Chapter 5 Discussion of the findings

The two areas of focus within the discussion that will help towards answering the research questions are shown in Table 5.1.

Table 5.1: Areas of focus for the research questions

Discussion areas	Research questions
Which elements of the *Deep Subject Knowledge* model succeed in identifying deep subject knowledge?	1. How does deep subject knowledge differ from the basic mathematical knowledge that primary teachers bring to the classroom? 2. How does deep subject knowledge impact on pedagogy?
Which aspects of the MaST Programme succeed in building deep subject knowledge?	3. How does the Maths Specialist Teachers (MaST) Programme develop deep subject knowledge in the participants?

Which elements of the *Deep Subject Knowledge* model succeed in identifying deep subject knowledge?

The *Deep Subject Knowledge* model (Figure 2.3) gives a broad view of the mathematical knowledge needed for teaching, as it includes knowledge of mathematical learning as well as teaching. Dealing with misconceptions, the quality of discussion and the ability to respond quickly to questions that arise are not explicit parts of PCK, introduced by Shulman (1986). However, Ball *et al.* (2008) emphasised the importance of dealing with misconceptions and Rowland *et al.* (2003) introduced the idea of 'contingency' or 'thinking on your feet' as key attributes of subject knowledge. In that respect the model is based on sound research into a teacher's subject knowledge necessary for teaching. The question was whether the model represented the development of *deep* subject knowledge.

Table 5.2: Summary of level of deep subject knowledge

BMK	**Ann**	**Beth**	**Claire**
a) Qualifications	GCSE mathematics	BSc (Hons) in Teaching Studies and Mathematics with Technology	BSc in Mathematics and Education Studies
b) Beliefs	Enthusiastic, favoured a discovery approach	Enthusiastic about maths, favoured a connectionist approach	Positive, favoured a transmission approach
c) Confidence	Confident	Very confident	Very confident
KTM			
a) Connections	Little opportunity given to making connections	Appropriate use of connections to reinforce skills and concepts	Little opportunity given to making connections
b) Progression	Strong at KS1, weaker at KS2	Good knowledge of curriculum	Good knowledge of curriculum
c) Representation	Practical approach – real objects used	Very good use of objects and images, language and symbols	Abstract problems presented – little use of representation
KLM			
a) Concepts	Good understanding of concepts and skills at KS1	Very good understanding of concepts and skills – dealt easily with misconceptions	Dealt well with any misconceptions – good differentiation
b) Interaction	Encouraged pupil talk, good discussion, some weaker use of language	Good use of language, allowed reasoning, appropriate questioning	Encouraged pupil talk, some less useful closed questions
c) Response	Dealt with any questions quickly and confidently	Quick, confident response to any questions	Dealt efficiently with any questions from pupils

KEY

- Strong evidence of DSK
- Some evidence of DSK
- Little evidence of DSK

Deep subject knowledge may be constantly developing, with teachers researching and building their repertoire of skills and knowledge, but is it identifiable?
Based on collating the evidence from the interviews and observations, I summarised the findings (Table 5.2) and made the following broad assertions:

- Beth showed deep subject knowledge, with strength in all nine strands.
- Ann has some elements of DSK, but more experience at KS2 is likely to increase her knowledge.
- Claire also shows some evidence of DSK, but perhaps needs to research teaching approaches to develop her knowledge of teaching mathematics.
- Ann and Claire showed more evidence of knowledge of children *learning* mathematics than they showed of *teaching* mathematics.

