What characterises effective teacher-initiated teacher-pupil dialogue to promote conceptual understanding in mathematics lessons in England in Key Stages 2 and 3?

Review conducted by the Mathematics Education Review Group

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TECHNICAL REPORT

The results of this systematic review are available in four formats:

SUMMARY	Explains the purpose of the review and the main messages from the research evidence
REPORT	**Describes the background and the findings of the review(s) but without full technical details of the methods used**
TECHNICAL REPORT	Includes the background, main findings, and full technical details of the review
DATABASES	Access to codings describing each research study included in the review

These can be downloaded or accessed at **http://eppi.ioe.ac.uk/reel/**

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List of abbreviations

BEI	British Education Index
BSRLM	British Society for Research into Learning Mathematics
CPD	Continuing Professional Development
DCSF	Department for Children, Schools and Families
DfEE	Department for Education and Employment
DfES	Department for Education and Skills
EPPI-Centre	Evidence for Policy and Practice Information and Co-ordinating Centre
ESRC	Economic and Social Research Council
IRF	Initiation-response-feedback sequence of interaction
IWB	Interactive whiteboards
KS1	Key Stage 1 (years 1–2; pupils aged 5 to 7 years)
KS2	Key Stage 2 (years 3-6; pupils aged 7 to 11 years)
KS3	Key Stage 3 (years 7-9; pupils aged 11 to 14 years)
KS4	Key Stage 4 (years 10-11; pupils aged 14 to 16 years)
NCETM	National Centre for Excellence in the Teaching of Mathematics
NLS	National literacy strategy
NNS	National numeracy strategy
OECD	Organisation for Economic Co-operation and Development
OFSTED	Office for Standards in Education
PDS	Professional development school
PGCE	Postgraduate Certificate in Education
PISA	Programme for international student assessment
REEL	Research Evidence in Education Library
SAT	Standard assessment test
TIMSS	Trends in International Mathematics and Science Study
TDA	Training and Development Agency for Schools
VLE	Virtual learning environment
WCS	Whole class section
WoE	Weight of evidence
WWC	What Works Clearinghouse (www.whatworks.ed.gov)

Abstract

What do we want to know?

In mathematics lessons in England in Key Stages 2 to 3, what characterises effective teacher-initiated teacher-pupil dialogue to promote conceptual understanding in mathematics?

Who wants to know and why?

This review was commissioned by the DCSF (formerly, the DfES) and will be of interest to all those concerned with the role of teacher-pupil dialogue in promoting pupils' conceptual understanding of mathematics.

What did we find?

It is the Review Group's view that the in-depth analysis of the included studies indicated the following:

- Traditional initiation-response-feedback (IRF) discourse dominated teacher-initiated teacher-pupil dialogue in mathematics lessons.
- Researchers investigating aspects of classroom discourse all argued that the quality of teacher-initiated teacher-pupil dialogue to promote pupils' conceptual understanding of mathematics needed to be improved.
- There were eight possible characteristics of effective teacher-initiated teacher-pupil dialogue: going beyond IRF; focusing attention on mathematics rather than performativity; working collaboratively with pupils; transformative listening; scaffolding; enhancing pupils' self-knowledge of how to make use of teacher-pupil dialogue as a learning experience; encouraging high quality pupil dialogue; and inclusive teaching. However, few studies provided evidence that such characteristics actually led to the promotion of pupils' conceptual understanding of mathematics.
- The strongest evidence of the promotion of pupils' conceptual understanding of mathematics came from studies that focused on the enhancement of pupils' self-knowledge concerning how to make use of teacher-pupil dialogue as a learning experience.

What are the implications?

A limitation of this review was the paucity of evidence concerning the effect of these eight identified characteristics on promoting pupils' conceptual understanding mathematics. Policymakers, practitioners and researchers need to consider how classroom practice can incorporate high quality teacher-initiated teacher-pupil dialogue.

How did we get these results?

The findings are based on an in-depth analysis of 15 studies.

CHAPTER ONE
Background

1.1 Aims and rationale for current review

The aim of this review is to consider the research evidence regarding the characteristics of effective teacher-initiated teacher-pupil dialogue which promotes pupils' conceptual understanding of mathematics in mathematics lessons in England in Key Stages 2 to 3.

This review arises from a tender for a systematic review drawn up by the DCSF (formerly, the DfES) in November 2006. The brief put forward by the DfES is worth reproducing in full below, as it serves to put this review question in the context of DfES thinking and concerns at the time.

> *Original brief for this study: What are effective teaching and learning strategies in mathematics in KS2 to KS4? The aim of this review is to gain insight into how good teachers plan a lesson or learning sequence: how they generate an appropriate pedagogy and structure for the learning; their choices about seating, tasks, differentiation, use of teaching strategies and techniques, etc., including use ICT and other equipment, plus teacher dialogue for example, questioning styles, whole class teaching and groups. It might result in sound advice to practitioners about the art of planning, a planning sequence, a toolkit for filling out parts of the lesson, strategies for use of starters and plenaries, etc. The review arises because the National Strategies gave a rather general structure for the daily mathematics lesson: starter, main teaching, plenary, and this was much looser than the definition of the literacy hour. It's that middle part - the main teaching - which needs definition. We know that lessons are variously planned to suit learning objectives, the pupils' prior knowledge, etc. Our hope is to articulate a sound process for planning lessons, which moves beyond a list of 'factors not to be forgotten', offers a helpful process for making decisions, with more emphasis on moving systematically through planning choices and drawing on the teaching repertoire Geographical scope would be UK, US, Canada and Australia. (DfES, November 2006).*

A meeting was held at the DfES in January 2007 to refine the review question. This discussion took account of the need to identify a review question that:

- could usefully contribute to DfES thinking on policy and practice;
- was relevant to current and planned DfES policy initiatives in the teaching and learning of mathematics in schools;
- was sharply focused;
- could draw upon sufficient research evidence.

A discussion at that meeting of the policy and research context identified the need to explore some aspect of the quality of teaching in mathematics lessons. It was felt at the meeting that too many mathematics teachers were still not engaging in a dialogue with pupils during lessons in a way that helps pupils gain an understanding of the mathematics they are doing, and that there was a need to consider whether relevant research evidence substantiates the view that such dialogue can have a positive impact on pupils' learning in mathematics.

It was also agreed at the meeting that research conducted in schools in England since 2000 would provide the most useful and appropriate scope for the research studies that would be included in the review. Such studies will have been undertaken within the context of the National Curriculum and the National Strategies that apply to schools in England, and as such, the findings of these studies will be much more likely to be accepted by teachers and policymakers as being relevant and generalisable to the current context for teaching and learning mathematics in schools in England than studies undertaken in other countries and/or studies undertaken before 2000.

It was also agreed to focus on Key Stages 2 to 4 and it was felt that commonalities across these stages could provide a secure base for identifying key features of effective pedagogy. It was also felt that the teaching of mathematics prior to Key Stage 2 was different in kind and had a somewhat different pedagogical context from that which pertains to Key Stages 2 to 4.

The findings of this review will have important implications for policy and practice, particularly in terms of considering the extent to which teachers can utilise high quality teacher-pupil dialogue as a vehicle through which pupils' understanding can be enhanced as part of the Every Child Matters agenda (which highlights the importance of enjoying and achieving) and the development of personalised learning in schools.

1.2 Definitional and conceptual issues

For many years, a distinction has been made in mathematics education between a teaching for procedural fluency approach to teaching ('procedural teaching') on the one hand and a teaching for conceptual understanding approach to teaching ('conceptual teaching') on the other.

Procedural teaching largely takes the form of a teacher exposition which demonstrates how to solve a particular type of problem, after which pupils are asked to follow the demonstrated technique by solving similar problems. Repeated practice of solving such problems, informed by feedback from the teacher on what the pupils are getting right or wrong, serves to instil in the pupil's mind how this type of problem can be solved in future (particularly when it occurs in a test or examination).

Conceptual teaching largely takes the form of exploring with pupils their understanding of the principles underlining particular types of problem and embedding the techniques for solving the problem within this understanding. This exploration can take the form of helping pupils to make links between their understanding of this problem with their understanding of previous types of problems which are relevant. An emphasis in this exploration is placed on developing an understanding of the key underlying concepts, and identifying and addressing any misconceptions. Such exploration can usefully include thinking about real life applications that can help embed understanding, and can also profitably make use of pupil-pupil small group discussion and investigation tasks (both ICT and non-ICT based). At its best, conceptual teaching can thus extend pupils' understanding beyond the boundaries of situated cognition (the tendency for knowledge and understanding to be tightly confined to the teaching situation in which it has been acquired) and enhance transfer of learning to unfamiliar contexts.

These two distinct approaches of teaching are, of course, extremes and the relationship between these two approaches is complex (Orton and Frobisher, 2005; Rittle-Johnson and Siegler, 1998). Most teachers will make use of both approaches within a single lesson or over a sequence of lessons. It would be rare to find a teacher whose procedural teaching never included any attempt to explore pupils' conceptual understanding and address their misconceptions; similarly, it would be rare to find a teacher whose conceptual teaching never included asking pupils to practise techniques that they have learnt. What differs between teachers is the balance between these two approaches that they typically use in their teaching.

In addition, a 'teaching approach' is not simply about what the teacher and pupils can be observed doing during the lesson: for example, the teacher is talking, while pupils are listening, or the pupils are engaged in small group discussion. Rather, it needs to include the notion of the 'teaching focus' or 'teaching purpose'. As Watson points out:

> *A teacher and class engaged in discussions about how to use a procedure could look much the same as a teacher and class engaged in discussion about the nature of number … [What to one observer might] seem instrumental might to another seem relational - lots of us learnt mathematics relationally in very instrumental classrooms. Hong Kong classrooms are an excellent example of this - lessons seem very instrumental but learning is often relational because the structure and sequencing of tasks lead people towards relationships. (A Watson, personal communication, 28 February 2007)*

Simply looking at the teacher's behaviour will not enable the observer to identify unequivocally whether procedural teaching or conceptual teaching is occurring; the observer needs to consider all elements of the teaching, including the teacher's planned learning outcomes, the content and nature of the discourse, and the type of feedback and assessment employed.

This review is primarily concerned with conceptual teaching, and the role that effective teacher-initiated teacher-pupil dialogue can play in promoting pupils' conceptual understanding of the mathematics they are doing.

Teacher-pupil dialogue in the context of procedural teaching tends to focus on ensuring that pupils can follow the technique that is being demonstrated. For example, a teacher teaching about Pythagoras' theorem will need to check that pupils are able to identify which side of a right-angled triangle is the hypotenuse, by impressing on pupils that it's the side opposite the right angle. In procedural teaching, the teacher may well set an exercise in which pupils are asked to identify the hypotenuse in a series of drawings of right-angled triangles oriented in different ways (to ensure that the hypotenuse does not always appear in the drawing as the side sloping from top left to bottom right).

This type of dialogue can be described as fostering lower-order identification and procedural thinking. On the other hand, teacher-pupil dialogue in the context of conceptual teaching tends to focus on helping the pupil to clarify their own thinking about the underlying key concepts, and in particular their reasons for how and why they have tackled a problem in a particular way and why they think the method they have used is valid. In the example of Pythagoras' theorem, pupils' conceptual understanding could be enhanced by the teacher presenting a variety of triangles with two lengths given, some with right angles and some without, and discussing with pupils which triangles the theorem can be applied to and how (given that for some right angled triangles, the missing side may not be the hypotenuse).

Another example might be a lesson on probability. Procedural teaching might begin by focusing on how the chance of throwing a particular number using a die can be expressed as a fraction, and then extending this principle to other situations. On the other hand, conceptual teaching might begin by exploring with pupils the notion of probability, how we use the term 'probable' in everyday life and how we use other similar terms, such as definite, likely, and impossible. This type of dialogue can be described as fostering higher-order conceptual thinking and can then contextualise what particular probability values used in mathematics mean (ranging from 0 to 1), and why calculating a probability value of say $p = 1.2$ would not make sense.

The notion of 'teacher-initiated' used in this review serves to focus the review on the way the teacher takes a pro-active stance in exploring with pupils' their thinking about the mathematics they are doing. In other words, instead of the teacher waiting until the pupil says they are stuck or do not understand how to solve a problem before engaging in a dialogue with the pupil, the teacher is pro-active in terms of asking pupils questions about what they understand and how they are tackling a problem.

Another difference between procedural teaching and conceptual teaching is that, when a pupil is stuck on a problem, in procedural teaching the teacher is likely simply to go over with the pupil the procedure that the pupil needs to follow, and perhaps diagnose and correct with the pupil what stage in following the procedure the pupil was not following. In conceptual teaching, on the other hand, the teacher tends to ask the pupil to explain how they are tackling the problem, and provide the pupils with prompts or clues embedded in enhancing pupils' understanding that will help the pupil arrive at a correct procedure and, moreover, help the pupil to understand why the procedure adopted works. This latter approach shares much in common with Vygotsky's notion of scaffolding (Hansen, 2005; Mason and Johnston-Wilder, 2004; Tanner and Jones, 2000b). In addition, in conceptual teaching, the teacher will also be keen to help pupils explore different ways of solving a problem, rather than simply to rehearse and apply one method.

In this review, the focus is on teacher-initiated dialogue that promotes conceptual understanding (higher-order thinking), rather than dialogue that simply fosters lower-order identification and procedural thinking.

While the focus in this review is on teacher-pupil dialogue, it is recognised that teacher-initiated teacher-pupil dialogue will often take place in the context of an activity involving pupil-pupil dialogue. For example, a teacher may ask two pupils to work together to consider a problem and, when they have done so, use a dialogue with the pupils to build upon the ideas that the pupils will have developed through their pupil-pupil discussion.

The term 'teacher-pupil dialogue' here is not restricted to one-to-one dialogue. Teacher-pupil dialogue can range from an individual teacher engaged in a one-to-one conversation with an individual pupil to an engagement with the whole class.

1.3 Policy and practice background

The need to drive up standards, including the mathematical attainment of pupils as indicated by the percentage of pupils who gain at least a grade C at GCSE, continues to be a major feature of government policy. This is particularly evident in the move to include a GCSE grade C pass in both Mathematics and English within the target of the percentage of pupils who gain 'five good passes at GCSE' (DfES, 2006a).

At the same time, there has been an increasing recognition in the National Strategies, and in the associated documentation which gives guidance to teacher on pedagogy, of the need to use teaching methods which help pupils to understand and enjoy the mathematics they are doing (DfES, 2003, 2004a). Further moves in this direction are in part a reflection of the implementation of the Every Child Matters agenda (DfES, 2004b, 2005), which includes 'enjoying and achieving' as a learning outcome for pupils, and in part a reflection of the implementation of 'personalised learning' (DfES, 2004c, 2005), which also gives weight to the importance of pupils' understanding and enjoying the work they are doing, rather than simply gaining high grades in examinations.

Several reports on policy and practice in schools concerning the teaching and learning of mathematics have expressed concerns regarding the extent to which teachers make far too much use of procedural teaching based on exposition, at the expense of using a greater range of activities, including the use of activities such as teacher-initiated teacher-pupil dialogue in way that will foster pupils' conceptual understanding of the mathematics they are doing in the classroom (QCA, 2004; Smith, 2004).

For example, in respect of secondary schools, the following was reported by Ofsted:

> *At its best, pupils' learning in mathematics was vibrant and laid foundations for their future progression; pupils were confident and achieved highly whatever their starting points. However, sometimes even within the same school, other pupils fared less well. Much weaker teaching was too narrowly focused on proficiency in examination technique at the expense of understanding of concepts and their interrelationships; a traditional style of exposition followed by practice was still favoured by many teachers. In these circumstances pupils were passive, and often bored, recipients. This led in turn to an emerging dependence on booster or revision classes. (Ofsted, 2006a, p 56, para. 234)*

Similarly, in respect of primary schools, Ofsted reported the following:

> *some teaching focused narrowly on preparation for tests. The most skilful mathematics teachers capitalised on pupils' answers, right or wrong, to make or reinforce teaching points. They also tackled pupils' misconceptions effectively and help them develop secure understanding of key concepts. (Ofsted, 2006a, p 53, para. 215)*

In addition, a report by Ofsted (2006b) examined the factors leading to high achievement, motivation and participation in 14-19 mathematics, as a contribution to the debate on the future of mathematics education in England following the publication of the Smith Report (Smith, 2004). The factors identified by Ofsted (2006b, pp. 2-3) in contributing to high achievement, motivation and participation included the following two factors:

- Secure subject knowledge on the part of the teacher, underpinning an approach to mathematics in which all topics are seen as part of a coherent set of related ideas, with clear progression and links to previous and future learning

- Teaching that focuses on developing students' understanding of mathematical concepts and enhances their critical thinking and reasoning, together with a spirit of collaborative enquiry that promotes mathematical discussion and debate

Conversely, the factors which acted against effective achievement, motivation and participation included the following:

- Teaching which presents mathematics as a collection of arbitrary rules and procedures, allied with a narrow range of learning activities in lessons which do not engage students in real mathematical thinking

- Weak assessment, including questioning, which fails to identify students' specific needs, probe their understanding of ideas and capitalise on incorrect responses

- A narrow focus on meeting examination requirements by 'teaching to the test', so that, although students are able to pass the examinations, they are not able to apply their knowledge independently to new contexts, and they are not well prepared for further study

Also relevant here is the 2020 Vision Report which linked personalised learning with high quality teaching, as follows:

> *Any strategy for personalising learning must focus on improving the consistency of high quality teaching to meet learners' needs as effectively as possible. This means strengthening the relationship between learning and teaching through [among others] dialogue between teachers and pupils, encouraging pupils to explore their ideas through talk, to ask and answer questions, to listen to their teachers and peers, to build on the ideas of others and to reflect on what they have learnt. (Gilbert, 2007, p 13)*

The need for pupils to understand the mathematics they are doing is also echoed in the secondary curriculum review launched by the QCA (2007, p 1) in which the QCA points out that there are 'a number of key concepts that underpin the study of mathematics. Pupils need to understand these concepts in order to deepen and broader their knowledge, skills and understanding'.

Taken together, these reports indicate the way in which recent policy initiatives have been undertaken to enhance the extent to which pupils are enabled to understand the mathematics they are doing, as opposed to simply solving problems by applying well-rehearsed rules and procedures. Moreover, a number of policy documents have made reference to the important role played by talk in the mathematics classroom in developing pupils' conceptual understanding (DfES, 2004d, 2006b).

1.4 Research background

Much research on effective teaching in mathematics has highlighted the tension that exists between procedural (or instrumental) teaching and conceptual (or relational) teaching (Boaler, 1997; Orton and Frobisher, 2005; Sutherland, 2007; Tanner and Jones, 2000b; Watson, 2006). However, it is important to recognise that there are benefits and shortcomings to both these approaches. On the one hand, procedural teaching has value as long as pupils can correctly identify and apply the rules and procedures they have learnt, but pupils can easily become unstuck as soon as they are required to apply these rules and procedures in a novel way, or when the answer they have obtained just does not make sense, and pupils also tend to find expository teaching boring and passive. On the other hand, conceptual teaching can provide a secure foundation for further progress, but can often be much more cognitively demanding, so that pupils become confused and lose confidence in what they are doing. It also needs to be borne in mind that conceptual teaching also places more demands on the teachers' subject knowledge (Huckstep et al., 2002). If teachers are insecure in their subject knowledge of mathematics, then encouraging them to engage in more conceptual teaching activities may not lead to the development in conceptual understanding that is intended.

What pupils are capable of understanding is dependent on their general cognitive development. At a certain age (or more precisely at a certain level of cognitive maturity), pupils are capable of solving particular problems by applying well rehearsed rules at a time when an understanding of why those rules work would be too taxing. Indeed, to some extent, in mathematics, a real understanding of how to solve a particular type of problem could sometimes arise more effectively and more easily by first learning to apply well-rehearsed rules, after which pupils gradually start to notice patterns that can form a basis for their conceptual understanding of why the rules work. In contrast, attempting to develop their conceptual understanding first might be too onerous and challenging.

There is evidence that, in some tasks, conceptual understanding precedes procedural fluency; in some tasks, learners gain procedural competence before conceptual; and, in other tasks, other work is suggestive of an 'iterative' process in which procedural and conceptual knowledge develop gradually and together - in the course of this, bi-directional relations are formed between the two types of knowledge (Rittle-Johnston et al., 2001; Rittle-Johnson and Wagner Alibali, 1999).

What the research evidence points to is the need for teachers of mathematics to make use of a judicious combination of teaching methods: not too much procedural teaching that would result in pupils becoming bored and disengaged, with little understanding of the mathematics they are doing; nor so much conceptual teaching that pupils continually face grappling with conceptual challenges at the expense of acquiring a knowledge of simple rules and procedures that they can apply to particular types of problems.

Getting this balance correct appears to be important in encouraging pupils to continue with the study of mathematics beyond GCSE. A recent study by Brown et al. (2007) looked at the attitudes towards mathematics held by year 11 pupils. They found that a sizeable number of those pupils who were predicted to gain an A or A* grade at GCSE did not intend to continue with mathematics at AS level or beyond: about 45 per cent of those predicted to gain an A grade and about 30 per cent of those predicted to gain an A* grade did not intend to continue with mathematics. Among the reasons some pupils cited for not continuing with the study of mathematics was the feeling that they did not understand the subject. This suggests that, if more pupils gained a conceptual understanding of the mathematics they were doing at GCSE, more of them might decide to continue with the subject.

What is evident from reports of current practice, however, is that the balance in practice makes too much use of procedural teaching and insufficient use of conceptual teaching, and there exists a perceived need to promote greater use of conceptual teaching.

It is interesting to note here that a recent research synthesis by Slavin and Lake (2006), looking at programmes designed to increase mathematical attainment in elementary schools, concluded that improving teachers' daily instructional process strategies will have more effect on increasing pupil attainment than changes that deal primarily with curriculum or technology. The types of instructional process strategies Slavin and Lake described in their report included a number of approaches which dealt with enhancing pupils' conceptual understanding of mathematics. In contrast, however, research by Brown et al. (2003) indicated that pupil gains in mathematics arising from the introduction of the National Numeracy Strategy are more likely to have occurred on account of changes to the curriculum (and, in particular, a closer match between what is taught and what is tested), rather than as a result of a change in pedagogy, characterised by adopting a three-part lesson format combined with whole-class interactive teaching.

Research on the development of pupils' conceptual understanding of mathematics has a long tradition. Indeed, work by Piaget in the 1950s on pupils' understanding of number concepts provided a basis for a close examination of how the child's conceptual understanding of mathematics develops, and how this development can be shaped and enhanced by the ways in which pupils are taught in school (Hansen, 2005; Mason and Johnston-Wilder, 2004; Tanner and Jones, 2000b).

