

# THE INFLUENCE OF EARLY CHILDHOOD MATHEMATICAL EXPERIENCES ON TEACHERS' BELIEFS AND PRACTICE

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*This paper shows how particular forms of formative familial experiences provide prospective teachers with the intellectual tools necessary for undertaking critical analyses of both the received and intended curriculum. Data from a multiple case study shows that beliefs formed through early mathematical experiences stay with individuals to reveal themselves in subsequent beliefs and practice.*

*Key words: teachers, early childhood, beliefs, practice, norms.*

## INTRODUCTION

This study follows in the tradition of research into the relationship between teachers' espoused beliefs and their enacted practices (Beswick, 2007; Skott, 2009; Thompson, 1984). It draws on a multiple case study of the whole class interactive phases of the mathematics lessons of six English primary teachers and the rationales they offer for their actions. The data yielded two distinct groups of three teachers, essentially defined, as I explain below, by their early mathematical experiences. All six teachers were similarly qualified, were enthusiastic teachers of mathematics and considered, by their colleagues and others, as ambassadors for the subject. It came as a surprise, therefore, when my analyses highlighted not only substantial differences in practice-related beliefs and the enactment of those beliefs but also the ways in which early childhood influences had moulded such different teachers. Three elements of teachers' practice were identified in the larger study: mathematical intentions, pedagogical approaches and classroom norms. In this paper, due to reasons of space, I report on *classroom norms* (Yackel & Cobb, 1996), and on two of the six teachers, one representative of each group, to highlight the resonance between beliefs, practice, and early childhood experiences.

## THEORETICAL BACKGROUND

A number of studies, both theoretical (Ernest, 1989) and empirical (Beswick, 2007; Furinghetti & Pehkonen, 2002; Skott, 2009), have highlighted the influential role of teachers' beliefs on classroom practice. In particular, Ernest argues that teachers' perspectives on the nature of mathematics influence the construction of their mental models of the subject and its teaching. Thus, although subject knowledge is important, it is not sufficient by itself to account for the differences between mathematics teachers. English teachers, the focus of this paper, are typically thought to hold beliefs more in accordance with traditional than reform practice, emphasising the mastery of symbols, skills and procedures (Andrews, 2007).

Warfield et al. (2005) argue that the relationship between "teachers' beliefs and their instruction is not as direct as sometimes thought" (p. 442), stressing that it is not unusual for individuals to hold contradictory beliefs, thereby making it difficult to determine how particular beliefs influence practice. This may be because teachers' mathematics-related beliefs draw on not only beliefs about mathematics and its teaching, but also beliefs about themselves as teachers and the classroom context in which it occurs. Moreover, beliefs about schools, teaching and mathematics will first be formed during childhood. Therefore, understanding teachers' beliefs, which here are construed to be "subjective, experienced based, often implicit knowledge" (Pehkonen & Pietilä, 2003, p. 2), and their genesis about mathematics is important if we are to understand the relationship between beliefs and observed practice.

We know that trainee teachers who experienced failure at school may develop beliefs and practices focused on protecting their students from the pain induced by such experiences. The opposite is also likely to be true; students who recall positive experiences as learners of mathematics will approach teaching positively. Thus, it seems reasonable to assume that mathematics teachers who learned procedural mathematics successfully may have difficulty accepting the validity of alternative practices; their experiences will foster beliefs that will underpin their approaches to mathematics teaching (Handal & Herrington, 2003). Moreover, Muir (2012) has shown how parents influence not only their children's beliefs and attitudes towards mathematics, but also their learning of the subject and the development of their self-efficacy. That is, there appears to be a clear link between parents' attitudes, perceptions and beliefs about mathematics and children's attitudes and performance in mathematics. Yet, little research has explored the nature of parental perceptions of and attitudes towards mathematics in general and its impact on their children's, children who subsequently become teachers, perceptions, values and understanding of the subject.