Each of the teachers was confident and effective, but there was a variation in their subject knowledge. A recent international comparative study in mathematics teacher training (Burghes and Geach 2010) highlighted the wide variation in the mathematics ability of trainee teachers in England, which is likely to have an impact on their effectiveness when teaching mathematics. Vorderman *et al.* (2011) agree with this and recommend an increased minimum entry requirement of mathematics for trainee teachers. To raise the basic mathematics knowledge of trainee teachers, a maths qualification relevant to teaching was seen as important to Ann, Beth and Claire, rather than a high qualification in mathematics. This supports the view of Burghes and Geach (2010) who recommend an AS Level award on mathematics concepts for intended primary teachers. Degree level mathematics may be mostly irrelevant to primary teaching, and it was actually seen as a negative point for Beth and Claire who did not find their mathematics degree helpful in the classroom. However, further study gave each of them confidence in the subject, including Ann with her science background, which has had a big impact on their work in school. Attitudes and beliefs as an element of BMK were evaluated in the research through the interview, with some evidence that attitudes can change despite prior qualifications. However, from the evidence of this small study, it seems that increased confidence through gaining a higher qualification in mathematics may be more important than the actual knowledge gained, which may have little impact. The findings of Askew *et al.* (1997), that prior academic attainment alone has little impact on the depth of subject knowledge, still hold true, but perhaps it has more of an impact on attitudes, belief and confidence than I previously thought. This would then support the findings of Rowland *et al.* (2009) and Allington and Johnson (2000) that effective teachers need to have good prior academic attainment.
Ann and Claire both stated that they taught mathematics as they had been taught themselves, reinforcing the findings of Ball (1990). This may be based on their maths experiences at

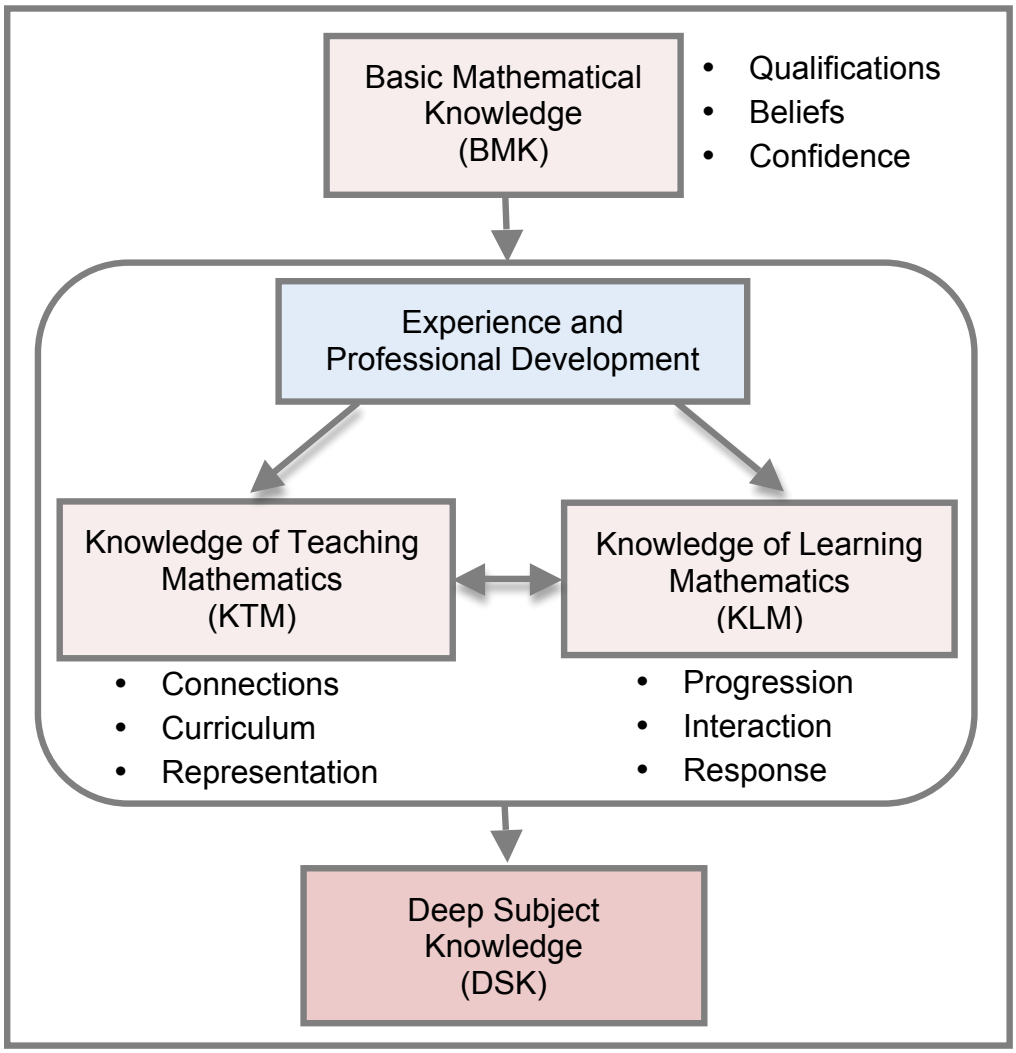
secondary school, as it is less likely that they would remember the methods and approaches in their primary education. It is significant that Claire, although the most highly qualified at mathematics, is the least experienced teacher and favours a transmission approach similar to the teaching she experienced, probably at secondary school. A concerning aspect of the findings is the apparent lack of impact of the training towards Qualified Teacher Status (QTS) on the subject knowledge and the teaching approaches of the teachers. The final report of the *Independent Review of Mathematics Teachings in Early Years Settings and Primary Schools* (Williams 2008) identified that teacher training did not guarantee that primary teachers would have a broad and deep mathematics knowledge and Aubrey (1997b) and Goulding *et al.* (2003) concluded that subject knowledge for teaching needed to be strengthened. This has been recognised by many universities who now offer mathematics subject knowledge enhancement courses and booster courses for students prior to an ITT programme. However, these are aimed at students who are training to teach mathematics at secondary rather than primary schools.