The importance of conceptual teaching also features in the ESRC's Teaching and Learning Research Programme (James and Pollard, 2006), which includes two projects focusing on mathematics learning: one looking at pupils' understanding of fractions and the other on their understanding of ratio and proportion:

> *The message of these projects is that the techniques or formulae are rarely enough to ensure real deep learning. Pupils need to develop a more strategic approach to their learning, based on key ideas, processes and principles which provide continuity. Learning that is grounded in this way takes less time. Learners with appropriate tools for problem-solving do not have to memorise information which becomes meaningless or is forgotten. (James and Pollard, 2006, p 13)*

Wright et al. (2002) make a similar point, and argue that the expert-teacher transmission mode of teaching mathematics is no longer appropriate: the teaching of procedures is clearly important, but needs to arise out of sense-making activities. They see a key aspect of the role of the teacher as being to use classroom talk to foster among pupils a sense of intellectual autonomy.

Within conceptual teaching, much has been made of the powerful influence that classroom talk can have on identifying and correcting pupils' misconceptions, and the role that teacher-pupil dialogue can play in this.

Sutherland (2007), in her report of a series of studies, illustrates how teachers can create a classroom climate in which pupils see mathematics as an exploratory activity, and how through the use of dialogue, the teacher can help pupils develop and deepen their understanding of mathematics. This point is echoed in a number of instructional programmes that have been evaluated by the 'What Works Clearinghouse' (WWC). For example, one research synthesis looked at the Connected Mathematics Project, which aims to help pupils to develop their understanding of key concepts in mathematic through an inquiry model of instruction (WWC, 2006).

Watson (2006) in her research on how teachers changed their classroom practice in order to enable low-attaining secondary school pupils to gain a better understanding of the mathematics they were doing, illustrates various ways in which the effective use of dialogue by a teacher can probe and extend pupils' thinking. Watson's research paid particular attention to the ways in which teachers make effective use of questions and prompts to help pupils explore their own thinking and address misconceptions. Such work has links with the ideas for developing thinking in mathematics underpinning the Cognitive Acceleration in Mathematics Education (CAME) approach and the Thinking Maths approach (Adhami, 2005; Goulding 2002; Shayer and Adhami, 2007).

Houssart (2001, 2004), in her research on classroom discourse in mathematics lessons in primary schools, provides a number of examples where, in spite of the teachers using a procedural teaching approach, some of the pupils in the class engaged in higher order conceptual thinking about the mathematics they were doing by discussing and sharing ideas with other pupils. Houssart called these pupils 'whisperers' and contrasted the typical nature of the teacher-initiated discourse (for example, ideas are often repeated; harder ideas are introduced only when the teacher thinks the pupils are ready) with the 'unofficial' discourse engaged in by the whisperers (for example, the whisperers tried to extend or supplement ideas; the whisperers took issue with things they did not like or disagreed with). Houssart argues that teachers could usefully listen out for these 'unofficial comments' and then build on these through dialogue to extend pupils' conceptual understanding.

Swan (2007), in a study of teaching GCSE mathematics in further education and sixth-form colleges, made use of the notion 'diagnostic teaching' as developed by Swan and his co-researchers. In this approach, mathematics lessons are designed in which pupils' existing concepts and methods are made explicit and pupils then engage in activities through which inconsistencies in their understanding are exposed. The 'cognitive conflict' that is created is then confronted and resolved through dialogue and discussion.

Cockburn (2006) explored, among other research aims, the extent to which primary school teachers were employing strategies that foster higher-order mathematical thinking. Cockburn concluded that pupils were more engaged in conceptual thinking during a 'connectionist' style of teaching (where the teacher's emphasis is on helping pupils to make links between different mathematics topics) compared with a 'discovery' style or a 'transmission' style. Cockburn's study built upon the distinction between these three styles (or orientations) developed by Askew (2002). It is interesting to note in the context of this review that the connectionist style places particular emphasis on the use of dialogue between the teacher and pupils to explore understandings. Askew describes it as follows:

> *In practice this meant that, for the connectionist orientation, teaching mathematics was based on a dialogue between teacher and children, so that teachers better understood the children's thinking and children gained access to the teachers' mathematical knowledge through the talk. (Askew, 2002, p 7)*

The importance of such dialogue is also highlighted in research by Lee (2006) on the use of mathematical language in the classroom. Lee argues that a key part of the role of the teacher in fostering pupils' conceptual understanding is that, through dialogue with pupils, the teacher helps pupils to use the language of mathematics to articulate their ideas. Higgins (2003) has also illustrated the ways in which talk, and the use of mathematical language and vocabulary, can be used to help develop pupils' understanding. He points out how teacher-pupil talk has two main benefits: (i) it enables pupils to avoid learning purely procedural skills based on algorithms they will probably forget, and (ii) it helps teachers to identify pupils' understandings that are secure and areas of uncertainty or misconception that need to be addressed.

Research on teacher-pupil dialogue in the context of developing pupils' conceptual understanding of mathematics has examined the nature of such dialogue and the different ways in which teachers use dialogue (Alrr and Skovsmose, 2002; Kieran et al., 2002). The essence of teacher-initiated teacher-pupil dialogue is that the teacher seeks to explore through a purposeful conversation with the pupil (or pupils) their understanding. It has been argued that, at its best, there is a sense of equality and collaboration between the teacher and the pupil in which each remains open-minded and displays a respect for the ideas of the other, within a supportive classroom climate (Barwell, 2005; Skidmore, 2006).

This review is also able to build upon a detailed knowledge of the studies referenced in three previous systematic reviews carried out by the Mathematics Education Review Group (Goulding and Kyriacou, forthcoming; Kyriacou and Goulding, 2004, 2006).

Finally, this review is also undertaken with an awareness of the wider international comparative research context provided by research literature that draws on international comparisons of pupil attainment and teaching methods regarding school mathematics, which includes, most notably, the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) programme (Leung, 2006; OECD, 2004; Ruddock et al., 2004).

It is therefore clear that there is a long tradition of research in mathematics education that can provide a sound research context for this review.

1.5 Purpose and rationale for the review

The purpose of this review is to provide those concerned with the effective teaching of mathematics with a synthesis of evidence concerning which characteristics of teacher-initiated teacher-pupil dialogue effectively promote pupils' conceptual understanding of mathematics in mathematics lessons in England in Key Stages 2 to 3. The review focussed on Key Stages 2 to 3 having found no studies pertaining to Key Stage 4. This review is timely, given the recent concerns expressed that too much teaching of mathematics is based on procedural teaching and not enough use is being made by teachers of conceptual teaching (for example, Ofsted, 2006a), and the current discussion about the need for changes to be made to the National Strategies in the wake of the implementation of the Every Child Matters agenda and personalised learning. It is interesting to note that the Smith Report (2004) recognised the importance of systematic reviews in mathematics education in providing an evidence base to inform policy and practice.

1.6 Authors, funders and other users of the review

The Review Group comprises individuals from the key groups involved in mathematics education: mathematics teacher educators, academic researchers, primary and secondary school teachers, local education authority advisers, and policymakers. Most of the group are also parents.

All members of the group expressed a willingness to be involved in all stages of the review process:

- identifying the review question
- outlining the scope and method for the review
- identifying studies to establish the main review database
- identifying studies based on paper titles and abstract (first stage inclusions)
- identifying studies based on full papers (second stage inclusions)
- mapping the second stage inclusions
- extracting data from and analysing the papers selected for the in-depth analysis
- writing the report

However, as work progressed, a core group was established to undertake the bulk of the work involved in the in-depth stage and writing the report.

The main audience for this review comprises student teachers, teachers, teacher educators, researchers and policymakers, although parents of school-aged children and other members of general public will also have an interest in this review question. It is intended to disseminate the findings of the review through internet access to the review report, publication in an academic journal, and conference papers.

1.7 Review question and approach

The review question for this review is as follows:

> *In mathematics lessons in England in Key Stages 2 to 3, what characterises effective teacher-initiated teacher-pupil dialogue to promote conceptual understanding of mathematics?*

The objectives of the review are as follows:

i) to identify relevant studies reported in England in the period 1 January 2000 to 30 March 2007

ii) to undertake a descriptive mapping of the relevant studies

iii) to undertake an in-depth analysis of the relevant studies

iv) to draw conclusions from these studies regarding which characteristics of teacher-initiated teacher-pupil dialogue effectively promote pupils' conceptual understanding of mathematics in mathematics lessons in England in Key Stages 2 to 3

In order to address this review question, the following four underlying questions needed to be considered:

i) In what ways do teachers use teacher-initiated teacher-pupil dialogue to promote pupils' conceptual understanding of mathematics in mathematics lessons in England in Key Stages 2 to 3?

ii) What evidence is there that such dialogue is more effective than other activities in promoting pupils' conceptual understanding?

iii) What evidence is there that particular characteristics of such dialogue are more effective than other characteristics in promoting pupils' understanding?

iv) Why and how are the identified characteristics of effective teacher-initiated teacher-pupil dialogue effective?

It is important to emphasise again the use of the phrase 'conceptual understanding' in this review. Conceptual understanding denotes pupils' understanding of the mathematics they are doing, based on an appreciation of mathematical ideas and their inter-relations; this can be contrasted with what is sometimes referred to as 'procedural understanding', which refers to solving problems through the application of rules and procedures which have been memorised and rehearsed (Orton and Frobisher; 2005; Rittle-Johnson et al., 2001).

The word 'characterises' is used in the review question in order to highlight those features of teacher-initiated teacher-pupil dialogue which can form a useful basis for improving classroom practice. The characteristics of interest here focus on why, when and how the teacher uses such dialogue in order to elicit and sustain its impact on promoting pupils' conceptual understanding. As such, it should be noted here that the focus of the review question deals with a subset of classroom dialogue.

The general approach adopted in this review was to provide a narrative synthesis which addressed the review question based on an in-depth analysis of relevant (that is, 'included') studies. The included studies were drawn from those studies identified by a search for relevant studies; they have have been included after criteria for exclusion have been applied. Thirteen studies were conducted in England and reported in the period 1 January 2000 to 30 March 2007; two further included studies were conducted in Wales and reported in the same period.

CHAPTER TWO

Methods used in the review

2.1 Type of review

This review includes studies that have collected empirical data (both statistical and narrative). It addresses a narrow review question and is relatively limited in scope. The analysis of the map is descriptive. The breadth of the question for synthesis is narrow. The extent of evidence for synthesis is adequate and the synthesis itself is integrative.

2.2 User involvement

2.2.1 Approach and rationale

User group involvement is reflected in the composition of the Review Group itself, which includes parents, school teachers, school governors, teacher educators, researchers and policymakers, although the data-extraction was undertaken by academics and researchers. Other user group involvement was largely through email and informal contacts at conferences, and through publicising the work of the Review Group through subject and professional associations, organisations and societies. In addition, papers based on this systematic review have been, and will be, presented at a variety of conferences. Digests of the key findings and implications for policy and practice will be drawn to the attention of different user groups. The initial stage of dissemination has largely been directed at academics, teacher educators, researchers and policymakers, but it is intended to widen the dissemination through the use of websites and articles in magazines and newspapers. It is too early to comment on the likely impact that this review will have on policy and practice. User perspectives on the review process and the provisional report will also be sought.

2.2.2 User involvement in designing the review

Following the announcement by the DfES of its brief for tenders to carry out a review on effective teaching of learning strategies in mathematics in KS2 to KS4, the DfES' original brief was circulated among Review Group members and to others involved in mathematics education, particularly those with recently published research in this area and those who had previously offered advice to the Review Group regarding review questions. These ideas were then carried forward to a meeting with the DfES in January 2007 at which the focus for the review question on teacher-pupil dialogue was developed. These ideas where further circulated and discussed among members of the Review Group and others, and also circulated within the DfES. A draft protocol was then produced and peer reviewed under the direction of the EPPI-Centre.

2.2.3 User involvement in process of conducting the review

Members of the Review Group were actively involved in all stages of the conduct of the review. In addition, email contacts were made with a wider audience of users (teacher educators, teachers, researchers) on aspects of the conduct of the review. Details of the agreed protocol were circulated to a number of professional organisations, teacher educators, researchers and policymakers.

2.2.4 User involvement in process of interpreting the review results

Members of the Review Group were actively involved in interpreting the review results. In addition, email contacts were made with a wider audience of users (teacher educators, teachers, researchers, and policymakers) on aspects of the conduct of the review and the emerging findings. The emerging findings have also been discussed with Mathematics

PGCE student teachers at the University of York through the use of a VLE blog.

2.2.5 User involvement in communicating/dissemination of review results

A paper on the emerging review results was presented at a meeting held at the DCSF with DCSF officials and at a meeting of the British Society for Research into Learning Mathematics (BSRLM); both meetings took place in November 2007, and comments made at these meetings helped shape the final version of the review report.

2.2.6 Any known plans for further interpretation and application

Plans for further interpretation and application will initially focus on preparing digests of the results, conference presentations, and journal papers.

2.3 Identifying and describing studies

2.3.1 Defining relevant studies: inclusion and exclusion criteria

For a paper to be included in the systematic map, it had to satisfy the following four criteria:

i) It is an academic paper published in an academic journal or presented at an academic conference during the period 1 January 2000 to 30 March 2007 in English.

ii) It reports a study presenting original data conducted in a primary or secondary schools in England and collected by the author(s).

iii) The study deals with mathematics teaching in Key Stages 2-3 lessons.

iv) The study deals with the characteristics of teacher-initiated teacher-pupil dialogue intended to promote pupils' conceptual understanding in mathematics.

These inclusion criteria were reformulated as four exclusion criteria (see Appendix 2.1 for further details):

i) Not an academic paper in English published in an academic journal or presented at an academic conference during the period 1 January 2000 to 30 March 2007.

ii) Not a report of a research study presenting original data collected by the author(s) in primary or secondary schools in England.

iii) Does not include data about mathematics teaching in mathematics lessons in Key Stage 2 to Key Stage 3.

iv) Does not deal with the characteristics of teacher-initiated teacher-pupil dialogue intended to promote pupils' conceptual understanding in mathematics.

These criteria were placed in the hierarchical order for ease of exclusion and, importantly, to act as a system of gradual filtering, so that the papers excluded at each stage can be readily identified in the future as a useful list of references to readers of the review report for other purposes, or be of use in subsequent systematic reviews undertaken by this Review Group.

2.3.2 Identification of potential studies: search strategy

The review focused on journal papers and conference papers. Journal papers offer a recognised degree of quality control, as such papers are normally (but not necessarily) peer reviewed 'blind' by at least two referees with expertise in the topic area, and submissions to a journal normally contain the author's most polished and carefully considered presentation of the empirical data and its interpretation, which can often also have benefited from revisions required by the referees prior to its acceptance for publication. In contrast, other types of publication do not benefit from such a process of 'blind' external evaluation. In addition, journal papers are unequivocally in the public domain and can be more easily accessed as a result, and the use made of a particular journal paper in a systematic review of the literature can therefore be more easily scrutinised and verified.

However, arguments specifically concerning the publication bias, which can occur if unpublished studies are not included in a systematic review, have been particularly well rehearsed (for example, Thomas and Harden, 2003; Torgerson, 2003). In order not to exclude important studies reported in the form of a conference paper, the search for relevant publications also included conference papers which are relevant to the review question and which, in particular, have appeared as full length papers in edited conference proceedings. As such, conference papers were carefully considered and, where appropriate, included in the in-depth analysis, on the same basis and using the same criteria as used for the consideration of papers published in journals.

Preliminary searches helped to establish the key sources for both electronic searching and handsearching which were likely to identify references relevant for this review, as well as other sources which were likely to be of limited value. Preliminary searches also indicated that it was an easy matter to access the archives of major journals in order to look at the titles of every paper published in the review period, and it is often possible to also consult the abstract and/or a full-copy of the paper online. Given the possibility that an electronic search of titles alone using even a very comprehensive set of keywords can still miss relevant papers, it was felt that a combination of handsearching and electronic searching of key journals in this way was important in adding to the list of potentially relevant papers identified by the electronic search of BEI. The importance of carrying out an extensive handsearch has been noted by Black (2004c) and, for this purpose, 28 key journals were identified.

The period 1 January 2000 to 30 March 2007 was chosen for this review, as this period provides an appropriate educational and policy context for considering research findings relevant to this review.

This enables the research evidence obtained during this period to be more readily applicable to this specific pedagogical context of teaching and learning mathematics that pertains at the time that this review is taking place. Research studies of the teaching of mathematics prior to 2000 deal with a different pedagogical context. By focusing on studies which deal with journals and conference papers from 1 January 2000 to 30 March 2007, any implications for policy and practice in schools drawing upon such studies can be made with greater confidence than research drawing on studies conducted when a different pedagogical milieu in schools was in operation.

Relevant studies were drawn from papers published in journals or conference proceedings during the period 1 January 2000 to 30 March 2007. Seven strategies were involved here.

i) Electronic search of BEI: The key search terms used were mathematics, numeracy, dialogue, discourse, discussion, interaction, misconceptions, talk and understanding (Appendix 2.2).

   Subject: Mathematics

   Population: Key Stages 2 to 4 pupils in mainstream classes in England

   Limits: English language, 1 January 2000 to 30 March 2007

ii) Electronic search and/or handsearch of 11 key journals in mathematics education (1 January 2000 to 30 March 2007), looking at every title and, where appropriate and available, the abstract and/or the full paper (Appendix 2.3)

iii) Electronic searches and/or handsearching issues of the following 17 selected key UK journals in Educational Research (1 January 2000 to 30 March 2007), looking at every title and, where appropriate and available, the abstract and/or the full paper (Appendix 2.3)

iv) Handsearch and/or electronic search of key recent conference proceedings (1 January 2000 to 30 March 2007), looking at every title and, where appropriate and available, the abstract and/or the full-paper (Appendix 2.3)

v) Searching the list of references at the end of papers identified as relevant

vi) Searching the list of references in recent books or chapters in an edited book dealing with primary mathematics

vii) Contacting researchers working in this field for their recommendations

2.3.3 Screening studies: applying inclusion and exclusion criteria

The inclusion/exclusion criteria were applied at the following three points:

i) to the title and abstract of papers from searching the electronic database

ii) to a full copy of papers not previously excluded on the basis of the title and abstract

iii) to additional papers identified by handsearching, citations and personal contacts

2.3.4 Characterising included studies

The included studies were mapped (characterised), using the EPPI-Centre's Data Extraction Guidelines (Version 2.0), together with its data-extraction software, EPPI-Reviewer (section 2.4.2).

Since all the studies included in the map were data-extracted, it was not necessary to use the EPPI-Centre's Educational Keyword Sheet (Version 0.9.7), which comprises generic keywords (Appendix 2.4), prior to data-extraction, as all the questions in the keyword sheet are answered in the data-extraction.

2.3.5 Identifying and describing studies: quality-assurance process

Application of the exclusion criteria to title (and, where available, abstracts) was carried out by one member of the Review Group. For quality-assurance purposes, a random sample of these papers was also screened by a second member of the Review Group, and any differences between the judgments made by the two Review Group members were discussed and resolved. In addition, a member of the EPPI-Centre also applied the exclusion criteria to a random sample of the papers in the first stage of screening, and any differences were discussed and resolved.

Application of the exclusion criteria to a full copy of the paper was conducted by pairs of Review Group members, working first independently and then comparing their decisions before coming to a consensus. This stage included papers that had been identified by handsearching. For quality-assurance purposes, a member of the EPPI-Centre also applied the exclusion criteria to a random sample of these papers, and any differences were discussed and resolved.

2.4 In-depth review

2.4.1 Moving from broad characterisation (mapping) to in-depth review

All the studies included in the systematic map were also included in the in-depth analysis.

2.4.2 Detailed description of studies in the in-depth review

Studies identified as meeting the inclusion criteria are analysed in depth using the EPPI-Centre's Data Extraction Guidelines (Version 0.9.7), together with its data-extraction software, EPPI-Reviewer. No review-specific questions were added.

2.4.3 Assessing the quality of studies and weight of evidence for the review question

Components were identified to help in making explicit the process of apportioning different weights to the findings and conclusions of different studies. Such weights of evidence are based on:

A Trustworthiness of studies: Taking account all quality assessment issues, can the study findings be trusted in answering the study's question(s)?

B Appropriateness of the research design and analysis for addressing the systematic review question

C Relevance of the particular focus of the study (including conceptual focus, context, sample and measures) for addressing the systematic review question

D An overall weight, taking account of A, B and C

Each of these three components (A, B and C) was assessed as low, medium or high.

Studies were judged to provide a high weight of evidence on A if the study provided high quality evidence that addressed the aims and research questions posed in the study, and the research design and methodology used was transparent and sound.

Studies were judged to provide a high weight of evidence on B if the study employed a high quality research design, methodology and analysis which addressed the review question, taking account of the extent to which the research design, methodology and analysis used were transparent and sound.

Studies judged to give high weight of evidence on C needed to provide evidence of the ways in which particular characteristics of teacher-initiated teacher-pupil dialogue had improved pupils' conceptual understanding of mathematics in mathematics lessons in England in Key Stages 2 to 3, taking account of the relevance of particular focus of the study, including its conceptual focus, the context, sample and the measures used.

In considering the overall WoE D, priority was given to considerations of relevance (WoE C) to the review question. The Review Group was looking for the best available evidence to answer the review question.

This meant that some studies reporting the work of small numbers of pupils or teachers, and some studies that did not follow-through with clear evidence of improved pupils' conceptual understanding, were still considered to be of some value in addressing our review question. In some cases, where there were some methodological shortcomings, it was still judged that the study had made a useful contribution to addressing the review question. Nevertheless, without clear evidence of the ways in which particular characteristics of teacher-initiated teacher-pupil dialogue had improved pupils' conceptual understanding of mathematics in mathematics lessons in England in Key Stages 2 to 3, a study could not be assessed as having high overall weight of evidence (WoE D). As such, a restriction was made that WoE D could not be higher than WoE C.

2.4.4 Synthesis of evidence

The responses to the generic questions used for the data-extraction, together with a consideration of the weight of evidence assessments, provided a basis for producing a narrative synthesis of data from the included studies, adopted to address the review question. Tables summarising the included studies are presented in Appendix 4.2 to provide readers with details of the included studies; further details of the included studies can also be found by consulting the uploaded data-extraction, which is available on the EPPI-Centre database REEL, which can be accessed via the EPPI-Centre website.

2.4.5 In-depth review: quality- assurance process

Data-extraction and assessment of the weight of evidence for each study was conducted by two people, working first independently and then comparing their decisions before coming to a consensus. As part of the quality-assurance process, a member of the EPPI-Centre staff data-extracted a sample of the included studies. Any differences between the judgements made by the Review Group and the member of the EPPI-Centre staff were discussed and resolved.

2.4.6 Deriving conclusions / implications

The synthesis was used to identify conclusions and implications. This was based on working within the Review Group to identify which aspects of the synthesis provided a sound foundation for conclusions and implications for policy and practice. These ideas were further circulated with informal advisers and presentations were made of interim findings. A draft Technical Report was forwarded to the EPPI-Centre for comment and a second draft was peer-reviewed. These two sets of comments also informed the derivation of conclusions and implications presented in the final version of the Technical Report.

