Encouraging Growth in Beginning Mathematics

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Encouraging growth in beginning mathematics teachers' questioning techniques

Abstract

This study explores the beliefs and practices of two beginning primary mathematics teachers participating in a short-term collaborative action research project. The aim of the project was to investigate how they asked questions, what kind of questions they asked and how they responded to children's answers. It then investigated the impact of a short intervention that aimed to encourage growth in their questioning techniques, in particular growth in two of the domains of Clarke and Hollingsworth's (2002) Interconnected model: their personal domain (knowledge and beliefs) and their domain of practice.

The study was carried out in a context where teachers generally have not participated in any pre-service education. The Ministry of Education curriculum and the approach to teaching and learning can be most accurately described as instrumentalist. The participating teachers work in a group of Egyptian schools where mathematics is taught through the medium of English. Improving the quality of classroom discourse is a priority for the owners of the group.

In the lessons before the intervention, questioning consisted predominantly of short, highly scaffolded testing questions asked of the whole class, with children 'chorusing' answers. Both teachers mostly reacted to children's answers to acknowledge whether they were correct or incorrect or sometimes ignored incorrect answers. After the intervention the questioning was much more targeted. Both teachers asked considerably fewer testing questions and scaffolding was greatly reduced. There was qualitatively different discourse in the post-intervention lessons, with both teachers attempting to follow-up incorrect as well as correct answers and involve more children.

The study suggests that even a short intervention within this context can encourage growth in beginning teachers' questioning techniques and highlights possible areas for further research and support.

Introduction

Discourse is a key feature of classrooms. Peressini and Knuth (1998) argue that from a psychological perspective, children develop mathematical understanding through social interaction. From a philosophical perspective they argue that mathematics is 'a social endeavour of classification and justification in which discourse is paramount' (p.108). From both of these perspectives, the importance of discourse in learning and doing mathematics is emphasised: it is key to developing mathematical thinking. Hiebert (1992) supports this perspective:

> 'Doing mathematics means agreeing on assumptions, making assertions about relationships, and checking if the assertions are reasonable. This occurs through classroom discussions and debates that include presenting and defending arguments, a highly social process.' (p.444)

As Desforges (1989) points out, such reasons for advocating classroom discussion and children's talk are based on constructivist perspectives on learning.

I currently work as Chief Education Officer for a group of 23 schools across Egypt catering for mostly Egyptian children from KG-12. The schools are nearly all Egyptian Language Schools: they follow the Egyptian curriculum and mathematics is taught through the medium of English. In contrast to the constructivist perspective referenced above, the approach to teaching and learning mathematics in these schools is predominantly instrumentalist. The emphasis is on children memorising individual facts and procedures that they are expected to use to answer mostly routine pencil and paper questions. The Egyptian mathematics curriculum is traditional. Teachers must follow highly-structured Ministry of Education textbooks: mathematics questions are repetitive and children have to use the 'correct' methods step-by-step to answer them. There are many written examinations and 'quizzes'. There is considerable pressure on the teachers to complete the curriculum, especially as the number of yearly hours for teaching mathematics is below the international average (Mullis, Martin & Foy, 2008).

Consequently, teachers are mostly instructors. Lessons are generally entirely whole-class with textbook questions worked on together and teachers leading the class through the solutions.

I observed many primary mathematics lessons in my role. Anecdotal evidence from these observations suggested that teacher questioning generally required children to state facts or give the next step in a procedure. Teachers looked for 'correct' answers matching either those given by the textbook, or that they had previously taught. As with the teachers in Nicol's (1999) study, my lesson observations suggested that most of the primary mathematics teachers in these schools 'struggle with not only how they might ask children questions but also what they might ask and for what purpose.' (p.53). A key issue was the type of discourse and in particular, teachers' questioning techniques.

It is important to note that very few of the primary mathematics teachers in these schools received any pre-service mathematics education. Teacher turnover is high: an increasing proportion have no previous teaching experience. Furthermore, very few teachers have participated in any mathematics professional development since starting teaching. However, teachers here generally welcome professional development opportunities.

My role across the group of schools is very wide: one of my responsibilities is to improve the quality of teaching and learning (across all subjects). Askew (2012) suggests, 'a model of three aspects that need to be considered when planning for communities of mathematicians' (p.97): tasks, tools and talk. He refers to these as the 'teaching tripod'. I have no opportunity to change the curriculum, and given the dominant role of the textbook it would be difficult to focus teachers on the tasks they ask children to do. However, given that I had already identified teacher questioning techniques as a key issue, 'talk' was clearly a pertinent focus for development.

This study therefore explores the questioning techniques of two beginning primary mathematics teachers. It attempts to identify more analytically their beliefs and practices. It then investigates the impact of a short intervention that aims to encourage growth in their questioning techniques. In particular, the study considers:

- how they asked questions;
- what kind of questions they asked;
- how they responded to children's answers.

Improving the quality of classroom discourse across the group of schools is a priority agreed with the owners: it has been identified as a key action to improve teaching and learning. The results of this study will help me as teacher educator to gain a greater understanding of primary mathematics teachers' questioning techniques. It will also enable me to prepare professional development to encourage growth in their questioning techniques.

Literature Review

Talk in the mathematics classroom

Alexander (2008) observes that spoken classroom discourse involves interaction between different participants: teacher-child or child-child. Askew (2012) also focuses on two distinct aspects of classroom discourse: ‘private talk and public conversation’ (p.132). I would argue that Askew’s distinction places greater emphasises on the role of the child in the dialogue, as in both private talk and public conversation it is the child who is predominantly talking. Additionally, Askew more helpfully identifies the two scenarios in which classroom discourse takes place and highlights that private talk and public conversation serve different purposes: ‘private talk is a necessary precursor to the public conversation being effective’ (p.132).

The role that a teacher plays in public conversation is clearly vital. Pimm (1987) describes the role of the mathematics teacher as, ‘an intermediary and mediator between pupil and mathematics, in part by determining the patterns of communication in the classroom’ (p.xiii). He suggests that the role of the teacher is analogous to that of a chess player, using the metaphor of a gambit: a move or series of moves that may lead to a short-term sacrifice in the hope of producing a long-term advantage. For example, when a teacher asks children to talk in pairs or small groups, (Askew‘s ‘private talk’), the teacher sacrifices control of the discussions, maybe even sacrifices awareness of what is being discussed. However, this hopefully leads to a longer-term advantage: more productive whole-class discussion, with children more confident and with more ideas to discuss. More importantly, the teacher sacrifices their position as, ‘the locus of mathematical authority’ (Peressini & Knuth, 1998, p.120), with the intention that over time children become less dependent on the teacher, more autonomous, and more active mathematically.

Alexander (2008) claims that,

> ‘Children, we now know, need to talk, and to experience a rich diet of spoken language, in order to think and learn... talk is arguably the true foundation of knowledge.’ (p.8)

However, Pimm (1987) suggests that children talking in the mathematics classroom is not intrinsically a good thing, and that ‘merely increasing the amount of pupil discourse in mathematics classrooms may not, by itself, prove beneficial’ (p.42). Alexander (2008) therefore pertinently suggests that two key questions when thinking about teaching are, ‘Do we provide and promote the right kind of talk; and how can we strengthen its power to help children think and learn even more effectively’ (p.10).

Dialogic teaching

Alexander (2008) describes UK primary classrooms in terms of:

> ‘…the relative scarcity of talk which really challenges children to think for themselves… the low level of cognitive demand in many classroom questions; the continuing prevalence of questions which remain closed…’ (p.14)

Even more recently, in the context of primary mathematics classrooms, Askew (2012) states,

> ‘The emphasis is on children reporting already complete mathematics and the talk resembles a series of monologues, with one child offering their solution followed by another. The other class members are [...] passive listeners [...] which usually means looking attentive and not interrupting.’ (p.128)

Whilst again, Askew provides no evidence to back up this claim, the suggestion is that much classroom talk is monologic (one-way communication). Askew’s observation adds weight to Pimm’s (1987) assertion that children talking in the classroom isn’t intrinsically positive. Alexander (2008) contrasts this with continental Europe, where:

> ‘Interactions between teachers and individual children are often sustained over a sequence of several question-answer exchanges’; ‘Questions are designed to encourage reasoning and speculation, not just to elicit right answers’; ‘ ‘Wrong’ answers are not glossed over but are treated as stepping-stones to understanding.’ (p.20)

Both Alexander and Askew (2012) emphasise that effective teaching promotes dialogue where questions, answers and responses, ‘progressively build into coherent and expanding chains of enquiry’ (Alexander, 2008, p.28). Both also imply that a key feature of dialogue is cumulative questioning.

Alexander (2008) identifies five principles of dialogic teaching. Unsurprisingly, one of these relates to dialogic teaching being *reciprocal*: ‘Teachers and children listen to each other, share ideas and consider alternative viewpoints’ (p.28). Another principle is concerned with dialogic teaching being *cumulative*: ‘Teachers and children build on their own and each other’s ideas and chain them into coherent lines of thinking and enquiry’ (p.28). Another principle is that dialogic teaching is *supportive* (children speak freely and without fear of being ridiculed for giving ‘wrong’ answers. Alexander suggests that it may be an uncomfortable experience for children to express their thinking and have it probed and examined, particularly if the classroom culture lacks openness. Askew (2012) emphasises this supportive principle of dialogic teaching, but uses the more powerful word *trust*. He goes further than Alexander, implying a reciprocity of trust: not only do children have to trust that the teacher and other children will be interested in their ideas, but teachers have to trust that children will have their own ideas and be able to express them. Askew therefore suggests that there needs to a shift in how dialogue is managed in the classroom from the teacher leading, explaining and children following the explanation to, ‘someone explaining; everyone following the explanation’ (p.138). In other words, to return to the phrase of Peressini and Knuth (1998) quoted previously, there is fluidity in the ‘locus of mathematical authority’.

Based on his principles, Alexander (2008, p.42) suggests ten characteristics of dialogic teaching. These include:

- Questions being structured to 'provoke' thoughtful answers. (Key issues raised by this are, what are effective questions and what is effective structuring of questions?)

- Children's answers being built upon and leading to further questions. (Key issues raised by this are, what are effective ways of responding to children's ideas, and how can teachers ensure that children's answers are built upon?)

The role of questioning in dialogic teaching, specifically these two characteristics and their associated issues, are the focus of subsequent sections of this literature review.

Watson and Mason (1998) recognise that asking questions is not the only way of promoting dialogue:

> 'We use prompts to refer to statements like "tell me…" which are essentially questions in that they expect a pupil response, even if there is no question mark, no raising of voice tones at the end.' (p.7)

Askew (2012) goes further, and citing Dillon (1985) suggests that it is more effective for teachers to encourage children to respond to mathematical statements than it is to ask them questions. He exemplifies this by suggesting that the statement, 'All squares are rectangles' will encourage qualitatively different dialogue than the question, 'Is a square a rectangle?' (p.130). Whilst there is some merit in this distinction, I find it rather simplistic as it seems to be based on the syntax of questions rather than their semantics. As Mason (2002a) observes, 'Not all utterances with a question mark are questions, and some assertions are actually questions' (p.248). Ainley (1987) and Boaler and Brodie (2004) make the same observation, distinguishing between questions and prompts. Boaler and Brodie chose only to include, 'utterances that had both the form and function of questions, and which were mathematical' in their study (p.777).

What are the forms and functions of different questions (and prompts) in teaching mathematics and how can they be described?

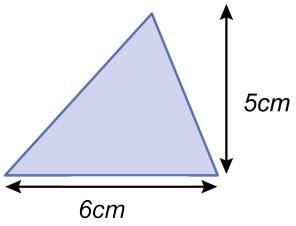
Forms and functions of questions in teaching mathematics

Closed and open questions

Traditionally, it has been common to classify questions as either closed or open. For example:

Closed question

What is the area of this triangle?



Open question

Find different triangles with an area of 15cm^2

Smith et al. (2004) carried out research in the UK on interactive teaching practices in the Primary Literacy and Numeracy Strategies. They defined and coded teachers' questions as either open (where teachers accepted more than one answer to a question) or closed (where teachers required a single specific answer). This study found that only 10% of teachers' questions were open and that 15% of teachers never asked an open question. Teachers of children in Year 1 and Year 2 asked fewer open questions than teachers of older children. Additionally, children's answers were generally very short with 70% of them limited to three words or less. It should be noted that their study only involved 35 primary literacy lessons and 37 primary numeracy lessons. However, it provides some evidence for the claims by Alexander (2008) and Askew (2012) quoted earlier, of the paucity of children's talk in UK primary classrooms. A weakness of the study is the rather limited categorisation of questions as being either open or closed.

Mason (2002a) takes the idea of open and closed questions further: 'There is a penchant for classifying questions as being open or closed, or more specifically, open-ended or open-fronted, and closed-ended or closed-fronted' (p.255). He describes the 'ended-ness' of a question in terms of whether or not there are specific, definite and established answers: the 'traditional' meaning of open and closed questions. He describes the 'fronted-ness' of a question in terms of whether or not the question specifies what the child has to do. There are however many issues in classifying questions purely in terms of the inherent characteristics of the question.

Intentions and perceptions of questions

Watson and Mason (1998) note that:

> '…the person asking the questions has criteria for what is an acceptable response, and it may even be that the intention of the 'open' questions' is to focus on expressing the generality of all possible answers. Thus most 'closed' questions can be opened up, and many apparently 'open' questions are nevertheless constrained.' (p.5)

I am not sure that it is always the case that the person asking an open question has a pre-conceived answer, but I do accept that this may often be true. Other authors have made similar observations. For example, Alexander (2008) comments that,

> 'Classrooms may be places… where supposedly open questions are really closed; …instead of thinking through a problem children devote their energies to trying to spot the one 'correct' answer.' (p.14).

Consequently one characteristic of dialogic questioning suggested by Alexander is that there is, 'consistency between form and intent' (p.43). In other words, open questions should have no pre-conceived answer. Both Watson and Mason (1998) and Alexander (2008) therefore identify a critical feature of teacher questioning: intention. Teachers may ask similar (forms of) questions but their pedagogical intentions may be different. A question may be open-ended, in the sense that it has many possible answers, but it may be asked by the teacher to try and elicit and then emphasise one possible answer. The

form of the question may be open-ended, but the pedagogical intention may be closed-ended. Therefore one difficulty with attempting to classify questions is that descriptions may identify the inherent form or characteristics of a question, but they may take no account of the pedagogical intention, (Boaler & Brodie, 2004).

Both Ainley (1987) and Mason (2002a) suggest that it is not *intention* that needs to be considered but *perception* (interpretation). Mason (2002a) states, '…the notion of 'openness' and 'closedness' is more to do with how the question is interpreted than with the question itself' (p.256). In other words, what is important is not just what the teacher intends, but what the children think that the teacher intends. Children's perceptions of their teachers' intentions play a key role in learning. For example, as Alexander (2008) notes, if a child perceives that a teacher is only attending to specific 'right' answers, then the child learns that mathematics is about giving answers. Furthermore, the child will learn that mathematics is concerned with knowing the 'right' answers. The word *perception* can also be used to describe the teachers' thoughts about the question as well as the children's. This is summarised extremely clearly by Ainley (1987):

> '…being open or closed seems not to be so much an attribute of the question *per se* as something read into it by the questioner or the hearer. Teacher and pupils may have different perceptions of this distinction, and students' perceptions may be altered by the way in which their answers are handled.' (p.25)

This suggests that it is crucial to consider teachers' and children's perceptions whatever form a question may take. An important consideration is whether or not teachers are always aware of their purpose in asking a particular question. Ainley (1987), Pimm (1987), Mason (2000) and Alexander (2008) all describe a particular form of questioning where teachers may not be aware of their intentions:

> '…a pattern of interaction in which the teacher asks a question and the students try to guess what is in the teacher's mind. As an observer, it is easy to characterize a teacher's questioning style as 'guess what is in my mind', but as a teacher it is much harder to recognize when it is happening, and even harder to do something about it.' (Mason, 2000, p.106)

Mason (2000) observes:

> 'Very often it is only when a response is received that the questioner realizes their question had an expected, pre-thought answer.' (p.98)

Thus, Mason suggests that teachers are not always aware of their intentions when asking questions. Furthermore, they are not always even aware of their intentions after a student has answered their question. As Pimm (1987) notes, a consequence of this *guess-what's-in-teacher's-mind* game may be that a teacher is so focused on expecting a particular answer, that they ignore or reject other equally valid answers.