It is evident that the three teachers in this study did not start teaching with deep subject knowledge even though they were well qualified. They each stated that they have increased their subject knowledge through the actual process of planning, teaching and to a lesser extent CPD, with research an important aspect of this development for Ann and Beth. However, Claire is dismissive of the place of research, simply taking and using anything given to her on courses to use in the classroom and nothing more. It is certainly a weakness in her development of DSK. Research skills are an element of DSK missing from the *deep subject knowledge model,* possibly positioned within the 'Experience and Professional Development' box. Without the desire and skill to research around aspects of teaching and learning mathematics, it is less likely that a teacher will have DSK. This supports the findings of the NCETM commissioned research into effective CPD in mathematics education (RECME Project, NCETM 2009) and the concerns of Burghes and Geach (2010) about the perceived lack of relevance of teaching theory and the practical implications. To develop knowledge about mathematics and ways of teaching, teachers need to value research, draw upon relevant research and, perhaps, need to develop research skills to use the research effectively.

The *Observation recording sheet* (Figure 3.1) proved to be very useful for focussing the observation on specific aspects of a teachers' subject knowledge as each lesson unfolded. However, a weakness of the *Deep Subject Knowledge* model, which was apparent as I was collecting evidence during the observations, was the similarity between *KTM b) Progression* and *KLM a) Concepts.* Looking for evidence of knowledge of the scope and sequence of the curriculum was difficult to distinguish from knowledge of mathematical concepts and skills,

which are part of the curriculum. For *KTM b) Progression* I focussed on the knowledge that each teacher had of the specific aspect of mathematics being taught and its place within the whole curriculum. The *KLM a) Concepts* strand focussed on the effectiveness of the methods the teacher used to meet the learners' needs, including dealing with misconceptions or recognising the next appropriate small step in knowledge or understanding. It is more accurate to rename these strands as *KTM b) Curriculum* and *KLM a) Progression* and so this is now a revised model (Figure 5.1).

Figure 5.1: Revised deep subject knowledge model



Two of the elements that were important features of deep subject knowledge were *making connections* and the use of *representation*. A tentative generalisation that could be made from this study is that each of the teachers valued the importance of connecting the mathematics to other areas of mathematics and also other curriculum subjects, but in reality each of them was concerned over the management of this. Ann was worried about *'getting lost'*, Beth planned *not* to make connections for fear of moving away from the focus and Claire classed herself as

a connectionist but actually controlled the lesson with a transmission approach. It has been suggested that the most effective teachers adopt a connectionist approach (Askew *et al.* 1997), but perhaps support is needed for teachers on how to manage this in the classroom.