CHAPTER THREE

Identifying and describing studies: results

3.1 Studies included from searching and screening

An electronic search identified 252 papers by using the specified search strategy (the main review database). In the first stage of screening on titles and abstracts, the four exclusion codes were applied to these by a member of the Review Group, resulting in 227 exclusions. The exclusion codes applied to each of these excluded papers are shown in Figure 3.1. The majority of the exclusions were the result of applying exclusion code 2 (original data collected by the author(s) in primary or secondary schools in England).

Full copies of the remaining 25 papers were then screened, using the inclusion / exclusion criteria (Appendix 3.2). In addition, a further 12 papers were identified as a result of handsearching (Appendix 3.3) and were added to the main review database.

The four exclusion codes were then applied to the full copy of these 37 papers. This resulted in a further 13 papers being excluded (Figure 3.1). All but two of these further exclusions were the result of applying exclusion code 4 (dealing with the characteristics of teacher-initiated teacher-pupil dialogue intended to promote pupils' conceptual understanding in mathematics). While exclusion code 2 specified that the study should involve data collected in England, two papers conducted in Wales were included due to their particular relevance to the review question (Jones and Tanner, 2002; Tanner and Jones, 2000a).

This resulted in 24 papers, reporting 15 studies, being identified for the systematic map. For each of the 15 studies, one main paper was identified, and nine subsidiary papers were identified (section 6.1). A subsidiary paper was defined as one which duplicated the report of the study already covered by the main paper. For example, the subsidiary paper could be a conference version of the study which was subsequently reported more fully in a major journal; or it could be a simplified version of the main paper; or it could be an enhanced version of the main paper which adds new data which are not relevant to the review question and omits some of the old data which is relevant; or it could present case studies of particular pupils or teachers; or it could present a detailed or exploratory analysis of a particular incident or interaction that occurred.

3.2 Characteristics of the included studies (systematic map)

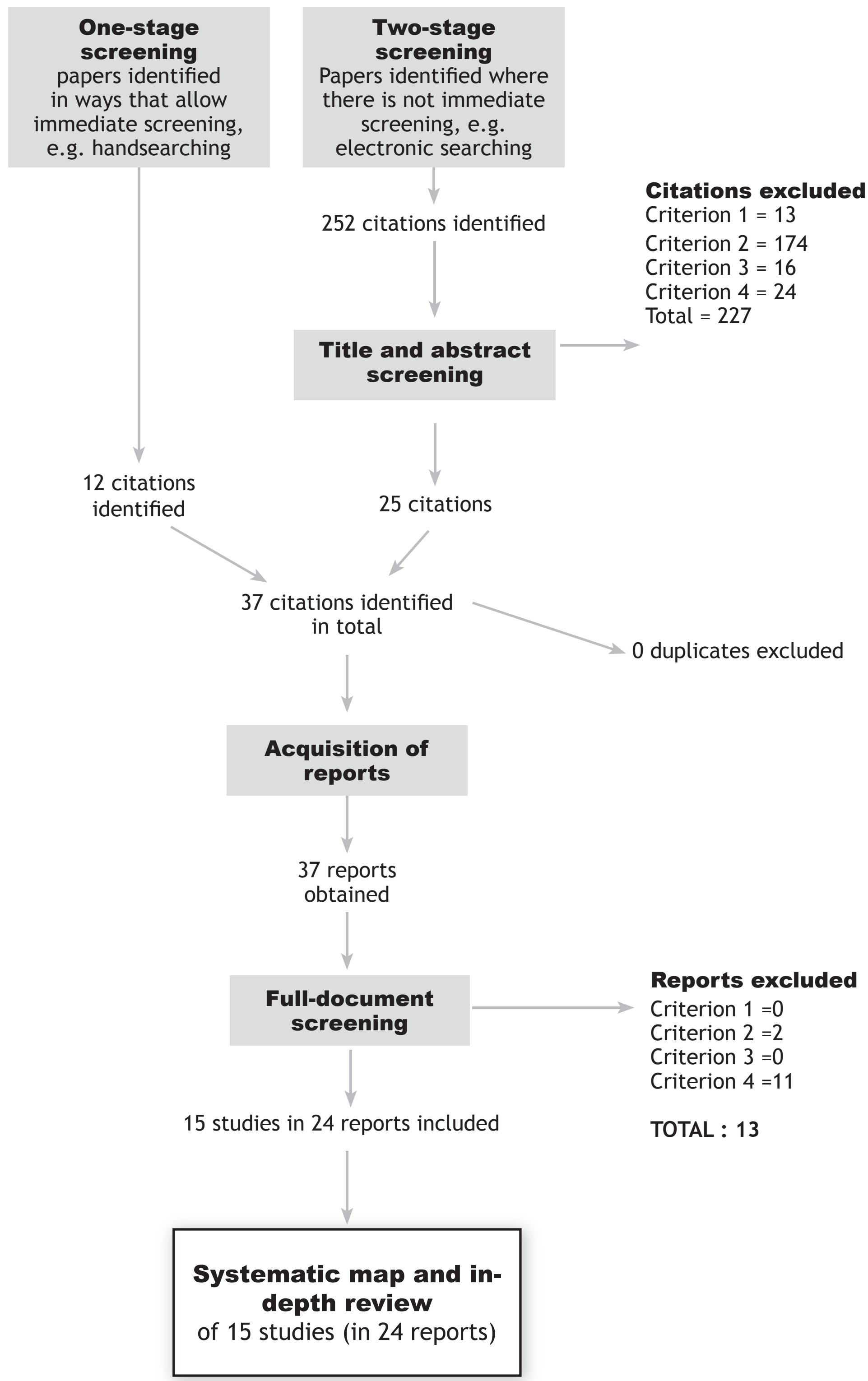
The data-extraction of the 15 studies was used to develop the systematic map. The data extraction also took account of the subsidiary papers where appropriate. Tables giving the characteristics of the fifteen included studies are shown in Appendix 3.1.

Six of the main papers were identified as a result of the electronic search strategy of BEI and nine of the main papers were identified as a result of handsearching. This supports Black's (2004c) observation that an over-reliance on an electronic search strategy based on keywords will almost certainly miss a number of important papers (Appendix 3.1, Table A3.1). Of the 15 main papers, eight were published in journals and seven as conference papers.

The approach adopted for the potential inclusion of studies successfully captured both large scale research studies (often externally funded) and small scale studies (often based on exploring new developments in practice). This resulted in a mixture of study types included in this review.

Since large scale studies published in major journals often have a long time lag between the start of the research and its publication, the inclusion of small scale studies presented at conferences meant that a greater range of evidence concerning recent initiatives in schools relevant the review question could be evaluated in this review.

Figure 3.1 Filtering of papers from searching to map to synthesis



All the studies were written in English; 13 included data collected in England and two presented data from Wales (Jones and Tanner, 2002; Tanner and Jones, 2000a).

All 15 main papers had a population focus which included pupils in one of the three Key Stages 2 to 4 which were the focus of this review. However, only four of the studies dealt with teacher-pupil dialogue in secondary schools and, in all four cases, this was restricted to pupils in Key Stage 3 (Table 3.1).

Table 3.1: Population focus regarding pupils in Key Stages 2 to 4

Main papers	KS2	KS3	KS4
Back (2005)	T		
Black (2004a)	T		
Black (2006)	T		
Bold (2002)	T		
Coles (2002)		T	
Hadjidemetriou and Williams (2003)		T	
Jones and Tanner (2002)		T	
Mercer and Sams (2006)	T		
Myhill (2006)	T		
Pratt (2006)	T		
Ryan et al. (2003)	T		
Smith et al. (2004)	T		
Smith and Higgins (2006)	T		
Tanner and Jones (2000a)		T	
Wilson et al. (2006)	T		

Nine studies were categorised in terms of study type as description, four studies were categorised as ‘exploration of relationships and two studies as ‘what works?’ (Appendix 3.1, Table A3.2). This reflects the largely exploratory tone of many of the recent studies dealing with teacher-pupil dialogue which seek to describe and categorise the nature of such dialogue and to identify the extent to which ‘good practice’ (that is, the type of practice widely advocated by those who wish to see pupils engaged in a thoughtful dialogue with their teacher) is occurring. From the point of view of addressing the review question, it is therefore disappointing that there were not more studies included here that had attempted to assess the extent to which an increase in pupils’ conceptual understanding of mathematics could be linked to characteristics of the teacher-pupil dialogue evident in classroom practice.

As noted in section 1.7, this review focused on particular subset of classroom dialogue. This is in part a reflection of the way in which the review question was framed, and in part a reflection of the nature and content of the included studies.

3.3 Identifying and describing studies: quality-assurance results

3.3.1 Quality assurance for the first stage of screening

A ten per cent sample of the 252 papers (25 papers) identified in the first stage of screening was screened by a second member of the Review Group. There were five cases where the code that had been applied was queried and, on each occasion, the reason given by the first reviewer for the code used was agreed. In every case, this was because the first reviewer had more knowledge of the paper. For example, the first reviewer might recognise the name of the author of the paper and the study which was reported, and know this study was conducted in the USA, even though this information was not given in the title and/or abstract of paper and, as such, was able to apply the most appropriate exclusion code at this stage, without the need to obtain a full-length copy of the paper.

A random sample of ten of the 252 papers identified by electronic searching was then screened by a member of the EPPI-Centre in London who was more uncertain about deciding which code to use, without further information regarding two of the papers. The greater degree of confidence by the first reviewer was due to two main factors.

Firstly, the first reviewer had greater knowledge of these papers. For example, the title of one paper did not make clear where the study was conducted, while the first reviewer was able to recognise from the title the study being reported in the paper and hence its location.

Secondly, the first reviewer often had a full-copy version of potentially relevant papers readily to hand and could thus, in a matter of seconds, identify a key feature of the paper from its abstract that warranted an appropriate exclusion code. The details available on the database for all 12 papers did not include an abstract, which meant that the EPPI-Centre reviewer had to reach a decision based solely on the name of the author, title and publication details. The first reviewer, on the other hand, was almost always able to consult an abstract of the paper.

Ideally, in the first-stage screening, the reviewer should have available the name of author, the title, the publication details and the abstract for each paper, but a number of databases unfortunately do not provide an abstract and, when they do, this is often only a condensed version written by the database provider of an original, and much longer, abstract written by the author.

This quality-assurance check clearly indicates how a reviewer experienced in the field with ready access to copies of the papers is able to screen out much more efficiently a number of papers at this first stage, although it is accepted that, in some cases, the papers screened out at this first stage by the first reviewer could strictly speaking be regarded as a second-stage exclusion (that is, excluded after consideration of a full-length copy of the paper rather than just on the basis of the title and/or abstract which was obtained by the electronic searching using the specified keywords). The difference between the first reviewer and the EPPI-Centre reviewer was also markedly enhanced by the fact that this review included a substantial amount of handsearching which had largely been completed prior to the first reviewer undertaking the first-stage screening. This often meant that the first reviewer had recently considered a full-length copy of a paper just prior to coming across the same paper in its summary form (that is, author and title, with or without a short abstract) in the main database drawn up from the electronic search using the keywords.

In terms of quality assurance, however, what is important is whether the procedure followed resulted in any papers being excluded during the first-stage screening process that should and would have been included in the descriptive mapping after consideration of a full-length copy of the paper. It was established that there were no cases in which a paper had been incorrectly excluded by the first reviewer.

3.3.2 Quality assurance for the second stage of screening

The four exclusion codes were applied to a full-length copy of these 37 papers by two members of the Review Group, working independently and then comparing their codes. There were only a few cases of disagreement, which were resolved after further consideration of the papers involved. A random sample of four of these 37 papers identified for second-stage consideration was sent to the EPPI-Centre reviewer for quality-assurance purposes. In three cases, the code applied by the EPPI-Centre reviewer agreed with the code applied by the two internal reviewers. In the fourth case, the EPPI-Centre reviewer had reservations about the way the data contained in the paper did not adequately disentangle data relating to literacy lessons from data related to numeracy lessons; the internal reviewers felt that, as specific examples had been given in the paper of numeracy lessons, this was sufficient to warrant inclusion.

3.3.3 Quality assurance for keywording

As it was decided that all 15 main papers identified for keywording would also be data-extracted, the mapping of the included studies was based on the data-extraction. The process of quality assurance for keywording was thus subsumed by the quality assurance for the data-extraction (section 4.3).

3.4 Summary of results of map

The majority of the main papers were identified by handsearching; all the main papers had been published. The majority of the studies were categorised as ‘description’. The majority of the studies dealt with teacher-pupil dialogue in Key Stage 2.

CHAPTER FOUR

In-depth review: results

4.1 The in-depth studies

Twenty-four reports of 15 studies met the inclusion criteria for the in-depth review. Details of these studies are shown in Appendix 4.1 in terms of four key aspects of each of the 15 studies:

i) the main aim(s) of the study

ii) the key research questions

iii) the research design

iv) the key findings concerning teacher-initiated teacher-pupil dialogue

4.1.1 Key findings of the included studies

This section presents key details of the nature of the findings and conclusions presented in each of the 15 studies. In this section, a summary of each of the 15 studies is presented. In the following section (the synthesis), the studies are considered in terms of eight key characteristics of teacher-initiated teacher-pupil dialogue which were identified. A continuous narrative style of report has been adopted.

Back (2005) explored the inter-relationship between the social purposes and mathematical foci of interactions which occur when talk takes place in the classroom. The author sought to examine the characteristics of conversations that succeed in involving pupils in expressing and developing their mathematical thinking and understanding. This study is based on participant observation of a ‘large number of lessons’ with a small number of teachers and classes from three primary schools in a market town near London. The analyses focused on a detailed study of the transcript of five lessons constituting a fine-grained analysis of talk in the classroom. Back argues that the three key language elements involved in engaging in mathematical forms of life are generalising, reasoning and argument. Back argues that every utterance in talk can be analysed in terms of its social and mathematical components. The social dimension of talk is connected with building and maintaining the social relationships within the class, between teacher and pupils, and between pupils. The mathematical dimension is concerned with the mathematical component of the talk and relates to the way in which the talk contributes to mathematical forms of life.

Back suggests that the social dimension can vary from open to closed, depending on the emphasis of the utterance in terms of its contribution to the social relationships within the class. Openness on the social dimension would suggest contributing to open relationships that encourage pupils and teachers to view themselves as joint participants in the teaching and learning processes. Closedness would be linked with rigid interpretations of the participants’ involvement and forcing them to follow predetermined patterns of contribution to the talk. The mathematical dimension is high when the teacher and pupils extend the mathematical component beyond recall of procedures towards participation in mathematical argument, mathematical thinking and reasoning. Back argues that, for talk to contribute to the induction of pupils into mathematical thinking and reasoning, it must be ‘highly mathematical’ and ‘socially open’.

Lesson extracts are used to illustrate the techniques used by the teachers to go beyond IRF sequences in order to ask pupils to explain their thinking, which include examples in which pupils take the initiative. While the study provides some examples of teacher-pupil dialogue which is both ‘highly mathematical’ and ‘socially open’, it does not provide evidence of its effectiveness in promoting pupils’ conceptual understanding of mathematics. This study was assessed as having a low weight of evidence.

Black (2004a) explored the qualitative nature of the differences in the quantity of teacher-pupil interactions experienced by pupils from different social backgrounds and the impact of such differences on pupil learning. More broadly the aims of this study were to (i) determine if some pupils consistently experienced different types of interaction with the teachers than others; (ii) determine why this might be the case, taking into account explanatory factors, such as teacher expectations and pupil cultural capital; and (iii) assess if the differences between the types of interaction pupils experienced were maintained across time.

Black presents an ethnographic case study of one year 5 primary classroom observed over a five-month period focusing on pupil participation in whole-class discussions during mathematics lessons. Lessons were recorded using a video camera and radio microphones. Interviews were also conducted with the teacher and pupils, during which they were shown videos of recorded lessons and asked to comment on what was happening. A coding framework was used to identify productive and non-productive interactions. Interactions were classed as productive if they contained verbal actions that appeared to create and maintain the shared understandings underpinning the learning process. Interactions were classed as unproductive if the teacher appeared to control its shape and form, and the pupil played a monosyllabic, passive role. Black categorises the 29 pupils into four groups based on the predominant experience of interaction.

The study indicates how pupils are treated differently in terms of access to discourse: for example, bright pupils' comments are taken seriously and developed - they are 'given the floor'. Some pupils engage in productive exchanges with teachers more often than others. The study indicated that certain pupils within the class were disadvantaged in the learning process. Only pupils who were regularly involved in productive interactions were accessing conversations that genuinely fostered shared understandings between teacher and pupil.

This study provides evidence of how teachers interact differently with pupils in the same class, ranging from 'productive' to 'unproductive' interactions, and that productive interactions involve teacher-pupil dialogue based on a genuinely shared understanding. Black argues that pupils who are consistently involved in productive interactions come to see themselves as full participants or learners, while those involved in non-productive interactions find themselves marginalised from the practice of classroom learning. Pupils' consistent involvement in productive/non-productive interaction is as much about the construction of an identity as it is about access to shared understandings with the teacher. The data illustrates how classroom dialogue can shape pupil identity. Black argues that failure to learn should not be conceived as a problem of cognitive challenge or difficulty, but in terms of understanding how social class, race and gender impacts on the classroom's micro-climate and the construction of identities of non-participation. Some pupils engage in productive exchanges with teachers more often than others, and this variation may be linked to an implicit set of social norms embedded in the classroom's microculture; the reasons behind such differences primarily relate to the teacher's expectations of ability and the cultural capital that pupils bring into the classroom, which both impact upon the communicative behaviour of teachers and pupils. Black argues that, in order to tackle issues surrounding educational disadvantage, there is a need to address the systems and processes that reproduce wider social inequalities within the classroom micro-climate.

While the study provides some examples of high quality teacher-pupil dialogue, it does not provide evidence of its effectiveness in promoting pupils' conceptual understanding of mathematics. This study was assessed as having a low weight of evidence.

Black (2006) explored pupils' understanding of the role and purpose of whole class discussions in supporting learning. Two research questions were posed:

- How do pupils perceive the role/function/purpose of talk in whole class discussions and is this influenced by the teacher's pedagogic style?
- In what ways do pupils conceptualise their participation and status in whole class discussions and how is this influenced by their level of attainment?

This study considers pupils' perceptions of their own participation in such discussions, based on the premise that effective learning requires pupils to see themselves as full participants with the right to make active contributions to classroom activities.

Phase 1 of the study comprised participant observation of two literacy and numeracy lessons and interviews with the class teacher, which provided information about the school culture and the classroom. During this phase, videotapes were made of a literacy and numeracy lesson. Phase 2 of the study comprised the collection of group interview data about discussion in literacy and numeracy lessons with 24 pupils: two groups of four pupils ('high fliers' and 'low attainers' as identified by the teacher) at each of three schools, followed by individual interviews. The pupils were mainly in year 5; however, in one school, the class observed contained both year 4 and year 5 pupils. One teacher at each school was the focus. Each group of pupils was interviewed using a video-prompting technique. Excerpts of the videos recorded in phase 1 were played to pupils as a memory prompt.

The data indicate how pupils perceive the nature of teacher-pupil interaction and how dialogue impacts on their participation and understanding. One teacher used a slightly non-traditional pedagogic approach, which appeared to be informed by an ‘enquiry’ based ideology (associated with the Children’s Philosophy Movement). In her class, the pupils viewed whole class discussions as a tool for developing understanding within a communal space which was both supportive and challenging.

The other two teachers, by contrast, used a more traditional style of teacher talk in whole class discussion: heavy bouts of questioning, with pupil replies limited. In both cases, the teachers dominated the discussion, giving pupils limited opportunities to talk to partners. Here, the pupils believed that the passive activity of listening to the teacher would help them learn, and that teacher-pupil talk was about teacher evaluation and assessment of pupil ability rather than constructing new understandings; these pupils viewed whole class discussions as listening to the teacher, being assessed and evaluated, and negotiating the risk of not getting the answer right.

The pupils in all three classes were acutely aware of the rule governed nature of classroom discourse. Such rules included putting your hand up to speak; listening to the teacher; not shouting out; not getting out of your seat; and showing each other respect.

Comparing the perceptions of high fliers with low achievers indicated a noticeable distinction in how they viewed the benefits of whole class discussions. Lower ability pupils viewed discussion as educational activities that were ‘done to them’ as part of the educational process and where they had little control over the activity. In contrast, high ability pupils indicated some awareness of the features of classroom discourse and how to extract benefit from it: for example, by staying focused and not going off on a tangent, and by making use of cued elicitation (giving clues or rephrasing as an easier question).

Pupils were aware that ability impacted on participation: pupils perceived that more able pupils understood the work better and were thus able to answer quicker and participate more. More interesting, though, was the high achievers’ view of class discussion as providing an opportunity for learning through which their status as learners and participators could be enhanced, while lower ability pupils distanced themselves more and spoke of those who participated as ‘they’ (that is, the clever ones). This reflects how high ability pupils adopted an identity as a participator, while lower ability pupils developed an identity as a non-participator.

Black argues that pupils need to view discussion as a tool for learning. The teacher needs to create a challenging and supportive communal space in which pupils can contribute and share their thoughts. The teacher needs to take care not to privilege the participation of the more able pupils in order to ensure that lower ability pupils do not develop identities as non-participants for whom classroom discussion is ‘for clever pupils and not for them’ and is something that is ‘done to them’, rather than something in which they can positively engage to advance their learning. Black argues that a pedagogic approach which is oriented towards discussion inquiry may bring about the recognition of learning as a process of understanding, trial and error, challenge and collaboration, as opposed to the passive act of listening.

While the study provides some examples of high quality teacher-pupil dialogue, it does not provide evidence of its effectiveness in promoting pupils’ conceptual understanding of mathematics. This study was assessed as having a low weight of evidence.

Bold (2002) explored the dialogic practices used by a teacher and his pupils when they explain the meaning of mathematical words. Two research questions were posed in this study: (i) How does the teacher interact with pupils to develop a shared understanding of the meaning of mathematical words? (ii) How do pupils express their understanding of the meaning of specific mathematical words and phrases?

Bold analysed data based on three mathematics lessons and eight structured interventions with year 5 pupils. The author observed three lessons consecutively on probability, using video-recording to capture evidence of the main teaching input, with occasional narrative recording of pupil-pupil or teacher-pupil interaction during class work. After watching the videotapes, she developed a questionnaire for the teacher who also watched the videos before responding to the questions. For the structured interventions, 16 pupils (eight mixed gender pairs), chosen by the teacher used a series of sheets to encourage discussion about probabilistic language. This also produced written and video evidence.

Bold used discourse analysis of the transcripts in both strands of the research. In the classroom observation, the focus was on dialogue between the teacher and the whole class. In the structured interventions, the focus was on peer interaction with researcher intervention. The aim was to identity the ways that both types of dialogue contribute to participants shared understanding of mathematical vocabulary.