Going beyond the overly crude distinction of questions being either open or closed, authors have adopted many different approaches to categorising the questions that teachers ask. These generally relate to the potential function of the questions. Appendix 1 lists the classifications used by authors in 12 different papers: there are clearly many commonalities, even if the terminology is not always consistent.

Controlling questions

Mason (2002a) argues that because it is cultural etiquette to answer questions, questions can be used to assert authority and *control*. Whilst Ainley (1987) uses an example from Australian Aboriginal culture that suggests this etiquette may not be true in all cultures, both Mason and Ainley provide a number of examples of how teachers use questions to control the behaviours of children. For example, 'Would you like to put your books away now?' (Ainley, 1987, p.24). Ainley describes such questions as pseudo-questions, as although they have the form of questions, (they start with interrogative words, end with question marks) they are implicit instructions. These questions are asked with the purpose of obtaining tacit agreement from the child in order to control their behaviour. Teachers may ask these questions when they become aware of 'inappropriate' classroom behaviour. Mason (2002a) suggests that the question, 'Where do we put the equals sign?' is also a controlling question, and whilst it is true that

a teacher may ask this question to control a child's explanations or try to get their attention, I think that it is equally possible that a teacher will use a question like this to *focus* a child's attention on a particular aspect of mathematics.

Focusing questions

Mason (2002a) provides a number of examples of what he terms *focusing* questions, whose purpose is to draw children's attention to something: 'What is next to the three?'; 'What do we do with…?' Nicol (1999) talks about similar questions that 'get students to the answer' (p.53). Similarly, Sahin and Kulm (2008) write about *guiding* questions. These all seem to be questions that focus attention: asking for a specific answer or the next step needed to solve a problem.

Boaler and Brodie's (2004) classification of questions similarly includes one type described as, 'Gathering information, leading students through a method' (p.777). These questions are described as those that require an immediate answer and focus on facts and procedures. Teachers *guide* children through asking them a sequence of factual questions. Franke et al. (2009) report that such sequences of questions are most effective in helping children provide a correct and complete explanation. Such sequences of questions may *scaffold* learning by focusing children's attention, particularly when they encounter difficulties. However, on some occasions, a sequence of focusing questions can turn into *funnelling* (Franke et al., 2009; Mason, 2000, 2002a; Wood et al., 1991). Funnelling is the process of a teacher asking one or more children increasingly specific and detailed questions in an attempt to help them answer a question. The teacher guides the children in the direction that they think is most appropriate, and questioning often becomes the *guess-what's-in-teacher's-mind* game, described previously. Wood et al. (1991) suggest that funnelling often begins with a child giving a 'wrong' answer. Mason (2002a) suggests that it is common when a child doesn't answer a question.

A number of authors write about a particular form of focusing questions: *leading* questions (Franke et al., 2009; Moyer & Milewicz, 2002; Wood et al, 1991). Leading questions focus children on particular aspects of the problem or the mathematics to guide them towards an answer, but as Franke et al. (2009) observe, 'it was the teacher who was primarily responsible for getting the explanation out on the table' (p.389). Ainley (1987) suggests that often teachers tell children significant pieces of information whilst asking a question:

> ' 'These two lines are equal, aren't they?' […] 'How many tens are there here (pointing)?' Emphasis either by tone of voice or by actions, adds to the information conveyed, and all too often also gives a clue to the desired response.' (p.25)

When teachers ask leading questions they are inviting children to focus on something that they (the teacher) is aware of and think is important, rather than starting from what the children notice and think is important. Moyer and Milewicz (2002) note that leading questions often lead to the *guess-what's-in-teacher's-mind* game, with children trying to work out what the teacher is thinking rather than focusing on their own thinking. Unsurprisingly, as Franke et al. (2009) observe, leading questions don't encourage children to explain. Indeed, they often don't provoke children to think.

Ainley (1988) uses the term *directing* questions: questions that are designed to provoke further thinking. The teacher may or may not know the answer to these questions. Ainley describes three sub-categories of directing questions:

> 'Structuring questions, typically a sequence of questions which 'activate' the subject's existing knowledge in such a way that new connections become clear.
>
> Opening-up questions, which suggest new areas of exploration…
>
> Checking questions, which encourage pupils to think again about a statement…'
> (p.93)

Clearly, teachers need to reflect on how and when they use these types of questions. For example, If a teacher only asks *checking* questions when a child has given a 'wrong' answer, then children will learn that such questions mean that they have got the answer 'wrong'. This may not encourage them to think. Similarly, *structuring* questions may turn into *leading* questions. If used reflectively, focusing questions may encourage children to notice something for themselves, rather than direct them to what the teacher notices.

Testing questions

Mason (2000) asserts that, 'The most common form of asking questions in an educational context is to test the comprehension of the students' (p.107). Unsurprisingly therefore, many authors refer to *testing* or factual questions. (Ainley, 1987, 1988; Alexander, 2008; Boaler & Brodie, 2004; Hiebert & Wearne, 1993; Mason, 2000, 2002a; Nicol, 1999; Sahin & Kulm, 2008). The purpose of these questions is to ask the child to recall a specific fact, definition, or the next step in a standard procedure.

Research seems to indicate that Mason's (2000) assertion is accurate. For example, in Hiebert and Wearne's (1993) study of teaching by six second-grade mathematics teachers, the most frequent type of question in all classes, 'requested recall of factual information' (p.410). In Boaler and Brodie's (2004) study in the US, more than 95% of the questions asked by teachers following a traditional curriculum required students to state or rehearse known facts or procedures. Between 60-75% of questions asked by teachers following a reform curriculum were also of this type (p.778). Both teachers in Sahin and Kulm's (2008) study asked, 'many more factual questions than other types of questions regardless of their teaching strategies' (p.221), but this is a very small sample. Although Sahin and Kulm suggest that the reason for this is that factual questions can be asked any time in a lesson regardless of the mathematics topic, I suggest that, as intimated by Hiebert and Wearne (1993) and Boaler and Brodie (2004), the number and types of questions asked by teachers is directly related to their beliefs and orientations.

Ainley (1987), Pimm (1987) and Mason (2002a) describe a particularly extreme form of testing questions, referred to by Pimm and Mason as *cloze* questions. These do not have the form of questions but are,

> 'part-sentences, left hovering in mid-air for the student to supply the missing word or phrase: 'This shape has four sides so we call it a…' (Ainley, 1987, p.24)

In contrast to Ainley's pseudo-questions that are implicit instructions, these are '*implicit* questions' (Ainley 1987, p.24). Often a one-word answer is all that is required by the teacher and as Ainley notes, the teacher most usually has a specific answer in mind. Consequently, this inevitably turns into the game of *guess-what's-in-teacher's-mind*, with all the associated problems highlighted previously. Pimm (1987) makes the important point that these questions enable the teacher to control the discourse. Consequently, these are both *controlling* as well as *testing* questions. Such questions do not encourage children to answer in the way that they want, to explain their ideas, or even to speak in sentences.

Mason (2002a) implies that all questions that teachers ask may be perceived as testing questions and he also indicates his own judgement of the value of these questions in promoting learning: 'Questions are seen as some sort of testing process, through which learners supposedly learn' (p.248). Ainley (1988) and Askew (2012) agree, suggesting that there is an inherent danger if children perceive teachers' questions as being testing:

> 'Because testing questions are so common, particularly in mathematics where answers are often seen as being clearly 'right' or 'wrong, there is a danger that pupils may perceive all teacher questions in this way. Such a perception would inevitably be detrimental to attempts to encourage discussion.' (Ainley, 1998, p.93-94)

An important characteristic of *testing* questions is that teachers already know the answers to them. (Ainley, 1987, 1988; Mason, 2000, 2002a; Wood et al., 1991). This is described by both Ainley (1987) and Mason (2000) using the adjective 'bizarre' as it is a

form of questioning that generally only occurs in teaching situations. Another related characteristic of testing questions is that children also usually know that teachers know the answers to them. (Ainley, 1987, 1988; Mason 2000, 2002a). This is where the danger lies, for if children perceive that all questions are testing, and if they believe that teachers know the answers to all the questions that they ask, then children start playing the *guess-what's-in-teacher's-mind* game, regardless of the question being asked. However, I am not sure that the research evidence supports the argument that children perceive all questions as testing. Ainley's (1988) study explored teachers' and children's perceptions of teachers' questioning styles. One of her initial conjectures was that,

> 'children would tend to interpret many teacher questions as testing questions, and in particular that both directing questions and genuine questions might be perceived in this way. (p.97)

The study indeed reported that there were several questions that teachers perceived as *directing* questions, but that some of the children perceived them as *testing* questions. There was only one question that was an *enquiry* question (see following) and all the children who were interviewed thought that the teacher did not know the answer to the question. An important caveat is that this was just one small-scale study.

Whatever their form, testing questions almost always require short if not one-word answers and as such do not promote children's talk. I suggest that this can be seen clearly just by referring to the average number of questions that teachers were asking in Hiebert and Wearne's (1992) study. In 40-minute lessons, teachers asked on average between 28 and 70 questions. This doesn't suggest that there was time for extended children's talk. Indeed the study reports that: the percentage of all talk that was teacher talk ranged from 77% to 91% (p.408); the most frequent student response was 1-2 words in length (p.409); the percentage of children's responses that were six words or longer ranged from 10% with three of the teachers, to 35% with another two of the

teachers (p.409). Ainley (1987) suggests that this kind of questioning, ‘creates the illusion of participation’ (p.24).

Genuine enquiry questions

Ainley (1988) classifies some questions as *genuine* questions. A key characteristic of a genuine question, in contrast to a testing or focusing question, is that the teacher doesn't know the answer and is asking the question for the purpose of getting information. Alexander (2008) uses the synonym *authentic* to describe a similar type of questions: ‘ “Authentic” questions are those for which the teacher has not pre-specified or implied a particular answer’ (p.15). Both adjectives, *genuine* and *authentic* indicate that these teaching questions have the same function as ‘everyday’ questions, rather than the ‘bizarre’ testing questions that teachers ask. Furthermore, as Alexander observes, when a teacher asks authentic questions they have no control over the answers and therefore less control of the dialogue that may occur.

For many teachers, particularly beginning teachers, there may be a perceived difficulty in asking *genuine* questions in a classroom, particularly if they see mathematics as being about ‘right’ and ‘wrong’ answers. After all, they have studied mathematics; they ‘know the answers’. Mason (2000) summarises this issue succinctly and provides a solution to the dilemma:

> ‘It is difficult to enquire genuinely about the answer to problems or tasks which have well-known answers and have been used every year. However, it is possible to be genuinely interested in how students are thinking…’ (p.107)

Nicol (1999) classifies these very simply as ‘questions to learn what students are thinking’ (p.53).

It is interesting that in Hiebert and Wearne’s (1993) classification of the kinds of questions asked by teachers, three of the four broad categories relate to potentially genuine enquiry questions: The category *Describe strategy* has example questions such

as, ‘How did you find the answer?’ or ‘Did anyone do this problem a different way?’ (p.402). One of the components of Fraivillig et al.’s (1999) framework for ‘Advancing Children’s Thinking’ similarly focuses on strategies for *eliciting children’s solution methods*. Another category Hiebert and Wearne (1993) identify is *Examine underlying features*. The purposes of these questions are to ask children to explain or analyse. An example question is: ‘Why did you work the problem like that?’ (p.402). Another component of Fraivillig et al.’s (1999) framework similarly focuses on strategies for *extending children’s mathematical thinking*. Hiebert and Wearne describe the positive effect of asking enquiry questions:

> ‘In contrast to the precisely constrained discourse that emerges from a sequence of procedural recall questions, the discourse that grows from describe or explain questions is less constrained.’ (p.411)

In other words, enquiry questions are better at stimulating children to talk and therefore think.

A number of authors talk about *probing* questions. (Boaler & Brodie, 2004; Franke et al., 2009; Moyer & Milewicz, 2002; Sahin & Kulm, 2008). Sahin and Kulm (2008) identify probing questions as those that:

> ‘– Ask students to explain or elaborate their thinking.
> – Ask students to use prior knowledge and apply it to a current problem or idea
> – Ask students to justify or prove their ideas.’ (p.224)

Sahin and Kulm observe that, ‘Probing questions… enabled students to think more deeply about the problems being discussed’ (p.227). Similarly Boaler and Brodie (2004) describe probing questions as, ‘getting students to explain their ideas’ (p.777). Some other authors, for example Moyer and Milewicz (2002), seem to unhelpfully – and in my opinion incorrectly – connect probing and follow-up questions. Questions that encourage children to think do not have to be a follow-up to testing questions.

Nystrand et al. (1997), quoted in Alexander (2008) suggest that genuine enquiry questions promote dialogue because they, 'signal to students the teacher's interest in what they think and know and not just whether they can report what someone else thinks or has said' (p.15). Mason (2002a) similarly argues that a critical feature of effective teacher questioning is being interested in what and how children are thinking. Consequently, he summarises his thoughts on questioning by stating:

> 'The key to effective questioning lies in using… controlling questions rarely, focusing questions sparingly and reflectively and genuine enquiry-questions as much as possible.' (p.257)

Questions promoting mathematical thinking

Most authors appear to classify questions into three or fours types as described above. Hiebert and Wearne (1993) identified nine distinct academic (rather than behaviour or organisational) question types that were then grouped into four categories. As suggested previously, three of these groups (six of the nine question types) offer potential for genuine enquiry questions. Indeed, Hiebert and Wearne based their classification of questions on their differing potential to promote thinking (as evidenced by children's talk):

> '…questions engender increasing levels of cognitive elaboration as one moves from the recall questions to the describe questions to the explain and analyze questions' (p.403)

I suggest that they have gone beyond merely identifying types of questions that offer greater potential for thinking and explaining (enquiry questions) and tried to consider the *levels* of thinking that different types of question may generate.

Boaler and Brodie (2004) similarly have nine categories of questions based on an analysis of practice, albeit informed by previous classifications including that of Hiebert and Wearne (1993). However, two of Boaler and Brodie's categories point to particular aspects of mathematics: one category relates to mathematical terminology; another is

concerned with, ‘Exploring mathematical meanings and/or relationships’ (p.777). I suggest that rather than merely considering thinking as generic mental activity, their classification hints at specific aspects of *mathematical* thinking.

Watson and Mason (1998) (and subsequently Jeffcoat et al., 2004) go further and seem to have classified questions in a unique way. Rather than classifying them according to the kind of response they elicit, or according to the *levels* of explanation and thinking that they may generate, they classified questions according to the *processes of mathematical thinking* that they attempt to stimulate. They developed their classification theoretically, through an analysis of, ‘the various kinds of mental activity which, together, typify mathematical thinking’ (p.7). They collected these mental activities into six groups, listed in Appendix 1. Furthermore, rather than developing a classification to *support research and analysis* of the questions teachers ask, the framework was produced to *support teachers to ask mathematical questions*.

The authors acknowledge that the mental mathematical activities that they have focused on are only concerned with, ‘thinking, reasoning and coming to know a concept’ (p.7). They do not consider mental activities such as calculating. Neither do they consider recall of facts or procedures: ‘Our interest is in using mathematical questions as prompts and devices for promoting pupils in thinking mathematically’ (p.4). I suggest that their classification takes the broad concept of enquiry questions, mathematizes it and deconstructs it. I argue that their framework is much more useful than merely considering generic *levels* of thinking: it helps teachers to draw children’s attention to different aspects of mathematical structure and to engage children in a broader range of mathematical thinking processes, rather than just asking them to explain their ideas.

Responding to children’s answers

Alexander (2008) argues strongly that:

> ‘There’s little point in framing a well-conceived question… if we fail to engage with the answer they give and hence with the understanding or misunderstanding which that answer reveals.’ (p.25)

He asserts that in practice a child’s answer to a question often signals the end of the dialogue.

