

Chapter 4 Analysis and Outcomes

The findings of the study, based on interviews and observations carried out with the three MaST participants, are structured as three case studies and reflect the four levels of Kirkpatrick's layered evaluation model. There is also an initial section detailing background information about each participant. The sections are:

Background information		
How did the participants feel about the MaST programme?	Level 1	Reaction
Has there been any increase in knowledge, understanding and skill, or change in attitudes?	Level 2	Learning
Have participants applied any increase in subject knowledge and changed their practice in school?	Level 3	Behaviour
What effects have there been on the school as a result of any increase in subject knowledge of the participant?	Level 4	Results

The observation notes written on the *Observation record sheets* (Appendices 2, 3 and 4) were typed up and any data used for the case study notes was highlighted to show the source of the evidence as a true and valid record of the observation. Coding references (Figure 4.1) for the *Observation record sheets* were used in the analysis to pinpoint the position of the data within each observation. As an example, *C BMK b* would reference evidence from the observation of Claire's beliefs as part of her basic mathematical knowledge.

Figure 4.1: Observation coding

A: Ann B: Beth C: Claire		
BMK	KTM	KLM
a) Qualifications	a) Connections	a) Concepts
b) Beliefs	b) Progression	b) Interaction
c) Confidence	c) Representation	c) Response

Each interview was recorded and then transcribed on to an *Interview analysis record sheet* (Appendix 1), which organised the content of the interview into the levels of Kirkpatrick's layered evaluation model. The data was highlighted as it was used for analysis, to show where the evidence was taken from. Interview analysis coding (Figure 4.2) was used, as with the observations, to pinpoint the position of the data within each interview. As an example, *B 2C* would be used to reference evidence from the interview of Beth's increase in knowledge in the 'Learning' layer.

Figure 4.2: Interview analysis coding

A. Background information			
Respondent	1. Qualifications	2. Confidence before MaST	3. Specialists or generalists?
A			
B			
C			

B. Reaction			
Respondent	1. Why take part in MaST programme?	2. Useful aspects of programme	3. Less useful aspects
A			
B			
C			

C. Learning		
Respondent	1. Attitudes and beliefs	2. Increase in knowledge
A		
B		
C		

D. Behaviour		
Respondent	1. Application of increased knowledge	2. Changed practice of participant in school
A		
B		
C		

E. Results		
Respondent	1. Effect on pupils	2. Effect on staff
A		
B		
C		

Background information

The three case studies (all names changed):

Ann (EYFS/KS1) has been teaching in the same school for five years following a BSc (Hons) in Science and Education Studies and a one-year PGCE. She currently teaches a mixed age Reception and Year 1 class in a small rural school of 64 children.	Beth (KS2) has been teaching for 11 years after studying for a BSc (Hons) in Teaching Studies and Mathematics with Technology. She currently teaches a Year 6 class is the mathematics subject leader at a 280-pupil primary school.	Claire (KS1) has been teaching for three years at KS1 in a 300-pupil city primary school, following a BSc in Mathematics and Education Studies in 2006. She is the DT subject leader and KS1 maths subject leader, and she is currently teaching a Year 2 class.
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Background: Case Study A

Despite studying mathematics only up to GCSE, Ann was a confident maths teacher from the start: *It's not something I find difficult. I enjoy maths. It's a strength after science, I used it within my degree and I could pull on all that knowledge* (A 1A).

Her initial maths teaching was largely based on the teaching she had experienced while at school, despite different techniques being used:

P: *Did anything surprise you when you started teaching maths?*

A: *Techniques were different to what I had been taught – the methods you used to teach children – for example different methods for addition and subtraction than I had been taught.*

P: *Did you base your teaching on how you had been taught?*

A: *Yes, initially - you go back to what you know, especially when it's new and then it develops as you go on. When I was taught subtraction we'd have done long subtraction, we wouldn't have done counting on to do subtraction you'd have taken one number from another number* (A 2A).