In the first lesson, the teacher altered pupils’ suggestions to ‘his meaning’ to make it potentially more shareable with the class. The teacher found it difficult to control the ‘open-dialogue’ due to the pupils’ subjective responses. In the second lesson, the teacher focused the discussion of one phrase (even chance) in order to reduce ambiguity. The third lesson focused on the probability scale as likened to a time-line. Bold reports that pupils found it difficult to locate real-life events on this scale because too many variables existed, making causal justification problematic.

During the structured interventions, Bold noted that some pairs of pupils were more able, or willing, to enter an educated discourse than others. She also noted that a willingness to enter into peer discussion did not necessarily support the development of a shared understanding.

This study highlights the problems facing a teacher in attempting to make use of extended dialogue, particularly in terms of how and when the teacher needs to take control over the nature and direction of the dialogue which occurs, and how to deal with the confusion that arises when the ambiguous use of words leads to pupils being confused in ways they can not easily resolve by themselves.

While the study provides some examples of high quality teacher-pupil dialogue, it does not provide evidence of its effectiveness in promoting pupils' conceptual understanding of mathematics. This study was assessed as having a low weight of evidence.

Coles (2002) explored forms of listening and hearing and associated strategies in year 7 mathematics lessons. This study considers case data involving two teachers (A and D), one of whom is Coles (teacher D), and focuses on teaching strategies related to listening and hearing in their two secondary school classrooms. The teachers were videotaped in each of the six half-terms that make up an academic year. The transcripts are analysed in terms of three forms of listening identified by Coles:

i) *Evaluative listening*: The listener sees what the other says in terms of 'right or wrong' and sees listening as the other's responsibility.

ii) *Interpretive listening*: This reflects an awareness of the fallibility of the sense being made; the listener will offer an interpretation and ask for clarification; the interpretive listener stands back from the speaker and seeks to make sense of what the speaker says from the listener's point of view.

iii) *Transformative listening*: The listener is open to interrogation of their own assumptions; this is evidenced by a willingness to alter ideas in a discussion, to engage in dialogue, to entertain other points of view, and to hold them as valid, independent of whether they are accepted or not.

The analysis indicates that teacher D (the author) makes consistent use of transformative listening; the other teacher (teacher A) tends to use interpretive listening, but in later lessons moves towards making more use of transformative listening. Teacher A's shift towards making greater use of transformative listening is illustrated by greater use of the following four strategies: (i) the teacher asking a question to which they do not know the answer; (ii) responding to pupils' suggestions; (iii) asking for feedback from the whole class; and (iv) asking a pupil to explain their idea to the class. These four strategies can all be seen as 'slowing down and opening up discussion'. These strategies were all evident in teacher D's lessons.

While the study provides some examples of high quality teacher-pupil dialogue based on the use of strategies that promote transformative listening, it does not provide evidence of its effectives in promoting pupils' conceptual understanding of mathematics. This study was assessed as having a low weight of evidence.

Hadjidemetriou and Williams (2003) explored the connection between teachers' stated strategies and intentions (or 'espoused theories') and their 'theories-in-use' (what they actually do) when engaging in reflective practice on argumentation.

Two research questions were posed in this study:

- How can/do teachers develop strategies which enhance mathematical dialogue and argumentation in their classroom discussion?

- Can we describe and account for these through video, narrative and case studies in ways which help our colleagues?

Hadjidemetriou and Williams present a case study of a teacher (Alan) based on observations of three year 9 (set 5) lessons, plus meetings and interviews with Alan and his colleagues. The data analyses Alan's espoused theories of his classroom practice. The data comes from three sources: (i) audio-taped meetings where all the teachers share their work with their colleagues, (ii) videotaped lessons, and (iii) interviews with the teacher after each lesson.

Hadjidemetriou and Williams identified eight espoused strategies (together with their aims/ intentions): (i) pinning pupils down to detail (aim: everyone is following); (ii) one minute discussion (aim: raise/harness the energy); (iii) leave tensions unresolved (aim: make 'them' do the mathematics); (iv) conflict strategy (aim: induce a change of method); (v) summarising and clarifying (aim: everyone is following); (vi) working with one method (aim: everyone is following) ; (vi) working with multiple problems method (aim: making connections/introduce generality); and (viii) slow the pace (aim: take everyone along).

They note that strategies can be subdivided into behaviour and intentions, and that different strategic behaviours can relate to the same intention. They also note from other data that the teachers' account of their strategies appear to be co-constructed with the researcher and somewhat unstable. In addition, the teachers' beliefs about what they do appear to be unsettled by being confronted with their own video.

While the study provides some examples of high quality teacher-pupil dialogue, it does not provide evidence of its effectiveness in promoting pupils' conceptual understanding of mathematics. This study was assessed as having a low weight of evidence.

Jones and Tanner (2002) explored the teaching approaches adopted by secondary school teachers introducing whole-class interactive teaching strategies into their own practice, and the extent to which they felt this had impacted on the quality of classroom discourse. The study looked at eight mathematics teachers in four secondary schools in Wales. Data included lesson observations, interviews, and discussion at group meetings.

Jones and Tanner reported that in every classroom, pupils were encouraged to contribute their ideas and to explain their methods in the class. The class atmosphere was supportive, and pupils were eager to contribute and willing to go to the board to demonstrate their approaches. Every teacher considered their pupils to have become far more confident about their mathematics. Some teachers developed approaches which provided focusing scaffolding. Some useful dialogue also occurred during plenaries to aid reflection and consolidate pupils' metacognitive self-knowledge.

They reported that the quality of the discourse was related to the degree of scaffolding used; the opportunities for reflection; and the degree of pupils' ownership over classroom processes. Jones and Tanner found the quality of the discourse was influenced by the teacher's ability to anticipate the possible responses and errors that might arise, and their confidence to 'go with the pupils'. They also reported a tension between encouraging pupils' confidence and involvement by accepting their contributions, and the need to progress to more mathematically acceptable strategies. They noted that teachers reported that pupils experiencing interactive whole class teaching gained in confidence about their mathematics.

While the study provides some examples of high quality teacher-pupil dialogue, it provides only limited (teacher-reported) evidence of its effectives in promoting pupils' conceptual understanding of mathematics. This study was assessed as having a medium weight of evidence.

Mercer and Sams (2006) evaluated an intervention teaching programme called Thinking Together designed to enable pupils to talk and reason together effectively. Three hypotheses were posed: (i) that providing children with guidance and practice in using language for reasoning will enable them to use language more effectively as a tool for working on mathematics problems together; (ii) that improving the quality of children's use of language for reasoning together will improve their individual learning and understanding of mathematics; and (iii) that the teacher is an important model and guide for pupils' use of language for reasoning.

This intervention study looked at 406 pupils and 14 teachers. This involved 196 year 5 pupils and 7 teachers in the target classes, and 210 pupils and 7 teachers in control classes. The intervention comprised 12 lessons. Lessons 1-5 introduced the talk skills; lessons 6-12 targeted a specific talk skill and a specific concept in mathematics or science. This study focused on the data concerning mathematics.

Mercer and Sams looked at five categories of 'exploratory talk' which could guide pupils' use of language, in terms of the extent to which teachers (i) used 'why' questions, in which they sought children's reasons for holding an opinion, or for having carried out a particular operation; (ii) used 'reasoning words', such as 'if', 'because', 'so'; (iii) offered reasons of their own to back up statements or proposals; (iv) checked that everyone who had a relevant idea had been heard; and (v) sought agreement among the class at the end of a debate. The study also contrasted, by way of example, two teachers, one of whom rarely modelled exploratory talk and the other whose engagement with pupils was more 'dialogic'.

Mercer and Sams reported that the target group made greater gains in mathematics, and that the data upheld all three hypotheses: (i) pupils can be enabled to use talk more effectively as a tool for reasoning; (ii) talk-based activities can help the development of individuals' mathematical reasoning, understanding and problem-solving; and (iii) the teacher of mathematics can play an important role in the development of pupils' awareness and use of language as a tool for reasoning.

This study is one of only two studies in this review categorised as 'what works'. The study provides some examples of high quality teacher-pupil dialogue and evidence of its effectiveness in promoting pupils' conceptual understanding of mathematics. This study was assessed as having a medium weight of evidence.

Myhill (2006) explored the nature and quality of teacher talk in whole class teaching and how teachers use such talk to develop and build on pupils' learning. The principal research question was: How do teachers use talk in whole class episodes to scaffold learning and develop understanding? In addition, the following six subsidiary research questions framed the research:

- How interactive are whole class episodes?
- How do teachers build on prior pupil knowledge?
- How do teachers use questions?
- How do pupils use questions?
- How is the handover to independence or 'critical

moments' handled?

- What do teachers believe about talk as a tool for learning?

The sample comprised year 2 pupils (in three first schools), and year 6 pupils (in three middle/ primary schools). 18 whole class teaching episodes of approximately 15 minutes each were video-recorded in national literacy strategy (NLS), national numeracy strategy (NNS) and a third curriculum area (total = 54 episodes). Each teacher also completed a post hoc reflection upon his/her talk using the video and a series of prompts as stimulated recall. The analysis looked at questioning, pupil participation, and the use of prior knowledge to scaffold learning. The study considers the nature and degree of the teachers' control over classroom discourse and focuses on three areas: (i) teachers' questioning; (ii) differential participation in interactions; and (iii) use of prior knowledge to scaffold learning.

Myhill reports that teacher discourse in whole class teaching provided limited opportunities for pupil learning; much whole class teaching involved relatively little interaction which supported and scaffolded pupils in their learning; teacher talk dominated whole class teaching; teacher-pupil interactions operated in highly conventional discourse patterns; the dominant interaction pattern was teacher-pupil-teacher-pupil, and only rarely was this pattern disrupted; the pupil's answer served to end an interaction sequence, and rarely to begin or initiate it; very little talk was initiated by pupils; the framing of discourse was predominantly structured upon a framework of teacher initiation and single pupil response; teacher orchestration of classroom talk and interaction patters which preserve the teacher's control of talk scenarios was the dominant pattern.

Overall, this study paints a picture of teaching in mathematics lessons being dominated by a mainly transmissive approach; the potential of teacher talk to develop pupil understanding or exploring pupils' misconceptions is rarely evident in the classroom practice observed. Myhill does, however, provide some examples of better practice, in which teachers scaffold learning by structuring questions and sequences of questions that build on thinking, although this is mainly evident in the context of factual questions.

While the study provides some examples of high quality teacher-pupil dialogue, it does not provide evidence of its effectiveness in promoting pupils' conceptual understanding of mathematics. This study was assessed as having a medium weight of evidence.

Pratt (2006) explored pupils' perceptions of interactive teaching making use of 'video stimulated reflective dialogue'. The focus of the study was on pupils' views about the roles of talking and listening. This study deals with one mixed year 3/4 class (7-9 year-olds) and two year 6 classes (10-11 year-olds) in two different schools (a year 3/4 class and a year 6 class in one school, and a year 6 in another school). Video-recordings were made of pupils engaged in whole class interactive mathematics lessons with their teachers. This was then shown to them during subsequent interviews; in the interviews the pupils were asked to talk about their actions and emotions rather than to interpret the events. This paper looks at three lessons. Within three days of the lesson, the researcher carried out paired video stimulated interviews. In all, there were 17 pairs of pupils (5 pairs of year 3/4 pupils and 12 pairs of year 6 pupils).

These interviews firstly examined pupils' views regarding video clips that dealt with five teaching situations: (i) the teacher was asking pupils for their views or for approaches to solving a particular problem; (ii) pupils were talking collaboratively, either as a whole class or, for short periods, in pairs/groups; (iii) teachers were selecting examples from pupils to use with the class and having to make choices about what to focus on and what to ignore; (iv) pupils were expected to explain their understanding of an issue publicly in order that others might share in it, particularly where this seemed problematic in some way for the speaker or the listener; and (v) the teacher was explaining an idea to the class.

The interviews then went on to explore the pupils' views of six teaching practices common to all teaching situations; these involved the extent to which learning mathematics is helped by the teacher: (i) asking questions; (ii) repeating your answers back to you; (iii) writing on the board; (iv) listening to you talk; (v) telling you things; and (vi) encouraging.

Pratt identified two themes which emerged from the analysis: (i) pupils' perceptions of what and why they were learning as a whole class; and (ii) pupils' perceptions of how this learning took place. With regard to the first theme (what/why), Pratt reports that the pupils in all three classes had a very clear view of what, and why, they were learning in a whole class interactive context. This view essentially focused on two issues: (i) the joint refinement of technique, whereby pupils understood that others might have solutions that were more useful, or more efficient, than their own; and (ii) the memorisation of best methods, whereby pupils perceived their job essentially being to remember the particular technique that was identified as the best for a particular problem.

Pratt notes that the idea of joint refinement techniques is encouraging (and reflected clearly the emphasis of all three teachers on reinforcing the need to listen carefully to each other); the second, with the focus on memory, is more problematic. The latter suggests that, despite the potential opportunity for an active and dynamic construction of meaning in a social setting, pupils' focus was largely on more passive memorisation. The pupils' responses also suggested it was mainly the teacher who identified what 'best' was in each case and hence what was to be memorised.

With regard to the second theme (how), Pratt considered pupils' responses relating to learning as a process in a whole class interactive setting. Three conceptual categories are identified in this respect:

i) *Authority in interaction*. Although pupils understood the purpose of class discourse to be the negotiation of solutions, there was no doubt about who was in control of judgements in this respect: it was the teacher who validated knowledge generated by the group and ultimately decided if things were 'right' or 'wrong'. This was sometimes done directly (for example, by saying 'That's wrong') and sometimes done indirectly (for example, through the teacher giving clues).

ii) *Difficulties in understanding explanations*. The pupils had a very clear sense of the practical difficulties of facilitating the process of idea sharing. Two problems were: (i) the clarity and comprehensibility of other pupils, and (ii) pupils' own resistance to conceptual change. The pupils were aware that some pupils were better than others at giving clear explanations (both in terms of audibility and comprehensibility). They were also aware of difficulties in hearing and understanding peers. The role of the teacher during interaction is more complex than suggested by the NNS.

iii) *The supremacy of listening over talking*. By year 6, pupils appeared to realise quite quickly that the process of listening to public talk was a means of learning in so far as they perceived classroom dialogue as a way to access a range of ideas, some of which might be of value in extending their own understanding. The year 3/4 pupils in this study were less clear about this.

Overall, this study concerning pupils' understanding of the purpose of whole class discourse highlights four main issues:

- Pupils have their own conceptions of what it means to learn may be largely based on notions of memorising 'best' results.

- Pupils may perceive the teacher as the arbiter of right and wrong and this may lead to impoverished interaction in relation to key mathematical processes, such as reasoning.

- Pupils are likely to understand those features of the teacher's role which impact on the form of the interaction, including dilemmas for the teacher, and may have insights into patterns of behaviour and difficulties in communication within the classroom which would be useful for teachers to know about.

- Listening may be privileged over talking by pupils and talking may be seen only as a means of generating 'something to listen to' rather than as a form of meaning making in its own right. This may have important implications for the way in which pupils engage, or not, with the interaction.

This study paints a picture of teacher-dialogue in which the teacher is in control and is seen as the key decider of what is right/wrong, and who provides pupils with clues. Pratt argues that there is a need for teachers to help pupils see discourse as a means of learning through talking as meaning-making.

While the study provides some examples of high quality teacher-pupil dialogue, it does not provide evidence of its effectiveness in promoting pupils' conceptual understanding of mathematics. This study was assessed as having a low weight of evidence.

Ryan et al. (2003) explored how two teachers began to develop their ideas and practice concerning the use of collaborative classroom discussion of pupils' misconceptions and errors in year 5 mathematics lessons. The study used case study methodology. Research-based materials used to begin, sustain and extend pupils' discussion, were presented to two teachers during a university-based training session for the study of teachers' understanding of pupils' mathematical arguments in discussion.

How these two teachers adapted or rejected these materials and strategies to their own practice was tracked over a three-month period. The teachers' lessons were videotaped and these recordings were used across the three-month period to prompt teacher reflection on what they were developing.

At the first meeting (baseline), the three researchers outlined the aims of the project and the two teachers described their current practice and reactions to errors and misconceptions in the classroom. Video extracts from NNS materials, where teachers responded to pupils' errors in the classroom, were used for discussion. This meeting made clear to the teachers that the project was about them developing their own ideas for classroom discussion. The first videotaped lesson was used to exemplify their current practice and act as a baseline for the development of classroom discussion. In their second lesson, discussion was the focus. The two baseline lessons and the two discussion lessons were then analysed and compared by the teachers and the researchers.

Ryan et al. found that the teachers endorsed the opportunity to explore new practice within a supported research environment in which they were able to take control of the agenda and develop their own practice, rather than deliver the practice of an outside agency.

However, the teachers felt the NNS structure for the 'numeracy hour' constrained teacher-pupil dialogue. The videos enabled the teachers to recognise existing practices of pupils' discussions, and that engaging in dialogue involved pupils learning a new skill.

Overall, this became a study of what mathematical discussion could be – how these two teachers defined mathematical discussion of misconceptions and errors. The study highlighted the need for teachers to control their own development in a creative way.

While the study provides some examples of how teachers can develop high quality teacher-pupil dialogue, it does not provide evidence of its effectiveness in promoting pupils' conceptual understanding of mathematics. This study was assessed as having a low weight of evidence.

Smith et al. (2004) explored primary school teachers' use of discourse strategies during whole class interactive teaching. Two research questions were posed:

- What discourse moves do teachers use during whole class interactive teaching?
- Do the patterns of discourse use by teachers vary across subjects (literacy versus numeracy lessons), stages (reception versus Key Stage 1 versus Key Stage 2 lessons) and teacher effectiveness (that is, comparing teachers identified as 'effective' using PIPS data with 'average' teachers?)

This study looked at a national sample of 72 primary teachers teaching literacy and numeracy (35 literacy and 37 numeracy). 60% of each sample were identified as 'effective' using performance indicators in primary schools (PIPS) data provided by the Curriculum, Evaluation and Management (CEM) Centre at the University of Durham, and the other 40% as 'average'. Effective teachers had positive value-added scores above 2; average teachers had value-added scores that were broadly zero (between -0.5 and +0.5).

The study made use of a computer-assisted systematic observation system which logged the actor, the discourse move, and who the receiver was. It therefore primarily focused on the three-part, initiation-response-feedback (IRF) structure. The system gathers data on teachers' questions, whether questions were answered (and by whom), and the types of evaluation given in response to answer.

The system captures whether questions were open or closed, who responded (boy, girl or both together) and teacher feedback (praised, criticised or accepted). The system also captures two feedback moves: probes (with the teacher staying with the same child to ask further questions) and uptake questions (with the teacher incorporating a pupil's answer into a subsequent question).

Video-recordings of a sub-sample of 14 effective teachers were collected: eight reception / KS1 teachers (comprising four literacy and four numeracy lessons) and six KS2 teachers (comprising 3 literacy and 3 numeracy lessons). The video-recordings were transcribed to compare the patterns of the teacher-pupil interactions across all 14 lessons.

The findings focused on the whole class section (WCS) of the lesson. The data indicated that teacher-directed interrogation of pupils' knowledge and understanding was the most common form of teacher-pupil interaction. Some teachers encouraged higher levels of pupil participation and engagement through open questions and different uses of the follow-up move.

The study provides evidence that traditional (IRF) patterns of whole class interaction in mathematics lessons have not been dramatically transformed by the introduction of the NNS. In the whole class section of literacy and numeracy lessons, teachers spent the majority of their time either explaining or using highly structured question and answer sequences. Far from encouraging and extending pupil contributions to promote higher levels of interaction and cognitive engagement, most questions asked were of a low cognitive level designed to funnel pupils' response towards a required answer. Effective teachers appeared to have a more interactive style as measured by the overall rate of discourse moves; however, the difference is quantitative than qualitative (the only difference being that effective teachers used more general talk).

Smith et al. argue that in order to bring about changes in the way teachers interact with their pupils, monitoring and self-evaluation needs to be a regular part of in-service training.

While the study provides some examples of high quality teacher-pupil dialogue, it does not provide evidence of its effectiveness in promoting pupils' conceptual understanding of mathematics. This study was assessed as having a medium weight of evidence.

Smith and Higgins (2006) explored the teachers' use of questions, and in particular how teachers react to pupils' responses, as a means of facilitating a more interactive learning environment. The study was part of a wider research project investigating the use of interactive whiteboards (IWBs) during literacy and numeracy lessons in UK primary classrooms based on real-time observation/coding of 114 year 5 literacy and numeracy lessons in 2003 (36 literacy using IWB, 36 literacy not using IWB, 36 numeracy using IWB and 36 numeracy not using IWB), and 70 literacy and numeracy lessons in 2004 with year 5 and 6 - all using IWBs). In addition, a further 29 lessons (15 numeracy and 14 literacy) were video-recorded. The videotapes were used to examine teacher behaviour more closely from a qualitative perspective.

The study noted that the tripartite IRF sequence identified as common to the structure of classroom interaction without IWBs was equally common in lessons using IWBs. However, the study also identified a purposive sample of those lessons which were less restrictive and teacher controlled (i.e. where there was a more symmetrical distribution of talk and where pupils' talk was noticeably more in-depth, exploratory and speculative). This identified only a maximum of five literacy and five numeracy sessions which contained some such behaviour at some stages of whole class interaction. An analysis of the transcripts of these episodes using the IRF structure was used to identify which behaviours facilitated a more interactive learning environment. This revealed that it is the quality of the feedback move in the IRF exchange, and not the questions themselves, which facilitates a more interactive learning environment, by the teachers:

i) *Encouraging pupil-pupil feedback by inviting pupil-pupil response and feedback:* The teacher conveyed to pupils that their utterances are taken seriously, pupils are given a more equitable distribution of utterance length, they are invited to agree/disagree with another pupils, and to offer unsolicited feedback to each other.

ii) *Encouraging a more symmetric interaction by demonstrating reciprocal engagement in pupils' responses*: Rather than explicitly promoting pupils to continue their utterances, the teachers reacted in a more conversational, less institutionalised manner, and made backchannel moves during pupils' responses, signalling authentic interest or expressed interest at the end of the pupil's utterance.

iii) *Following pupils' ideas, where teachers demonstrated a more flexible approach to unpredicted pupil responses*: For example, they sometimes turned the feedback move into another question, or asked for clarification. Such questions are authentic in that they genuinely ask something unknown, ratifying the importance of the pupil's original response, while also creating the opportunity for the pupil to expand upon their original response. Another example is a teacher suggesting a pupil's response could be followed up at some future stage, or incorporating the pupil's unpredicted ideas into the immediate discussion, or using them to frame a new activity; such responses by teachers encouraged pupils to have ownership not only over the solution to problems but also over the flow of the lesson.