Smith et al. (2004) coded teachers’ responses to children’s answers in terms of whether they praised, criticised or merely accepted the answers. They also coded two other teachers’ responses: *probes*, where teachers asked further questions of the child who had just answered and *uptake* questions where teachers’ took a child’s answer and used it as part of a subsequent question. Rowland et al. (2015) also identify three kinds of teachers’ responses to ‘unexpected ideas and suggestions’ from children: ‘*to ignore, to acknowledge but put aside, and to acknowledge and incorporate*’ (p.79). I posit that Smith et al.’s (2004) first three categories (praise, criticise, accept) are sub-categories of *acknowledge but put aside*. Similarly, *probes* and *uptake* questions are sub-categories of *acknowledge and incorporate*. Rowland et al. (2015) suggest that it is rare to find instances of teachers intentionally ignoring children’s answers. Whilst my own observations lead me to agree that acknowledging children’s answers is most common, I have observed many instances in my current context of teachers ignoring children’s answers. This is particularly the case when children have given ‘wrong’ answers to testing questions. In Smith et al.’s (2004) study, the teachers probed and asked the same child further questions in only just over 11% of questioning; uptake questioning occurred in only 4% of questioning. A*cknowledge but put aside* was obviously the most common teacher response. Consequently, this seems to provide some evidence for Alexander’s (2008) assertion that dialogue often ends with a child’s answer. This is maybe not surprising given that Franke et al. (2009) note that, ‘Little research-based evidence exists to help teachers make the transition from asking the initial question to pursuing student thinking’ (p.380).

Teachers can respond to a child's answer by asking more questions. These could be any of the question types described previously. However, Mason (2002a) advises that teachers should be asking enquiry questions most frequently. Hiebert and Wearne's (1993) second question type, *Describe strategy*, is clearly a good example of this. Franke et al. (2009) provide a cautionary note:

> '…researchers have found that teachers readily begin asking students open-ended questions after the students have solved a problem (e.g., "How did you solve that problem?") and can elicit an initial student explanation. Teachers find it more difficult, however, to follow up on student explanations and pursue students' thinking…' (p.380)

Askew (2012, p.134-136) suggests a number of practical strategies that teachers can use to *acknowledge and incorporate* children's answers that do not necessarily involve further questioning:

– **Revoicing**: supporting children as they talk. This includes saying what they said and asking them if it was accurate. Fraivillig et al. (1999) describe this as being a common strategy used by the 18 teachers in their study. Pimm (1987) uses the evocative term *echoing* to describe this technique. O'Connor and Michaels (1993) however, emphasise that this strategy is more than merely repeating. They suggest that it can be an *aligning* strategy that acts to relate children's different ideas. Additionally, because revoicing involves interpreting a child's answer, it allows the teacher to reintroduce, alter or clarify the idea and then pass it back to the child to validate; other children participate by listening, reflecting and maybe expressing their own positions. O'Connor and Michaels suggest that the strategy is particularly powerful as it can, 'lend authority to a hesitant voice' (p.328);

– **Repeating**: encouraging other children to repeat what a child has just said, then asking the first child if it was an accurate repetition;

– **Rephrasing**: asking children to explain what they heard in their own words, then asking the first child if the rephrasing was accurate;

– **Building on**: asking the class if anyone wants to add anything to what was said, or if anyone thought or did anything similar. I suggest that a teacher can also ask the child to say more about their answer.

These kinds of responses, common in everyday discourse, show children that the teacher is listening to and valuing what they have to say. Additionally, although the teacher is part of the dialogue they are not the authority in the dialogue: they seek to involve other children. Most importantly, they keep the dialogue open.

Watson and Mason (1998) suggest that some teachers may not promote dialogue because they lack confidence in responding to unexpected answers. I suggest that some teachers have difficulties in dealing with 'wrong' answers: this may be precisely because they were unexpected. However, it may be because of gaps in their own knowledge, or because of their beliefs in what it means to be a teacher. Wood et al. (1991) describe a teacher who,

> 'found that accepting her students' incorrect answers unconditionally created a contradiction with her beliefs about the nature of mathematics and her role as a teacher and member of the wider society. She still felt that it was her responsibility as a teacher to correct and eliminate children's errors.' (p.602)

Nicol (1999) suggests simply that responding to a child's answer is concerned with, 'listening and comprehending a student's ideas or comments, and weighing the various options within that context' (p.59). However, all these stages (listening, reflecting, making a decision) are far from simple. For example, Peressini and Knuth (1998) describe a teacher who appears to merely compare a child's method to the 'correct' method that he knows. Although he is listening to the child's method, he doesn't attempt to make sense of their method. This is what Mason (2009) citing Davis (1996) refers to as *listening for* rather than *listening to*. Desforges (1989) notes that,

> ‘teachers, frequently rushed to interpret children’s responses and to correct errors. They did not pause to check or test their own interpretations, let alone the child’s responses.’ (p.148)

These examples contrast with Watson and Mason’s (1998) view that reflective teachers ‘listen to answers and think: “what does that response reveal about understanding?” and adjust the lesson accordingly’ (p.5). Teaching requires an awareness of what students are doing and how they are responding. It requires reflection on what these actions and responses mean: what students know and what they understand. It requires making informed decisions about what to say or do next. One of the difficulties facing teachers is that they have to act *in-the-moment*.

Acting *in-the-moment*

According to Adler (1990), Schon (1987) defines a reflective teacher as ‘one who can think while acting and thus can respond to the uncertainty, uniqueness and conflict involved in the situations in which professionals practice’ (p.8). This is echoed by Watson and Mason’s (1998) notion of *unexpectedness*. Similarly, Rowland and Zazkis (2013) assert that, ‘teaching involves dealing with unpredictable, *contingent* events in the classroom‘ (p.138). They describe contingent events as, ‘events that were not anticipated or planned, usually triggered by an answer or a remark contributed by a student’ (p.138–9). As Coles and Scott (2015) unequivocally state: ‘Contingency and the unexpected are therefore intimately connected’ (p.130).

The knowledge that teachers need to be able to respond to contingent events, including children’s answers to questions, has been described as *knowing-to-act* in the moment, (Mason, 2002b, 2015; Mason & Johnston-Wilder, 2004). Rowland et al. (2005) identify this as one of the four components of their Knowledge Quartet: contingency or knowledge-in-*inter*action. Rowland and Zazkis (2015) posit that how teachers respond to contingent events is, ‘dependent on their mathematical knowledge’ (p.151). Mason and Davis (2013) go further, and whilst they acknowledge factors such as teachers’ beliefs

and teaching styles, they assert strongly that teachers own mathematics knowledge is 'the major factor' (p.184) in teachers' *knowing-to-act*. They offer a broad interpretation of teachers' mathematical knowledge that includes their mathematical thinking and pedagogical strategies. I suggest that it is potentially unhelpful to try and isolate the one major aspect of *knowing-to-act*: it is surely the interaction of different aspects of teachers' knowledge that defines this capacity. Indeed, Rowland and Zazkis (2015) remark that:

> '…the teacher's ability to capitalize on these contingent situations is underpinned by their knowledge and awareness of the mathematical potential of the unexpected opportunity and by an interest in, and commitment to, mathematical enquiry.' (p.137)

Whilst they clearly emphasise the importance of teachers' mathematical knowledge, they also imply the importance of teachers' beliefs. I suggest that they highlight another key factor: *awareness*. Mason and Davis (2013) also emphasise the importance of teacher awareness, referring to, 'the vital connective tissue between *mathematical awareness* and *in-the-moment pedagogy*' (p.183). This suggests two distinct stages: *noticing* and then *having an action come to mind*.

A number of authors suggest that noticing involves identifying something that is noteworthy, (e.g. van Es & Sherin, 2002; Mason, 2002b; Coles & Scott, 2015). Mason (1998, 2009) and Coles and Scott (2015) suggest that teachers need to be aware of what they are noticing. Indeed, Mason (2009) suggests that this is a necessary state of being for genuine enquiry teaching:

> 'If you are unaware in the moment of how you are using your own powers, you are unlikely to be aware of possibilities for learners to use their own, and certainly unaware of opportunities to fade your prompts so as to turn direct instruction into scaffolding-and-fading.' (p.209)

Mason (2009, 2015) distinguishes between reacting and responding: reacting tends to be 'automatic and habit-driven' (Mason, 2015, p.119) whereas responding involves

reflecting on what is noticed, considering alternative actions and being able to justify the chosen action.

Given the knowledge that teachers need to act *in-the-moment*, in particular to deal with children's (unexpected) answers to genuine enquiry questions, it should be no surprise that many teachers seem to ask so few of these questions and experience difficultly in acknowledging and incorporating children's answers. As Mason (2015) notes:

> 'something unexpected can be a form of awakening… opening up fresh possibilities of action… However it can also trigger tunnel vision (few if any actions available) or freezing (no actions available).' (p.110)

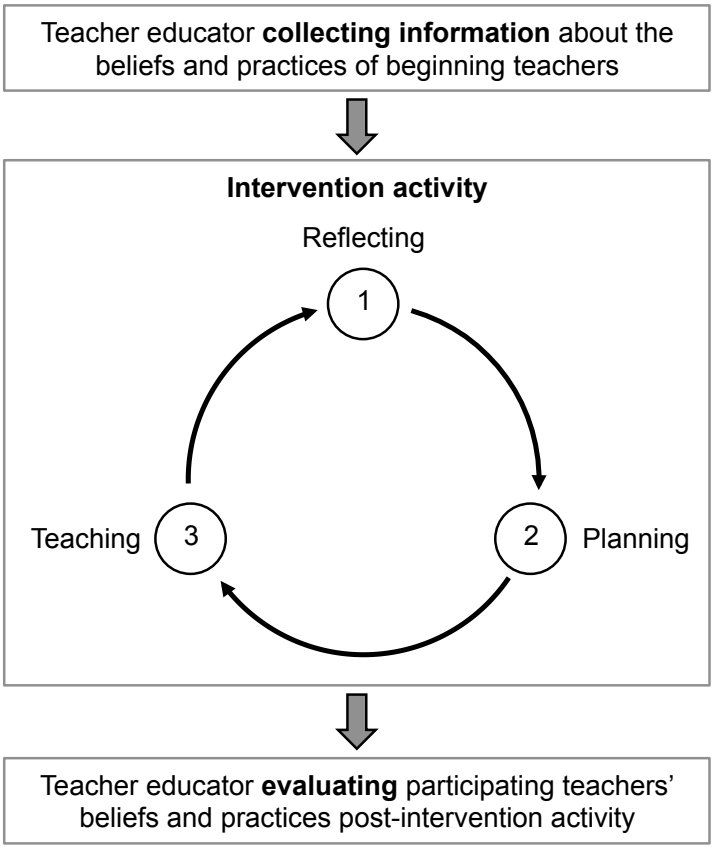
Methodology

Overview

The study comprised three phases:

1. collection of information about the beliefs and practices of beginning mathematics teachers in relation to questioning;
2. intervention activity (professional development);
3. evaluation of participating teachers' beliefs and practices post-intervention.

The second phase, the intervention activity, involved a cycle of three elements: reflecting on practice, planning and teaching. The whole study is summarised below:



The study follows an action research model in both intention and structure. Elliott (1978) describes action research as, 'concerned with the everyday practical problems experienced by teachers' (p.356). Similarly, Altricher et al. (1993) state that,

> 'Action research is intended to support teachers, and groups of teachers, in coping with the challenges and problems of practice.' (p.4)

This project was designed to help teachers to improve their questioning techniques: an important challenge facing teachers. Action research consists of cycles of planning, action, observation and reflection (Elliott, 1978; Altricher et al., 1993; Fazio & Melville, 2008), with practitioners involved in both 'doing' and 'reflecting'. This project involved the teachers in reflecting on and then adapting their practice.

Altricher et al. (1993) suggest that, 'action research will usually be initiated by teachers' (p.5). In my context, this is unlikely due to the educational culture and beliefs about what it means to be a teacher. Consequently, I initiated the project but attempted to develop a collaborative approach to implementing it in a number of ways.

1. I met with the General Supervisor for Primary Mathematics (analogous to a primary mathematics adviser) and all primary mathematics teachers in their first year of teaching to discuss whether they would find it useful to participate in a project focusing on questioning.
2. I discussed my ideas for the intervention activities in advance with the participating teachers and encouraged them to help shape this phase of the project. During meetings they were able to choose activities that they felt would be most helpful.
3. The teachers chose the classes they would try out new ideas with; they also chose episodes in lessons to talk about and reflect upon.
4. In addition to our 'formal' meetings, I encouraged the teachers to meet, plan together and observe each other teaching.

5. I discussed and agreed plans with senior colleagues in schools. This was important, as any professional growth in the teachers participating in the project would unlikely be sustained without their support. Furthermore it would increase the possibility of extending this professional development model to other teachers.

I thought that it was important that teachers took increasing responsibility for their learning as the project developed. In part, this was based on Jaworski's (2001) assertion that,

> '…"co-learning partnerships" between teachers and educators, enabling teachers to share responsibility in the development process, lead to more effective development.' (p.295)

I also wanted to model a teaching and learning situation in which there was fluidity in the 'locus of mathematical authority'.

I therefore suggest that the project involves two levels of action research: the teachers, supported by me as facilitator, reflecting on their practice in questioning; myself as teacher educator reflecting on my practice in supporting the professional growth of the teachers.

Participants and ethics

I invited 12 primary mathematics teachers across the group of schools in their first year of teaching to an initial meeting. During the meeting I explained the purpose of the project and we discussed the proposed different phases. I distributed written information that included the aims of the project, why they had been invited to participate and what might happen.

Given my senior role, it was important that I addressed a range of ethical considerations. I spent considerable time in the initial meeting emphasising that my role in this project

was as researcher and not Chief Officer of the schools. I was aware of the potential ethical and educational issues that could be raised by the power differential (Jaworski, 2001) and that during the project the teachers might play the *guess-what's-in-researcher's-mind* game, telling me what they thought I wanted to hear. I therefore attempted to re-position myself explicitly as an equal colleague. During interviews and meetings I constantly re-affirmed that what they said would be confidential and that I was interested in what they genuinely thought. I also attempted to re-position myself using a range of psychological devices, including where I sat and what I wore. As Elliott (1978) comments,

> 'Since action-research involves unconstrained dialogue between 'researcher' (whether he be an outsider or teacher/researcher) and participants, there must be free information flow between them.' (p.356)

I therefore shared anything that I recorded during the project with the participants, whilst similar to Jaworski (2001), I emphasised that their personal learning journals were confidential and that they could choose if they wanted to share anything from them with me.

In the initial meeting (and throughout the project) I emphasised that teachers were free to choose whether to participate and that they could withdraw at any stage. I reassured them that they would be completely anonymised: neither their name nor the name of their school would be used. I emphasised that all data collected, particularly from lesson observations, would only be used in the project and not for any other purpose: it would not be shared with anyone, including their School Directors. I explained that all data collected would be stored securely on my password-protected laptop and back-up drive and would be deleted once the project was completed. I also gained permission from the owner of the company and School Directors of the schools involved. Getting formal approval from the School Directors was another important marker that in this project I was not in a position of authority over them or the teachers.

Ten teachers agreed to participate and signed a consent form. Three teachers from one school withdrew before the project started: one left the school; another had health issues and the third didn't want to participate as the only teacher from the school. The seven remaining teachers all took part in the first phase of the study. My intention was to write a case study of two teachers from one school, but that all seven teachers would participate. I wanted all the teachers to participate because it would more likely lead to a wider range of beliefs and ideas being expressed and discussed (Barnett, 1998).

Unfortunately, between the first and second phase of the study the Ministry of Education announced that the end-of-grade exams would take place significantly earlier than expected. This would place considerable extra pressure on the teachers, as they would be expected to 'finish the curriculum' much sooner. In addition to the semester finishing much earlier, around four more weeks of teaching time would be lost due to the plethora of 'quizzes' and revision lessons that would have to take place in the month prior to the examinations. I met all seven teachers in their schools to discuss the issue. Five teachers wanted to take part, but felt unable to participate in the intervention activity until the children had left the school immediately after the exams. Due to the proposed intervention involving reflecting-on classroom practice, we established that this wouldn't be possible. I reminded them that they were able to withdraw from the study, which they chose to do. We therefore agreed to work together at the beginning of the next semester. The two teachers in the remaining school were still keen to participate. Niveen and Rana (both pseudonyms) were selected as the two case study teachers by default rather than by design.

Niveen had graduated from the Faculty of Commerce in July 2015 and joined the school in October 2015. For the first three months she supported other teachers in their classrooms. In January 2016, when the project began, she became a full-time teacher, teaching one class in Grade 2 and two in Grade 3. Rana had studied English at university, graduating in 2007. She joined the school in September 2015 and

immediately began teaching three Grade 1 classes. Both teachers had not received any training before or since joining the school.