Ann described her development as a teacher, reiterating the idea on three separate occasions that she developed her teaching skill 'on the job' as she gained experience: *I was teaching Y2, 3, 4 when I started so felt I had enough knowledge to deliver what I needed to deliver but I've developed my teaching style as I've gone along* (A 1A). *I think you learn on the job and anything you don't know you find out, or a good teacher would research or ask a teacher that*

does know (A 3A). The skills I've got have developed as I've taught – equally my teaching styles have - you find what works and what doesn't work and obviously you have CPD which also informs what you're doing and improves your styles (A 2A). CPD was mentioned almost as an afterthought, perhaps only recalled because of the focus of the interview.

The lack of experience in teaching at KS2 has left gaps in her knowledge of the curriculum and progression through the school. She is evidently concerned over the difficulty of knowing the progression and curriculum demands for the full primary stage, reinforced when she states: *I don't know all the ins and outs up to Y6 and this is part of having deep subject knowledge - I avoid Y5/6 like the plague! (C 2A).*

When questioned about the possibility of teachers having deep subject knowledge, she focuses again on the problems of progression and continuity when teaching maths:

P: *Can all teachers have this deep subject knowledge?*

A: *I think they get stuck (laughs) in their class, in their zone, if they're not moved around the school into different year groups they forget what's going on either side of their class so sometimes they haven't got that knowledge of where they're going next or where they've come from – if they've got gaps (A 3A).*

Background: Case Study B

Beth found her degree useful for preparing her for teaching primary mathematics:

First of all I've got the confidence to know what I'm talking about, and secondly it gave me a deeper insight. When I got to college and looked at maths at a deeper level it made me question my own knowledge. Although I can't say I learnt a phenomenal amount of maths at college it made me question what I need to know and research and to update my own maths knowledge (A 1B).

However, she felt some of her confidence was misplaced: *I would say I was over-confident with my own maths knowledge, before MaST, so the MaST has made me question my own knowledge again (A 2B).* What it has given her is the ability and confidence to use her own research to develop her teaching: *My own level of interest and my own research actually gave me more knowledge and understanding rather than what we were taught – it made me question everything and want to find out about things (A 2B).*

Beth believes that a mathematics qualification higher than a GCSE is important in order to teach mathematics effectively: *Maybe not A level because that's too specialised – maybe a*

more in-depth knowledge of the curriculum you teach - something at college as part of your course (A 3B).

She thinks that it is a good aim for every teacher to have deep subject knowledge in English and mathematics as they are the basics that all other learning can build upon. It is interesting that, once again, the importance of research and planning is emphasised: *If I were to teach a history topic I could teach it through English - I could go off and research the bit about history (A 3B).*

Background: Case Study C

Claire feels that her degree has not particularly helped her with her teaching: *it was too abstract to help me with my teaching of maths (A 1C).* She also feels that she lacked understanding when working on her degree: *my maths degree wasn't taught for understanding, I was taught to apply processes and I don't feel that I had a good enough understanding of it - I applied processes to get through it (A 1C).*

Her 'A' level in mathematics and her degree have, however, given her confidence in mathematics, and put her in a stronger position than her colleagues: *I do feel like I could confidently approach anything better than most (A 2C).* She believes that teachers should all have a higher mathematics qualification to raise their confidence and competence at teaching mathematics: *I don't think enough of our staff have studied maths to a high enough level... they have a secure nuts and bolts of it but they don't make links like I make links (A 3C).*

Despite the fact that she felt her degree has not particularly helped her subject knowledge for teaching, she recognised the impact it has had on her teaching following an observation of her teaching as well as that of the other staff by the maths subject leader: *When he came to see me he said he can tell straight away that you have a sounder and more secure subject knowledge than everyone else.*

He said you are like me - because he also has a maths degree - the way that you are confident enough to question things out of the children that other people would skirt over (A 3C).

She continued by describing their aim to change the teaching of the other staff to match their own approach: *What we have to do is make sure the other members of staff are like us and are more willing to take risks and step outside the box of their own comfort zone and take a lesson in a completely different tangent if that crops up out of it (A 3C).*

Level 1 Reaction: how did the participants feel about the MaST programme?

Reaction: Case Study A

Ann initially took part in the MaST programme to gain Masters credits, but it was also because she was already confident at teaching mathematics:

A: I do like maths and feel I have a strength in maths and could make that stronger.

P: So it wasn't because you had a weakness in maths?

A: No! (Sharp reply and slightly indignant) (B 1A).