Smith and Higgins argued that the episodes of classroom interaction from video-recorded numeracy lessons support the argument that, in order to 'open' classroom interaction in mathematics lessons, emphasis should be less on the questions teachers ask, and more on the manner in which teachers react to pupils' responses to questions. They noted that the teachers in the study who used whole class teaching as a means of creating an interactive learning environment did so by careful use of the feedback move in the IRF exchange. These teachers encouraged pupils to respond to each other's contributions by inviting peer reviews and arguments/disagreement. They also showed authentic engagement by making backchannel moves during pupils' responses, followed by exclamations of interest and surprise, questions of clarification, and statements relating the responses to their own experiences or opinion. They also restated pupil responses by paraphrasing and linking with others' responses. They were willing to forgo control of the lesson and follow pupil ideas as an impetus for further discussion or new activity. Teachers used 'conservational tactics' not as alternatives to questions, but as alternatives to evaluative feedback.

Smith and Higgins concluded that it is not the type of questions teachers ask that limit pupils' response; rather, it is the feedback given in reaction to pupil responses and the historical precedence of the perception of teacher intent this engenders, which either opens or restricts classroom interaction. Using such conversational tactics as regular alternatives to evaluative feedback means that pupils will come to view the purpose of questions as a tool to focus their minds on a problem to be jointly solved, in order to arrive at a shared and possibly new understanding. Smith and Higgins argued that, because 'teacher intent' is likely to frame subsequent feedback, the training of teachers in 'interactive pedagogy' needs to focus on 'teacher intent' regarding how the feedback they give to pupils encourages pupils to engage in talk for learning.

While the study provides some examples of high quality teacher-pupil dialogue, it does not provide evidence of its effectiveness in promoting pupils' conceptual understanding of mathematics. This study was assessed as having a low weight of evidence.

Tanner and Jones (2000a) explored the impact of an action research project designed to develop pupils' metacognitive skills on their performance in mathematics. It was anticipated that the use of suggested classroom teaching strategies would produce improved pupil performance in problem-solving and modelling situations which were similar in character to those used on the course: 'near transfer'. It was further hypothesised that the development of metacognitive skills would lead to improved learning in mathematics through 'far transfer' into the cognitive domain (that is, the more usual content areas of mathematics which had not been specifically targeted by the project).

This study looked at nine classes in Wales (years 7 and 8) which had followed a course emphasising metacognitive skills. The mathematical thinking skills project emphasised the skills of planning, monitoring and evaluating; the classroom practices included strategies to scaffold pupils' thinking and to encourage reflective discourse.

A quasi-experimental design was employed which involved pre-testing, post-testing and delayed-testing of control and experimental groups. 641 pupils in 12 pairs of classes were involved, of whom 314 experienced intervention lessons and 327 followed their usual curriculum.

Two teachers from each of six secondary schools formed an action research network. In each school, two equivalent pairs of classes were identified to act as control and intervention groups. In every class, the pairs of classes were either mixed ability groups or parallel sets. One pair was in year 7 (11-12 year-olds), and one pair in year 8 (12-13 year- olds). The control classes were taught by their normal teacher who had no direct involvement with the project. The intervention took place within a period of 12 school weeks, and regular participant observation of the lessons was undertaken.

Written tests were used to assess pupils' cognitive development. Metacognitive skills were assessed through a section on the written paper entitled 'planning and doing an experiment'. Metacognitive self-knowledge was assessed by asking pupils to predict the number of questions they would get correct before and after each section (forecasting and postcasting). Pupils were pre-tested before the intervention teaching began and post-tested at the end of the course in July. Delayed testing took place four months later after the summer holidays.

The participant observations revealed that the extent to which the teachers had adopted the suggested approaches was variable. As a result, three teachers were dropped from the final analysis. The quantitative analysis thus deals with the remaining eight teachers and their nine classes (one intervention teacher taught two groups) and their 499 pupils.

Using the participant observation data, the eight teachers were classified into four characteristic groups according to the teaching styles employed:

(i) *Taskers* focused on the demands of the task rather than the underlying aim of teaching metacognitive skills.

(ii) *Rigid scaffolders* were far more directive in their approach to planning, with an emphasis on demonstrating and sharing the teacher's own previously identified plan rather than helping pupils to develop their own plans.

(iii) *Dynamic scaffolders* made full use of the social structure of one of the strategies called 'Start-Stop-Go' to frame their pupils' behaviour and constrain them to act as experts rather than novices, but the teacher was the most significant participant in the discourse, validated conjectures and used focusing questions to control its general direction, ensuring that an acceptable whole class plan was generated.

(iv) *Reflective scaffolders* also used the social structure of Start-Stop-Go to constrain pupils to act as experts rather than novices, but they encouraged several approaches to the problems rather than constrained the discourse to a class plan.

A comparison of each of these four groups with the control group revealed the following:

- The taskers' pupils showed no advantage over the controls in any test.
- The rigid scaffolders' pupils showed an advantage over the controls in only the metacognitive delayed tests with a very small effect size of 0.09.
- The dynamic scaffolders' pupils were more effective than controls at developing metacognitive skills, with an effect size of 0.36.
- The reflective scaffolders' pupils had a significant effect size in all four areas: metacognitive skills development (0.40), forecasting (0.07), postcasting (0.14) and cognitive development (0.21).

Tanner and Jones argued that the success of the reflective scaffolders was conjectured to be due to their emphasis on self-evaluation and reflection. They concluded that participation in reflective discourse can encourage objectification and the development of metacognitive self-knowledge. They further conjectured that teaching approaches which support the development of active metacognitive skills in combination with passive metacognitive knowledge enhance not just the application of previously known mathematics to new contexts but also enhance the learning of new mathematics.

This study is one of only two studies in this review categorised as 'work works'. The study provides a good example of a project based on teaching strategies aimed to foster high quality teacher-pupil dialogue and evidence of the project's effectiveness in promoting pupils' conceptual understanding of mathematics. This study was assessed as having a medium weight of evidence.

Wilson et al. (2006) explored teacher-pupil interactions in mathematics lessons in North East England and in St. Petersburg (Russia). The focus was on the patterns of interactions, both public and private, the number and duration of interactions, and the nature of the dialogue. The sample looked at mathematics lessons of three classes of different ages (7-11 years) observed every day for a week at two schools in each country.

For the sample of 25 mathematics lessons in England, they reported that the NNS has resulted in a consistent pattern of lesson structure, incorporating substantial amounts of public exchange in whole class settings. The middle phase of the lesson tends to contain interaction

Table 4.1: Weight of evidence of studies included in the in-depth review

Main paper	Component A: Trustworthiness of the study in answering the study's question(s)	Component B: Appropriateness of research design and analysis for addressing the review question	Component C: Relevance of particular focus of the study for addressing the review question	Composite D: Overall weight taking account of A, B and C
Back (2005)	Low	Medium	Low	Low
Black (2004a)	Medium	Low	Low	Low
Black (2006)	Medium	Low	Low	Low
Bold (2002)	Low	Low	Low	Low
Coles (2002)	Low	Low	Low	Low
Hadjidemetriou and Williams (2003)	Low	Low	Low	Low
Jones and Tanner (2002)	Medium	Medium	Medium	Medium
Mercer and Sams (2006)	Medium	Medium	Medium	Medium
Myhill (2006)	Medium	Medium	Medium	Medium
Pratt (2006)	Low	Low	Low	Low
Ryan et al. (2003)	Low	Low	Low	Low
Smith et al. (2004)	High	Medium	Medium	Medium
Smith and Higgins (2006)	High	Low	Low	Low
Tanner and Jones (2000a)	Medium	Medium	Medium	Medium
Wilson et al. (2006)	Medium	Low	Low	Low

which is exclusively private, although, where the teacher is working intensively with an identified group of pupils, the interaction is public within the group, but not intended to include the rest of the class. Teachers tended to ask a series of short, closed questions, maximising the number of pupils required to provide oral responses. This type of 'interactive pace' was mitigated by the use of longer interactions which have the potential for extending pupils' thinking. There is, however, some evidence of pupils being asked to provide an oral explanation of the method they have used. The use of teacher-pupil dialogue to construct new understanding was also examined, and some examples of this were noted during 'private interaction'. The data suggests that teachers are attempting to employ a pedagogy using the whole class interactive teaching as a basis for getting the pupils to think for themselves and relate mathematics to their own prior cognitive structures, but that asking pupils to think for themselves can create difficulties for pupils if they have an imperfect grasp of the mathematics they are using.

Overall, two issues were highlighted in this study:

(i) There is tension between interaction and cognitive pace, and tension between collective involvement and responses to individual needs.

(ii) Public interaction has become far more common since the introduction of the NNS.

While the study provides a good analysis of typical patterns of teacher-pupil dialogue, it does not provide evidence of its effectiveness in promoting pupils' conceptual understanding of mathematics. This study was assessed as having a low weight of evidence.

4.1.2 Characteristics of the included studies

Much of the greater interest in researching teacher-pupil dialogue in primary school mathematics lessons (rather than in secondary schools) evident in this review (Chapter 3, Table 3.1) can be linked to the introduction of the national numeracy strategy. Indeed, many of the studies included in this review explicitly pointed out that their study of teacher-pupil dialogue had been prompted by the prominence given to enhancing the quality of teacher-pupil dialogue as part of the introduction of interactive whole-class teaching. However, it is also likely that the difficulty of gaining access into secondary schools, particularly in terms of conducting research on pupils in Key Stage 4, may also partly explain this imbalance.

As also noted in Chapter 3, the approach adopted for the inclusion of studies resulted in a mixture of study types being included in this review.

4.1.3 Weight of evidence results

No study received an overall weight of evidence rating of 'high'; five studies were rated 'medium', and 10 studies were rated 'low' (Table 4.1).

It needs to be borne in mind, however, that the use of a three-point rating scale (high, medium and low) for each of the components A, B and C, means that each band is fairly broad (that is, each category contains a wide range of quality).

The lack of studies receiving an overall weight rating of 'high' was due to the absence of any high quality studies which evaluated an intervention strategy that aimed to raise pupils' conceptual understanding of mathematics through high quality teacher-pupil dialogue.

4.2 Synthesis of evidence

The 15 studies indicate that the use of IRF sequences remains the dominant form of discourse in mathematics lessons during whole class interactive teaching. IRF sequences are typically distributed by the teacher around the classroom so that different pupils are engaged in the interaction, but, for each individual pupil the interaction is short, usually requires an answer to a closed question, and is terminated by evaluative feedback (for example, 'Yes', 'No', 'Well done') (see, in particular, Myhill, 2006; Smith et al., 2004; Wilson et al., 2006) (overall WoE: 2 medium, 1 low).

In considering this finding - that the use of IRF sequences remains the dominant form of discourse in mathematics lessons, emerging from the in-depth analysis of the included studies – it is necessary to bear in mind that the included studied cannot be said to have investigated a representative sample of mathematics lessons in England. However, this finding is line with the wider research on mathematics in England that has been published recently, some of which is highlighted in Chapter 2 of this report, and some of which is referred to the included studies.

There is, however, evidence indicated here that some teachers are making use of extending teacher-initiated teacher-pupil dialogue. This can involve asking the pupil to explain or justify their answer and method, asking the pupil a follow-up question, and asking another pupil to comment on the first pupil's answer and then returning to the first pupil to ask that pupil to reconsider their previous answer.

Teachers also engage with pupils on a one-to-one basis during private dialogue when the teacher is typically giving help or support to pupils, while they are working individually on problems and tasks set by the teacher. Surprisingly, little research is reported here on the dialogue during such interactions. This may be a consequence of the way in which the introduction of the NNS has focused research attention on the whole class interactive teaching component of lessons. This is a pity, as more needs to be known about the characteristics of high quality dialogue during such private interactions.

There are also periods during a lesson in which a small group of pupils may be asked to work collaboratively on a problem and to discuss and share ideas. During such small group work tasks, the teacher may circulate from group to group to observe or listen in on their progress and to initiate dialogue. Again, surprisingly little research is reported here on the dialogue which occurs in such contexts.

As such, the synthesis which follows is largely based on studies which focused on teacher-initiated teacher-pupil dialogue during whole class interactive teaching, but it is worth noting that some of the data collected in these studies deals with teacher-initiated teacher-pupil dialogue occurring in other contexts.

Few studies provided evidence that such characteristics actually led to an improvement in the conceptual understanding of mathematics (Jones and Tanner, 2002; Mercer and Sams, 2006; Tanner and Jones, 2000a; overall WoE: 3 medium). Although the study by Jones and Tanner (2002) was less robust than the other two studies, it also gained an overall WoE of medium due to the pertinence of its focus and approach to addressing the review question. Only two studies presented data from which an effect size was calculated (Appendix 4.1). In the case of Mercer and Sams (2006), an effect size of 0.59 was reported for the 'Thinking Together' programme on SAT scores; in the case of Tanner and Jones (2000a), an effect size of 0.21 was reported the 'Mathematics Thinking Skills Project' for reflective scaffolders on cognitive development. However, the nature of the data and differences in the outcomes reported does not enable these three studies to be converted to a common metric, let alone meta-analysed to produce a summary effect size.

There is little doubt that keeping classroom talk mathematically focused in the classroom presents a challenge to teachers. In particular, there is a tension between providing a comfortable social space for pupils and establishing a challenging intellectual environment. While some of the studies touch upon this challenge and this tension, the data itself does not form a basis for a critical examination of these.

The synthesis below is framed in terms of eight key characteristics of effective teacher-initiated dialogue aimed to improve pupils' conceptual understanding of mathematics. This synthesis, however, needs to be treated with caution, in the light of the paucity of studies which obtained clear evidence of the effectiveness of these characteristics. In addition, when considering these characteristics, one needs to be aware of the extent to which contextual factors (for example, pupils' relationships with teachers, classroom climate, affective states and self-conception) may influence the degree to which these characteristics promote authentic teacher-pupil dialogue.

The eight characteristics identified in this synthesis were as follows:

i) going beyond IRF

ii) focusing attention on mathematics rather than performativity

iii) working collaboratively with pupils

iv) transformative listening

v) scaffolding

vi) enhancing pupils' self-knowledge of how to make use of teacher-pupil dialogue as a learning experience

vii) encouraging high quality pupil dialogue

viii) inclusive teaching

The identification of these eight characteristics was based on a thematic content analysis of the characteristics of the teaching strategies evident in the reports of the included studies. This was initially developed by members of the Review Group and then shared with others outside the Review Group. The wider consultation indicated that these eight characteristics made intellectual sense and were a fair reflection of the characteristics of teaching strategies portrayed in the included studies, although it was recognised that the characteristics were interconnected and to some extent also overlapped.

i) Going beyond IRF

This characteristic deals with the ways in which teachers go beyond the typical use of IRF which involves asking pupils to answer closed questions and then giving the pupil some evaluative feedback on their answer. A number of studies addressed this characteristic (Back, 2005; Hadjidemetriou and Williams, 2003; Mercer and Sams, 2006; Myhill, 2006; Ryan et al., 2003; Smith et al., 2004; Smith and Higgins, 2006; Wilson et al., 2006 - overall WoE: 3 medium and 5 low). These studies point towards the use by teachers of open-ended questions and follow-up questions.

Hadjidemetriou and Williams (2003) include in their list of strategies used by teachers to encourage pupils to engage in mathematical argument the use of pinning pupils down to details and the use of one-minute discussions. Ryan et al. (2003) explored how teachers could make use of mathematical discussion of misconceptions and errors to extend teacher-pupil dialogue.

Mercer and Sams (2006) provide evidence of the way an intervention programme, Thinking Together, can enable teachers and pupils to move beyond IRF through the use of words such as 'why', 'if', 'because' and 'so', that underpin the notion of exploratory talk which requires pupils to reason mathematically. Back's (2005) study also highlights the link between going beyond IRF and the nature of mathematical thinking.

Myhill (2006) notes that there is a danger in thinking that, if a teacher asks a lot of questions, then this will promote a dialogue with pupils. In fact, what is needed is that, instead of asking so many questions, teachers should make greater use of inviting pupils to 'tell us what they think'. This can then form a basis upon which the teacher and pupil can use a dialogue to co-construct understanding. Myhill notes that generating and extending pupil thinking requires a sensitive shaping of the discourse and sensitive listening to pupils' responses.

Smith et al. (2004) noted that some teachers encouraged high levels of pupil participation and engagement in teacher-pupil dialogue through the use of open questions and the use of a variety of follow-up moves in response to the pupils' answers. The importance of the follow-up move is evidenced in the study by Smith and Higgins (2006), which indicated that it is the quality of the follow-up move by the teacher in an IRF exchange, and not the questions themselves, which facilitates a more interactive learning environment.

Wilson et al. (2006) noted strategies used by teachers to move beyond IRF in order to foster mathematical thinking. These included asking pupils to explain the method they had used, and using teacher-pupil dialogue in a private interaction to construct a new understanding.

ii) Focusing attention on mathematics rather than performativity

This characteristic deals with the ways in which teachers can use dialogue to get pupils involved in mathematical thinking rather than getting correct answers. A number of studies addressed this characteristic (Back, 2005; Coles, 2002; Hadjidemetriou and Williams, 2003; Jones and Tanner, 2002 - overall WoE: 1 medium and 3 low). These studies point towards the use by teachers of dialogue which engages pupils in thinking and arguing mathematically.

Back (2005) refers to the need for pupils to engage in mathematical forms of life. For example, Back notes that asking a 'why question' focuses pupils onto the mathematics and away from a focus on getting the correct answer. Coles (2002) refers to the use by teachers of strategies which have the effect of 'slowing down and opening up discussion'. This phrase is very telling as a number of studies have noted a tension between sustaining a lesson with pace and eliciting intellectual depth. Where pupils are used to interactions with the teacher occurring 'with pace', the use of 'slow-down' strategies can be effective in injecting a more thoughtful approach by pupils towards the nature of the mathematics in which they are engaged.

The use of slow-down strategies is also one of the strategies listed by Hadjidemetriou and Williams (2003) to engage pupils in mathematical thinking. Another strategy used by teachers was to leave tensions unresolved, so that the creative energy generated can be used to motivate the pupils to discuss and do the mathematics themselves (rather than have the teacher explain or demonstrate how to do the mathematics); Hadjidemetriou and Williams use the invocation here to 'make them do the maths!'. Another strategy they identified was to ask pupils to make connections by working with different types of problems and methods in order to identify generalities.

The use of slow-down strategies is also supported by Jones and Tanner's study (2002) which notes that the quality of discourse is enhanced when teachers provide pupils with opportunities for reflection.

iii) Working collaboratively with pupils

This characteristic deals with the ways in which teachers can use dialogue to establish a learning environment in which pupils and teachers are working collaboratively in exploring mathematical problems. A number of studies addressed this characteristic (Back, 2005; Black, 2004a, 2006; Jones and Tanner, 2002; Smith and Higgins, 2006 - overall WoE: 1 medium and 4 low). These studies illustrate ways in which teachers take pupils' answers seriously and work with them in a spirit of collaboration.

Back (2005) refers to the need for teachers to see themselves as joint participants in the teaching and learning process, where there are opportunities for teachers and pupils to negotiate the exchanges that take place, including where teachers allow pupils to take control over the talk. Jones and Tanner (2002) note that the quality of discourse was enhanced by the degree of pupils' ownership over classroom processes and the teachers' confidence to 'go with the pupils' by allowing them to develop their ideas and the teachers to follow the pupils' thinking even if it appears to be taking the teachers in a direction that they did not anticipate or intend.

Black (2004a, 2006) noted that only those pupils (usually the more able pupils) who regularly had productive exchanges with the teacher saw themselves as being engaged in developing a shared understanding of the mathematics with their teacher; it is important to ensure that all pupils in the class (not just the more able pupils) have regular productive exchanges with the teacher.

Smith and Higgins (2006) reported a number of strategies that teachers used to establish a more interactive and collaborative learning environment. In particular, these included inviting pupil-pupil response and feedback to be interspersed within the teacher-pupil dialogue; adopting a more conversational style when responding to pupils' utterances; and following pupils' ideas by asking questions that enable the pupil to further expand on their ideas.

iv) Transformative listening

This characteristic deals with the ways in which teachers listen to pupils' contributions in a manner that conveys that there is a genuine 'meeting of minds' and that the teacher is genuinely willing to change their own thinking in the light of what the pupil has said. Two studies addressed this characteristic (Coles, 2002; Myhill, 2006 - overall WoE: 1 medium and 1 low). These studies highlight the importance of how the teacher interacts with pupils to create a leaning environment in which teacher dialogue can be used to enhance the quality of pupils' engagement in classroom discourse.

Transformative listening is well illustrated in the study by Coles (2002), who identifies four teaching strategies to promote such listening:

(i) the teacher asking a question to which they do not know the answer

(ii) the teacher responding to pupils' suggestions

(iii) the teacher asking for feedback from the whole class

(iv) the teacher asking a pupil to explain their ideas to the class.

These four strategies can all be seen as 'slowing down and opening up discussion'. Myhill (2006) also notes the importance of sensitive listening to pupils' responses as a basis for enhancing teacher-pupil dialogue.

v) Scaffolding

This characteristic deals with the ways in which teachers use dialogue to scaffold pupils' thinking and understanding. A number of studies addressed this characteristic (Jones and Tanner, 2002; Myhill, 2006; Tanner and Jones, 2000a - overall WoE: 3 medium). The use of scaffolding of itself will enhance the quality of teacher-pupil dialogue through the need for both the teacher and the pupil to go beyond IRF.

Jones and Tanner (2002) noted that the quality of discourse used in lessons was related to the degree of scaffolding used. They provided examples of different types of scaffolding used by teachers. One example involved the teacher focusing pupils' attention during a class discussion on key features and merits of particular strategies suggested by pupils for solving a challenging problem. Another example was to discuss with pupils a deliberate mistake in order to identify and clarify the nature of the mistake, thereby focusing pupil attention on the key features of investigating the particular problem at hand. Tanner and Jones (2000a) also noted in another study that the use by a teacher of 'reflective scaffolding' was the form of scaffolding that was most effective; in reflective scaffolding, the teachers not only provide pupils with an opportunity to reflect on the task in which they are engaged, but also allow the pupils to take control over the dialogue to probe their thinking further (that is, the teacher resists constraining or directing the way in which the discourse develops).

Myhill (2006) reported on the ways in which teachers can scaffold learning by structuring questions and sequences of questions that build on thinking and also makes use of pupils' prior learning.

vi) Enhancing pupils' self-knowledge of how to make use of teacher-pupil dialogue as a learning experience

This characteristic deals with the ways in which teachers can enhance pupils' self-knowledge about the nature of the learning process so that pupils can develop skills that will enable them to make better use of classroom dialogue. Pupils need to appreciate how talking and listening to teachers and other pupils is a learning experience. A number of studies addressed this characteristic (Black, 2006; Jones and Tanner, 2002; Mercer and Sams, 2006; Pratt, 2006; Ryan et al., 2003; Tanner and Jones, 2000a - overall WoE: 3 medium and 3 low).