Consequently, this paper aims to address the following questions: How do primary teachers of mathematics conceptualise the whole class aspect of their work? With sub-questions: 1) What knowledge and beliefs underpin their actions? 2) In what ways do the espoused beliefs resonate with the enacted? 3) What justifications do they present for their actions?

## **DATA COLLECTION AND ANALYSIS**

A number of studies (Thompson, 1984; Beswick, 2007) have shown that case study can facilitate our knowledge and understanding of the relationship between teachers' espoused beliefs and enacted practice. Thus, a multiple exploratory case study (Stake, 2002) was undertaken to examine individual teachers' perceptions of, and justifications for, what they believe they do in the whole class interactive phases of their mathematics lessons. This involved six primary teachers, each considered locally to be an effective teacher of mathematics or, importantly, an ambassador for

the subject. Such an approach controlled for various teacher characteristics such as teacher confidence or indifference towards teaching the subject.

For each teacher, data collection involved an initial semi-structured interview, followed by between three and six, video-recorded, lesson observations. To examine the relationship between espoused and enacted practice recorded lessons were viewed jointly by me and the teacher concerned as components of repeated video stimulated recall interview (SRI). Data were analysed by means of constant comparison (Glaser & Strauss, 1967), a process whereby newly collected data from one lesson were compared with data collected from the previous lessons and interviews, and, in so doing, facilitates the development and refinement of theory. In this paper, due to limitations of space, I discuss two of these teachers; each one being representative of one of the two distinct groups that emerged from the larger study.

## **THE STUDY RESULTS AND DISCUSSION**

In the following I present and discuss a summary of the data on each teacher's *background* and the *classroom norms* that emerged in the observations and explicitly emphasised by the teacher in the interviews that followed. The first section on their background is presented against the three broad headings that structured the interview analyses. Teacher utterances are italicised. These concern the following: 1) Mathematics as a subject; 2) Confidence in mathematics knowledge for teaching; 3) Being a teacher of mathematics.

### **Mathematics as a subject**

Both teachers (Caz and Gary), stated they enjoyed mathematics as a child. However differences between these teachers were only highlighted when specific aspects of their enjoyment were discussed.

Caz believed she had a *natural talent* for mathematics and recalled how she assumed everyone else was enjoying mathematics just as she was. She could not understand why mathematics *wasn't so obvious to everybody at school*. She believed her enjoyment of mathematics stemmed from a family view in which mathematics was challenging but interesting. She spoke much about her engagement in exploring mathematics at home as a young child with her father and younger brother. Believing that the sort of *games found on the Nintendo DS today with puzzles and games and things, were similar to the things we used to do with pencil and paper together at home*. She had always enjoyed playing with, number and logic puzzles, and remained keen to engage her own class in interesting mathematics, like the exploration of the work of Fibonacci that she had experienced as a child with her family. She believed her father had a significant influence in how she viewed mathematics.

Gary in contrast described how he found mathematics unproblematic at school, and could describe very little about family influence regarding the subject. He remembered being good at the subject, and talked about *the rightness and wrongness*

of mathematics. In particular he remembered *he enjoyed working through his text books, getting lots of ticks and feeling very motivated by the correctness of his neatly presented work*. He appeared to enjoy a procedural approach to learning mathematics, appreciating *small steps* and clearly defined levels of progress. Gary remembered learning and *memorising tricks* and talked about how *they worked for me*, and therefore used them in his approach with his class.

### **Confidence in Mathematical knowledge for Teaching**

Both teachers were confident in their mathematical knowledge for teaching. Gary trained as a primary generalist with a mathematics specialism, whereas Caz gained a degree in early child psychology, before gaining her teacher status, where she studied children development and theories of learning which she often referred to in her interviews. Gary remembered how he found the specialism of his degree interesting, but did not remember anything in particular about his training, other than teaching approaches acquired during teaching practice.