The aspects of the programme that she has found the most useful have mainly concerned the practical ideas that she can use in the classroom. This not only includes maths ideas, but also research findings that may involve a different teaching approach: *We did some work on the Crystal Maze and that was good because it gave you ideas and made you think outside the box for some ideas (B 2A).*

You have your own ideas but they're not always right and you're trying to develop other teachers, so if you have some background from other research you can say that this works and you can prove that it works and I've tried it in my class (B 2A).

Conversely the MaST programme was less useful when the content lacked relevance to Ann in her situation at her school. She could see the purpose of developing the participants' own subject knowledge, but still thought some of the content was beyond the Primary phase: *Some of it was aimed too high, it was very difficult to see how you could break it down and bring it into school. I know it was aimed to develop our own individual subject knowledge, which I haven't got a problem with, but it's seeing the relevance sometimes (B 3A).*

We looked at base 3 and base 6 and base 4 and I was thinking how would that be of any relevance to children in a primary school? ... there were elements of the course that were way above – there was a session on pattern near the beginning and I came out thinking I have no idea what I have just learnt (B 3A).

When prompted about the relevance of that session on pattern now that she was near the end of the 2-year programme, she was still negative about the relevance:

P: As time has gone on, have you seen any use of that work?

A: *No, not that bit (laugh). There was stuff aimed at us as learners that we could bring back into school but there were elements that hadn't been brought down to our level – where were the connections to a primary learner?* (B 3A)

Reaction: Case Study B

Beth was very clear about her reasons for applying for the MaST Programme:

I wanted to be a champion of maths (B 1B). She then reinforced this and focussed the statement on to the importance of being a role model for the girls in her school: *There are so few women in maths as well and its always been a very male subject – I wanted to be a role model for the children I teach and if I was teaching girls for them to know that maths wasn't a scary subject, they too could be OK with maths* (B 1B).

The word 'scary' is repeated again when talking about some teachers' feelings about mathematics. She mentioned the difficulties of raising the profile of mathematics in her school and attitudes of the staff towards mathematics when Beth talks at staff meetings: *Maths is seen by a lot of the teachers as a scary subject and when we are in staff meetings and I turned the subject to maths the body language would change and turn to folded arms and a real fear of maths... I wanted to change that image so everyone had an enjoyment of the subject and not seen as something strange to enjoy* (B 1B).

She was aware of problems she has of 'putting people's backs up' because of her strong personality, so, for her, the support on the MaST Programme on mentoring and coaching was as important as the aspects on subject knowledge and pedagogy. She believes it is having a positive impact in the school: *It was the mentoring and coaching side of it as how to put it across was as important, and it is working, it really is working, I'm pleased about it. It's very slow, drip, drip, but it's working* (B 1B).

A key part of the MaST Programme for Beth was the very first session when the five big ideas and four pairs of pedagogies were introduced to the group. It related to and clarified her beliefs and her approach to teaching mathematics: *It summed up everything I believed in but hadn't been able to actually put into words* (B 2B).

Her views about MaST are not all positive, however. She questioned the subject knowledge of some of the HEI tutors, believing that some of them had less subject knowledge than she had herself as they were unable to answer some of the questions she raised: *I found it very frustrating to have people standing up there as experts and giving wrong information* (B 3B).

She also has problems seeing the relevance of the essays given as assignments, and struggles to motivate herself to complete these assignments: *I've hated it, absolutely hated it, and I've seen no benefit of it personally but I know it has to be done as part of the Masters* (B 3B).

When prompted about the possible relevance of the research side of essay writing, she disagreed, adamant that the assignments have been of very little benefit to her: *because I'm not doing research that really interests me I'm doing it to write an essay* (B 3B).

Reaction: Case Study C

The school has an established and experienced maths subject leader, who is also an AST and Leading Teacher. This has caused a dilemma for Claire as she has aspirations to be the maths subject leader: *I couldn't see where my role fitted in school because there was no room for me. If I want to develop maths further in a school then I'm going to have to move schools* (B 1C). She was advised by a colleague to apply for the MaST Programme to support her professional development: *a teacher said you should go on this – it would give you a qualification, it would raise your profile and you'd learn something from it as well* (B 1C).