Enhancing pupils' self-knowledge of how to make use of teacher-pupil dialogue as a learning experience seems to depend on the pedagogic style adopted by the teacher. Black's (2006) study indicates that those pupils who experience an enquiry-based style of teaching in which the teacher uses whole class discussions to create a communal space developing understanding, view dialogue as a tool for learning. In contrast, pupils experiencing a traditional style of teacher talk view teacher-pupil dialogue as being about being evaluated. Indeed, Ryan et al. (2003) give an example of how pupils used to this can be destabilised when they come across a teacher who uses dialogue to try to generate a shared understanding by asking them to explain their answer or method, as the pupils think the teacher would only ask such a question if their answer was wrong. Pratt (2006) makes a similar point, in reporting instances of pupils asking to explain their answer appearing to be confused about what the teacher is expecting them to do: for example, are they being asked to justify their answer, make their meaning clear, or to confirm their understanding? Black argues that a pedagogic approach which is oriented towards discussion-based inquiry may enable pupils to view learning mathematics as a process of understanding, trial and error, challenge and collaboration, as opposed to the passive act of listening.

Tanner and Jones (2000a) reported that the development of metacognitive skills through the use of teacher-dialogue involving scaffolding can improve pupil performance in mathematics, and enhance the pupils' ability to engage in reflective discourse. In a further study, Jones and Tanner (2002) reported on useful dialogue occurring during plenaries which consolidated pupils' metacognitive self-knowledge and aided the pupils' ability to reflect on the mathematical activities in which they were engaged.

Mercer and Sams (2006) provide evidence of the way an intervention programme, Thinking Together, can enhance pupils' metacognitive self-knowledge concerning the way they can use talk-based activities in lessons to enhance their mathematical understanding.

Pratt (2006) reported that pupils typically privilege listening over talking as helping them to learn and, when pupils do engage in talking, it is seen as generating something for others to listen to. Pratt notes that, for high quality dialogue to enhance pupils' understanding of mathematics, pupils need to see how talk itself is meaning-making, such that talking itself can enhance their understanding.

vii) Encouraging high quality pupil dialogue

This characteristic deals with the ways in which teachers respond in an encouraging manner to pupils' contributions. Two studies in particular have looked at this characteristic (Jones and Tanner, 2002; Smith and Higgins, 2006 - overall WoE: 1 medium and 1 low). These studies point to the need for teachers to be accepting towards pupils' contributions, to encourage pupils to develop their contributions further, and to allow the direction of a lesson to follow the pupils' contributions.

Jones and Tanner (2002) noted that being accepting towards pupils' contributions might enhance the quality of the discourse, but might also create a tension for the teacher in wanting to direct pupils' attention towards mathematically acceptable strategies.

Smith and Higgins (2006) identified ways which teachers convey to pupils that their contributions were valued. These included incorporating the pupils' responses into a discussion or for framing a new activity; asking for clarification; conveying through backchannel moves during a pupil's utterance an attentiveness and genuine interest in what the pupil is saying; and, importantly, allowing the lesson to follow pupils' ideas. Smith and Higgins refer to these strategies as 'conversational tactics'.

viii) Inclusive teaching

This characteristic deals with the ways in which teachers can convey to all pupils, regardless of ability, that their contribution is equally valued and that all pupils in the class are engaged and have their answers taken seriously. One study addressed this characteristic (Black, 2004a - overall WoE: low). This study provides clear evidence of how 'bright' pupils are more likely to engage in productive exchanges with their pupils (characterised by their answers being taken more seriously by the teacher and being 'given the floor'). Inclusive teaching involves strategies to make sure less able pupils also feel able to contribute and have their ideas taken seriously, so that they do not develop a self-identity as non-participants.

4.3 In-depth review: quality-assurance results

Data extraction and assessment of the weight of evidence brought by the study to address the review question was conducted by two people, working first independently and then comparing their decisions before coming to a consensus. Four papers were data-extracted by a member of the EPPI-Centre, with whom there was a broad measure of agreement. Any differences were discussed and resolved. Most discussion centered on questions concerning study type.

4.4 Summary of results of synthesis

It is the Review Group's view that the in-depth analysis of the included studies indicates the following:

- Teacher-initiated teacher-pupil dialogue in mathematics lessons is still dominated by traditional IRF discourse (3 studies; overall WoE: 2 medium, 1 low).

- There is a clear consensus among the authors of the included studies looking at aspects of classroom discourse of the need to enhance the quality of teacher-initiated teacher-pupil dialogue in order to promote pupils' conceptual understanding of mathematics (15 studies; overall WoE: 5 medium and 10 low).

- The studies detailed and illustrated examples of what the authors viewed as effective teacher-initiated teacher-pupil dialogue (15 studies; overall WoE: 5 medium and 10 low).

- An analysis of these examples led to the identification of eight characteristics of effective teacher-initiated teacher-pupil dialogue:

i) going beyond IRF (8 studies; overall WoE: 3 medium and 5 low)

ii) focusing attention on mathematics rather than performativity (4 studies; overall WoE: 1 medium and 3 low)

iii) working collaboratively with pupils (5 studies; overall WoE: 1 medium and 4 low)

iv) transformative listening (2 studies; overall WoE: 1 medium and 1 low)

v) scaffolding (3 studies; overall WoE: 3 medium)

vi) enhancing pupils' self-knowledge of how to make use of teacher-pupil dialogue as a learning experience (6 studies; overall WoE: 3 medium and 3 low)

vii) encouraging high quality pupil dialogue (2 studies overall WoE: 1 medium and 1 low)

viii) inclusive teaching (1 study: overall WoE: low)

- Few studies provided evidence that such characteristics actually led to the promotion of pupils' conceptual understanding of mathematics (3 studies; WoE: 3 medium).

- The studies that did offer some evidence of the promotion of pupils' conceptual understanding of mathematics largely focused on the enhancement of pupils' self-knowledge concerning how to make use of teacher-pupil dialogue as a learning experience (3 studies; WoE: 3 medium).

CHAPTER FIVE
Implications

5.1 Strengths and limitations of this systematic review

5.1.1 Strengths

By focusing on recent studies conducted in England (with two inclusions from Wales), the review was able to look at studies conducted in the policy and pedagogical context within which current classroom practice is taking place. This meant that the studies considered here outlined their rationale for the study and also interpreted the results of their studies in this context. The relevance of these studies in considering their implications for current practice are thus much easier to assess compared with studies that are conducted in other countries and studies conducted in the more distant past.

The review was also able to include a number of very useful papers by considering recent conference papers, most of which were identified by handsearching. Indeed, five of the 15 main papers were handsearched conference papers. This meant that the review was able to draw on a wider spread of papers than would have been possible had it relied exclusively on the electronic search strategy adopted.

The review was also able to include a number of papers exploring developments in classroom practice. This meant that the usefulness of the review was broader than one which might only have focused on an evaluation of current practice in schools.

5.1.2 Limitations

One limitation of this review is that, by focusing on recent studies conducted in England, the synthesis did not include studies conducted in other countries or in the more distant past that might have contained high quality evidence addressing the review question.

Indeed, the main limitation of this review was the paucity of high quality evidence concerning the link between each particular characteristic of teacher-initiated teacher-pupil dialogue on the one hand and the promotion of pupils' conceptual understanding of mathematics on the other. The characteristics of effectiveness identified in this review are largely based on a consensus that appears to exist among these researchers. This means that the eight characteristics identified in the synthesis reported here are best thought of as 'likely candidates' for effectiveness rather than as characteristics for which this review was able to assess high quality evidence to support its impact on pupils.

In addition, when considering these characteristics, the extent of contextual factors (for example, pupils' relationships with teachers, classroom climate, affective states and self-conception) may influence the degree to which these characteristics promote authentic teacher-pupil dialogue. The synthesis reported here was not able to assess the influence of such contextual factors.

Some of the characteristics may seem to have more evidential support than others. Unfortunately, because the impact of these characteristics on pupils' conceptual understanding of mathematics (in terms of effect sizes) could not be assessed, a further limitation of this study was that it was not possible to group the characteristics in terms of the degree to which the evidential support was strong, medium or low. Indeed, it was attempting to do so was thought to be possibly ill-founded and misleading.

A further analysis might usefully look to see what evidence exists elsewhere to corroborate or otherwise the importance of these eight characteristics; such a further analysis might usefully include looking at reviews held on the What Works Clearinghouse (WWC) database (www.whatworks.ed.gov) and also forthcoming reports that emerge from the Mathematics Matters Project: What

Constitutes the Effective Learning of Mathematics?, being undertaken by the National Centre for Excellence in the Teaching of Mathematics (NCETM) (www.ncetm.org.uk); and the Review of Mathematics Teaching in Early Year Settings and Primary Schools being undertaken for the DCSF by Sir Peter Williams.

Another limitation was that the bulk of the studies dealt with Key Stage 2, and no study focused on Key Stage 4. It is necessary to be cautious about generalising to teaching and learning mathematics in Key Stage 3, and even more so looking at Key Stage 4, when considering studies which focused on Key Stage 2.

5.2 Implications

5.2.1 Policy

The pedagogical approach embodied in the National Strategies includes the advocacy of dialogue to stimulate the quality of pupils' mathematical thinking. Nevertheless, the included studies considered here indicate that the teaching of mathematics in Key Stages 2 to 4, in terms of the use of teacher-pupil dialogue within the whole class interactive teaching phase of lessons, is dominated by traditional IRF discourse delivered with pace.

It is the Review Group's view that the in-depth analysis of the included studies indicates that teachers have not implemented the National Strategies in a fashion that gives sufficient weight to the use of dialogue to stimulate the quality of pupils' mathematical thinking. The studies reviewed here indicate, in part, that this is a reflection of the need to teach with pace and the need to cover the curriculum content in the time available. In addition, teachers have reported that the testing regime and the drive to meet challenging national targets for attainment levels in mathematics places constraints on teachers' time to use a more reflective dialogue with pupils. It needs to be reiterated here, however, that the findings of this review are based on 15 included studies for which the majority of the studies (10 out of 15) were assessed as having 'low' overall weight of evidence. Nevertheless, the thrust of these studies, taken as a whole, do point towards the need for policymakers, in conjunction with others, to give some thought as to how a shift away from the dominance of traditional IRF classroom discourse can be brought about.

5.2.2. Practice

Those involved with improving classroom practices need to consider how teacher-initiated teacher pupil dialogue can be enhanced by taking account of the eight characteristics identified in this review: going beyond IRF; focusing attention on mathematics rather than performativity; working collaboratively with pupils; transformative listening; scaffolding; enhancing pupils' self-knowledge of how to make use of teacher-pupil dialogue as a learning experience; encouraging high quality pupil dialogue; and inclusive teaching.

The studies reported here indicate that some teachers are genuinely surprised when confronted with evidence of how much use they make of traditional IRF discourse, especially when they espouse using other type of dialogue in their own practice. Attention needs to be given to how teachers can be supported to reflect upon their current practice better so that they are able to appraise better the extent to which they are making use of high quality teacher-initiated teacher-pupil dialogue.

The development of classroom practice which incorporated more high quality teacher-initiated teacher pupil dialogue needs to take account of what type of messages are being given to beginning teachers (during initial teacher training and in the early years of their careers) about how to make use of other forms of teacher-pupil dialogue in mathematics lessons which embody the eight characteristics identified in the synthesis. In addition, more experienced teachers also need appropriate continuing professional development (CPD) experience to extend and develop their classroom practice in this direction. It may well be the case that aspects of personalised learning, assessment for learning, and the Every Child Matters agenda, considered in Chapter 1 of this review, will afford a basis to support such a development within CPD. Any consideration of effective CPD strategies in this respect might usefully include looking at the findings of relevant systematic reviews available at the EPPI-Centre website (http://eppi.ioe.ac.uk).

It is important, however, to bear in mind that the learning interface between teachers and pupils is a complex phenomenon within which implementing changes in classroom practice that may enhance conceptual understanding presents a number of challenges. Changes in classroom practice need to be grafted on to those benefits that accrue from aspects of current practice, and also take account of why some teachers may have reservations or find it difficult to implement such changes, given the realities of classroom life and the policy and pedagogical context within which they are teaching.

5.2.3 Research

There are two clear implications for research. Firstly, as noted above, there appears to be a paucity in recent research conducted in England included in this review of high quality evidence concerning the link between each particular characteristic of teacher-initiated teacher-pupil dialogue on the one hand and the promotion of pupils' conceptual understanding of mathematics on the other. This requires attention, lest the general consensus among the researchers identified in this review, leads to an assumption that these characteristics have a positive impact on pupils' conceptual understanding, and that bringing about such a positive impact is unproblematic. A consideration of relevant existing reviews of research might be helpful here.

The second implication is that more research is needed on the development of innovative teaching practices which make use of teacher-initiated teacher-pupil dialogue. In particular, there is a need for research into how to prepare pupils to make the best use of teacher-initiated teacher-pupil dialogue. For example, this review indicates that pupils need to understand how such dialogue is part of the learning process.

The third implication is that lessons that can be drawn from international evidence on this topic need to be identified, and a systematic review to assess such evidence could prove to be very valuable.

Finally, research needs to look at other opportunities within the classroom, outside the whole class interactive-teaching phase of the lesson, where teacher-initiated teacher-pupil dialogue can make an effective contribution to the promotion of pupils' conceptual understanding of mathematics.

CHAPTER SIX

References

6.1 Studies included in map and synthesis

This consists of 15 studies in 24 papers. The main paper in each study is marked with an asterisk (*).

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Appendix 1.1: Authorship of this report

This work is a report of a systematic review conducted by the English Review Group.

The authors of this report are:

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Advisory group membership

The membership of the Advisory Group is the same as the Review Group. However, other individuals (teachers, researchers, policymakers) with an interest in the review question were invited to comment of the work of the Review Group at appropriate times. This was largely done through email and through informal conversations at conferences.

Conflict of interest

There were no conflicts of interest for any member of the Review Group.

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We would also like to thank numerous individuals who kindly sent us copies of their published and unpublished papers; and also all those within the mathematics education community who provided the Review Group with general advice and comments, particularly Margaret Brown, Celia Hoyles, John Monaghan, Tom Roper and Anne Watson.

Appendix 2.1: Inclusion and exclusion criteria

For a paper to be included in the systematic map, it had to satisfy the following four criteria:

i) It is an academic paper in English, published in an academic journal or presented at an academic conference during the period 1 January 2000 to 30 March 2007.

ii) It reports a study presenting original data conducted in a primary or secondary schools in England and collected by the author(s).

iii) The study deals with mathematics teaching in Key Stages 2-4 lessons.

iv) The study deals with the characteristics of teacher-initiated teacher-pupil dialogue intended to promote pupils' conceptual understanding in mathematics.

These inclusion criteria were reformulated as four exclusion criteria and placed in an hierarchical order, for ease of exclusion and, importantly, to act as a system of gradual filtering, so that the papers excluded at each stage can be readily identified in the future as a useful list of references that could be drawn upon for other purposes by readers of the review report, or may indeed be of use in subsequent systematic reviews undertaken by this Review Group.

Exclusion codes: criteria for excluding a paper

EXC1 Not an academic paper in English published in an academic journal or presented at an academic conference during the period 1 January 2000 to 30 March 2007 (examples of exclusion: a paper which is a descriptive outline of an approach; or a descriptive summary of a study which is intended for a practitioner audience; or a brief descriptive introduction of papers comprising a conference symposium)

EXC2 Not a report of a research study presenting original data collected by the author(s) in primary or secondary schools in England (examples of exclusion: a review of the literature; or a paper which offers a critique of policy and practice; or a study dealing with teaching in a special school)

EXC3 Does not include data about mathematics teaching in mathematics lessons in Key Stages 2 to Key Stages 4 (examples of exclusion: a study of teaching pupils outside the normal classroom; a study which looks at mathematics education curriculum in schools; or a study looking at performance in national examinations)

EXC4 Does not deal with the characteristics of teacher-initiated teacher-pupil dialogue intended to promote pupils' conceptual understanding in mathematics (examples of exclusion: a study dealing with pupils' understanding of a specific topic; a study of teaching by a learning support assistant or another adult; a study dealing solely with pupils' mathematical attainment; or a study which deals solely with pupil-pupil dialogue)

Appendix 2.2: Search strategy for electronic databases

BEI search strategy

Conducted via Dialog on 2 April 2007

Number	Database	Search term	Information added since	Results
1	British Education Index - 1975 to date	(MATH$ OR NUMERACY) AND (DIALOGUE OR DISCOURSE OR DISCUSSION OR INTERACTION$ OR MISCONCEPTION$ OR SCAFFOLDING OR TALK OR UNDERSTANDING)	Unrestricted	613
2	British Education Index - 1975 to date	YEAR=2007 OR YEAR=2006 OR YEAR=2005 OR YEAR=2004 OR YEAR=2003 OR YEAR=2002 OR YEAR=2001 OR YEAR=2000	Unrestricted	40,809
3	British Education Index - 1975 to date	PT=CONFERENCE-PAPERS OR PT=JOURNAL-ARTICLE	Unrestricted	137,933
4	British Education Index - 1975 to date	LG=EN	Unrestricted	150,882
5	British Education Index - 1975 to date	1 AND 2 AND 3 AND 4	Unrestricted	252

Appendix 2.3: Journals handsearched

Electronic search and/or handsearch of 11 key journals in mathematics education (1 January 2000 to 30 March 2007), looking at every title and, where appropriate and available, the abstract and/or the full paper

Educational Studies in Mathematics

For the Learning of Mathematics

Journal of Mathematics Teacher Education

Journal for Research in Mathematics Education

International Journal of Mathematics Teaching and Learning

Mathematics Education Review

Mathematics in Schools

Mathematics Teaching

Micromath [incorporated within Mathematics Teaching in 2005]

Research in Mathematics Education

Teaching Mathematics and its Applications

Electronic searches and/or handsearching issues of the following 17 selected key UK journals in educational research (1 January 2000 to 30 March 2007), looking at every title and, where appropriate and available, the abstract and/or the full paper:

Assessment in Education

British Educational Research Journal

British Journal of Educational Psychology

British Journal of Educational Studies

Cambridge Journal of Education

Curriculum Journal

Educational Psychology

Educational Research

Educational Review

Educational Studies

Evaluation and Research in Education

Journal of Education Policy

Oxford Review of Education

Research in Education

Research Papers in Education

Scottish Educational Review

Welsh Journal of Education

Handsearch and/or electronic search of key recent conference proceedings (1 January 2000 to 30 March 2007), looking at every title and, where appropriate and available, the abstract and/or the full paper:

British Educational Research Association

British Society for Research into Learning Mathematics

European Conference on Educational Research

European Society for Research in Mathematics Education

International Group for the Psychology of Mathematics Education

Scottish Educational Research Association

APPENDIX 2.4 EPPI-Centre Keyword sheet, including review-specific keywords

(version 0.97 Bibliographic details and/or unique identifier)

A1. Identification of report
Citation
Contact
Handsearch
Unknown
Electronic database (please specify)
. . . .

A2. Status
Published
In press
Unpublished

A3. Linked reports
Is this report linked to one or more other reports in such a way that they also report the same study?
Not linked
Linked (please provide bibliographical details and/or unique identifier)
. . . .
. . . .
. . . .
. . . .

A4. Language (please specify)
. . . .

A5. In which country/countries was the study carried out? (please specify)
. . . .
. . . .
. . . .

A6. What is/are the topic focus/foci of the study?
Assessment
Classroom management
Curriculum*
Equal opportunities
Methodology
Organisation and management
Policy
Teacher careers
Teaching and learning
Other (please specify) . . . .

A7. Curriculum
Art
Business studies
Citizenship
Cross-curricular
Design and technology
Environment
General
Geography
Hidden
History
ICT
Literacy - first language
Literacy further languages
Literature
Maths
Music
PSE
Physical education
Religious education
Science
Vocational
Other (please specify) . . . .

A8. Programme name (please specify)

. . . .

A9. What is/are the population focus/foci of the study?
Learners
Senior management
Teaching staff
Non-teaching staff
Other education practitioners
Government
Local education authority officers
Parents
Governors
Other (please specify) . . . .

A10. Age of learners (years)
0-4
5-10
11-16
17-20
21 and over

A11. Sex of learners
Female only
Male only
Mixed sex . . . .

A12. What is/are the educational setting(s) of the study?
Community centre
Correctional institution
Government department
Higher education institution
Home
Independent school
Local education authority
Nursery school
Post-compulsory education institution
Primary school
Pupil referral unit
Residential school
Secondary school
Special needs school
Workplace
Other educational setting (please specify)
. . . .

A13. Which type(s) of study does this report describe?
A. Description
B. Exploration of relationships
C. Evaluation
  a. naturally-occurring
  b. researcher-manipulated
D. Development of methodology
E. Review
  a. Systematic review
  b. Other review

Appendix 3.1: Details of studies included in the systematic map

Table A3.1: Identification of report (N = 15 studies)

BEI searched journal paper	4
BEI searched conference paper	2
Handsearched journal paper	4
Handsearched conference paper	5
Total	**15**

Table A3.2: Type of study (N=15 studies)

Description (9 studies)	**Exploration of relationships (4 studies)**	**What works? (2 studies)**
Black (2006)	Back (2005)	Mercer and Sams (2006)
Bold (2002)	Black (2004a)	Tanner and Jones (2000a)
Coles (2002)	Smith et al. (2004)	
Hadjidemetriou and Williams (2003)	Smith and Higgins (2006)	
Jones and Tanner (2002)		
Myhill (2006)		
Pratt (2006)		
Ryan et al. (2003)		
Wilson et al. (2006)		

Appendix 3.2: Possible inclusions identified by electronic search strategy (25 papers)

This refers to using specified keywords within BEI. The following 25 papers were included after first screening on the basis, looking at the title and, where available, the abstract, held on the database records. A full copy of each of these 25 papers was then obtained, and, as can be seen below, 12 of these 25 papers were then included in the systematic map.