### **Being a Teacher of Mathematics**

When discussing being a teacher of mathematics, colleagues' utterances frequently referred to the latest official directives and exploited the vocabulary embedded in them. Admittedly, they were all mathematics specialists, so perhaps this should have been expected. It could be argued that this acceptance and exploitation of vocabulary, only teachers would be expected to understand, reinforces primary teachers' professional identity, not least because "our identities are composed and improvised as we go about living our lives embodying knowledge and engaging in our contexts" (Connelly & Clandinin, 1999, p. 4). That is, continuing participation in this 'nationally led' vocabulary is not only a source of identity within the primary teacher community (Wenger, 1998) but the means by which they remain part of the primary teaching community.

In conclusion, the initial interviews revealed both interesting and pertinent characteristics about the project teachers. When analysing their backgrounds, views and beliefs, a dichotomy of experiences emerged: Caz was representative of one group, and Gary the other. The table below illustrates the very strong differences between these teachers' perception of mathematics.

Experientially-formed beliefs: Beliefs as learner, trainee and experienced teacher.	Teacher	
	Caz	Gary
Believes they have a natural talent for the subject and strongly influenced by family views about the subject	✓	
Found mathematics unproblematic in their own schooling of the subject		✓
Found mathematics challenging but enjoyable in their own learning of the subject	✓	

Enjoyed a mechanical approach to mathematics at school – the challenge of working through text books and levelled cards of questions		✓
Influenced by courses and training in how children learn or the learning of mathematics	✓	
Influenced by teachers they have worked with and Senior management team		✓
Concerns about children’s engagement with the mathematical learning e.g. children groupings and how discussion develops learning	✓	
Concerns about children reaching targets and motivating children to work and achieve		✓
Believes the way mathematics is taught now is much better or more fun than when they were young	✓	✓

**Table 1: Differences in perceived beliefs**

The results resonate strongly with earlier research highlighting the connections between beliefs formed during the early learning of mathematics and practice (Thompson, 1984; Ernest, 1989). The characteristics of these two groups will be discussed below, but, crudely, the first group, represented by Caz, held a relational perspective on mathematics and its teaching, while the second, represented by Gary, illustrate an instrumental (Skemp, 1976). Moreover, the evidence indicates that the members of both groups still enjoyed the same things as when they were young, and that these formative beliefs are not only deep rooted but reflected in their perspectives on their own classrooms. This perspective will now be presented through the classroom norms emphasised by each teacher in observations and SRIs.

### Classroom Norms

**Classroom Norms** (CN) emerged from the data in all cases of the study which identified a regular pattern to the way in which the teachers conducted their Whole Class Interaction (WCI) in mathematics lessons. Each individual was seen to behave and offer consistent perceptions for that behaviour thus establishing a classroom norm as described by Yackel & Cobb (1996) and Chazan et al. (2012). Utterances made by the teacher are presented in all cases in *italics*.

The teachers fall into the same two groups as presented earlier in their background influences. That is, ‘the understanding that students are expected to explain their solutions and their ways of thinking is a social norm, whereas the understanding of what counts as an acceptable (mathematical) explanation is a sociomathematical norm’ (Yackel & Cobb, 1996, p. 461). There are three main threads to the discussion of classroom norms which are presented in the table (2) below:

<b>Structural Norms</b>	highlight the lesson structures through which teachers present mathematics during WCI phases. For example, the emphasis made on explicit learning objectives and success criteria, discussion, and particular peculiarities of whole
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	class phases, time and flexibility
<b>Cognitive Norms</b>	encompass the emphasis a teacher makes to developing children as enquirers and problem solvers of mathematics in general, the precision and fluency procedures, and whether an instrumental or a relational approach to teaching and learning is made in WC phases
<b>Attitudinal Norms</b>	illustrate the emphasis the teacher places on developing children's confidence, motivation to learning/mathematical learning, enjoyment of learning/mathematics and the teacher's actions and styles connected to <i>social</i> relationships emphasised by the teacher