The first residential weekend of the MaST Programme had the biggest impact on Claire, changing her attitude towards the teaching of mathematics: *...once you'd got into a different mind-set you approached it from a connectionist sort of approach and it just took off from there* (B 2C).

She has enjoyed the focus of representation, mathematical thinking and pattern: *...it's the big ideas I like* (B 2C). However, proportionality, another of the 'big ideas' has not been as useful for her: *I'm not so keen on proportionality, but perhaps that's because it doesn't fit so well into Y2* (B 3C).

The aspect of representation in particular has influenced her teaching and assessment: *The thing that helped me most was looking at jottings and representations - it helped me get an idea of what was going on in children's heads plus it informed my assessment better* (B 2C).

Claire has found the most appropriate aspects of the programme for her are those ideas that can be used and applied in school: *It's bouncing ideas off that are more effective than any of the theory* (B 2C). Conversely, she could not relate some of the content that she remembers working on at 'A' Level to her work in school, and also did not see the value of these activities as she had already experienced them: *Some of this we did at A level like graph*

theory and algorithms and finding the shortest path, the postman algorithm, and I thought, yes this is useful, and I know the course is targeting everybody but that stuff I know what to do and I would spend my time better doing something else – I didn't need to do that (B 2C).

Level 2 Learning: Has there been any increase in knowledge, understanding and skill, or change in attitudes?

Learning: Case Study A

Ann was hesitant when asked about her subject knowledge, with obvious concern over her knowledge of any mathematics higher up the school:

P: *Do you think you now have deep subject knowledge?*

A: *I think, I have, yea, (hesitates) I think I have what I need – I have a deep understanding of maths but if I was to go in and support a teacher I would still feel the need to go in and do my research to make sure I know expectations (...for different ages) – I'm not overly sure (...of this) (C 2A).*

She used many of the ideas from the MaST Programme, learning to adapt some of the ideas so that they were suitable for her class. This 'adopt – adapt – innovate' process, advocated in the National Primary Strategies (2005), was apparent in her approach:

We did a 100-square in Urdu and I did a number line to 10 in Hindu when we were doing Divali – we were looking at pattern so it was developing the ideas (C 2A).

Her beliefs and approach towards teaching mathematics firmly favour a 'discovery' approach (Askew *et al.* 1997). This was apparent in the lesson observation and interview: *In order to get the children to know what they're doing they need to be doing it, talking about it, investigating it....*

I'm very much into let the children learn so that they've got that understanding and then I'll go and talk to them and identify any gaps that are in their learning and fill those gaps, and there's quite a lot of investigative maths that goes on in here....

Let them explore and then focus on bits that need reinforcing - backwards way on really... (C 1A).

In the observed lesson, Ann took a practical approach, with the children actively involved in solving a problem using real objects. Children explored, with Ann's role as a prompt, asking questions to move on their thinking. She allowed them to discover things for themselves,

stood back from pairs working together and let them make mistakes to work out their own ways of moving forward (A BMK b).

Learning: Case Study B

Beth already had good subject knowledge, a positive attitude towards mathematics teaching and a confidence in the subject before taking part in the MaST Programme. She was recognised as a Leading Teacher of Mathematics in 2005 by the LA School Improvement Service and so has experience of supporting teachers in other schools in the county. It meant that the MaST Programme had not changed her teaching approach radically, but she does feel she now has deeper subject knowledge: *The MaST has made me question my own knowledge again* (C 2B), and she is now more aware of the importance of making connections across the maths curriculum: *You can go off on tangents and make connections and then bring it back to the lesson rather than focussing on a single objective and not being afraid to go off* (C 1B).

The observed lesson showed examples of Beth's enthusiasm and passion for mathematics. At the very start of the lesson she used the phrase, '*Wow me with your knowledge*' (B BMK b), and she continued in this vein, motivating the pupils to respond to questions or explain their thinking. She used mathematical language confidently and accurately, explaining fractions and division clearly (B BMK c). She showed her confidence towards the end of the lesson when she dealt with an issue a group had with decimal remainders. She enjoyed the challenge and was enthusiastic about the group coming up with a problem to solve.

