subset of mathematics. The teachers giving a subject content response appear to have an instrumentalist view of mathematics but it is not known if they also display signs of a Platonist view.

Mathematical relationships

The 12% of responses in this category talked about making links between mathematical concepts and recognising relationships. Some of the responses recognised links between areas of school mathematics while others were concerned with the big picture of mathematics.

> **Mathematics is** making connections between different elements of number, shape and space, algebra etc. to work out a given problem.
>
> **Mathematics is** making links between many ideas of number and shape.
>
> **Mathematics is** spotting patterns and solving problems.
>
> **Mathematics is** understanding number patterns and their relationships.

Mathematics is making connections.

Mathematics is understanding concepts and applying them to different contexts.

For many mathematics educators, mathematical relationships are at the core of the subject. Although most of the teachers' comments in this category contained the word 'link' or 'relationship', a number of them still only cited these as existing within the subset of school mathematics. The teachers giving these responses appear to have more of a problem solving view of mathematics.

What next?

Ernest's (1989) model appears to suggest that the teachers with a problem solving view of mathematics are the most effective. There is little evidence from this cohort of primary teachers that they view mathematics in terms of problem solving. It seems that in order for them to become effective teachers of mathematics they will need to shift their view of mathematics from Platonist or instrumentalist to one of problem solving.

By the time that BMCE starts in April 2010, the first cohort of teachers will have embarked on this programme. We will have greater information about who the teachers are and their own knowledge of mathematics. The findings in this paper suggest that for primary teachers, mathematics engenders an affective response rather than a clear view of how they see mathematics.

The challenge to the universities and local authorities involved in this programme is to facilitate teachers to change the way they view both the teaching and learning of mathematics in order to raise the attainment of their pupils. This paper suggests that the providers of the programme will also need to challenge the way the teachers view mathematics as a subject.

References

The Open University. 1994 ME825 *Researching Mathematics Learning*, Milton Keynes, The Open University.

Allen, B. and C. Shiu. 1997 Learning Mathematics is Like … Views of tutors and students beginning a distance-taught undergraduate course, *British Society for Research into Learning Mathematics, Conference Proceedings*, University of Nottingham, 1997: 8-11.

Ernest, P. 1989. The Impact of .Beliefs on the Teaching of Mathematics, in *Mathematics Teaching: The State of the Art* , ed. P. Ernest. London, Falmer Press, 249-254.

Ruffell, M., J.H Mason, and B.M. Allen 1998 Studying Attitude to Mathematics**,.** *Educational Studies in Mathematics* 35(1): 1-18.

Schoenfeld, A.H. 1988. When Good Teaching Leads to Bad Results: The Disasters of "Well-Taught"' Mathematics Courses. *Education Psychologist*, 23(2): 145-166.

Shulman, L.S. 1986. Knowledge and Teaching: Foundations of the New Reform. *Harvard Educational Review,* 57 (1): 1-21.

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