Pre-intervention and post-intervention evaluations

I carried out pre-intervention and post-intervention evaluations so that I could analyse any changes that took place during the course of the project. There were two components: a lesson observation followed by an interview with each teacher.

The purpose of the lesson observations was to collect data on the teachers' practice in questioning. Anecdotally, I had observed previously a consistent pattern of questioning across all teachers in the schools. Consequently, I judged that observing each teacher once at the beginning and once at the end of the study would be sufficient. It is not possible to generalise how typical these lessons were of their usual pattern of questioning: questioning might vary according to the nature of the mathematical topic, the class being taught, or the context of the lesson (Hill et al., 2012). However, although the findings would not be generalisable, they would provide me with adequate insight into the teachers' practice pre- and post-intervention. This would also put less pressure on participants.

Unlike much previous research, rather than coding questions purely in terms of whether they were testing / focusing / enquiry questions, I decided to code them in terms of the processes of mathematical thinking that they attempted to stimulate. I developed an observation checklist based on an adapted version of the categories of questions contained in Jeffcoat et al. (2004), but also incorporating elements of Boaler and Brodie's (2004) study. Similar to Watson (2007), I did not seek to identify any hierarchy in the questions that teachers used, merely to describe them in terms of the teachers' possible mathematical intention. Additionally, I wanted to capture how questions were targeted: in previous observations I noticed that teachers frequently asked questions of the whole class, encouraging children to yell out the answers in unison. Finally, I wanted

to capture how the teachers responded to children's answers. I devised a coding for possible responses that went beyond the basic categorisations used by Smith et al. (2004) and Rowland et al. (2015) and built on the strategies described by Askew (2012). I piloted the checklist in three lessons and revised it. The final checklist is contained in Appendix 2.

As Heibert and Wearne (1993) note,

> 'Classroom discussions are frequently not clean exchanges of unambiguous questions and responses. Coding teachers' questions requires a number of procedural decisions' (p.403)

I therefore made the following decisions when coding questions in lessons:

- to record all utterances that had the function of questions, even if they didn't have the form of questions;
- to record repeated questions only if there was a response from a child between questions;
- not to differentiate between different kinds of non-mathematical controlling questions;
- not to record questions that didn't require a verbal response, e.g. implicit instructions and rhetorical questions.

Even so, I found the process of coding questions in lessons difficult. I was pleased that, with the written consent of the teachers, I had audio recorded the lessons.

Many writers refer to beliefs being an important factor in teachers' questioning techniques, (Boaler & Brodie, 2004; Desforges, 1989; Hiebert & Wearne, 1993; Mason & Davis, 2013; Wood et al., 1991). Simon and Tzur (1999) highlight the strong interrelationship between beliefs and practice and suggest that teachers' practice can only be understood by considering this interrelationship. Additionally, as described previously and as Mason (2002b) comments, 'At the heart of all practice lies noticing:

noticing an opportunity to act appropriately' (p.1). The purpose of the interviews was to gain insight into both of these aspects of participants' questioning.

I decided to use video as a stimulus for one-to-one semi-structured interviews to help me learn what participants considered significant and noticed. A semi-structured interview would allow me to steer the direction of the interview more than an unstructured one, but there would be considerable opportunity for the teachers to influence the flow of the discussion. I chose two classroom videos: both were from UK primary classrooms, but the teaching offered many contrasts in style. For example, one video contained a brief whole class episode followed by children working in pairs with teacher support. This teacher asked mostly testing questions and only one enquiry question. Her responses to children's answers were predominantly *acknowledge but put aside* (Rowland et al., 2015). The other video was entirely whole class and the teacher asked children to explain their answers more. I was interested in what differences (if any) the teachers noticed in the videos.

Jaworski (1990) suggests that a ten-minute clip of video is the normal maximum before observers begin to get restless. Seago (2004) states that she does not use videos longer than six minutes as, '…there is only so much that people can passively observe before they feel a need to discuss their observations and interpretations' (p.268). Coles (2013a) recommends no more than five minutes and generally aims for clips around three minutes. I chose two different length videos (1' 25" and 8' 24") videos, partly because this would help me to decide on an appropriate length of video for the intervention activity.

The questions I drafted for the interviews are contained in Appendix 3. With the written consent of the teachers I recorded their observations and comments during the interviews.

Intervention activity

The intervention activity was designed to incorporate the key features of Clarke and Hollingsworth's (2002) interconnected model of professional growth. This considers teacher growth in relation to changes in teacher knowledge and beliefs as well as changes in practice. I provided various external stimuli to help develop new knowledge and encourage participants to enact their new knowledge and then reflect on their practice. I intended to overtly link theory and practice through the processes of reflection and enaction in order to promote growth in teaching, (Jaworski, 2001; Korthagen et al., 2006).

A key element of the intervention activity was that I wanted to model dialogic teaching. As Berry and Loughran (2002) observe,

> '…how we taught had much greater impact on student teachers' thinking about practice than what we taught.' (p.15)

Like all learners, teachers need to construct their own understanding and to reflect on what they are learning. In order to teach in this way, they need to experience learning in this way and to notice the teacher behaviours that facilitate such learning, (Kothagen, 2004; Korthagen et al., 2006; Sherin & Han, 2004). Therefore, although I planned thoroughly, I knew that my own teaching had to be contingent: I needed to model reflective practice and decide how to respond to the ideas of participants *in-the-moment*, (Berry & Loughran, 2002; Loughran, 2006; Dinkelman, 2003).

Originally I planned around 14 hours of intervention activity spread over a two-month period. This was very limited, but given the context it was as much time as I could expect from the teachers. However, the sudden Ministry of Education announcement meant that even this was impractical, so through discussion with Niveen and Rana it

was reduced to eight hours over a three-week period. This is a serious limitation in the study. A summary of the intervention activity is contained in Appendix 4.

Stage 1

The relationship between teachers' beliefs and practice is beyond the scope of this study. A key dilemma facing teacher educators is whether to try and change beliefs, hoping that this will alter practice, or whether to focus on changing practice, hoping that this will affect beliefs. A composite of both approaches is probably necessary. Korthagen (2004) accentuates the importance of starting from practice and describes a five-stage strategy for conceptual change in beginning teachers:

1. they reflect on a concrete experience from practice;
2. the teacher educator supports them to become aware of their, 'often-implicit beliefs' (p.89) that are playing a role in this and similar situations;
3. the disadvantages of the beliefs are examined, leading to dissatisfaction;
4. the beginning teacher is offered an alternative theory;
5. they practice alternative behaviours based on the new beliefs.

This strategy unhelpfully implies a deficit-model of teacher knowledge. In contrast, Swan (2011) describes a more neutral four-stage approach to working with teachers:

1. recognise existing beliefs and practices;
2. analyse new practices;
3. suspend disbelief and adopt new practices;
4. reflect on the experience.

Both approaches echo Wilson and Cooney's (2002) view that teacher development is, 'rooted in the ability of the individual to doubt, to reflect, and to reconstruct' (p.132) and both aim to make teachers aware of possible reasons behind their classroom practice. I began the intervention activity by supporting the teachers to become aware of their

beliefs. Similar to Swan (2011), I wanted to do this in a non-judgemental way and asked participants to discuss pre-prepared statements about teaching and learning mathematics and sort them into whether they agreed, disagreed or were unsure, (Appendix 5). This led to discussion about Askew et al.'s (1997) three teacher orientations: *transmission, connectionist, discovery*.

In the next part of the intervention I wanted the teachers to reflect on actual classroom practice. There is wide agreement in the literature that video is a useful tool for this. As Brophy (2004) notes,

> '…its affordances make it uniquely valuable for conveying the complexity and subtlety of classroom teaching as it occurs in real time' (p.287).

Ingram (2014) builds on this, adding that it offers, 'a more authentic experience for student teachers than paper-based resources' (p.52). I would argue that this includes written descriptions and transcripts of lessons: these do not have the immediacy of video and they do not convey the complexities of interaction. I therefore chose to use video as a key tool of the intervention activity, partly because it would provide participating teachers with an authentic experience and bridge the theory–practice gap (Blomberg et al., 2014). Furthermore, video is widely recognised as useful in developing teachers' skills of noticing, (Blomberg et al., 2014; Santagata & Angelici, 2010; Seago, 2004; Seidel et al., 2011; Sherin, 2004; Sherin & Han, 2004; Sherin & van Es, 2009; Star & Strickland, 2008; Star et al., 2011; van Es & Sherin, 2002, 2008).

I thought that video offered many advantages over observing live lessons:

- it would be less threatening to participants;
- it provided an opportunity for participants to observe different practice than they would experience in local classrooms, (Blomberg et al., 2014; Jaworski, 1990; Sherin & Han, 2004; Star & Strickland, 2008);

- it could be analysed, paused and repeatedly played back, (Borko et al., 2008; Coles 2013a, 2013b; Ingram, 2014; Jaworski, 1990; Seago, 2004; Sherin, 2004; Sherin & Han, 2004).

However, video is not intrinsically useful; it depends how it is used, (Blomberg et al., 2014; Seago, 2004; Coles 2013; Sherin & Han, 2004). Consequently, I made a number of decisions when choosing and using the video:

- Siedel et al. (2011), van Es (2012) and Seago (2004) describe advantages and disadvantages of teachers' watching videos of their own teaching versus others' teaching. Siedel reports that there are contrasting points of view, noting that some researchers have argued that observing video from teachers' own classrooms is more familiar and more motivating. Seago (2004) takes a different stance, suggesting that using videos of unknown teachers, 'provides an opportunity to study an instance of teaching that is emotionally distant enough to create a safe place to scrutinize practice carefully' (p.263). For this stage of the intervention I decided to use a video of an unknown teacher because it would be less threatening for the participants and allow them to observe practice different from their own.
- I struggled to find examples of primary-level dialogic teaching within a context that would be familiar to the teachers. I wanted to find an example of good (not best) practice that they could realistically aspire to and recognise as being achievable. I was unable to find any videos of teaching within a similar context and eventually chose a video from a Grade 4 classroom in the U.S.
- I selected a three-minute clip from the video, having learned from my experiences in the pre-intervention evaluation.
- A number of writers comment that without guidance, (beginning) teachers find it difficult to notice important classroom episodes and describe and interpret what they see (Seago, 2004; Santagata & Angelici, 2010; Star & Strickland, 2008; van

Es & Sherin 2002). Consequently, they recommend having specific goals in mind when using video, focusing teachers on particular aspects of teaching and learning. They provide varying degrees of guidance and scaffolding. Some use extremely focused written questions to direct teachers' attention, (e.g. Hess, 2004). Although I had an explicit goal, I decided to provide little scaffolding. I was interested in discovering what the participating teachers noticed and also wanted to model genuine enquiry by allowing them initially to choose what to focus on. I facilitated discussion in a semi-structured way, asking participants what they noticed before focusing on questioning. I encouraged them to describe what they noticed, *giving an account of*, before moving on to interpret what they noticed, *giving an account for*, (Coles, 2013a, 2013b; Jaworksi, 1990; Mason, 2002b). Given participants' levels of English, I prepared a transcript (Appendix 6) of the video that I offered on noticing that they were struggling to understand some of the audio.

- We watched the video clip once, then during the discussion I gave participants the opportunity to rewind, pause and replay as often as they wanted.

Stage 2

The first stage of the intervention concerned participants developing their self-awareness and then *observing teaching and learning*. I designed the first activity in the second stage so that they would *experience learning* in a dialogic way. I prepared three short mathematical tasks and the participants chose a task involving adding and subtracting. I attempted to model dialogic teaching; afterwards I encouraged them to reflect on their experiences as learners and what they noticed about my teaching.

I designed the second activity in this stage so that participants could begin to *experience teaching* in a dialogic way, focusing on how they might respond *in-the-moment* to children's answers. I wanted them to experience, 'contingent disturbances that they will

experience in the classroom' (Rowland, et al., 2015, p.89), but within a safe and supportive context rather than the complexity of a real classroom. I prepared three scenarios of teacher question followed by a child's response(s) (Appendix 7), with the intention that one of the participants would take the role of the teacher and another would take the role of child. For each scenario they would role-play a possible subsequent dialogue, which we would then discuss and consider alternative ways that the teacher could have responded.

I hoped that by this stage the teachers would recognise that we had been exploring an alternative paradigm of teaching and learning to that in their classrooms. This stage of the intervention ended with the teachers discussing what they had learned. I prepared some PowerPoint slides, which I referred to in the discussion and gave them for reference (Appendix 8).

Stages 3 and 4

By this point, I hoped that the teachers had begun to develop knowledge, attitudes and beliefs that would enable them to, 'suspend disbelief and adopt new practices' (Swan, 2011). I also hoped that they would be more able to reflect on their practice. My intention during these next stages was to begin to support the teachers in moving from *knowing-about* to *knowing-to-act* (Mason, 2015). These stages therefore involved participants teaching two lessons and reflecting on them. I thought that it was important to offer them a framework to support their reflections (Appendix 9), which I adapted from the ALACT model described by Korthagen et al. (2006).

My model aimed to focus teachers on identifying and describing what happened in key episodes rather than the whole lesson. This was to encourage them to identify what was significant and then reflect on it in greater detail. I also separated the reflection into two stages, *accounting-of* and then *accounting-for* (Jaworski, 1990; Mason, 2002b). Whereas Korthagen et al. (2006) encouraged the teachers to audio record their

experiences, I encouraged participants to observe and video each other's lessons to build on their earlier experiences of using video. They were given the choice about doing this and I emphasised that the videos were confidential to them. I therefore encouraged a shift from participants looking at videos of others to looking at videos of their own practice. I asked participants to reflect individually before discussing as a group. I hoped that I had previously modelled non-judgemental observation and established the norms that would enable them to safely share their practice with each other (Borko et al., 2008; Brophy, 2004; Coles, 2013b; van Es, 2012).

Throughout the intervention activity, with participants' consent, I recorded their comments to gain insight into any changes in their knowledge and beliefs.

Results and Discussion

Pre-intervention evaluation

Lesson observations

One of the main characteristics of all seven teachers who participated in the pre-intervention phase was the large number of questions they asked. This ranged from 48 to 95 questions in around 30 minutes: more than the teachers in Hiebert and Wearne's (1992) study.

Rana asked 95 questions in 33 minutes. She was teaching place value to a Grade 1 class of 24 children. 100% of the mathematical questions asked were testing: nearly all required children to state facts. This compares to 95% testing questions asked by the teachers who were following a traditional curriculum in Boaler and Brodie's (2004) study. My coding of Rana's questioning is contained in Appendix 10. None of her questions attempted to stimulate any of the processes of mathematical thinking that I had identified (Q3-9). This could be partly due to the nature of the topic. I found it difficult to decide whether to code many of Rana's mathematical questions as *stating facts* or *using terminology* because these questions involved the terminology tens and units. Although I could have coded them as both, I decided to only code questions that specifically asked the children to name the position of the digit as *using terminology* and coded questions where Rana used the terminology as *stating facts*. This indicates an inherent problem in my categorisation of questions: the coding is clearly debatable and the categories are not mutually exclusive.

The majority (63%) of Rana's questioning was directed at the whole class, with children mostly shouting out answers individually or in unison. 'Chorusing' (Shahrill & Clarke, 2014) may be a cultural phenomenon: It was common in five of the seven lessons I observed. A typical interaction was as follows:

Rana:	*(Writes 53 on the whiteboard)* 'What's this number?'
Children:	'53.'
Rana:	'53. We want to put houses. Where is tens? (*One-second pause)* 53. Where is tens?'
Children:	'Five.'
Rana:	'Five tens… 50… Five tens, right? 53. Where is tens?'
Children:	'Five tens.'
Rana:	'Five tens. And units is…?'
Child:	'Three.'
Rana:	'Three… Five is the tens and three is the units. Okay? *(Writing on the whiteboard)* 53 equals 50 plus… plus what? How many units?'
Child:	'Three.'
Rana:	'Three. 50 plus three… Where is tens? *(No pause)* Five. Where is units?'
Children:	'Three.'
Rana:	'Three.'

Questioning was highly structured and scaffolded, but without any fading (Mason, 2000; van de Pol et al., 2011). In the interaction above (lasting 1' 16"), Rana asked six questions to support the children to partition 53 into tens and ones. Throughout the lesson, questions were generally short, often only three words, often repeated. Rana may have repeated questions where the correct answer was already established to encourage participation: the number of children shouting out the answer increased each time. It is also possible that she was supporting children to rehearse the correct answer.