The emphasis in the early sessions of the MaST Programme on relational rather than instrumental understanding (Skemp 1976) had an impact on her approach. She showed a strong belief in the importance of relational understanding and 'making sense', repeatedly asking if the children understood the process they had gone through (B BMK b), and using a very practical approach to help them visualise the fractions. 35 minutes into the lesson, Beth continued representing $\frac{3}{4}$ of 24 practically, showing the importance she placed of children connecting the calculation to the visual image and not just memorising a rule (B BMK b).

Beth's subject knowledge was apparent in the observed lesson. She had a good understanding of progression, for example moving on from unitary fractions of amounts to demonstrate that $\frac{1}{3}$ of 27 = 9 and $\frac{2}{3}$ of 27 = 18 in a clear and practical way (B KTM b). She also dealt confidently with misconceptions or challenging questions. One group asked how to work out $\frac{1}{5}$ of 22. They asked if it was 4 remainder 2, and so is that 4.2? She explained:

The remainder is shared across the whole number. $\frac{1}{5}$ of 22 is 4 and then $\frac{1}{5}$ of the remainder 2 is added to it. She used a drawing to demonstrate that $\frac{1}{5}$ of 2 is 0.4 (B KLM a).

Learning: Case Study C

Claire is confident in her own ability and this has had an impact on her attitude to teaching mathematics: *I have a very positive attitude to maths and because I am confident in maths... this has passed on to the children (C 1C).*

Her observed lesson reinforced this enthusiasm and excitement she has for the subject (C BMK b) and a confidence with the language of mathematics (C BMK b).

Claire showed good subject knowledge when responding to misconceptions or when dealing with any questions or problems from the children. At the start of the lesson she heard a group talking about a 1-number, 2-number and 3-number, not using the word 'digit'. She dealt with this and reinforced the role of digits in HTU numbers. She responded quickly to a lack of understanding of inverses and realised that children were having problems when the equals sign was in the middle of a number sentence, giving simpler examples (C KLM c). She reinforced the meaning of the equals sign as 'is the same as', so that balance and equality became the important concept to focus on (C KLM a).

When questioned about her own subject knowledge, Claire reiterated that it had not come from her degree: *...that's come from the MaST course (C 2C).* She believed that her degree would enable her to be a good teacher of mathematics, but the MaST programme has made her evaluate and alter some of her teaching methods: *...the process has been quite gradual through the MaST course that the methods that I was teaching were effective, but not as effective as they could have been... (C 2C).*

She now believes she has adopted a connectionist approach to her teaching once she realised that her teaching was not as effective as it could have been: *...because I was teaching it how I was taught it and not making enough connections between things (C 2C). If you don't lay the right foundations and make the right connections then when you come to applying then you're not going to be able to do it... (C 1C).*

She stated that making connections is now an important part of her teaching, not just to support the understanding of her pupils, but also in her own subject knowledge:

I always felt I had deep subject knowledge, when I finished my degree, but the more I learn the more it deepens and the more I attend MaST the more personal connections I make between things (C 2C).

Level 3 Behaviour: Have participants applied any increase in subject knowledge and changed their practice in school?

Behaviour: Case Study A

Ann now has a higher expectation of her class, which is largely down to an increase in open tasks and a change in questioning technique. There are more open questions and time for children to work practically and talk, with Ann listening in during investigations, prompting, scaffolding and guiding when necessary. She is confident in her subject knowledge to work in this way, and prefers it to the methods encouraged during her teacher training.

I do much more open teaching, I extend the children a lot more and expect more of them – I did algebra with my year ones last year and they rose to the challenge...

I would never have done something in year one like that before (D 2A).

I feel they're going to learn more by doing it for themselves rather than being talked to. When we did our training it was do this, and do this - very much on the clock, which I didn't like very much (A 1A).

Within the observed lesson the children worked in an investigative way and there was evidence of the use of open questions, with time for the children to think and respond: *How are you going to make a decision? How can you measure size? How is it going to help you decide?* (A KLM b).