**Table 2: Classroom norm key threads**

*Structural norms* appeared very similar between teachers, for example, both teachers presented learning objectives (LOs) on their boards, but their rationale for doing so was quite different. In so doing, they exploited routine behaviours familiar to them and their children. Caz, LOs were broad and, I argue, commensurate with her ambitions that her children should remember the mathematics and not the context. For example Caz had asked her class to increase the mass of cake sizes by ten, she *said I want them to remember we were multiplying by 10 and 100 and not learning about cakes!* She consistently encouraged her children to offer ideas and questions about the learning objectives (a social norm). However the manner in which children responded to questions indicated their awareness that they were expected to provide mathematical justifications or reasoning behind their contributions. In short, she presented mathematics as a way of thinking and behaving (sociomathematical norm).

In contrast Gary spent much time emphasising what he intended to be learnt, with between three and six LOs presented every lesson, meticulously going through each in detail. Such actions, while superficially mathematical, concerned the establishment of behavioural, rather than cognitive patterns of working and so, I argue, reflect a social norm, because they are no more than a 'telling' of what children are to learn. This approach was also seen in his use of success criteria (a list of how children will learn the objectives displayed). This is an important distinction and something likely to be hidden from Gary, who believed, as his institutional management team had reiterated, an effective teacher is one who ticks off each of a series of 'teaching skills'. For example: *go through learning objectives with the class – tick. Go through the vocabulary – tick.* It is not wrong it is simply reflective of instrumentally- rather than relationally-focused beliefs (Skemp, 1976).

Discussion was managed in different ways. For Caz discussion frequently included paired talk, questioning and argumentation. She expected children to think and make connections between the mathematics and real-life experiences, as described by Weber et al. (2008). Gary typically followed an Initiation Response and Feedback (IRF) format. The manner, in which this played out in enacted practice, was quick with rapid closed questions answered by selected students. The social norm was for children to sit quietly in front of their teacher and listen and wait to be asked.

To summarise these differences is to acknowledge that children develop learnt behaviours as either autonomous or dependent learners. Autonomous learners ask their teacher questions and offer ideas even if they might be wrong. They talk about their mistakes and misunderstandings publicly. Dependent learners are quiet, essentially passive, but highly attentive to their teacher. The key point however, is directly related to their teacher's approach (Lawson, 2004), and I would argue, their teacher's belief of what it is to be a learner.

*Cognitive norms* differed greatly between what the teachers perceived as games, and what they understood by whole class discussion. Games were played in both teachers' lessons, and in particular at the beginning. Caz used, for example, speed against the clock games for recalling facts, through perhaps dance routines to jog memory and paired games to develop calculation strategies and vocabulary. She said they *really enjoy playing those sorts of games* (competitive pairs). *They make it really hard for each other too* (with their questions). The emphasis for using games was to make their *children think and talk using new mathematical vocabulary and plan their strategies to win* thus providing an opportunity to behave mathematically (a sociomathematical norm).

Although Gary also used games his rationale was quite different. He frequently used structured tasks, such as writing out times-tables forwards and backwards, which he described as a game. He justified these as time fillers (social norm) and not a sociomathematical norm. At other times he exploited a game called 'popcorn', whereby he calls out a number and, in one variant of the game, children sit if the number is odd and stand if it is even. He varied it so to try to catch children out and, in observed lessons children seemed to enjoy the activity. Interestingly, Gary spoke about it as *breaking up the lesson, to get a bit of movement going, we even go into the millions of whole number, just associating a bit of quick thinking ...that's an even number, I need to stand up, odd numbers oh I sit down*. In such accounts we can see a social rather than mathematical norm where the emphasis was on having fun.

All teachers develop cultural routines and rituals that children come to know (Alexander, 2000) and two such rituals, concerned thinking time. Gary provided short opportunities, typically between three and seven seconds, for children to think about a question before answering. Caz provided several minutes for discussion through whole class or paired talk. Such distinctions typically permeated the lessons of each group.