Ainley J, Luntley M, Jones I (2004) What teachers know. Paper presented at: *British Educational Research Association Annual Conference*, University of Manchester, 16-18 September. EXC4

Andrews P, Sayers J (2004) International comparisons of mathematics teaching: searching for consensus in describing opportunities for learning. Paper presented at: *British Educational Research Association Annual Conference*, University of Manchester, 16-18 September. EXC4

Andrews P, Sinkinson A (2000) A rational model for the teaching of mathematics: the impact of comparative studies. Paper presented at: *British Educational Research Association Annual Conference*, Cardiff University: 7-10 September. EXC2

Billington E, Fletcher A (2000) More talk, less chalk? An exploration of whole-class interactive teaching in mathematics. T*he Redland Papers (University of the West of England)*, 8 (summer): 19-29. EXC4

Black L (2002) 'She's not in my head or in my body': constructing pupil identities of exclusion and full participation in classroom learning processes. Paper presented at: *British Educational Research Association Annual Conference*, University of Exeter: 12-14 September. INC

Black L (2004b) Teacher-pupil talk in whole-class discussions and processes of social positioning within the primary school classroom. *Language and Education* 18: 347-360. INC

Black L (2006) Young children's perspectives on whole class discussions. Paper presented at: *British Educational Research Association Annual Conference*, University of Warwick: 6-9 September. INC

Boylan M, Lawton P (2000) 'I'd be more likely to speak in class if ...': how some year eight students experience teacher questioning and discussion strategies. In: Rowland T (ed.) *Proceedings of the New Researchers' Day Conference on 17 November and the Day Conference on 18 November, both held at the University of Surrey Roehampton. BSRLM Proceedings 20*. London: British Society for Research into Learning Mathematics, pages 7-12. EXC4

Brown L (2000) Do the students learn the teacher or the teacher learn the students? Making meaning out of developing mathematical classroom cultures. In: Rowland T (ed.) *Proceedings of the New Researchers' Day Conference on 17 November and the Day Conference on 18 November, both held at the University of Surrey Roehampton. BSRLM Proceedings 20*. London: British Society for Research into Learning Mathematics, pages 13-18. EXC4

Burns C, Myhill D (2004) Interactive or inactive? A consideration of the nature of interaction in whole class teaching. *Cambridge Journal of Education* 34: 35-49. INC

Crisp V (2005) Constructing meaning from school mathematics texts: potential problems and the effect of teacher mediation. Paper presented at: *British Educational Research Association Annual Conference*, University of Glamorgan, 14-17 September. EXC4

Edwards J-A, Jones K (2001) Exploratory talk within collaborative small groups in mathematics. In: Pope S (ed.) *Proceedings of the Day for New Researchers on 16 November and the Day Conference on 17 November, both held at the University of Southampton. BSRLM Proceedings 21*. London: British Society for Research into Learning Mathematics), pages 19-24. EXC4

Hadjidemetriou C, Williams J (2001) Evaluating teachers' knowledge in relation to their children's learning. In: Rowland T (ed.) *Proceedings of the Day Conferences held at Manchester Metropolitan University, 3 March. BSRLM Proceedings 21.* London: British Society for Research into Learning Mathematics, pages 7-12. EXC4

Hardman F, Smith F, Mroz M, Wall K (2003) Interactive whole class teaching in the national literacy and numeracy strategies. Paper presented at: *British Educational Research Association Annual Conference*, Heriot-Watt University, Edinburgh: 11-13 September. INC

Higgins S (2001) ICT and teaching for understanding. *Evaluation and Research in Education*, 15: 164-171. EXC2

Kelly P (2002) Children's experiences of mathematics. Paper presented at: *British Educational Research Association Annual Conference*, University of Exeter: 12-14 September. EXC4

Mercer N, Sams C (2006) Teaching children how to use language to solve maths problems. *Language and Education* 20: 507-528. INC

Myhill D, Brackley M (2004) Making connections: teachers' use of children's prior knowledge in whole class discourse. *British Journal of Educational Studies* 52: 263-275. INC

Pratt N (2006) 'Interactive' teaching in numeracy lessons: what do children have to say? *Cambridge Journal of Education* 36: 221-235. INC

Rowland T (2000) (2000) Analysis of classroom mathematics discourse: shifting attention from transaction to interaction. Paper presented at: *British Educational Research Association Annual Conference*, Cardiff University: 7-10 September. EXC4

Ryan J, Kassem D, Sarland C (2003) What teachers learn from children's mathematical arguments in discussion: moving to a new pedagogical model. Paper presented at: *British Educational Research Association Annual Conference*, Heriot-Watt University, Edinburgh: 11-13 September. INC

Ryan J, Williams J (2001) Charting key elements of children's mathematical argument in discussion: a teaching tool. In: Rowland T (ed.) *Proceedings of the Day Conferences held at Manchester Metropolitan University, 3 March. BSRLM Proceedings 21.* London: British Society for Research into Learning Mathematics, pages 55-60. EXC4

Smith H, Higgins S (2006) Opening classroom interaction: the importance of feedback. Cambridge Journal of Education 36: 485-502. INC

Smith F, Hardman F, Higgins S (2006) The impact of interactive whiteboards on teacher-pupil interaction in the National Literacy and Numeracy Strategies. *British Educational Research Journal* 32: 443-457. INC

Wilson L, Andrew C, Below J (2006) A comparison of teacher/pupil interaction within mathematics lessons in St. Petersburg, Russia and the North-East of England. *British Educational Research Journal* 32: 411-441. INC

Appendix 3.3: Possible inclusions identified by handsearching (12 papers)

Handsearching refers to searching by hand and electronic searching of the contents of key journals and conferences proceedings, and involves an exhaustive inspection of titles, and where appropriate, of abstracts and the contents of papers. Handsearching also makes use of citations and personal contacts. This approach operated in parallel to the electronic search strategy based on the use of keywords. All these papers are included in this review, either as a main paper or as a subsidiary paper.

Back (2005)

Back (2000)

Black (2004a)

Bold (2002)

Coles (2002)

Hadjidemetriou and Williams (2003)

Jones and Tanner (2002)

Myhill (2006)

Myhill and Dunkin (2005)

Myhill and Warren (2005)

Smith et al. (2004)

Tanner and Jones (2000a)

Appendix 4.1: Details of studies included in the in-depth review

Study 1

Back (2005) (Main paper, handsearched)

Back (2000) (Subsidiary paper, handsearched)

The main aim(s) of the study

The study aims to explore the inter-relationship between the social purposes and mathematical foci of interactions which occur when talk takes place in the classroom and seeks to examine the characteristics of conversation that succeed in involving pupils in expressing and developing their mathematical thinking and understanding.

The key research questions

How do teachers interact with pupils through classroom talk in ways that induct pupils into mathematical forms of life?

The research design

The study is based on observations of mathematics lessons in three primary schools.

The key findings concerning teacher-initiated teacher-pupil dialogue

i) The management of talk in the classroom is complex (p 802).

ii) Teacher-pupil talk can usefully be analysed in relation to its social and mathematical components.

iii) Excerpts from transcripts demonstrate how teachers can go beyond IRF in order to induct pupils into mathematical forms of life.

iv) The characteristics presented as illustrations of this reflect talk which is both 'highly mathematical' and 'socially open' (p 799).

v) Examples of 'socially open' are pupils asking questions and challenging assertions made by the teacher (p. 803); pupils taking initiative in negotiating a discussion (p 803); pupils resting control from the teacher (p 803); and interactions which exemplify that pupils and teachers view themselves as joint participants in the learning and teaching process (p 803)

Study 2

Black (2004a) (Main paper, handsearched)

Black (2002) (Subsidiary paper, BEI)

Black (2004b) (Subsidiary paper, BEI)

The main aim(s) of the study

The study aims to explore the qualitative nature of the differences in the quantity of teacher-pupil interactions experienced by pupils from different social backgrounds and the impact of such differences on pupil learning (p 34).

More broadly, the aims were as follows:

i) to determine if some pupils consistently experienced different types of interaction with the teachers than others

ii) to determine why this might be the case, taking into account explanatory factors such as teacher expectations and pupil cultural capital

iii) to assess if the differences between the types of interaction pupils experienced were maintained across time (p 36)

The key research questions

- Do some pupils experience productive forms of interaction with the teacher, while others do not?
- Do some pupils consistently experience non-productive interactions?
- How might this impact on their access to classroom learning processes? (p 36)

The research design

A five-month ethnographic case study of 29 pupils in a year 5 class, based on observations of mathematics lessons (using videotapes and radio microphones) and interviews with the pupils and the teacher. The data is analysed in terms of the pupils' experience of productive and non-productive interactions with the teacher.

The key findings concerning teacher-initiated teacher-pupil dialogue

i) Different pupils are treated differently in terms of access to discourse: for example, bright pupils' comments are taken seriously and developed - they are 'given the floor'.

ii) Some pupils engage in productive exchanges with teachers more often than others.

iii) The 29 pupils were allocated to one of four groups: Group A comprised eight pupils who experienced more productive interactions than non-productive; Group B comprised five pupils who experienced non-productive interactions more often; Group C comprised nine pupils involved in ten interactions or less over the entire period; and Group D comprised six pupils involved in productive and non-productive interactions on an equal number of occasions, plus or minus 1.

iv) Certain pupils within the class (i.e. Groups B and C) were disadvantaged in the learning process; only pupils who were regularly involved in productive interactions (Group A pupils) were accessing conversations that genuinely fostered a shared understanding between teacher and pupils (p 39).

v) These patterns appeared to be consistent over the period of the observations.

vi) Pupils who are consistently involved in productive interactions come to see themselves as full participants or learners, while those involved in non-productive interactions find themselves marginalised from the practice of classroom learning (p 34).

vii) Pupils who adopt a dialogic role in interactions tapped into the underpinning pedagogic goals of classroom interactions which permeate the teacher's intended meaning. Those who don't adopt/secure this role, don't have such access.

viii) Elements of the social context reinforce/facilitate this position: pupils with increased cultural capital are more likely to adopt this role; pupils' capacity to secure this role is affected by teacher estimation of pupil ability; and gender factors affect the quality and type of interaction.

Study 3

Black (2006, BEI)

The main aim(s) of the study

This study aims to explore pupils' understanding of the role and purpose of whole class discussions in supporting learning (p 1). This study of pupils' perceptions of their participation in such discussions is based on the premise that effective learning requires pupils to see themselves as full participants with the right to make active contributions to classroom activities.

The key research questions

i) How do pupils perceive the role/function/purpose of talk in whole class discussions and is this influenced by the teacher's pedagogical style?

ii) In what ways do pupils conceptualise their participation and status in whole class discussions and how is this influenced by their level of attainment? (p 2)

The research design

Phase 1 of the study comprised participant observation of two literacy and two numeracy lessons, and interviews with the class teacher in each of three schools (one class per school); in phase 2 of the study, a group interview was conducted about discussion in literacy and numeracy lessons with 24 pupils: two groups of four pupils (four 'high fliers' and four 'lower attainers' as identified by the teacher) at each of the three schools, followed by individual interviews. The pupils were in year 5 (i.e. 9-10 year-olds) in two classes, and in years 4 and 5 in the third class.

The key findings concerning teacher-initiated teacher-pupil dialogue

i) The data indicates how pupils perceive the nature of teacher-pupil interaction and how dialogue impacts on their participation and understanding. The findings are grouped into two main categories: the first relates to the impact of the teacher's pedagogic style on their views, and the second relates to the impact of the pupil's ability on their views.

ii) Mrs Hughes (at St Charles' School) used a slightly non-traditional pedagogic approach which appeared to be informed by an 'enquiry' based ideology (associated with the Children's Philosophy Movement). During lessons, she used a low controlled approach which gave pupils the space to formulate their opinions and evaluate each other's ideas. Additionally, she encouraged and praised discussion throughout (p 5). When asked about the purpose of whole class discussion, her pupils stated they helped with the learning process. Many of her pupils made comments which reflected some awareness of the purpose of an inquiry-based pedagogy and how it helped them to understand a given topic. The pupils tapped into the trial and error nature of learning which suggests they felt it was okay to make mistakes (p 5). The lesson observed contained features of 'good quality talk' as identified in the research literature: for example, allowing pupils to test out ideas as a way of modifying one's existing understanding, and the teacher allowing pupils to take their own direction. The pupils also referred to 'agreeing' and 'explaining' as features of good talk. The pupils viewed whole class discussions as a tool for developing understanding within a communal space which was both supportive and challenging (p 9).

iii) Mrs Jones (at St Luke's School) and Mrs Ashton (at St Margaret's School), by contrast, used a more traditional style of teacher talk in whole class discussions: that is, heavy bouts of questioning, with pupil replies limited. In both cases, the teacher dominated the discussion, giving pupils limited opportunities to talk to partners. Here, the pupils believed that the passive activity of listening to the teacher would help them learn (p 7). These pupils believed teacher-pupil talk was about teacher evaluation and assessment of pupil ability rather than the construction of new understandings (p. 8). In these classes, pupils commented on the negative consequences of getting an answer wrong, such as being teased by other pupils or your reputation being spoiled, whereas getting the correct answer (i.e. the teacher's predetermined answer) was highly valued (p 8). The pupils viewed whole class discussions as listening to the teacher, being assessed and evaluated, and negotiating the risk of not getting the answer right (p 9).

iv) Pupils in all three classes were acutely aware of the rule-governed nature of classroom discourse. Such rules included putting your hand up to speak; listening to the teacher; not shouting out; not getting out of your seat; and showing each other respect (p 9).

v) Comparing the perceptions of 'high fliers' with 'low attainers' indicated a noticeable distinction in how they viewed the benefits of whole class discussions. Lower ability pupils viewed discussion as educational activities 'done to them' as part of the educational process and where they had little control over the activity. In contrast, high ability pupils indicated some awareness of the features of classroom discourse and how to extract benefit from it: for example, by staying focused (and not going off on a tangent), and by making use of cued elicitation (clues or rephrasing as an easier question) (p 9).

vi) Pupils were aware that ability impacted in participation: pupils perceived that more able pupils understood the work better and were thus able to answer quicker and participate more (p 10). More interesting, though, was the high achievers' views of classroom as providing an opportunity for learning through which their status as learners and participators could be enhanced, while lower ability pupils distanced themselves more and spoke of those who participate as 'they' (i.e. the clever ones). This reflects how high ability pupils adopted an identity as a participator, while lower ability pupils developed an identity as a non-participator (p 12).

Study 4

Bold (2002, handsearched)

The main aim(s) of the study

This study aims to explore the dialogic practices used by the teacher and pupils when they explain the meaning of mathematical words (p 7).

The key research questions

- How does the teacher interact with pupils to develop a shared understanding of the meaning of mathematical words?
- How do pupils express their understanding of the meaning of specific mathematical words and phrases? (p 8)

The research design

Observation of three year 5 mathematics lessons (including video recording), followed by a questionnaire for the teacher and structured interventions with eight mixed gender pairs of pupils to encourage discussion

The key findings concerning teacher-initiated teacher-pupil dialogue

i) In the first observed lesson, the teacher altered pupils' suggestions to 'his meaning' to make it potentially more shareable with the class. The teacher found it difficult to control the 'open-dialogue' on account of the pupils' subjective responses.

ii) In the second observed lesson, the teacher focused the discussion on one phrase in order to reduce ambiguity. However, the use of different phrases in different contexts still created ambiguity. His closed questioning technique might lead to the development of a narrow definition (of even chance) that is not transferable across contexts.

iii) In the third observed lesson, a probability scale was likened to a time line. However, pupils found it difficult to locate real-life events on this scale because too many variables existed making causal justification problematic.

iv) During the structured interventions, some pairs of pupils were more able, or willing, to enter into an educated discourse than others. A willingness to enter into peer discussion did not necessarily support the development of shared understanding. (p 10)

Study 5

Coles (2002, handsearched)

The main aim(s) of the study

This study aims to identify forms of listening and hearing, and associated teaching strategies in year 7 mathematics lessons.

The key research questions

What evidence is there in the transcripts of year 7 mathematics lessons given by two teachers of different forms of listening and associated teaching strategies?

The research design

Transcripts of year 7 lessons by two teachers; one lesson was video-recorded in each half-term over the course of the academic year, yielding 6 recordings for each teacher.

The key findings concerning teacher-initiated teacher-pupil dialogue

i) Transcripts 1-3 were analysed for teacher A. Transcript 1 indicates that teacher A does not evaluate the pupils' contributions as right or wrong (p 26). The task for the pupil is to fit their comments and suggestions to the teacher's plan. Teacher A interprets the pupils' comments and gives feedback in relation to the idea he has chosen to focus upon. In transcript 2, the listening moves from interpretive to transformative. There is a feel of collaboration and participation in the dialogue - the characteristic of transformative listening (p 27). The participatory nature of discussion is even more evident in transcript 3 (p 28).

ii) Two transcripts (transcripts 4-5) are analysed for teacher D (the author). There is evidence of transformative listening in all the videos of teacher D, and these are evidenced in transcripts 4 and 5.

iii) The analysis of teacher A's teaching strategies indicate a number of teaching strategies used in transcript 2 that were not evident in transcript 1:

- the teacher asking a question to which they do not know the answer;
- responding to pupils' suggestions
- asking for feedback from the whole class
- asking a pupil to explain their answer to the class

iv) These strategies can all be seen as 'slow down and opening up discussion' (p 31).

v) These strategies were all evident in teacher D's lessons from the start of the year.

Study 6

Hadjidemetriou and Williams (2003, handsearched)

The main aim(s) of the study

This study aims to identify the connection between teachers' stated strategies and intentions (or 'espoused theories') and their 'theories-in-use' (what they actually do) when engaging in reflective practice on argumentation during classroom discussion.

The key research questions

- How can/do teachers develop strategies which enhance mathematical dialogue and argumentation in their classroom discussion?
- Can we describe and account for these through video, narrative and case studies in ways which help our colleagues? (p 26)

The research design

Video-recording of three year 9 mathematics lessons, interviews with the teacher after each lesson, and audio-taping of meetings of teachers to discuss their work with colleagues

The key findings concerning teacher-initiated teacher-pupil dialogue

The teacher espoused eight strategies (together with their aims/intentions):

i) Pinning pupils down to detail; intention: everyone is following.

ii) One-minute discussion; intention: raise/harness the energy.

iii) Leave tensions unresolved; intention: make 'them' do the mathematics.

iv) Conflict strategy; intention: induce a change of method.

v) Summarising and clarifying; intention: everyone is following.

vi) Working with one method; intention: everyone is following.

vii) Working with multiple problems method; intention: making connections/introduce generality.

viii) Slow the pace; intention: take everyone along.

Study 7

Jones and Tanner (2002, handsearched)

The main aim(s) of the study

This study aims to explore the teaching approaches adopted by a group of secondary school mathematics teachers introducing whole-class interactive teaching strategies into their own practice, and the extent to which they felt this had impacted on the quality of classroom discourse.

The key research questions

- What do teachers think constitutes whole-class interactive teaching?
- How do these teachers implement this approach?
- What impact have the teaching strategies they adopted had on the pupils?

The research design

This study looks at eight teachers who took part in an action research project to develop, trial and evaluate teaching strategies for whole class interactive teaching, with particular reference to the quality of classroom discourse; monthly meetings were held over a five-month period; lessons were observed; the teachers were also interviewed.

The key findings concerning teacher-initiated teacher-pupil dialogue

The findings are presented in three sections:

i) *Types of interactions*. In every classroom, pupils were encouraged to contribute their ideas and to explain their methods in the class. The class atmosphere was supportive, and pupils were eager to contribute and willing to go to the board to demonstrate their approaches. Every teacher considered their pupils to have become far more confident about their mathematics.

There was a tension evident between encouraging pupil confidence and involvement by accepting their contributions and the need to progress to more mathematically acceptable strategies.

Some strategies helped pupils 'to stay with the teacher'.

One strategy was asking pupils to explain in their own words a method used by other pupils.

ii) *Developing strategies for scaffolding*. Some teachers developed approaches which provided focusing scaffolding. Focusing scaffolding created opportunities for reflection.

iii) *Plenaries*. Some teachers struggled to find time for plenaries. Two teachers adopted the format of asking pupils to 'write down three key things which you have learned this lesson'. Some teachers used a variety of strategies to help pupils reflect and consolidate pupils' metacognitive self-knowledge, and linked these to the intended learning outcomes for the lesson.

Study 8

Mercer and Sams (2006, BEI)

The main aim(s) of the study

This study aims to evaluate a teaching intervention programme called 'thinking together', designed to enable pupils to talk and reason together effectively.

The key research questions

Three hypotheses are presented (p 509):

i) Providing pupils with guidance and practice in using language for reasoning will enable them to use language more effectively as a tool for working on mathematics problems together.

ii) Improving the quality of pupils' use of language for reasoning together will improve their individual learning and understanding of mathematics.

iii) The teacher is an important model and guide for pupils' use of language for reasoning.

The research design

Seven year 5 target classes received a teaching intervention programme; their progress was compared with that of seven year 5 control classes; the intervention involved both science and mathematics, but this paper deals only with the mathematics data.

The key findings concerning teacher-initiated teacher-pupil dialogue

i) The pupils in the target classes mean SAT scores increased from 2.43 to 5.53; for the control classes, the increase was from 2.39 to 4.20. The increase for the target classes was significantly greater (effect size 0.59).

ii) This supports the view that the intervention was effective in improving pupils' study of the mathematics curriculum.

iii) Extracts from transcripts 2 and 3 provide evidence of how two teachers involved in the intervention used part of the initial whole-class session of Thinking Together to introduce a mathematics activity. The first teacher essentially engages in a monologue, while the second teacher embodies some of the ground rules for exploratory talk in whole-class dialogue. These transcripts provide evidence of how the second teacher's engagement with pupils was more 'dialogic'.

iv) Transcripts 4 and 5 provide examples of pupils' discussions in groups to illustrate some kinds of variations in talk. Transcript 5 is illustrative of a more collaborative approach adopted by pupils in group B compared with those pupils in group A in transcript 4. The group B pupils in the more 'dialogic class' achieved better post-intervention grades in mathematics than those in group A.

v) The interviews with teachers and pupils also provided evidence of the effects of the intervention programme on learning activity and social interaction, indicating that both teachers and pupils felt that exploratory talk had helped them learn more (p 524).

Study 9

Myhill (2006, Main paper, handsearched)

Burns and Myhill (2004, Subsidiary paper, BEI)

Myhill and Brackley (2004) (Subsidiary paper, BEI)

Myhill and Dunkin (2005) (Subsidiary paper, handsearched)

Myhill and Warren (2005) (Subsidiary paper, handsearched)

The main aim(s) of the study

This study aims to explore the nature and quality of discourse during whole class teaching and how teachers use talk to develop and build on pupils' learning.

The key research questions

The principal research question (p 22) was as follows:

- How do teachers use talk in whole class episodes to scaffold learning and develop understanding?

The following six subsidiary research questions framed the research:

- How interactive are whole class episodes?
- How do teachers build on prior pupil knowledge?
- How do teachers use questions?
- How do pupils use questions?
- How is the handover to independence or 'critical moments' handled?
- What do teachers believe about talk as a tool for learning?

The research design

These papers looked at 54 episodes of whole class teaching based on video-recorded lessons in NLS, NNS and a third curriculum area. The data was collected for year 2 classes in three first schools and for year 6 classes in three middle/primary schools; the focus was on teacher talk. Data was also collected using structured observation schedules, post hoc stimulated recall teacher reflection, post-observation interviews of pupils, and context field notes.

The key findings concerning teacher-initiated teacher-pupil dialogue

i) Teacher discourse in whole class teaching provided limited opportunities for pupil learning.

ii) Much whole class teaching involved relatively little interaction to support and scaffold pupils in their learning.

iii) Teacher talk dominated whole class teaching.

iv) Teacher-pupil interactions operated in highly conventional discourse patterns.

v) The dominant interaction pattern was teacher-pupil-teacher-pupil, and only rarely was this pattern disrupted: the pupil's answer served to end an interaction sequence, and rarely to begin or initiate it.

vi) Very little talk was initiated by pupils.

vii) The framing of discourse was predominantly structured upon a framework of teacher initiation and single pupil response.

viii) Teacher orchestration of classroom talk and interaction patterns which preserve the teacher's control of talk scenarios was the dominant pattern.

ix) More specifically:

- *re: Teachers' questioning*

  Classified teacher questions into four categories: procedural (8%), factual (64%), speculative (16%) and process (12%)

Low level of questions related to higher order thinking (p 28)

Questions also categorised by 11 functions (listed): factual elicitation was the most common (26%), then building on thinking (17%), building on content (10%), practising skills (9%), recapping (8%), cued elicitation (7%), checking understanding (7%), class management (6%), developing reflection (5%), checking prior knowledge (3%), and, finally developing vocabulary (2%).