Rana used the cloze technique (Ainley, 1987; Pimm, 1987; Mason, 2002a) five times during the lesson. For example, 'The three is called…?'

Children's answers were nearly always one word; occasionally two words. This is similar to the findings of Hiebert and Wearne (1993), but an important caveat is that in my context these were very young children and neither Rana nor the children were conversing in their first language.

Rana's responses to children's answers were almost exclusively *acknowledge but put aside* (Rowland et al., 2015). Her most common response to children's correct answers was to repeat them:

Rana: 'What's this number?'
Children: '13.'
Rana: '13. Where is tens?'
Children: 'One… One ten.'
Rana: 'One… One ten. Where is units?'
Children: 'Three.'
Rana: 'Three.'

The repeating of answers was an implicit acknowledgement of correctness, apparently recognised as such by the children: Smith et al.'s (2004) *accept*. In contrast to O'Connor and Michaels (1993) *revoicing*, she did not build on children's answers and there was no opportunity for them to comment. Rana also praised children's correct answers, using 'Excellent' on 17 occasions.

Disproving Rowland et al.'s (2015) assertion that it is rare to find teachers intentionally ignoring answers, Rana ignored incorrect answers ten times. She also ignored correct answers when children other than those she targeted the question at shouted out answers. This might also be a cultural phenomenon as I observed it in six of the seven lessons. I suggest that 'ignoring' may be more common in lessons where children are encouraged to shout out answers. Apart from ignoring incorrect answers, Rana's other main technique for dealing with them was to simply say, 'No' and repeat the question.

Rana: '8 tens? Equals?'
Incorrect answer
Rana: 'No. 8 tens? 8 tens? Equals? What is it?'
Incorrect answer
Rana: 'No. 8 tens. 8 tens? Equals? What?'
Incorrect answer
Rana: '80.'

Rana also used leading questions seven times in response to an incorrect answer. For example:

Rana: '45. Where is tens?'
Child: 'Five.'
Rana: 'Five is a ten? 40 (*strongly emphasised)* five, 40 (*strongly emphasised)* five. Where is tens?'
Child: '4.'
Rana: '4… 4 tens. 4 tens equal 40. Right? Excellent.'

She never probed children's answers. This could be due to the nature of the topic being taught or the fact that questions mostly gave children a choice between two answers.

Niveen asked 87 questions in 28 minutes. She was teaching multiplication to a Grade 3 class of 25 children. My coding of Niveen's questions is contained in Appendix 11.

In the first eleven minutes of the lesson Niveen was rehearsing multiplication facts: unsurprisingly 100% of the mathematical questions she asked were testing questions. Initial questions were directed at individual children. One of the surprising differences between Niveen's questioning in this part of the lesson and Rana's questioning overall was the length of wait-time. As Niveen's questions in this part of the lesson were testing recall, it might be expected that she would have given children little time to answer. On the contrary, Niveen waited considerably longer than Rana had done for a child to answer before repeating the question or asking other children. A typical interchange was as follows:

Niveen: 'Eight by three equal?'
(Waits 17 seconds)
Child: '21.'
Niveen: '21? Eight by three equal 21?'
Children: '24.'
Niveen: '24. Ok.'

It was not obvious why Niveen waited so long for children to answer: the curriculum expectation is that children 'know' the answer. One of the weaknesses of the study is that I did not discuss their lessons with the teachers in the interviews.

The interaction above also highlights some other common features of Niveen's questioning. In contrast to Rana, Niveen never said 'No' in response to a child's incorrect answer. She always *implicitly* acknowledged that an answer was incorrect either by repeating the question, or by repeating the answer using a questioning tone:

Niveen:	'Six by four equal?'
Child:	'28.'
Niveen:	'Six by four equal? Again. Six by four equal?'
Children:	'24.'
Niveen:	'24.'

If a child was unable to answer a question, or gave an incorrect answer she generally asked the question again of the whole class, or occasionally targeted another child. Niveen's responses to children's answers in this part of the lesson were exclusively *acknowledge but put aside*. She explicitly acknowledged correct answers and used praise more than Rana: the most common praise was again, 'Excellent'. However, as with Rana, she frequently repeated correct answers as an implicit acknowledgement of correctness. One of my difficulties in recording both teachers' responses was deciding whether to code these implicit acknowledgements. I decided not to code them: in future I might have two categories to differentiate between explicit and implicit acknowledgement.

The remainder of the lesson focused on multiplying 3- and 4-digit numbers by single-digit numbers using the standard short-multiplication algorithm. Her questioning in this part of the lesson became less targeted and more directed at the whole class, with children shouting out answers.

Similar to Rana, Niveen sometimes repeated a question that had been already answered correctly to encourage the children to rehearse the answer:

Niveen: 'Two in which place?'
Children: 'Units.'
Niveen: 'Two in which place?'
Children: 'Units.'
Niveen: 'Two in which place?'
Children: 'Units.'

As with Rana, questioning was highly structured and scaffolded. An example of the questioning that took place when calculating 895 × 3 is contained in Appendix 12. Niveen asked 23 questions in this interaction (lasting 2' 20"). The questions were generally short, and of similar forms. They took children step-by-step through the algorithm. Niveen asked more *cloze* questions than Rana. This may be because the focus was on helping children to acquire algorithmic knowledge: learning the precise words that they should use when carrying out these calculations. For example, 'Write seven and carry up…?' Niveen also asked several leading questions: sometimes when children were unable to answer a question, and sometimes to focus them on an important part of the algorithm. For example, 'Can I put two digits in this place?'

A crucial difference between Rana and Niveen's lessons is that Niveen asked four questions that attempted to stimulate different processes of mathematical thinking. On one occasion she asked the children to exemplify:

Niveen: 'Can I do two-digits or more by one-digit?'
Children: 'Yes.'
Niveen: 'Yes. Right. Like what?'
(Children shout out various numbers)

Whereas the second question ('Like what?') clearly asked the children to provide examples, I found the first question ('Can I do…') difficult to code. It did not seem to

either encourage children to state facts or to think mathematically. I do not think that it promoted authentic conjecturing because the children had already encountered 2- and 3-digit by single-digit multiplication. I therefore coded this question as orientating children: Niveen seemed to use this question to move the lesson from multiplication facts to multiplication by partitioning. Nevertheless, this indicates the inherent difficulty in coding questions: it is based on my perception as hearer (Ainley, 1987).

Unlike Rana, on three occasions Niveen followed up a child's answer and asked them to explain. For example:

> *(A 12 by 3 grid is shown on the whiteboard, 10 columns are yellow and 2 are blue)*
>
> *Niveen:* 'Anyone tell me how many squares we have?'
>
> *(Children shout out many different answers, most apparently random, which Niveen ignores. One child says 36)*
>
> *Niveen:* '*Name*. How you know?'
>
> *Name:* 'Twelve by three.'

I posit that this is still not a genuine enquiry question: Niveen knew, and was looking for, this answer.

Niveen's responses to children's answers changed during the second part of the lesson. Although she still most frequently responded to an incorrect answer by either repeating the question or repeating the answer, she increasingly ignored incorrect answers and sometimes didn't acknowledge correct answers: she moved quickly onto the next question without even repeating the answer. The act of moving on, rather than repeating the answer, implied correctness. These slight changes in technique may reflect the different contexts of the two parts of the lesson: learning an algorithm versus stating facts; questions targeted at individual children versus questions asked of the whole class. This highlights the danger of trying to generalise a teacher's questioning techniques on the basis of one lesson (Hill et al., 2012).

Clearly there were some key similarities in the questioning techniques use by Rana and Niveen in both lessons:

- Even more than previous studies, there was a predominance of highly scaffolded testing questions (Boaler & Brodie, 2004; Hiebert & Wearne, 1993). This could be due to a number of factors, including children's ages, the mathematics being taught or it could be related to culture.
- No genuine enquiry questions. (Ainley, 1988; Mason 2000, 2002a)
- No (or few) questions to stimulate mathematical thinking. (Watson & Mason, 1998)
- Rana and Niveen *reacted* to children's answers rather than *responded*, (Mason, 2015). Rana especially did not follow up children's answers: both teachers predominantly *acknowledged but put aside* answers or sometimes ignored incorrect answers. (Rowland et al., 2015)

Semi-structured interviews

The interviews were less informative than I had hoped. This is partly because my prepared (and contingent) questions were not very successful in focusing the teachers on their beliefs. Conducting the interviews in English was problematic: both teachers sometimes had difficulty expressing themselves.

Rana didn't comment on the teachers' questioning in either video and could only remember one question (in the second video) when prompted. For each video, when asked about how the teachers responded to children's answers, Rana observed that they said 'excellent' and encouraged the children. She also linked this to her own practice, saying that this was how she responded to children. Even when prompted Rana could not remember any incorrect answers. This might suggest that she didn't identify incorrect answers and how to deal with them as being noteworthy. Rana was unable to describe any differences between the two teachers' questioning techniques but she said that she thought the questioning in the second video was better. When

probed about this judgement, she described the practical nature of the activity rather than anything related to questioning.

Niveen gave more detailed descriptions of both videos than Rana: she noticed more. Given that Niveen noticed more *in-retrospect,* this might suggest that she noticed more *in-the-moment*. This could partly explain why she followed-up children's answers on three occasions: she noticed the opportunity to act (Mason & Davis, 2013).

In contrast to Rana, Niveen noticed and commented on the first question that the teacher asked in the first video. She described the teacher as trying to make a connection between fractions and real-life. Unprompted, Niveen identified the *explain* question that she used in her own lesson, 'How do you know?' as an example of a good question. She commented that sometimes she asks children if they 'have other ways' as this enables her to 'get her goal'.

Similar to Rana, Niveen did not remember any child giving an incorrect answer in the first video. She commented that the teacher asked questions in a friendly way and responded to children's answers with 'excellent'. She did remember one incorrect answer in the second video, but inaccurately described the episode, suggesting that the teacher had said 'No' but in a 'friendly way'.

Neither teacher commented on differences between the kinds of questions asked in the videos and the teachers' responses. It is impossible for me to decide how much this is because the teachers did not have the knowledge, (Rowland & Zazkis, 2015) or because of their beliefs, or because they did not attend to the questioning (Mason, 2002b).

Intervention phase

I give only an overview of Stages 1 and 2 of the intervention phase. This is mainly because there are some key episodes in these stages worthy of explanation and

analysis. It is also because Niveen and Rana didn't carry out Stages 3 and 4 as I had hoped. Rather than videoing whole lessons and then choosing significant episodes to reflect on, due to examination pressures they decided in advance which question(s) from the textbook they would video teaching. It would have been interesting, though beyond the scope of this study, to explore the reasons for their choices, but for this study it meant that I was unable to learn what they thought was noteworthy in the action of the lessons.

Stage 1

The summary of the results of Rana and Niveen's discussion about the pre-prepared belief statements is contained in Appendix 13.

The first statement that Rana and Niveen discussed highlighted key differences between them:

> 'Effective teaching of mathematics is based on giving clear explanations followed by structured practice questions for children to answer'.

Rana immediately said that she agreed with this. Niveen disagreed saying, "This is what we do in Egypt", but carried on to suggest that teachers, "should start with a question to make them [children] think" and that there are, "many ways to answer every problem". In the ensuing debate, which involved Rana giving examples to challenge Niveen's stance, Niveen seemed to be *aware* of opportunities to promote thinking, but didn't appear to *know how to act*.

There was considerable debate about the statement,

> 'If a child answers a question correctly then I know that they understand'.

Rana immediately said that she agreed but Niveen argued that, 'they might know the way but don't know the meaning'. After much discussion Niveen convinced Rana.

Rana's initial opinion possibly explained why her responses to children's correct answers were to *acknowledge but put aside*. Niveen's opinion seemed somewhat at odds with her practice.

Unsurprisingly, Rana agreed with the statement,

> 'The main reason that I ask questions is to test if the children have learned what I am teaching them'.

Rana's reason was that she needed to know if she 'had taught them correctly or not'. Niveen disagreed, which although consistent with her previous espoused beliefs seemed to conflict with what I had observed in her lesson. During the discussion Niveen suggested that there are two types of questions: those that test if the children understand and those that encourage them to think.

The statement,

> 'It is important that I tell a child if their answer is right or wrong'

caused much discussion. Niveen was initially worried about *how* a child is told, particularly if they give an incorrect answer. Rana initially argued that they should be told. Niveen challenged Rana:

> 'I have to discuss his answer... How he did this… You don't tell them, 'Right', 'Wrong'…'

Rana was persuaded, but added the caveat that children should still be told they are right in order to increase their self-confidence:

> 'Ask them first, 'Why?' or 'How you get this answer?'… then he will explain, then you will say, 'Excellent'… '

She suggested that if a child gave a wrong answer then she would not say 'No', but would ask the question again: this assertion is only partly supported by her practice that I observed.

There were some inconsistencies between their espoused beliefs and the practice that I had observed. There were also apparent contradictions between their responses to different statements. Exploring these inconsistencies and contradictions is beyond the scope of this study: they may reflect genuine differences between beliefs and practice or they could be due to each teacher only being observed once. Another factor may be that discussions were in English rather than Arabic.

This activity provoked a lot of discussion and reflection. As I related what they said to the lessons I had observed, the discussion seemed to enable them, especially Rana, to become more aware of the role their beliefs played in their practice (Korthagen et al., 2004). As with the teachers described by Swan (2011), through the discussion Rana and Niveen recognised that their current practices focused on children learning facts and developing fluency in standard methods through copying and repetition: they both actually expressed a desire to teach differently. This activity gave me much greater insight into their knowledge and espoused beliefs than the pre-evaluation interviews.

The video in the second part of the workshop also stimulated considerable discussion.

As soon as they had finished watching the video for the first time, Rana asked Niveen, ‘What was her [the teacher’s] first question?’ In contrast to her interview, Rana immediately seemed to be attending to the questioning. This is probably to be expected given that they had focused on questioning in the previous part of the workshop. They were both highly engaged whilst trying to describe what they noticed in the video, focusing closely on the dialogue. They experienced some difficulty understanding what was being said and struggled to reconstruct what happened due to the discussion being in English. Despite frequently pausing and rewinding the video the transcript proved essential. It took much replaying of the video before they understood the discourse, even with the transcript.

After much discussion and some prompting Rana and Niveen identified that the teacher's first question asked a particular child to *explain* something rather than give a specific answer. When I asked them more generally what they noticed about this teacher's questioning, Rana observed:

> 'She tried to discuss with them… she didn't ask them a specific question… she wants them to speak… she wants them to say what they think'.

When probed about what she meant by a specific question, Rana gave examples of testing questions. In contrast with her interview, Rana distinguished between different types of questions. Furthermore, she went on to say that the teacher encouraged the children, 'to say why… but not through a question… through a statement.' Rana demonstrated more awareness of the subtleties of questioning than she had in her interview. There could be many reasons for this including greater attention to questioning. It is also possible that the statements activity, which had encouraged Rana and Niveen to reflect on their own beliefs, had equipped them to apply this increased awareness to reflect on (different) practice. For example, when asked about how the teacher responded to the children, Rana immediately stated that, 'she never said that they were right or wrong', echoing one of the statements they had discussed earlier. Interestingly, neither Rana nor Niveen noticed a mistake made by one of the children in the video. I deliberately drew their attention to this via the transcript and encouraged them to describe in their own words what happened and how the teacher responded. (She wrote exactly what the child said on the board without comment). From my pre-intervention evaluations I thought that it was important to help them to notice incorrect answers and also to see how an experienced teacher reacts *in-the-moment* to such unexpected answers. Rana in particular found it difficult to interpret this episode. This led into an extended discussion about the role of the teacher in the lesson: 'She make the students speak and respond to each other' (Rana); 'She didn't ask a lot of questions' (Niveen).

Stage 2

The following exchange took place at the beginning of the second workshop:

Rana: 'Because of that first session and what I see, I decided to change my way of teaching.'

Researcher: 'Ok. Why did you decide to change your way?'

Rana: 'I was surprised… with that teacher we saw in the video.'