There has been some discussion in primary education about what pace actually means. Official documentation in England (OfSTED, 2005) indicate that a fast pace is necessary during direct teaching. However, the confidence of the official version of pace is at odds with the literature, e.g. Alexander (2000) write that 'an observer may be deceived into concluding that pace of classroom talk equates with pace of pupil learning' (p. 430), perhaps a pointless exercise if it is not appropriate.

The belief of both project teachers, quite naturally, is that they do what they do because they believe their approaches are effective and educationally beneficial. Yet the research into WCI phases of mathematics lessons (Alexander, 2010) indicates otherwise. In conclusion, the pace and the relationship to the amount of thinking time given to children dichotomised the teachers. Although the time provided for thinking reflected a social norm in each classroom, the conceptions presented by each teacher highlighted differences in a mathematical emphases. Caz believed that children should co-construct their answer to develop mathematical thinking, whereas Gary believed *he* was structuring children's thinking.

*Attitudinal norms* were presented through their different emphasis on children's enjoyment, confidence and motivation of mathematics. When Caz, emphasised her desire for their children to enjoy mathematics, she did so in relation to their structuring their children's learning of mathematics. It was a cognitive tool rather than an end in itself. Consequently, her ambition reflected a sociomathematical rather than a social norm. Gary, however, discussed enjoyment in very different ways. While it could be argued that his desire for their lessons to be fun helped to maintain his children's focus and concentration, he believed that enjoyment of mathematics would lead to success and increased confidence, as found by Skott's (2009) research on teachers. Gary spoke of how 'target children' were asked lots of questions to build their confidence, for example. Frequently, saying ...*oooh that was a very good answer* or *good girl* or *good boy*. Such actions reflect a social norm (Yackel & Cobb, 1996). A justification for his actions may lie in the fact that he paid great attention to the children he perceived as weak. Gary was focussed on progressing all his class two sub-levels in their curricular assessments (as instructed by his senior management) and so worked hard on those at the margin of that.

To summarise classroom norms, important similarities and differences between the teachers' beliefs and practices are highlighted. The classroom norms illustrated in these two classrooms seem in accordance with individual teacher's core beliefs about learning. What is of substantial interest, and an appropriate site for future research, is the clear distinction between the two groups of teachers was either constantly encouraging social norms or encouraging sociomathematical norms. The group, emphasising social norms focus on the achievement of particular behaviours which just happen to be in mathematics, not the mathematics itself. The opposite reflects a more relational learning that is created through sociomathematical norms that encourage a collective, co-constructed learning is rooted in mathematics.

## **CONCLUSION**

Both teachers were, not only considered to be strong mathematically, but leaders of the subject, (according to local definitions) effective teachers of primary mathematics. Yet two distinct groups of teachers consistently emerged through their background perspectives and their classroom norms, despite the fact that all these



teachers are well qualified, there remain substantial differences between them in respect to their early background experiences related to the subject, and how their subject knowledge plays out in the classroom.

This study indicates that what transpires during the whole class interactive phases of a lesson is far more complex than a simple analysis of subject knowledge can reveal (Skott, 2009). Teachers draw on core beliefs about mathematics and mathematics teaching that are frequently immune to change (Handal & Herrington, 2003). The findings of this study, suggest qualitatively different teacher characteristics. On the one hand are teachers who behave autonomously; teachers who mediate the constraints within which they work, and perceive learners to be autonomous. On the other hand teachers who appear dependent are mediated by the constraints within which they work, and emphasise dependent learners in the classroom norms. Of course, this is a simple summary that belies the layers of complexity of what an individual teacher chooses to do in any given set of circumstances. Yet it highlights a strong relationship between how they viewed, valued and played with mathematical ideas at an early age, and continue to manifest this approach in their own teaching.

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