However, Ann revealed that she is surprised with their ability: *Poor children! (laugh) I challenge them but they usually rise to it. Really surprised with some of the things they can actually do (E 1A).* Her repeated expression 'backwards way on' perhaps show that she is not totally at ease with working in an investigative way. *Sometimes I do input one day and do more of a focussed lesson – and then an investigation and sometimes backwards way on like last Friday (D 2A).* The hesitant and unsure language used for negative numbers – 'past, behind zero' also shows a possible weakness in her use of mathematical language:

All my year 1s can count backwards from 10 and keep going into negative numbers and understand that they can do 3 take away 7, whereas I know people have said that you can't do 3 take away 7. They've got that knowledge of numbers that go past, (hesitate) behind zero (E 1A).

The emphasis on the MaST Programme of making connections between areas of mathematics was noted by Ann, but was not particularly put into practice. There is an over-riding feeling of the need for control in her teaching, despite the fact that her planning and teaching approach shows a desire for the children to explore, investigate and take ownership of their learning. Making connections appears to be less of a priority in her teaching, and in the lesson observation she missed a possible opportunity to connect spring balances to number lines to reinforce the positional aspect of number (A KTM a).

You need to know what you're doing, what your expectations are and what the end product is. Preparation and planning is key to it – especially when it's an open-ended task. It could go on forever – you need to have a focus to pull them back in. (D 2A)

Could have had a whole day on that – lots of science in there... Making connections for them see where things are relevant to the maths but then you can't do too many connections because they will get lost – they'll be like, what am I doing, what am I learning? (D 1A)

I use success criteria in planning but if it goes off on a tangent then I'm happy to go with that, I won't always pull them back because that's not going to develop their learning - developing their learning is going with them and if they're going completely wrong that's when its time to intervene (D 1A).

Behaviour: Case Study B

Beth is aiming to change the emphasis in her teaching from her dominating the lesson, to children taking more control of their learning, so favouring a constructionist approach: *I want to be that person who isn't doing the teaching, I want them to be doing the finding out and I think that's quite difficult to get to (D 2B).* This was apparent in her use of open questions and time allowed for the children to respond, as highlighted previously.

In the observed lesson Beth focused on the representation of mathematical concepts and skills to support children's learning, using Cuisenaire Rods to represent fractions of amounts. She made use of the interactive whiteboard to represent the rods, creating a strong visual image based on the concrete objects. At the end of the lesson she used the image of the rods to show

remainders, and then finished with $\frac{3}{5}$ of 25 = 15 represented on whiteboard as visual image. She also used a drawing of rods to show that $\frac{1}{5}$ of 2 is 0.4 (B KTM c).

Beth is keen to use open questions to allow the children to think mathematically.

In the observed lesson she used a range of open questions to challenge the children and engage them in reasoning and discussion. Examples included:

Tell me what you can see in front of you? What can you tell me?

See what you can find? What do you notice?

Tell me something about what you have in front of you? How do you know?

Tell me what you can see? How could you prove that to me?

Asking questions such as these allowed the children to explain and justify their reasoning.

Beth expected them to talk and gave positive responses related to their statements:

That's good – how could you show that in a different way? (B KLM b).

This emphasis on representation and the use of open questions is not radically different to her teaching before the MaST Programme, although it has justified her approach. However, an aspect of her teaching that has changed is an increased emphasis on making connections, despite being a little cautious about this in case she loses direction in the lesson: *...especially if you have a relationship with that class, if they show an interest in something, your automatic reaction is to build on that interest because they've asked the question about it (D 1B).*

During the observed lesson, Beth made a conscious effort to connect aspects of mathematics, explicitly linking division, multiplication and fractions throughout the lesson. At the start of the lesson, she reinforced the point that each of the children's statements connected to 14 and reiterated the connections between multiples, factors, double and half (B KTM a). At one point she did not take the opportunity to link the pattern of $\frac{1}{12}, \frac{2}{12}, \frac{3}{12} \dots$ to equivalent fractions. She later explained that she wanted to avoid that connection and had talked this through with her colleague:

I know what I'm going to do, I'm going to go into equivalent fractions and I had to talk the lesson through with him to make sure I wasn't going to go there... (D 1B).

She had not forgotten this possible link though, and towards the end of the lesson she showed $\frac{1}{4}, \frac{2}{4}, \frac{3}{4}$ and $\frac{4}{4}$ of 24, and asked what they noticed about $\frac{2}{4}$.

She then linked this to equivalent fractions (B KTM a).