The unexpectedness of what Rana observed in the video had disturbed her, thus providing an opportunity for growth (Rowland et al., 2015; Mason 2002b). A crucial aspect of the video appears to be that it showed an unknown teacher demonstrating *different* practice (Jaworski, 1990). Rana went on to describe excitedly an episode from a lesson that she had just taught:

> 'It was a revision sheet booklet… Many statements and we just put true or false. I started to ask them, 'This statement is true or false?' They yell, 'me, me, me'… I choose one: 'It's true' 'Why it's true?'…'

Rana had become aware of the potential for probing children's thinking and learned an alternative way of responding to children's answers rather than just *acknowledge but put aside*. She had also noticed an opportunity to act differently. Rana was aware of the difference in her practice.

Rana then described how the first child 'didn't know', so she asked another child why it was true and he answered her, but in Arabic. This led to a discussion about why children sometimes don't answer. Niveen talked about children 'knowing' but not being able to express themselves. Rana described how one child in the lesson had said, 'It's true' and had given his reason when asked, but then another child said, 'No, that's wrong, because…' and they had argued with each other. Rana was very happy. Her description suggested that she, and the children, had engaged in a qualitatively different form of classroom discourse. Rana had reflected on what she had observed and discussed in the first workshop and then tried to enact this (Clarke & Hollingsworth, 2002; Jaworkski,

2001; Korthagen, 2004; Korthagen et al., 2006). Crucially, this had been her initiative: her move to enactment occurred earlier than I had expected.

This unplanned discussion lasted around 18 minutes. Consequently, it reduced the time for the planned activities. However, I thought that it was more important to start from their reflections on their own practice (Korthagen, 2004) and I also wanted to model contingent teaching.

Although Rana and Niveen were actively engaged in the mathematics activity (mental addition), in the subsequent discussion they found it difficult to identify characteristics of the teaching and learning that they had experienced despite considerable prompting. They attended to the *mathematics*, rather than my *teaching* of the mathematics. In this way, the activity was not very successful in stimulating discussion about dialogic teaching. They may have noticed some things, but as Mason (2002b) suggests these may not have been conscious.

The question and answer cards stimulated useful discussion about responding to children's answers. I began by describing an episode from a lesson when a child gives the answer 42 to the question 34 + 7: how would they respond? There was initially a long pause, but when Rana eventually suggested asking the question again, Niveen responded that this merely 'tells him his answer is wrong': interestingly, this was the tactic that Niveen used most frequently in her lesson. Rana accepted this and suggested asking other children if they agreed with the child's answer. Niveen on the other hand proposed asking the child to show how they had got the answer. Rana and Niveen had a number of different actions come to mind: with prompting they were able to reflect on and discuss these and they were also able to suggest what children might think and feel in reaction to different teacher responses. When I asked them how they deal with similar situations in their lessons, Rana laughed and said, 'No, it's wrong'. Rana in particular appeared to be becoming more self-aware.

Both teachers struggled to deal with the unexpected answers in the role-play part of the activity. During the activity their respective responses above ('Who agrees?' and 'How did you get that?') became their *standard* responses, along with the response, 'Why?' The activity provoked helpful discussion and it successfully enabled them to experience trying to deal with contingent events. The key question for me as teacher educator was whether having an increased awareness of self, having reasons to act differently and having knowledge of different actions would be reflected in growth in their *real* questioning practice.

Post-intervention evaluation

Lesson observations

All children's names are pseudonyms.

Rana's post-intervention lesson was a revision lesson with a Grade 1 class. My coding of her questions is contained in Appendix 14.

Rana targeted her questions at individual children much more than in the pre-intervention lesson.

Although the whole-class part of this lesson was nine minutes shorter than the pre-intervention lesson, one of the most startling differences between the two lessons was that Rana asked proportionately far fewer questions post-intervention. This is partly because she allowed children much more time to answer, but it also reflects that she asked far more questions that required children to explain answers.

The initial seven mathematical problems that Rana asked children were all testing questions that required children to state a fact or carry out a simple procedure. This was inevitable given that the lesson was a revision lesson and the questions were taken from the Ministry textbook. In contrast to her pre-intervention lesson, Rana asked no leading

questions or *cloze* questions. Her questioning was much less scaffolded, This may be because it was a revision lesson, or because it was later in the semester, or because there had been growth in her questioning. A typical interaction was:

Rana:	*(Writing on the whiteboard)* '64 plus 13 equal? If you know the answer just raise your hand. Ahmed?'
Ahmed:	'77'
Rana:	'77. Can you come and do it on the board?'
(Ahmed writes 77 on the whiteboard)	
Rana:	'How you get 77?'

Ahmed explained that he added the four and three and then the six and one. Rana asked the class who agreed with the answer. She then asked a specific child to say why they agreed. When the child could not explain Rana asked a third child. When he finished talking Rana *revoiced* his explanation. Rather than merely repeating what he said, '…six tens plus one ten…' Rana said, '…Sixty plus ten, six tens plus one ten…': she used the opportunity to clarify the meaning of six tens and emphasise the *quantity value* of the numbers rather than the *column values* (Thompson, 1999, 2000). She then asked the children if this was right. Whereas her practice in the pre-intervention lesson had been to repeat in order to acknowledge correct answers, in this lesson she revoiced on three occasions to clarify answers. Interestingly, her decision to emphasise the quantity value of the numbers was almost certainly influenced by the mathematical activity in the second intervention workshop, which focused on mental addition. I had emphasised the importance of the quantity value during these discussions.

The whole exchange lasted four minutes. In contrast to her first lesson, Rana *acknowledged and incorporated* (Rowland et al., 2015) rather than *acknowledged but put aside*. Whereas in the first lesson she had not asked any follow-up questions, in this exchange alone she asked five such questions. Compared to the pre-intervention lesson she asked more questions that encouraged children to explain, ('Why?' 'How do you know?') and tried to stimulate dialogue ('Who agrees with…?'). I suggest that this

indicates that Rana had gained *foundation* knowledge (Rowland et al. 2005). She had learned alternative actions and was enacting them.

However, the episode described above involved anticipated answers and planned actions: it does not reveal how Rana dealt with incorrect (unexpected) answers. The discourse in relation to the second problem in the lesson, which lasted three minutes, provides some evidence:

Rana:	'The smallest two-digit number is 11 or 10 or 12? Magdi? Which is the smallest two-digit number?'
Magdi	'11'
Rana:	'11 *(Writes 11 on the whiteboard*) Magdi said 11 is the smallest two-digit number. Who has another answer? What is the smallest two-digit number? Mona?'
Mona:	'10 is the smallest and 99 is the biggest.'
Rana:	'Smallest is 10 and bigger is 99. Mona said 10 and Magdi said 11. Who agree with Magdi and who agree with Mona? If you are agreeing with Mona stand up...'

Her response to the incorrect answer is completely different from her typical response in the pre-intervention lesson. Rather than ignoring the answer, or saying 'No', she asked other children to comment. In fact, in this lesson she didn't once say 'no' or ignore incorrect answers. Rana copied the technique that she had noticed the teacher in the video using (writing answers on the board). She also put into practice the action that she had suggested in the second workshop (asking the class if anyone has another answer).

Niveen's post-intervention lesson was a revision lesson with a Grade 3 class. My coding of her questions is contained in Appendix 15.

As with Rana, Niveen asked considerably fewer questions post-intervention. This again reflects the fact that she asked many more questions requiring children to explain their answers. However the proportion of questions targeted at the whole class with children shouting out answers remained similar (52%). This could be partly because the class was difficult to manage.

The initial mathematical problems that Niveen asked children were all testing questions. Most were multiple-choice from the Ministry textbook. A typical interaction was:

(Written on the board is 21 ÷ 3, with the choice of three answers: 4, 7, 8)
Niveen: '21 divided by three?'
Abdul: 'Seven.'
Niveen: " 'Seven. Why? Why you choose seven?'
Abdul: 'Seven by three equal 21.'
Niveen: 'Because seven by three equal 21. Anyone disagree?'
(Various indistinguishable comments from children)
Niveen: 'Who agree?'

Although Niveen had asked three follow-up questions pre-intervention, in this lesson she asked the question 'Why?' after every correct and some incorrect initial answers. Whilst she appeared to believe that it was important to encourage children to think and explain their answers, she did not yet seem to discriminate between which answers were useful or not to probe. For example, Niveen asked the question whether $^1/_4$ was 'third, quarter, half' in letters/words. As soon as a boy gave the answer, 'Quarter', she asked him, 'Why?' Unsurprisingly the boy was unable to explain. Niveen then asked if anyone else agreed with the answer and followed up by asking the class, 'Why?' No child was able to explain and over six further minutes was spent asking who agreed/disagreed and why. This suggests that Niveen was still reacting, rather than responding (Mason, 2015). What had changed from the pre-intervention lesson was the form of the reaction. This could be because she only had a limited range of actions that came to mind and she had decided which were effective and which were not. Nevertheless, she was now predominantly *acknowledging and incorporating* (Rowland et al., 2015).

The following interaction reveals the extended and different nature of the discourse in the post-intervention lesson, particularly in relation to her responses to incorrect answers:

(Writes on the board 18 ÷ 3 = 24 ÷ ___)

Niveen: '18 divided by three equal 24 divided by what?'

Manar: 'Eight.'

Niveen: 'Eight. What do you think?' *(Pointing to Mahmoud)*

Mahmoud: 'Six.'

Niveen: 'Six.' *(Points to Sara)*

Sara: 'Eight.'

Niveen: 'Eight.' *(Points to Jeena)*

Jeena: 'Six.'

Niveen: 'Six. Manar… Why you choose eight? *(Waits 5 seconds)* How you get it?'

(Manar found it difficult to explain, despite Niveen rephrasing the question a few times and encouraging her. After almost one minute Manar said that 24 divided by three equalled eight, which Niveen repeated. Niveen then asked Mahmoud why he chose six. After about ten seconds another child shouted out that 24 divided by six equalled six, which Niveen wrote down)

Niveen: 'Anyone have another opinion? Have another answer? Or another way?'

There is an obvious difference between this exchange and Niveen's questioning related to short multiplication in the pre-intervention lesson. Whereas her questioning in the pre-intervention lesson was highly scaffolded (she led children through the algorithm step-by-step), she initially provided no scaffolding for this problem and was clearly reluctant to lead the children at all. Admittedly, these are different types of problem and the fact that this was a revision lesson may partly explain the lack of scaffolding. This interaction continued for a further five minutes of unproductive discussion during which six and eight were still the only suggested answers. Niveen then asked a focusing question apparently to try and scaffold:

Niveen: '18 divided by three equals six. 24 divided by what equal six?'

Heba: 'Eight'

Niveen: 'Eight… You want to say six by eight equal 24? Right?'

Niveen's technique for dealing with different (especially incorrect) answers had clearly developed. She didn't ignore incorrect answers in this lesson, but similar to Rana she copied the teacher's technique from the video and recorded them. Whereas in the pre-

intervention lesson, repeating the question was an implicit acknowledgement of an incorrect answer, in this lesson she asked children if they had different answers, agreed or disagreed: she did this whether the answer was correct or incorrect. She also specifically repeated incorrect answers as well as correct answers. In the exchange described above, even after seven and a half minutes of discussion and failure to agree on the correct answer, Niveen persisted in incorporating children's incorrect answers: when many children suggested loudly that the answer was six, she wrote six and asked the child what 24 divided by six was and then what 18 divided by three was. It took just under eleven minutes of discussion to establish the correct answer.

There are some notable differences in the questioning techniques used by Rana and Niveen in comparison with the pre-intervention lessons:

- Fewer questions overall, and considerably fewer testing questions.
- Substantially less scaffolding.
- A noticeable shift from *acknowledge but put aside* children's answers to *acknowledge and incorporate*: this included both correct and incorrect answers: there was a considerably greater proportion of questions that asked children to explain their answers or asked other children if they agreed or disagreed with an answer.

Semi-structured interviews

These interviews were carried out during Ramadan.

Rana was extremely tired and found it difficult to concentrate: she couldn't recount anything after I played the first video. After I replayed it, in contrast to the pre-intervention interview she noticed the teacher's questions and how she responded to the children's answers, including the incorrect answer. Rana noticed that the teacher didn't involve the other children in dialogue and focused only on one child at a time: she judged that this was a weakness. Rana struggled to give an account of key episodes in

the second video, but did observe that the teacher didn't embarrass the child who gave an incorrect answer. Compared to pre-intervention, Rana seemed more aware of incorrect answers. She also judged that the teacher in the second video used questioning to engage other children. When asked what she had learned during the project, Rana talked about wanting to ask questions to make children think. She also talked about how her responses to children's incorrect answers had changed from, 'No, you are wrong' or 'Excellent':

> 'Now I try to be… patient… and make the other children to share with me. To make the children say to his friend his question, not to me.'

There were differences in Niveen's description of the first video compared to pre-intervention. She noticed the incorrect answer and she also echoed Askew's (2012) phrase 'private talk' to describe when the children were talking in pairs. She described some of the questions as being 'closed', focusing on what the children have previously learned. Similar to pre-intervention, Niveen judged the teacher's responses to correct answers ('Excellent') as 'good' because they 'encouraged students'. Although Niveen's responses to children's answers had shifted more to *acknowledge and incorporate*, she didn't immediately notice that the responses from the teacher in the video were always *acknowledge but put aside*. Only after considerable probing did she comment that the teacher never asked a child to explain their answer. Unlike pre-intervention, Niveen described differences in the questioning between the two videos:

> *Niveen: 'The previous teacher just take the answer and… 'It's good… it's brilliant…'*
>
> *Researcher: 'What did this teacher do… that was different?'*
>
> *Niveen: 'When she asked, she want to know why you give this answer.'*

She also commented that, 'she made the other students to correct mistakes'. Niveen was able to distinguish different characteristics of the questioning. This could be

because she had attended to the questioning more, or her knowledge had improved, or she had developed the language to express these differences.

Conclusion

Research aims

This study enabled me to analyse the beliefs and practices of the two teachers. I learned more about how they asked questions, the kind of questions they asked and how they responded. Before the intervention, questions were predominantly asked of the whole class and 'chorusing' of answers was common. Both teachers asked a large number of short, highly-scaffolded testing questions. Neither teacher asked any genuine enquiry questions. Only Niveen asked a small number of questions to stimulate mathematical thinking. Both teachers reacted to children's answers and mostly *acknowledged but put aside* (often implicitly) or sometimes ignored incorrect answers.

There are important caveats however:

- These findings were based on only one lesson observation of each teacher. The questioning in these lessons may not have been representative, due to the nature of the mathematics topic or the context of the lesson. As Shahrill and Clarke (2014) note, 'A teacher's practice cannot be characterised by a single lesson' (p.1).
- These findings cannot be generalised and applied to all primary mathematics teachers or even all beginning primary mathematics teachers in my schools. Even though the initial observations yielded similar results across all seven teachers, the sample size was small.

The study was successful as I observed growth in both teachers' questioning techniques. Rana in particular targeted questions much more and there was less 'chorusing'. Both teachers asked considerably fewer (testing) questions and scaffolding was greatly reduced. Whereas Mason (2002a) emphasises that the key to effective scaffolding is *fading*, and this was absent in the initial observations, in the final observations there were very few directing questions, particularly from Niveen.

> ‘If everything is always explicit, students are supported in becoming dependent on the teacher to make things explicit; but if too much is left implicit, many students may never encounter what is being made available to them.’
> (Mason, 2000, p.99)

This shift in their practice may be described as moving from too much explicitness to too much implicitness. For example, when Niveen gave the children the follow-up problem, 14 ÷ 2 = 35 ÷ ___ , they shouted out similar incorrect answers and were unable to solve it. This is despite the eleven minutes spent working on the previous problem during which Niveen had asked only one directing question.

There was growth in how both teachers dealt with children’s answers, with *acknowledge and incorporate* (Rowland et al., 2015) becoming the norm. There was qualitatively different discourse in the final lessons, with both teachers attempting to incorporate both incorrect and correct answers and involve more children. The shift to *acknowledge and incorporate* was not without its issues: Rana and Niveen still *reacted* rather than *responded* (Mason, 2015). Rowland et al. state that ‘a degree of automaticity in one’s own actions’ (p.87), is needed to create space for reflection-in-action. This might suggest that there has been growth in Rana and Niveen’s *foundation* knowledge but not in their *contingent* knowledge (Rowland et al., 2005). However, if mathematical knowledge is key to teachers’ *knowing-to-act*, (Mason & Davis, 2013; Rowland & Zazkis, 2015), then this might suggest that Rana and Niveen had not yet developed the *foundation* knowledge that they need to help them respond to children’s unexpected answers.

