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

Report written by Chris Kyriacou and John Issitt

EPPI-Centre
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REPORT

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

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The results of this systematic review are available in four formats. See over page for details.

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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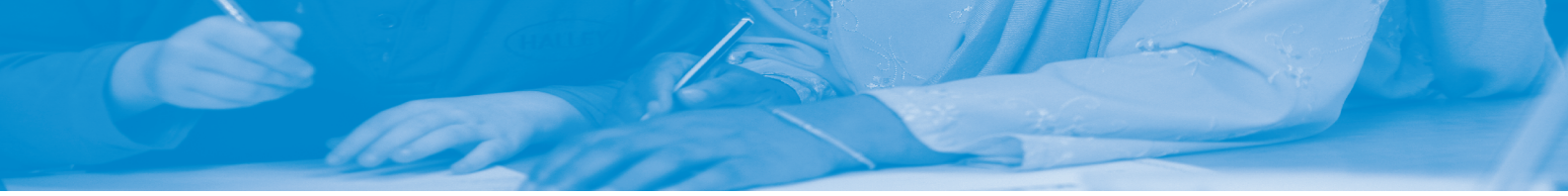
List of abbreviations

BEI	British Education Index
CPD	Continuing Professional Development
DCSF	Department for Children, Schools and Families
DfES	Department for Education and Skills
EPPI-Centre	Evidence for Policy and Practice Information and Co-ordinating Centre
IRF	Initiation-response-feedback sequence of interaction
NNS	National numeracy strategy
SAT	Standard assessment test



Preface

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 the Review Group find?

The Review Group's 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?

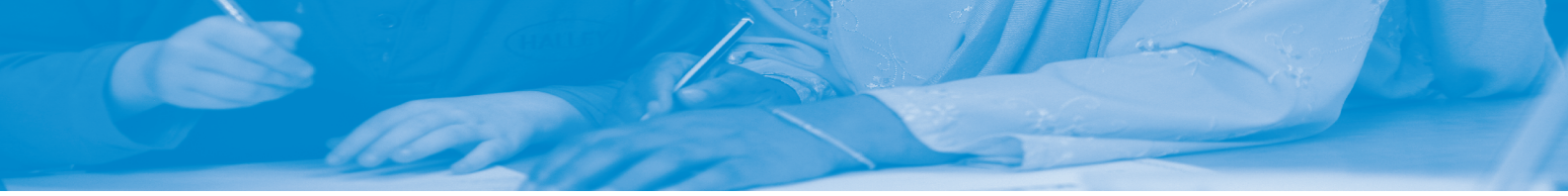
A limitation of this review was the paucity of evidence concerning the effect of these eight identified characteristics on promoting pupils' conceptual understanding mathematics. Policymakers, practitioners and researchers need to consider how classroom practice can incorporate high quality teacher-initiated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

How did we get these results?

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

Where to find further information

http://eppi.ioe.ac.uk/cms/Default.aspx?tabid=405



CHAPTER ONE

Background

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.

A meeting was held at the DCSF in January 2007 to refine the review question. It was felt 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. Those at the meeting also agreed to focus on research dealing with Key Stages 2 to 3 conducted in schools in England since 2000. Through the review, it was found that there were no studies relating to Key Stage 4 however, so the review focuses on Key Stages 2 to 3.

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 (Orton and Frobischer, 2005; Rittle-Johnston and Siegler, 1998; Sutherland, 2007; Watson, 2006).

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. 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 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.

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 question

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?

Policy and practice context

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. 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. Further moves in this direction are in part a reflection of the implementation of the Every Child Matters agenda, which includes 'enjoying and achieving' as a learning outcome for pupils, and in part a reflection of the implementation of 'personalised learning', 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 (e.g. DfES, 2003; QCA, 2004, 2007; Ofsted, 2006a,b).

Taken together, these reports point to 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 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, 2004, 2006).

Research context

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 way pupils are taught in school (Hansen, 2005; Mason and Johnston-Wilder, 2004).