Behaviour: Case Study C

Claire emphasised the move towards a connectionist approach in her interview and a change in approach to her teaching. In the observed lesson there was some evidence of this during the starter activity, with links made between properties of numbers, pattern, place value and the inverse relation between addition and subtraction. These were not particularly built on to support the learning, more used as points of reference for the children to see the place of the mathematics being taught (C KTM a). Despite her belief that she is now a connectionist, the observed lesson had evidence of Claire favouring a predominately transmission approach to her teaching. In the introduction to the main part of the lesson, she explained a method for solving missing number problems and then did not value different methods given by the children to solve other examples. She had a method and a strategy in her mind and the children were not using this strategy, which caused her a small level of frustration. In fact, this non-constructivist approach, with Claire imparting her own methods of solving missing number problems with the children not taking ownership of these methods, caused them to become confused by the use of inverses (C BMK b). At the end of the lesson, Claire used success criteria to check if the children understood the methods. The children were asked to put their thumbs up if they felt confident to work out $\square + 14 = 16 + 16$ and only four children put their thumbs up (C KLM b).

Claire introduced the missing number problems as an abstract activity with no relation to a real-life problem or a context, making it difficult for the children to make sense of (CBMK b). She used a number line and 100-square to help with the representation, but the most success was had with the lower attaining group who used bucket balances and cubes (C KTM c).

Claire made use of open questions, particularly in the starter activity: *What do you notice? What is the same? What is different?* (C BMK b), with one example later in the lesson: *How did you know?* (C KLM c). These had been taken directly as examples from the MaST Programme. It reinforces the fact that MaST has not inspired Claire to research and investigate further, she takes relevant parts of the course content and uses that: *...all the other theory based stuff I could really do without. It really doesn't make me think I want to find out all about... timesing or find out how to teach this method better, I really take what they give me and apply it. I take what the course gives me and welcome that with open arms* (D 1C).

Level 4 Results: what effects have there been on the school as a result of any increase in knowledge of the participant?

Results: Case Study A

Ann was very positive about the impact of the MaST programme on the pupils in her class. This may be due to an increase in her deep subject knowledge or a change in pedagogical approach:

They've got a broader knowledge, a deeper understanding of number because discussions go on and you listen in and they really understand it – it's all that investigative work and talk and resources that are available to them (E 1A).

An increased confidence to use open tasks and investigations is apparent, but throughout the interview there is also an emphasis on allowing children to talk and discuss, which was a strong part of the lesson observed:

We do a lot of talking partners and a lot of group discussions... I'm putting the onus on the children and asking for feedback. Getting them to question themselves – talk to your partner - do they agree with you? ...discussions that go on and you listen in and they really understand it – its all that investigative work and talk and resources that are available to them (E 1A).

One child got onto a 4-square and did it in 10 minutes. The discussion around it ... I would never have done something in Y1 like that before (D 2A).

To emphasise the importance of this to her, she reinforces the fact that her class are good at questioning and discussing, unlike other classes in the school: *That's something that another class can't do - they can't question their partner to do their thinking – so that's what I'm trying to develop (E 2A).*

Ann is not the subject leader and this came over as a slight problem in her attempts to have an impact on the staff in her school. She is also lacking in confidence with the mathematics at Upper Key Stage 2 so perhaps does not feel yet able to work with these teachers. She uses 'we' as a pronoun instead of 'I' when describing her input in any staff training, perhaps implying that the subject leader takes on this role:

We're trying to bring up everyone's skills and bring them up to the same level. We're using elements of the strategy and the MaST to get everybody teaching maths in a similar way.

We all have different teaching styles and don't want to take that away from teachers. The elements from the MaST course we've picked are the ones that work for our school and we're developing them across the school (E 2A).

Results: Case Study B

Beth believes that the MaST programme has had a positive impact on her pupils, particularly with the lower ability children. She has shifted her teaching approach:

...completely away from method teaching into an understanding one especially with the lower ability children. They can't retain methods – I never knew why they couldn't retain methods and they just can't because they don't have an understanding, so now everything is through understanding using the resources (E 1B).

The influence of Skemp (1976) and his views on relational rather than instrumental understanding is apparent here, along with the strong link with representation using resources.