Again there are a number of important caveats:

- These findings were based on only one lesson observation of each teacher. Once again, the questioning in these lessons might not be representative.
- I cannot assume that any changes in their practice will become embedded in the long-term. This is particularly relevant given that the final observations took place

very soon after the intervention and immediately before an almost four-month summer break. I have therefore planned to visit both teachers again during the next semester.

Based on these findings I have identified two specific areas for further support:

- Scaffolding and fading. Supporting teachers to move *gradually* from explicitness to implicitness though asking a, 'sequence of directed or focused questions which over time gradually become more general and more indirect as prompts until they disappear altogether' (Mason, 2000, p.100).
- Identifying and supporting growth in the knowledge teachers need to respond rather than react to children's unexpected answers.

Methodology

Evaluations

One of my greatest difficulties was using the observation checklist. This was not just the practical difficulty of trying to code questions accurately *in-the-moment*. As highlighted previously, some of the questions were difficult to code even when using the audio recording of the lessons. I hadn't anticipated sufficiently that some of the categories were not mutually exclusive: whereas coding questions against one category does not fully convey the complexity of questioning, multiple-coding using a simple checklist like mine may lead to other problems, such as an inflated sense of the number of questions asked. Another problem related to implicit and explicit acknowledgement of children's answers. Naively, I had not predicted the possible variations of *acknowledge but put aside*. In many ways, trying to use the checklist highlighted the complexity of questioning, but it also pointed out my own uncertainties and lack of knowledge. Additionally, my attempt to code questions was based purely on the form rather than the function of the question. I unfortunately made little attempt to explore the intentions of

the questions that were asked, but based my judgements purely on my perceptions as researcher. Admittedly, this raises the issue of how a researcher codes questions where the espoused intention of the teacher and perception of the children are different. As with Boaler and Brodie (2004) my coding 'does not capture important issues of sequencing or intent' (p.781).

Although this was an initial study, in retrospect, my checklist was too encompassing and took insufficient account of my context. Given my knowledge of teaching in Egypt, it was unrealistic to expect that teachers would ask many questions that stimulated mathematical thinking. Although the checklist enabled me to record these where they occurred, it may have been better to focus more precisely on analysing just one aspect of questioning, such as initial teacher questions or teachers' responses to answers. Obviously this runs the risk of ignoring the complexity of questioning but it could enable me to explore the chosen aspect in greater depth and prepare a more targeted intervention.

Shahrill and Clarke (2014) advocate observing a sequence of lessons to understand a teacher's practice. In any future study I would also observe more than one lesson, but I would ensure that the lessons covered a range of mathematical topics. Hopefully this would ensure that I observed a more representative range and diversity of the teachers' questioning practice. Rather than just coding individual questions, I would consider focusing on sequences of episodes of discourse: in this study these provided me with much greater insight into the teachers' practice. As in Shahrill and Clarke's study, I would video the lessons rather than audio-record them, whilst recognising the issues associated with video being more intrusive. In place of the semi-structured interviews that I conducted in this study, I would show the teachers video of some particular episodes from their lessons: this would enable me to discuss their intentions and it might also give me better insight into their beliefs. I would consider coding questions in collaboration with the teachers. This would also serve as a model for Stages 3 and 4 of

the intervention. Clearly, if the teachers watch videos of their own practice then this may generate issues identified by some researchers such as emotional involvement leading to reduced ability to reflect critically, and increased self-attention (Siedel et al., 2011). Alternatively it may motivate teachers and stimulate their prior knowledge and beliefs more effectively (Borko et al., 2008).

Intervention activity

Despite issues associated with the teachers working in English rather than Arabic, the intervention activity appeared successful. Although I cannot prove that the growth in questioning described above was due to the intervention activity, comments such as the one made by Rana about the first workshop, combined with neither teacher reporting any other possible contributory factors, suggest that the intervention activity was the catalyst for this growth.

One of the obvious limitations in the intervention activity was its brevity. Furthermore, the unfortunate timing of the examinations meant that Rana and Niveen were not fully focused on Stages 3 and 4. Consequently, I would argue that the full potential of the intervention was not realised as they spent less time reflecting on their practice and they had less support to move from *knowing-about* to *knowing-to-act* (Mason, 2015). This could be a major reason why they were still reacting rather than responding to children's answers.

Stage 1 in particular was very productive. The belief statements activity successfully made Rana and Niveen more aware of the reasons underpinning their practice and it challenged their beliefs. An obvious limitation was that there was only the three of us involved in discussion: more teachers would likely have produced a greater diversity of opinions and argument. As mentioned previously, the video was also clearly successful in that it unsettled and disturbed the teachers by showing them different practice that encouraged them to reflect on their own practice. Blomberg et al. (2014) and other

researchers suggest that beginning teachers in particular may benefit from some form of scaffolding when first watching videos of lessons. I had decided to use virtually no scaffolding for this study, but in future I would prepare some focused questions and spend time looking at particular episodes in more detail. For example: ‘How did the teacher respond to that answer?’ ‘Why might (s)he have responded in this way?’ ‘Could (s)he have responded differently?’ Such questions in many ways may support my questioning and help me better focus the attention of the teachers.

A strength of this study was the collaboration with the teachers. Planning the intervention activity in consultation with them and responding and adapting to their needs not only allowed me to model contingent teaching, but it successfully gave Rana and Niveen responsibility for their own development. This is evidenced by the way that they both began to try and enact what they had reflected on during the first workshop. The collaborative approach also successfully initiated the concept of ‘co-learning partnerships’ (Jaworski, 2001) with teachers working together and reflecting on their practice supported by the teacher educator. This has been commented on positively across the school group and I have investigated the possibility of setting up a video club with some teachers in Rana and Niveen’s school.

Most published studies related to using video within professional development tend to describe long-term projects. My study suggests that video may be a catalyst to growth even in a very short intervention: this obviously needs further investigation. It cannot be assumed that the intervention activity would encourage similar growth in other primary mathematics teachers across the schools. However, the study enabled me to reflect on the activities, adapt them and then prepare a short professional development programme that I have already begun to roll out to all primary mathematics teachers. This was particularly at the request of the five teachers who had been unable to continue with the study.

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Appendix 1

Classifications of teachers' questions

Author(s)	Classifications
Ainley (1987)	• Pseudo-questions • Implicit questions • Genuine questions • Test questions • Provoking questions
Ainley (1988)	*A small-scale project exploring teachers and children's perceptions of teachers' questions* • Pseudo-questions • Genuine questions • Testing questions • Directing questions
Alexander (2008)	• Authentic questions • Test questions
Boaler and Brodie, (2004)	• Gathering information, leading students through a method • Inserting terminology • Exploring mathematical meanings and/or relationships • Probing, getting students to explain their thinking • Generating discussion • Linking and applying • Extending thinking • Orienting and focusing • Establishing context
Franke et al. (2009)	*A case study of three elementary teachers following a Cognitively Guided Instruction programme* • General questions • Specific questions • Probing sequences of specific questions • Leading questions
Hiebert and Wearne (1993)	Asking children to recall: • Recall facts • Recall procedures • Recall prior work Asking children to describe strategies: • Describe strategy • Describe alternative strategy Asking children to generate problems: • Generate story • Generate problem Asking children to examine underlying features: • Explain • Analysis

Author(s)	Classifications
Mason (2000)	• Focusing attention of students • Testing (monitoring students' understanding) • Enquiry
Mason (2002a)	• *Norming* and controlling questions • Testing questions • Focusing questions • Genuine enquiry
Moyer and Milewicz (2002)	*A study of questioning strategies used by 48 pre-service teachers during one-to-one diagnostic mathematics interviews* • Checklisting • Instructing (guiding and leading) • Probing and follow-up
Nicol (1999)	*A study of questioning used by 14 prospective Grade 6/7 teachers* • Questions to learn what students are thinking • Questions to get students to the answer • Questions to test students' thinking
Sahin and Kulm (2008)	*A case study of a first-year teacher and an experienced teacher's intentions and questions when teaching sixth-grade mathematics* • Factual questions • Guiding questions (often a sequence of questions consisting of factual questions, or open-ended questions or a mix of both) • Probing questions
Watson and Mason (1998) Jeffcoat et al. (2004)	Grouped processes of mathematical thinking: • Exemplifying – Specialising • Completing – Deleting – Correcting • Comparing – Sorting – Organising • Changing – Varying – Reversing – Altering • Generalising – Conjecturing • Explaining – Justifying – Verifying – Convincing* – Refuting * Convincing is not included in Jeffcoat et al. (2004)

Appendix 2

Checklist for coding questions

Targeting questions

T1: Asks question of whole class and encourages shouting out (individually/unison)
T2: Asks question of whole class but requires children to volunteer answers
T3: Directs question at a specific child

Types of question

Q1: Asks question that requires children **to state facts or procedures** *What is the sum of…? How do you add…?*
Q2: Asks question that requires children **to use mathematical terminology** *What is the name of…? How do we write…? What is the meaning of…?*
Q3: Asks question that requires children **to exemplify** *Which two numbers add to 10? Can you give an example of…?*
Q4: Asks question that requires children **to complete or correct** *What is wrong with…? What can be added so that…?*
Q5: Asks question that requires children **to compare and contrast** *What is the same about…? Which is different?*
Q6: Asks question that requires children **to change or vary** *What happens if you change…? Can you do this in a different way…?*
Q7: Asks children **to make links** between mathematical relationships and ideas *Where else have you used…? What other ways could we…?*
Q8: Asks question that requires children **to conjecture, generalise or extend** *Would this work with different numbers? Is this always true?*
Q9: Asks question that requires children **to explain, justify, verify or refute** *How would you work out…? Can you explain what…? Can you explain why…?*
Q10: Asks question **to orientate** children and focus them *What is the question asking you? What is important information in this sentence?*
Q11: Asks leading question that direct children to the expected answer
Q12: Asks non-mathematical question

Responding to answers

R1: Ignores ‘wrong’ answers and waits for the ‘correct’ answer
R2: Replies to a child’s answer to acknowledge whether it is ‘right’ or ‘wrong’
R3: Follows up a child’s answer to ask them to clarify or explain (Note Q code above)
R4: Follows up a child’s answer by asking another child to repeat/rephrase it *Can you say what Ahmed said in a different way?*
R5: Follows up a child’s answer by asking other children to comment or add (Note Q code above) *Is it right? What do you think about that? Can you say something more?*
R6: Other response, including revoicing

Appendix 3

Questions for pre- and post-intervention evaluations

Watch two short videos (1’ 25’’ and 8’ 24”) of episodes from two lessons as a stimulus.

After each video:

- What did you notice?
- What questions did the teacher ask?
- Why do you think the teacher asked these questions?
  - What was the purpose of the questions?
  - Why do you think the teacher asked them in this way?
- What other ways could she have questioned the children?
  - How do you think the children might have answered differently?
- What did you notice about how the teacher responded to the children’s answers?
  - What other ways could she have answered?

After both videos:

- Can you think of an example of ‘good’ questioning that you saw?
  - Why do you think that it was good?
  - What do you think are the features of good questioning?
- Can you think of an example of ‘poor’ questioning that you saw?
  - Why do you think that it was poor?
- What are the different reasons that you ask questions?
- How do you generally respond to children’s answers?
- In what ways do you think that questioning can promote learning?

Appendix 4

Summary of intervention activity

Stage 1 (Workshop) **1.5 hours**

Reflection on beliefs about questioning (particularly dealing with students' responses) within a mathematical context:

1.1 Participants discuss pre-prepared statements about teaching and learning mathematics and sort them into whether they *agree*, *disagree* or are *unsure*. Participants can modify any statements if they wish. This leads into a more general discussion on beliefs, referring to Askew et al.'s (1997) three teacher orientations.

1.2 Participants watch and then reflect on a video of an unknown teacher's lesson.
- What do they notice? (Giving an *account of*)
- What do they notice about the teacher's questioning? (Giving an *account of*)
- Why do they the think that the teacher is asking these questions? What do they suggest about what the teacher believes about how children learn mathematics? (Giving an *account for*)
- What do they notice about the children's responses and how the teacher responds to them? (Giving an *account of*)
- Why do they think that the teachers respond in this way? (Giving an *account for*)

Stage 2 (Workshop) **1.5 hours**

Reflection on questioning behaviours (particularly in dealing with students' responses) within a mathematical context:

2.1 The participants work on a mathematical task and the teacher educator models dialogic teaching. This is followed by discussion on the teaching and learning approaches experienced.

2.2 Role play: one of the participants is a teacher asking a question and then responding to a child's (the other participant's) answer (using pre-prepared cards).

2.3 Discussion about the knowledge and skills that teachers need when questioning.

Stages 3 and 4: **2.5 hours x 2**

Reflecting-on practice. Participants each teach two lessons which are observed and videoed by the other participant:

3.1 After each lesson, each participant reflects individually and notes:
- What they intended, expected and how they prepared
- Key episode(s) which they give *an account of*
- An *account for* the key episode(s)
- Alternative actions

3.2 The key episode(s) of the lesson are then discussed in pairs with teacher educator input.

3.3 The participants plan to try and enact the alternative actions in a subsequent lesson.

Appendix 5

Intervention activity: beliefs statements

1. Children should be supported to work things out for themselves rather than being given methods to follow.

2. Children learn mathematics through memorising basic facts and repeatedly practising skills.

3. Effective teaching of mathematics is based on giving clear explanations followed by structured practice questions for children to answer.

4. Children will learn mathematics more efficiently if they listen carefully to my explanations about how to solve a problem and then practise those methods.

5. Understanding the method used to solve a problem is as important as being able to use the method accurately.

6. It is important that I tell a child if their answer is right or wrong.

7. If a child answers a question correctly then I know that they understand.

8. The main reason that I ask questions is to test if the children have learned what I am teaching them.

9. Telling children a method to use and giving them sufficient opportunities to practise using it is an effective way of teaching mathematics.

10. Children learn mathematics more effectively if they are able to discuss their ideas and answers to mathematical problems with each other.

11. Children learn mathematics more effectively if they are able to develop and use their own methods for solving problems.

12. I always begin with easier questions and problems and work up to harder ones, as otherwise children make mistakes.

13. It is better to spend time looking at different methods of answering a few problems rather than answering many problems using one method.

14. I try to make sure that children don't make mistakes when they are learning something new.

Appendix 6

Intervention activity: video transcript

Equivalent Fractions: placing fractions on a number line. Grade 4

Teacher 1	Ok. Graham and Kelly had something very interesting to say about why um... one half should go in the same, is another name for two fourths and should go in the same place. Graham do you want uh to tell us? Graham told me.
Kelly	Well, one half plus one half equals a whole, and two fourths plus two fourths equals a whole,
Teacher 1	Well that's an interesting argument… one half plus one half equals a whole, and two fourths plus two fourths equals a whole. Does that make sense?
Erik	Uh I think they're kind of off. It's true, but they're kind of off. It's true that one half plus one half equals one whole, but two fourths plus two fourths equals four fourths which is one whole.
Teacher 1	*[Writing on the chalk board]* Ok, so we have one half plus one half equals one whole, two fourths plus two fourths equals one whole, or two fourths plus two fourths equals four fourths equals one whole.
	How many of you agree with that? Does that make sense?
	That's very neat. I hope you notice, Mrs. Phillips, that they're adding fractions.
Teacher 2	Yes, I noticed.
Teacher 1	That's very neat. That's very neat. Ok. That's very neat. David? Hold on let's hear what David has to say for a moment?
David	Well I was thinking. That uh that like four fourths equals one half which equals two halves.
Teacher 1	Say that one more time David.
David	Uh, four fourths should be equals one half *[Teacher 1 writes on the board].*
Erik	Four fourths equals one half? Four fourths? Two fourths.
David	Two fourths.... oh wait one whole.
Erik	Four fourths is equal to one whole.
David	Yeah that's what I mean.
Teacher 1	*[Continues to write on board.]* You want me to change this? Four fourths equals one whole.
David	Yeah um and two fourths is equal to one half.
Teacher 1	Why?
David	Because um.... two fourths uh would be equal to right up right next to is like in the middle of like one whole and um…
Teacher 1	In the middle between what numbers?
David	Zero and one.
Teacher 1	Between zero and one. Ok.