Video-analysis suggests a pattern of teaching that is principally transmissive (p 30).

- *re: Differential participation in interactions*

Interactivity was defined in terms of the number of opportunities pupils have to contribute to classroom discourse and the extent of the involvement or participation. Teachers recognised, that despite a commitment to full participation, in practice not all pupils became involved. High achievers were more involved and participatory in the teaching episodes than low achieving peers: they voluntarily involve themselves in positive learning interactions, such as putting hands up and joining collective responses. Low achievers were more likely to be engaged in more negative interactions such as being off-task. Asking questions, soliciting volunteers through raised hands, and selecting someone to answer was the dominant shape of whole class discourse. Teachers try to equalise opportunities by both gender and ability in choosing which volunteers they select, but this does not address the non-participation of non-volunteers. (Figures 3 and 4 deal with pattern of interaction by ability and gender). Boys were less compliant with classroom conventions of turn-taking or signalling a willingness to speak through hands up; they are more likely to engage in unsolicited calling out.

- *re: Use of prior knowledge to scaffold learning*

Teachers' actual use of pupils' prior knowledge was minimal. Only 3% of questions and 3% of statements explicitly addressed prior knowledge (based on video data).Teacher reflections confirmed this. This gives little opportunity for pupils to reflect and articulate their learning. Whole class discourse is more oriented to teachers' curriculum delivery goals than to guiding pupils towards greater understanding. Pupils were clear about the focus of the learning in curriculum terms but not in terms of the principles and ideas underpinning the learning objectives. Misunderstandings, particularly among low achievers, occurred because pupils made connections between ideas introduced in the lesson and their own prior knowledge establishing misconceptions.

Study 10

Pratt (2006, BEI)

The main aim(s) of the study

This study aims to explore pupils' perceptions of interactive teaching making use of 'video stimulated reflective dialogue' (p 221). The focus is on pupils' views about the roles of talking and listening.

It is the author's view that 'few, if any (studies) have explicitly sought the views of young learners in respect of their role in interactive whole class teaching. It is an attempt to do just this which forms the focus of this paper…Hearing what children have to say in this respect helps to illuminate the norms, expectations and practices of classroom discourse, and its implications for teaching'.

The key research questions

- What views do pupils hold regarding classroom discourse during whole class interactive teaching in mathematics lessons?
- More particularly, what role do they think classroom talk plays in their learning?

The research design

34 pupils were interviewed in pairs about their views on the role of classroom discourse following a video-recorded lesson; extracts from the videotapes were shown to the pupils during the interview.

The key findings concerning teacher-initiated teacher-pupil dialogue

Two themes emerged from the analysis:

i) pupils' perceptions of 'what' and 'why' they were learning as a whole class

ii) pupils' perceptions of how this learning took place (p 225)

This paper focuses on the second theme: that is, on 'how' pupils thought learning was taking place during whole class interactive teaching events.

With regard to the first theme (what/why), Pratt reports that the pupils in all three classes had a very clear view of what, and why, they were learning in a whole class interactive context. This view essentially focused on two issues:

a. the joint refinement of techniques, whereby pupils understood that others might have solutions that were more useful, or more efficient, than their own

b. the memorisation of best methods, whereby pupils perceived their job essentially being to remember the particular technique that was identified as the best for a particular problem

Pratt notes that the idea of joint refinement of techniques is encouraging and reflected clearly the emphasis of all three teachers on reinforcing the need to listen carefully to each other; however, the second, with the focus on memory, is problematic. The latter suggests that, despite the potential opportunity for an active and dynamic construction of meaning in a social setting, pupils' focus was largely on more passive memorisation. The pupils' responses also suggested it was mainly the teacher who identified what 'best' was in each case and hence what was to be memorised (p 226).

With regard to the second theme (how), Pratt considered pupils' responses relating to learning as a process in a whole class interactive setting. Three conceptual categories are identified in this respect.

a. *Authority in interaction*. Although pupils understood the purpose of class discourse to be the negotiation of solutions, there was no doubt about who was in control of judgements in this respect: it was the teacher who validated knowledge generated by the group and ultimately decided if things were 'right' or 'wrong'. This was sometimes done directly (for example, by saying, 'That's wrong') and sometimes done indirectly (for example, by the teacher giving clues).

b. *Difficulties in understanding explanations*. The pupils had a very clear sense of the practical difficulties of facilitating the process of ideas sharing. Problems were (i) the clarity and comprehensibility of other pupils, and (ii) pupils' own resistance to conceptual change. (p 228)

   The pupils were aware that some pupils were better than others at giving clear explanations, both in terms of audibility and comprehensibility). They were also aware of difficulties in hearing and understanding peers. The role of the teacher during interaction is more complex than suggested by the NNS.

c. *The supremacy of listening over talking*. By year 6, pupils appeared to realise quite quickly that the process of listening to public talk was a means of learning, in so far as they perceived classroom dialogue as a way to access a range of ideas, some of which might be of value in extending their own understanding. The year 3/4 pupils in this study were less clear about this.

There is an ambiguity involved when teachers ask for an explanation as to whether what the teacher wants is for pupils to make their meaning apparent or to confirm a point has been understood. If teachers moved too quickly from the former to the latter, without giving pupils an opportunity to discuss the ideas involved, then pupils often disengaged from the discourse. Pupils tended to privilege listening to talking as contributing to their understanding.

Study 11

Ryan et al. (2003, BEI)

The main aim(s) of the study

This study explores how two teachers began to develop their ideas and practice concerning the use of collaborative classroom discussion of pupils' misconceptions and errors in year 5 mathematics lessons.

The key research questions

One key research question is presented: how do teachers begin to use pupils' mathematical discussion in their classrooms (p 1)? (A slightly different wording is presented on page 4, but the page 1 version is the better of the two versions.)

i) How do teachers develop mathematical discussion in their classrooms?

ii) What do they learn from such discussions?

iii) What materials are seen to be productive?

iv) What impact does collaborative discussion have on teaching practice?

The research design

Two teachers and three researchers are involved in a project designed to discuss and explore with the two teachers their ideas and practice concerning the use of collaborative classroom discussion of pupils' misconceptions and errors; records are kept over a three-month period of five meetings and three lessons which were video-recorded. (The first lesson acted as a baseline regarding their current practice at the start of the project; the subsequent two lessons illustrate how the teachers tried to develop their practice in line with the aim of the project.)

The key findings concerning teacher-initiated teacher-pupil dialogue

i) The introduction of pupils' collaborative discussion was found by the teachers to challenge significantly the NNS model in terms of their pedagogy.

ii) Constraints of the NNS pedagogical model were related in particular to time and unitising of learning episodes.

iii) The teachers endorsed the opportunity to explore new practice within a supported research environment in which they were able to take control of the agenda and develop their own practice rather than deliver the practice of an outside agency. (p. 1)

iv) The need to close discussion within the hour is a constraint.

v) The videos enabled the teachers to recognise existing practices of pupils' discussions.

vi) The teachers felt the pupils were learning a new skill (p 16).

Analysis: First lesson

CASE 1: DEBRA

Planned her first lesson using NNS model. Several tensions identified between lesson focus/objective and wanting to respond to children's responses; between time planned and time taken; between coverage of the strand and getting side tracked by the children. Debra created her own model for discussion: (a) exchange of ideas, (b) find differences, and (c) sort it out.

CASE 2: KATE

Also planned first lesson using NNS model. Knowing-in-action was how she gauged responses to questions to guide direction of whole class teaching. Kate used questions extensively and sought children's reasoning. The socio-mathematical norm was 'finding the right answers by the end of the lesson'.

Analysis: A discussion lesson

(lesson with discussion as the focus)

CASE 1: DEBRA

Children were presented with a misconception. Agenda to shift the socio-mathematical norms in terms of what constitutes 'doing' mathematics - felt to be very different to the NNS approach. Children's role to be teacher-detectives - place themselves in the teacher role to explain to another student.

CASE 2: KATE

Planned discussion lesson around structure of NNS - used problem solving and set up competition between groups. Moving from setted groups to mixed ability was disturbing. Remix felt to be unsuccessful. She and children aware of time constraints. Also tried to shift the socio-mathematical norms. What to do when stuck.

Study 12

Smith et al. (2004, Main paper, handsearched)

Hardman et al. (2003, Subsidiary paper, BEI)

The main aim(s) of the study

The study aims to explore primary school teachers' use of discourse strategies during whole class interactive teaching.

The key research questions

- What discourse moves do teachers use during whole class interactive teaching?
- Do the patterns of discourse used by teachers vary across subjects (literacy versus numeracy lessons), stages (reception versus Key Stage 1 versus Key Stage 2) and teacher effectiveness (that is, comparing teachers identified as 'effective' using PIPS data with those identified as 'average' teachers)?

The research design

The main focus is on 72 observed lessons, together with 14 video-recorded lessons, which are analysed in terms of teacher-pupil discourse

The key findings concerning teacher-initiated teacher-pupil dialogue

72 lessons – 35 literacy, 37 numeracy. Approximately one-third fell into each of reception (Key Stage 1 and Key Stage 2). 60% were taught by 'effective' teachers. Teacher-directed interrogation of pupils' knowledge and understanding was the most common form of teacher-pupil interaction. Some teachers encouraged higher levels of pupil participation and engagement through open questions and different use of the follow-up move. Findings focus on the whole class section (WCS) of the lesson.

i) The average lesson lasted 53 minutes, and the whole class section lasted 32 minutes (60% of the lesson).

ii) Some lessons were entirely made up of whole class teaching.

iii) There was no significant difference in the amount of whole class teaching in literacy and numeracy lessons.

iv) Key Stage 2 lessons usually lasted about 4 minutes longer than Key Stage 1 lessons.

v) 43% of teachers did not use an uptake question during WCS.

vi) 15% of teachers did not ask any open questions during WCS.

vii) Most frequent discourse moves were closed questions (69 per hour), evaluation (65 per hour), explaining (50 per hour) and direction (39 per hour).

viii) Most dominant discourse move for pupils was to answer a questions (118 per hour) followed by choral response (13 per hour), presentation (13 per hour) and spontaneous contribution (9 per hour).

ix) The mean duration and percentage duration for each discourse move indicate that explaining was of the longest duration (mean 20.3 seconds), followed by direction (mean 17.1 seconds). Closed questions and evaluation were frequent but lasted about the same length as other discourse moves.

x) Significantly more direction took place in numeracy lessons, compared with literacy lessons.

xi) Closed questions and choral responses were more common in numeracy than in literacy lessons.

xii) Uptake questions were rare in both numeracy and literacy lessons, but more likely in literacy lessons.

xiii) Only one discourse move was significantly different between effective and average teachers - general talk – and this suggests that effective teachers created opportunities for more informal talk.

xiv) Effective teachers make more discourse moves in general, compared with average teachers.

xv) Transcripts of the 14 video-recorded lessons showed little difference in the discourse pattern across literacy and numeracy lessons. Teacher explanation and teacher-directed question-and-answer made up the majority of the discourse moves (78% in literacy, 77% numeracy).

xvi) Some teachers, however, encouraged higher levels of pupil participation and engagement through open questions and different use of the follow-up move. Through feedback which went beyond evaluation of the pupil's answer (that is, probing and the use of uptake), teachers sometimes extended the answer to draw out its significance, or to make connections with other contributions during the lesson topic so as to encourage greater pupil participation (p 407).

xvii) Questionnaire responses indicated teachers had no clear concept of what interactive whole class teaching is. Although most teachers reported that they valued and frequently invited pupils to elaborate on their answers, the analysis suggests that opportunities for sustained and extended dialogue by the pupil are rare.

Study 13

Smith and Higgins (2006, Main paper, BEI)

Smith et al. (2006) (Subsidiary paper, BEI)

The main aim(s) of the study

This study aims to explore the teachers' use of questions and, in particular, how teachers react to pupils' responses as a means of facilitating a more interactive learning environment (p 485).

The key research questions

How do teachers make use of questions during classroom interaction in literacy and numeracy lessons, and are there certain types of use that are more effective in promoting exploratory talk by pupils?

The research design

This study focuses of a sample of 184 real-time observed and 29 video-recorded literacy and numeracy lessons with year 5 and year 6 pupils; these lessons are then analysed in terms of the teachers' use of questions and the learning environment created. (Most lessons involved the use of interactive whiteboards (IWBs), as this study was part of a wider project looking at the impact of IWBs, but the impact of using IWBs, was not part of the study reported here, per se.)

The key findings concerning teacher-initiated teacher-pupil dialogue

i) Table 1 and Figure 1 revealed that a typical open question lasted about four seconds, but they happened relatively infrequently, comprising just over 2% of the total discourse moves.

ii) Initial viewing of video-recorded lessons largely corroborated the quantitative analysis. Lessons using IWB continued to mirror the tripartite IRF sequence identified as common to the structure of classroom interaction without IWBs.

iii) The search for a purposive sample of those lessons which were less restrictive and teacher controlled (that is, where there was a more symmetrical distribution of talk and where pupils' talk was noticeably more in-depth, exploratory and speculative) identified only a maximum of five literacy and five numeracy sessions which contained some such behaviour at some stages of whole class interaction (p 489).

iv) An analysis of the transcripts of these episodes using the IRF structure was used to identify which behaviours facilitated a more interactive learning environment.

v) This revealed that the more interactive the lesson (in a socio-constructivist sense), the less the IWB was used.

vi) This also revealed that it is the quality of the feedback move in the IRF exchange, and not the questions themselves, which facilitates a more interactive learning environment (p 490).

a. Encouraging pupil-pupil feedback by inviting pupil-pupil response and feedback: The teacher conveys to pupils that their utterances are taken seriously, pupils are given a more equitable distribution of utterance length, they are invited to agree/disagree with another pupils', and to offer unsolicited feedback to each other.

b. Reciprocal engagement: Teachers also encouraged more symmetric interaction by demonstrating reciprocal engagement in pupils' responses. Rather than explicitly promoting pupils to continue their utterances, teachers reacted in a mote conversational, less institutionalised manner, and made backchannel moves during pupils' responses, signalling authentic interest or expressed interest at the end of the pupil's utterance.

c. Following pupils' ideas: Some teachers demonstrated a more flexible approach to unpredicted pupil responses. For example, they sometimes turned the feedback move into another question, asking for clarification. Such questions are authentic in that they genuinely ask something unknown, ratifying the importance of the pupil's original response, while also creating the opportunity for the pupil to expand upon their original response. Another example would be a teacher suggesting a pupil's response could be followed up at some future stage; or incorporating the pupil's unpredicted ideas into the immediate discussion or using them to frame a new activity; such responses by teachers encouraged pupils to have ownership not only over the solution to problems, but also of the flow of the lesson (p 499).

Study 14

Tanner and Jones (2000a, handsearched)

The main aim(s) of the study

The study aims to explore the impact of an action research project designed to develop pupils' metacognitive skills on their performance in mathematics.

The key research questions

- How successful are the classroom practices advocated in the Mathematical Thinking Skills Project in developing pupils' metacognitive skills and improving their performance in mathematics?
- It was anticipated that the use of the suggested classroom teaching strategies would produce improved pupil performance in problem solving and modelling situations which were similar in character to those used on the course: 'near transfer'.
- It was further hypothesised, however, that the development of metacognitive skills would lead to improved learning in mathematics through 'far transfer' into the cognitive domain (that is, the more usual content areas of mathematics which had not been specifically targeted by the project) (p 23)

The research design

Twelve teachers involved in an action research network agreed to develop and trial teaching strategies and materials designed to develop pupils' metacognitive skills; pairs of classes in year 7 and in year 8 were identified in each of six schools to act as the intervention class and the control class. The 12 control classes were taught by their normal teacher. Pre-tests, post-tests and delayed-tests of the 24 classes together with participant observation of the intervention classes were used to assess whether the intervention had led to the development of metacognitive skills and improved performance in mathematics.

The key findings concerning teacher-initiated teacher-pupil dialogue

The participant observations revealed that the extent to which the teachers had adopted the suggested approaches was variable. As a result, three teachers were dropped from the final analysis. The quantitative analysis thus deals with the remaining eight teachers, and their nine classes (one intervention teacher taught two groups) and their 499 pupils.

Multivariate analysis of variance (MANOVA) was used to analyse the three levels of test (pre-test, post-test, and delayed-test) and two types of class (control and intervention).

i) *Metacognitive skills*: Both control and intervention groups improved their scores on active metacognitive skills over the period of the intervention, but the intervention group improved more than the control group. The effect size was 0.191 and highly significant ($p<0.001$). This improvement was sustained in the delayed-test.

ii) *Passive metacognitive knowledge* or *'knowing what you know' (forecasting)*: Intervention groups improved their scores on forecasting over the period of the intervention, and this improvement was sustained in the delayed-test, but the effect size of 0.013 was not significant.

iii) *Post-casting*: Intervention groups improved their scores on post-casting over the period of the intervention, and this improvement was sustained in the delayed-test; the effect size of 0.022 was small but significant ($p <0.05$).

iv) *Cognitive development*: Intervention groups improved their scores on cognitive development over the period of the intervention, and this improvement was sustained in the delayed-test; the effect size of 0.021 was small but significant ($p<0.05$).

Using the participant observation data, the eight teachers were classified into four characteristic groups according to the teaching styles employed:

i) ‘Taskers’ focused on the demands of the task rather than the underlying aim of teaching metacognitive skills.

ii) ‘Rigid scaffolders’ were far more directive in their approach to planning: their emphasis was on demonstrating and sharing the teacher’s own previously identified plan rather than helping pupils to develop their own plans.

iii) ‘Dynamic scaffolders’ made full use of the social structure of Start-Stop-Go to frame their pupils’ behaviour and constrain them to act as experts rather than as novices, but the teacher was the most significant participant in the discourse and validated conjectures and used focusing questions to control its general direction ensuring that an acceptable whole class plan was generated.

iv) ‘Reflective scaffolders’ also used the social structure of Start-Stop-Go to constrain pupils to act as experts rather than as novices, but they encouraged several approaches to the problems, rather than constrained the discourse to a class plan.

A comparison of each of these four groups with the control group revealed the following:

i) The taskers’ pupils showed no advantage over the controls in any test.

ii) The rigid scaffolders’ pupils showed an advantage over the controls in only the metacognitive delayed tests with a very small effect size (0.09) significant ($p<0.05$).

iii) The dynamic scaffolders’ pupils were more effective than controls at developing metacognitive skills, with an effect size of 0.36 ($p<0.001$).

iv) the reflective scaffolders’ pupils had a significant effect size in all four areas: metacognitive skills development (0.40, $p<0.001$), forecasting (0.07, $p<0.01$), post-casting (0.14, $p<0.001$) and cognitive development (0.21, $P<0.001$).

The success of the reflective scaffolders was conjectured to be due to their emphasis on self-evaluation and reflection.

Study 15

Wilson et al. (2006, BEI)

The main aim(s) of the study

This study aims to explore teacher-pupil interaction in mathematics lessons in North East England and in St. Petersburg (Russia).

The key research questions

- What patterns of teacher-pupil interactions are evident in a sample of mathematics lessons with pupils aged 7-11 years in North East England and in St. Petersburg (Russia)?
- To what extent do these patterns differ across the two settings?

The research design

The study collects data on teacher-pupil interaction during a sample of mathematics lessons in England and Russia.

The key findings concerning teacher-initiated teacher-pupil dialogue

For the sample of 25 mathematics lessons in England:

i) The most common number of sections in the lessons were four or five, although there was a clear underlying three-part structure reflecting the three-part lesson structure advocated by the NNS. In each section, the number of private, mixed or public interactions is given (Table 1).

ii) The characteristic pattern was public interaction in phases 1 and 3, and private interaction in phase 2.

iii) There was a strong tendency for whole class interactions to consist of two stages: the teacher initiates, the class responds.

iv) Private interactions occur in sections of the lessons in which pupils are working on written tasks and this is associated with monitoring.

v) The length of the lessons varied considerably: the shortest lesson was 35-39 minutes in length, and the longest was 90-94 minutes in length; the modal length (comprising 7 lessons) was 60-64 minutes in length, mean 60.8 minutes (s.d. 10.6).

vi) The number of interactions also varied considerably: these ranged from 40-49 (three lessons) to 150-159 (two lessons), with a modal value (comprising 4 lessons) of 70-79; mean 90.7 (s.d. 33.4); the mean density (number of interactions per unit time over the whole lesson) was 1.3.

vii) Public sections are normally dominated by large numbers of short interactions; longer interactions are generally private.

Appendix 4.2: Key characteristics identified in the synthesis of evidence

Key characteristics	Main papers and overall WoE
Going beyond IRF	Back (2005) *Low* Hadjidemetriou and Williams (2003) *Low* Mercer and Sams (2006) *Medium* Myhill (2006) *Medium* Ryan et al. (2003) *Low* Smith et al. (2004) *Medium* Smith and Higgins (2006) *Low* Wilson et al. (2006) *Low*
Focusing attention on mathematics rather than performativity	Back (2005) *Low* Coles (2002) *Low* Hadjidemetriou and Williams (2003) *Low* Jones and Tanner (2002) *Medium*
Working collaboratively with pupils	Back (2005) *Low* Black (2004a) *Low* Black (2006) *Low* Jones and Tanner (2002) *Medium* Smith and Higgins (2006) *Low*
Transformative listening	Coles (2002) *Low* Myhill (2006) *Medium*
Scaffolding	Jones and Tanner (2002) *Medium* Myhill (2006) *Medium* Tanner and Jones (2000a) *Medium*
Enhancing pupils' self-knowledge concerning how to make use of teacher-pupil dialogue as a learning experience	Black (2006) *Low* Jones and Tanner (2002) *Medium* Mercer and Sams (2006) *Medium* Pratt (2006) *Low* Ryan et al. (2003) *Low* Tanner and Jones (2000a) *Medium*
Encouraging high quality pupil dialogue	Jones and Tanner (2002) *Medium* Smith and Higgins (2006) *Low*
Inclusive teaching	Black (2004a) *Low*

The results of this systematic review are available in four formats:

SUMMARY	Explains the purpose of the review and the main messages from the research evidence
REPORT	Describes the background and the findings of the review(s) but without full technical details of the methods used
TECHNICAL REPORT	**Includes the background, main findings, and full technical details of the review**
DATABASES	Access to codings describing each research study included in the review

These can be downloaded or accessed at **http://eppi.ioe.ac.uk/reel/**

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