The effectiveness of the representations used to teach a mathematical concept or skill is key to the pupils' understanding, and it is a clear pointer to the depth of knowledge of a teacher. Each of the teachers was clear in her understanding of the importance of representation, but only Beth showed good use of a range of models and images and appropriate language, demonstrating good knowledge of *teaching* mathematics. Each of the teachers used effective questioning and very good interaction with the children, showing strength in their knowledge of mathematical *learning*. This is reinforced by their comments during the interviews of the value they place on children's learning, each of them aiming to teach less to allow children to investigate, discover and become active learners.

Which aspects of the MaST Programme succeed in building deep subject knowledge?

Each of the teachers was unequivocal in their belief that the MaST Programme has had a positive impact on their mathematics teaching generally and their subject knowledge specifically. Claire and Beth have both questioned and re-evaluated their approach because of the programme, and it has given Ann increased confidence in teaching the subject. The five *'big ideas'* and the opening sessions of the programme appear to have had the biggest impact, showing the importance of starting the course strongly with a weekend residential. The open questions aimed at prompting children's thinking, *'What do you notice?'* and *'What is the same and what's different?'* were also introduced in the first weekend session. These were evident in the observed lessons and the simplicity and effectiveness of the questions made it easy for the participants to share with other staff in school. Beth in particular found this an effective and non-threatening way to change teachers' practice, which is something each of the teachers interviewed is finding difficult. Ann and Claire are not the subject leaders, hindering their efforts to share the ideas with other staff, and Beth is making slow, steady progress by targeting one supportive teacher to work with. Based on this, I agree with Beth that the mentoring and coaching aspects of the MaST programme should support participants in implementing change in each school. This is currently a possible weakness of the programme according to an evaluation report of the programme (Davies 2011), who found that the training for mentoring and coaching at a residential weekend did not engage the participants as much as other aspects of the training.

The challenging mathematical content of the MaST Programme has been managed by each of the teachers in the study, but this may have been helped by their prior knowledge of mathematics and confidence in the subject. All the applicants for the MaST Programme were chosen because of their passion for mathematics, so it is likely that they are receptive to trying the ideas out in school. What is notable in this study, however, is that they each only value the mathematics content that directly relates to their own teaching. They found the mathematics that was beyond primary level, and in Ann's case beyond KS1, to be irrelevant and adding little, apart from some confusion, to their subject knowledge. This is in contrast to the assertion of Watson (2008) that teachers should learn mathematics at a personal level. It also goes against the aspect of curricular knowledge that emphasises the importance of teachers understanding the mathematics being taught within the *'big picture'* of the whole curriculum (Shulman 1987, Rowlands *et al.* 2003).

Each of the teachers valued practical ideas that they could take away and use directly with their class. Ann adapted some of the ideas but still emphasised how important it was to try activities taken from the MaST Programme to see if they work with her class. Claire was adamant that the practical ideas were of greater value than researching teaching and learning theory. This lack of interest or perceived value in researching was a surprise considering the level of research they have already carried out for their qualifications for QTS. Perhaps teachers with a higher qualification in mathematics feel less inclined to continue researching as teachers. Beth, with a good mathematics qualification, has not enjoyed the research necessary for the assignments and essays but values the place of research providing it is relevant and is of interest to her. This would support the views of Aubrey (1994) and Els de Geest (2011) that teachers are more likely to increase their subject knowledge through conducting their own research about mathematics. Research may be an important element to include in any CPD, but there are two aspects that need considering:

1. Is the research into mathematics teaching and learning that is shared with the participants recent, relevant and useful?
2. Are the assignments that require teachers to conduct their own research personal, useful and manageable to the teachers?

Perhaps there is a place for teaching more research skills on the MaST programme so that the participants are able to analyse and evaluate any study they carry out or any research paper they read.