David	and um so then one half of it would be in the same place.
Teacher 1	Ok.
David	So the half would have to be in the same place.
Teacher 1	Ok.
David	Because if you put them right next to each other the one half would be in the same place as both of them because would one half would be equals on both sides.
Teacher 2	What might be helpful is that David drew a picture here, which I found very helpful to me in understanding his argument and I think it might be hard for everyone out there to understand what David says.
Teacher 1	Would you sketch it up here David?

Appendix 7

Intervention activity: question and answer cards

Teacher: "What is 3 more than 5?"

Child: "7"

How do you respond?

Teacher: "What kind of shape is this?" 

Child 1: "A diamond"

How do you respond?

Child 2: "A parallelogram"

How do you respond?

Teacher: "Can you tell me a fraction bigger than $^{2}/_{5}$?"

Child: "$^{1}/_{3}$"

How do you respond?

Child: "Because the smaller the denominator the bigger the fraction"

How do you respond?

Appendix 8

Intervention activity: supporting PowerPoint slides

Talk in the mathematics classroom

Now...?

‘The emphasis is on children reporting already complete mathematics and the talk resembles a series of monologues, with one child offering their solution followed by another. The other class members are [...] passive listeners [...] which usually means looking attentive and not interrupting.’ (p.128)

Askew, M. (2012). Transforming primary mathematics. Abingdon: Routledge

Future...?

?

1

Dialogic teaching

Questions and statements that encourage students to think, explain, reason, conjecture and generalise rather than just remember

Answers that are explained, probed, followed up and built upon rather than just taken

Sequences of questions which build together to form coherent and deepening dialogue rather than a series of monologues

2

Types of questions

- **Testing questions**
  What is 7 + 4? What is this shaped called?
- **Controlling & focusing questions**
  Which number do we start with? What do we do with the 2?
- **Cloze questions**
  This shape is called a…? The next thing we do is carry down the...?
- **Genuine enquiry**
  How did you work that out? Can you explain why...?

'The key to effective questioning lies in using… controlling questions rarely, focusing questions sparingly and reflectively and genuine enquiry-questions as much as possible.' (p.257)

Mason, J. (2002). Minding Your Qs and Rs: effective questioning and responding in the mathematics classroom*, in L. Haggerty (ed.) Aspects of Teaching Secondary Mathematics: perspectives on practice*. 248–258. RoutledgeFalmer, London

3

Questions can be asked that require children to:

- **state facts or procedures**
  What is the sum of…?
  How do you add…?
- **use mathematical language**
  What is the name of…?
  How do we write…?
- **exemplify**
  Which two numbers add to 10?
  Can you give an example of…?
- **complete or correct**
  What is wrong with…?
  What can be added so that…?
- **compare and contrast**
  What is the same about…?
  Which is different?
- **change or vary**
  What happens if you change…?
  Can you do this in a different way…?
- **make links between mathematical relationships and ideas**
  Where else have you used…?
  What other ways could we…?
- **conjecture, generalise or extend**
  Would this work if…?
  Is this always true?
- **explain, justify, verify or refute**
  How would you work out…?
  Can you explain why…?

4

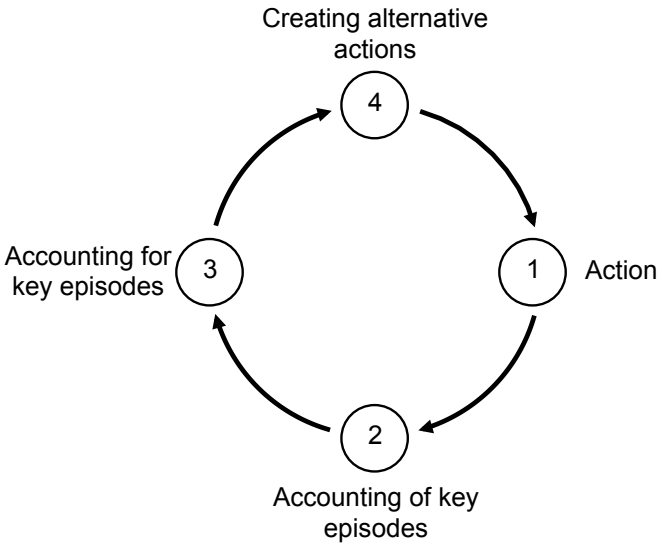
Responding to children's answers and ideas

- **Rephrasing** what a child has said and then asking them if you are correct.
  Sara, so you think that…
- **Repeating**: asking a child to say what another child said in their own words.
  Can you explain what Sara has just said?
- **Comparing**: asking children to compare their ideas and methods.
  Do you agree or disagree with what Sara just said and why?
- **Adding to**: asking a child to say more.
  Can you tell me a bit more Sara?
  Can anyone add to what Sara has just said?
- **Reasoning**: asking a child to explain why they think something, or why they have done something, or asking other children to try and explain.
  Why do you think that…?
  Ahmed, why do you think that Sara has done that?

5

Appendix 9

Prompts for reflection



Step 1: Describe what I intended

1. What did I want to achieve?
2. What did I expect?
3. What did I want to try?

Step 2: Describe key episode(s)

4. What did I do?
5. What did the children do?

Step 3: Give reasons for the key episode(s)

6. What might I have been thinking and feeling?
7. What are the possible reasons for what I did?
8. What are the possible reasons for what the children did, thought and felt?
9. What does this mean for me? What have I discovered?

Step 4: Create alternative actions

10. What other possible ways could I have acted and thought?
11. What are advantages and disadvantages of each?
12. What will I do next time?

Appendix 10

Rana: pre-intervention lesson (33 minutes)

Targeting questions

T1: Asks question of whole class and encourages shouting out (individually/unison)	53
T2: Asks question of whole class but requires children to volunteer answers	7
T3: Directs question at a specific child	35

Types of question

Q1: Asks question that requires children **to state facts or procedures** *What is the sum of…? How do you add…?*	78
Q2: Asks question that requires children **to use mathematical terminology** *What is the name of…? How do we write…? What is the meaning of…?*	2
Q3: Asks question that requires children **to exemplify** *Which two numbers add to 10? Can you give an example of…?*	
Q4: Asks question that requires children **to complete or correct** *What is wrong with…? What can be added so that…?*	
Q5: Asks question that requires children **to compare and contrast** *What is the same about…? Which is different?*	
Q6: Asks question that requires children **to change or vary** *What happens if you change…? Can you do this in a different way…?*	
Q7: Asks children **to make links** between mathematical relationships and ideas *Where else have you used…? What other ways could we…?*	
Q8: Asks question that requires children **to conjecture, generalise or extend** *Would this work with different numbers? Is this always true?*	
Q9: Asks question that requires children **to explain, justify, verify or refute** *How would you work out…? Can you explain what…? Can you explain why…?*	
Q10: Asks question **to orientate** children and focus them *What is the question asking you? What is important information in this sentence?*	
Q11: Asks leading question that direct children to the expected answer	7
Q12: Asks non-mathematical question	8

Responding to answers

R1: Ignores 'wrong' answers and waits for the 'correct' answer	10
R2: Replies to a child's answer to acknowledge whether it is 'right' or 'wrong'	77
R3: Follows up a child's answer to ask them to clarify or explain (Note Q code above)	
R4: Follows up a child's answer by asking another child to repeat/rephrase it *Can you say what Ahmed said in a different way?*	
R5: Follows up a child's answer by asking other children to comment or add (Note Q code above) *Is it right? What do you think about that? Can you say something more?*	
R6: Other response, including revoicing	

Appendix 11

Niveen: pre-intervention lesson (28 minutes)

Targeting questions

T1: Asks question of whole class and encourages shouting out (individually/unison)	45
T2: Asks question of whole class but requires children to volunteer answers	2
T3: Directs question at a specific child	40

Types of question

Q1: Asks question that requires children **to state facts or procedures** *What is the sum of…? How do you add…?*	57
Q2: Asks question that requires children **to use mathematical terminology** *What is the name of…? How do we write…? What is the meaning of…?*	1
Q3: Asks question that requires children **to exemplify** *Which two numbers add to 10? Can you give an example of…?*	1
Q4: Asks question that requires children **to complete or correct** *What is wrong with…? What can be added so that…?*	
Q5: Asks question that requires children **to compare and contrast** *What is the same about…? Which is different?*	
Q6: Asks question that requires children **to change or vary** *What happens if you change…? Can you do this in a different way…?*	
Q7: Asks children **to make links** between mathematical relationships and ideas *Where else have you used…? What other ways could we…?*	
Q8: Asks question that requires children **to conjecture, generalise or extend** *Would this work with different numbers? Is this always true?*	
Q9: Asks question that requires children **to explain, justify, verify or refute** *How would you work out…? Can you explain what…? Can you explain why…?*	3
Q10: Asks question **to orientate** children and focus them *What is the question asking you? What is important information in this sentence?*	16
Q11: Asks leading question that direct children to the expected answer	2
Q12: Asks non-mathematical question	7

Responding to answers

R1: Ignores 'wrong' answers and waits for the 'correct' answer	12
R2: Replies to a child's answer to acknowledge whether it is 'right' or 'wrong'	34
R3: Follows up a child's answer to ask them to clarify or explain (Note Q code above)	2
R4: Follows up a child's answer by asking another child to repeat/rephrase it *Can you say what Ahmed said in a different way?*	
R5: Follows up a child's answer by asking other children to comment or add (Note Q code above) *Is it right? What do you think about that? Can you say something more?*	
R6: Other response, including revoicing	

Appendix 12

An episode from Niveen's pre-intervention lesson: 895 × 3

Niveen	Three by five equal?
Child 1	15.
Niveen	15. Can I write 15 here? *(No pause).* How many digits?
Children	Two.
Niveen	Two. Can I put two digits in this place?
Children	No.
Niveen	No. I put…?
(Indiscernible shouting from children. Niveen targets a child)	
Niveen	Three by five equal?
Child 2	Three by five equal 15.
Niveen	Put…?
Child 2	Erm… Put five.
Niveen	Put five. And carry up…?
Child 2	One.
Niveen	One. Excellent. Three by nine equal?
Child 2	Three by nine equal… is it 27?
Niveen	27. Excellent. 27. Can I write 27?
Children	No.
Niveen	No.
Child 2	Carry up two. Carry up one.
Niveen	Write seven and carry up…?
Child 2	One.
Children	Two.
Niveen	Two… Carry up two… 27. But… nine carry up… something? Nine carry up something?
(Indiscernible murmurs from children. Some say "yes" and some say "no" in Arabic)	
Niveen:	Look. Nine carry up something? *(Points to the 'one' previously carried up)*
Children	No.
Niveen	No?
Child 3	One.
Niveen	Which one?
Child 3	One! Carry up one!
Niveen	Nine carry up…?
Child 3	Nine carry up one.
Niveen	One. Nine carry up one. Ok. So one plus 27 equal?
Child 2	One plus 27 equal… 28.

Niveen	28. Can I write 28? No. I write eight and carry up…?
Children	One.
Niveen	One?
Child 2	Two.
Niveen	Two. Carry up two. Three by eight equal?
Child 2	Three by eight equal... 26.
Niveen	Three by eight equal?
Child 2	24.
Niveen	24. Eight carry up something?
Child 2	Two.
Niveen	Two. Carry up two. Two plus twenty-four?
Child 2	Two plus twenty-four… equal… erm… 26.
Niveen	Write it. Understand? Now it's easy?

Appendix 13

Workshop 1: results of discussion about beliefs

Disagree	Unsure	Agree
I try to make sure that children don't make mistakes when they are learning something new	Effective teaching of mathematics is based on giving clear explanations followed by structured practice questions for children to answer	Children should be supported to work things out for themselves rather than being given methods to follow
If a child answers a question correctly then I know that they understand	The main reason that I ask questions is to test if the children have learned what I am teaching them	It is better to spend time looking at different methods of answering a few problems rather than answering many problems using one method
Children will learn mathematics more efficiently if they listen carefully to my explanations about how to solve a problem and then practise those methods	I always begin with easier questions and problems and work up to harder ones, as otherwise children make mistakes	Understanding the method used to solve a problem is as important as being able to use the method accurately
Children learn mathematics through memorising basic facts and repeatedly practising skills		Children learn mathematics more effectively if they are able to develop and use their own methods for solving problems (Rana added: 'For brighter students')
It is important that I tell a child if their answer is right or wrong		Children learn mathematics more effectively if they are able to discuss their ideas and answers to mathematical problems with each other
Telling children a method to use and giving them sufficient opportunities to practice using it is an effective way of teaching mathematics		

Appendix 14

Rana: post-intervention lesson (24 minutes)

Targeting questions

T1: Asks question of whole class and encourages shouting out (individually/unison)	2
T2: Asks question of whole class but requires children to volunteer answers	8
T3: Directs question at a specific child	9

Types of question

Q1: Asks question that requires children **to state facts or procedures** *What is the sum of…? How do you add…?*	7
Q2: Asks question that requires children **to use mathematical terminology** *What is the name of…? How do we write…? What is the meaning of…?*	1
Q3: Asks question that requires children **to exemplify** *Which two numbers add to 10? Can you give an example of…?*	
Q4: Asks question that requires children **to complete or correct** *What is wrong with…? What can be added so that…?*	
Q5: Asks question that requires children **to compare and contrast** *What is the same about…? Which is different?*	
Q6: Asks question that requires children **to change or vary** *What happens if you change…? Can you do this in a different way…?*	
Q7: Asks children **to make links** between mathematical relationships and ideas *Where else have you used…? What other ways could we…?*	
Q8: Asks question that requires children **to conjecture, generalise or extend** *Would this work with different numbers? Is this always true?*	
Q9: Asks question that requires children **to explain, justify, verify or refute** *How would you work out…? Can you explain what…? Can you explain why…?*	11
Q10: Asks question **to orientate** children and focus them *What is the question asking you? What is important information in this sentence?*	
Q11: Asks leading question that direct children to the expected answer	
Q12: Asks non-mathematical question	

Responding to answers

R1: Ignores 'wrong' answers and waits for the 'correct' answer	
R2: Replies to a child's answer to acknowledge whether it is 'right' or 'wrong'	5
R3: Follows up a child's answer to ask them to clarify or explain (Note Q code above)	6
R4: Follows up a child's answer by asking another child to repeat/rephrase it *Can you say what Ahmed said in a different way?*	
R5: Follows up a child's answer by asking other children to comment or add (Note Q code above) *Is it right? What do you think about that? Can you say something more?*	8
R6: Other response, including revoicing	3

Appendix 15

Niveen: post-intervention lesson (29 minutes)

Targeting questions

T1: Asks question of whole class and encourages shouting out (individually/unison)	18
T2: Asks question of whole class but requires children to volunteer answers	5
T3: Directs question at a specific child	12

Types of question

Q1: Asks question that requires children **to state facts or procedures** *What is the sum of…? How do you add…?*	9
Q2: Asks question that requires children **to use mathematical terminology** *What is the name of…? How do we write…? What is the meaning of…?*	1
Q3: Asks question that requires children **to exemplify** *Which two numbers add to 10? Can you give an example of…?*	
Q4: Asks question that requires children **to complete or correct** *What is wrong with…? What can be added so that…?*	
Q5: Asks question that requires children **to compare and contrast** *What is the same about…? Which is different?*	
Q6: Asks question that requires children **to change or vary** *What happens if you change…? Can you do this in a different way…?*	
Q7: Asks children **to make links** between mathematical relationships and ideas *Where else have you used…? What other ways could we…?*	
Q8: Asks question that requires children **to conjecture, generalise or extend** *Would this work with different numbers? Is this always true?*	
Q9: Asks question that requires children **to explain, justify, verify or refute** *How would you work out…? Can you explain what…? Can you explain why…?*	16
Q10: Asks question **to orientate** children and focus them *What is the question asking you? What is important information in this sentence?*	7
Q11: Asks leading question that direct children to the expected answer	1
Q12: Asks non-mathematical question	1

Responding to answers

R1: Ignores 'wrong' answers and waits for the 'correct' answer	
R2: Replies to a child's answer to acknowledge whether it is 'right' or 'wrong'	4
R3: Follows up a child's answer to ask them to clarify or explain (Note Q code above)	14
R4: Follows up a child's answer by asking another child to repeat/rephrase it *Can you say what Ahmed said in a different way?*	
R5: Follows up a child's answer by asking other children to comment or add (Note Q code above) *Is it right? What do you think about that? Can you say something more?*	11
R6: Other response, including revoicing	4