Recognising the difficulties she has faced in the past when attempting to improve or change the mathematics teaching of her colleagues, she decided to begin by encouraging the staff to use simple open questions. This, in particular, has been a great success: *Those two simple questions – 'What's the same and what's different?' and 'What do you notice?' – that was so easy to put across to other teachers, just throw these into your lessons somehow. That was a really friendly way of changing peoples practice and I would say that has been the most powerful thing (E 2B).*

After this initial success, the impact of the MaST Programme on the staff has been slow and measured. It is now gathering pace, with positive effects throughout the school. Beth started by coaching a Y6 colleague: *He was a really good candidate to choose because he will try out new ideas, he's not afraid if something goes wrong in a lesson - he doesn't see it as a failure. He sees it as something to learn from, so I knew I could change his practice (E 2B).* This colleague then became an ally, supporting Beth when it came to working with other staff and changing their practice: *...throughout the rest of the school, I've had INSET where I've tried to increase teachers' knowledge and put across new ideas. What I'm trying to do is gradually work my way through people, but it's been really successful with one particular teacher and it's starting to spread as well (E 2B).*

She has had particular success in the Reception class, with their concern for using accurate language and dealing with misconceptions fitting in with the content of the INSET provided:

...it's the R teachers that have taken it on board more than any other year group because they see whatever they do as the starting point of misconceptions... ...the language side especially (E 2B).

The support and training has extended to working with Teaching Assistants, updating their subject knowledge and the use of resources to support small groups of children.

Results: Case Study C

Claire's confidence and positive attitude towards maths has, she believes, had an impact on the children in her class: *I have a maths friendly classroom... and everybody in my classroom approaches maths in such a way that they can do it. They never have any of this 'oooh maths is hard I can't do that,' because I would never say that (E 1C).*

Claire began teaching in Reception class and struggled to connect her prior learning in her degree with the teaching of that class. The MaST Programme has coincided with her move to a Year 2 class, and she feels that she is now able to use more accurate mathematical language and challenge the pupils: *...now my children know the commutative law and they know the associative law and they know the difference between them. Perhaps if you went into another teacher's class they wouldn't be using that terminology in the same way that I can confidently do that (E 1C).*

She believes that the MaST Programme has had an impact on the school, particularly at KS1: *...there has been a big rise in results and this year we have looked at gifted and talented and children achieving L3 at Y2 (E 2C).*

Attainment of the children has risen in the SAT tests which she believes is due to the influence of her work from the MaST Programme, for which she has been rewarded with the KS1 mathematics subject leader role: *...we've got the best SATs results we've ever had in maths and because of that I've adopted a role in KS1 (E 2C).*

Evaluation of the research design

This small-scale case study had limitations due to the size of the sample and the difficulty in measuring the impact of a teacher's subject knowledge on the learning of the pupils through interviews and observations. I used the four levels of Kirkpatrick's layered evaluation model (1994) to structure the research, which was successful in building up the evidence systematically. I felt that the study was valid, with the interview questions answered honestly and corroborated by the observations. The research instruments of observation and interview were reliable for this study, helped by the development of an analytical framework to collect, collate and analyse the data.

Organising the evidence as three case studies proved to be a useful method for comparing findings and looking for generalisations in the results. Structuring each case study to match the four levels of Kirkpatrick's layered evaluation model maintained a focus on the teachers' depth of subject knowledge, with each layer bringing out developing evidence of the impact of the MaST programme on their subject knowledge.

The aspect of the evaluation that proved to be less successful concerned the lack of data collected at the *Level 4: Results* stage. The limitations of this study through the research methods of interviewing and observation and with the design of my research framework were apparent when evaluating the impact on the school as a result of any increase in subject knowledge of the participants. I was not able to verify the impact of the MaST Programme on the progress and attainment of the pupils in the school without analysis of the school attainment test scores and other school pupil data, both before and after the MaST Programme. I had made the decision not to include test score analysis, as I wanted to focus on teacher's own subject knowledge. However, gathering evidence through interviewing staff or pupils may have supported the *Level 4: Results* layer. Despite the evaluation model having shortcomings in this respect, it still provided some interesting lines of enquiry and findings for discussion.