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 (Cockburn, 2006; Higgins, 2003; Houssart, 2004; Lee, 2006; Sutherland, 2007; Swan, 2007; Watson, 2006). 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 about 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, and is also undertaken with an awareness of the wider international comparative research

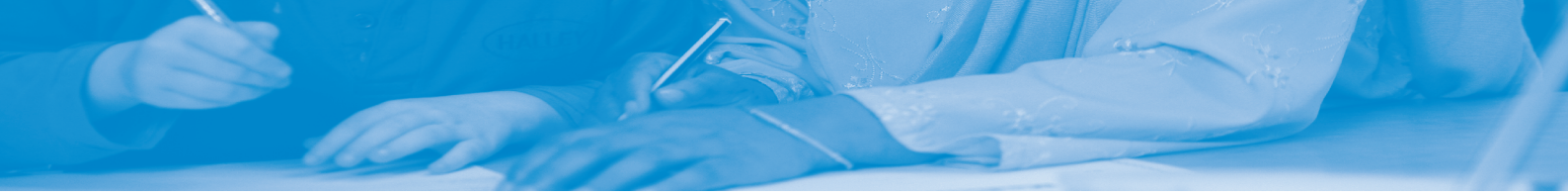
context provided by research literature that draws on international comparisons of pupil attainment and teaching methods regarding school mathematics, which includes, most notably, the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) programme.

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.

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.



CHAPTER TWO

Methods of the review

This review followed the procedures for searching, recording, analysing and reporting developed and maintained by the Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre), which includes the use of software developed by the EPPI-Centre for this purpose and quality assurance procedures (see technical report: http://eppi.ioe.ac.uk).

User involvement

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. Further details of user involvement are given in the Technical Report.

Identifying and describing studies

Identifying relevant studies involved carrying out an electronic search using keywords of bibliographic databases, handsearching through key journals and conference proceedings, citations, and publications recommended by contacts. For a paper to be included in the systematic map, it had to satisfy the following four criteria:

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

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

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

iv) The study dealt 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 the Technical Report).

In-depth review

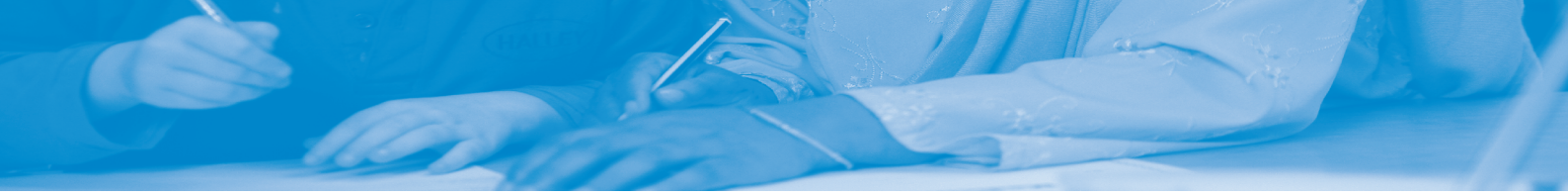
All the studies included in the systematic map were included in the in-depth analysis. Each study was given an overall weight of evidence based on the following three components:

A Trustworthiness of studies: taking account of 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, with the caveat that D could not be higher than C



CHAPTER THREE

What research was found?

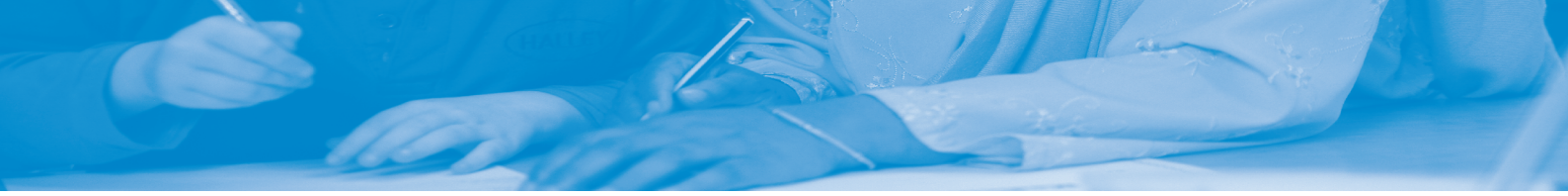
Fifteen studies were identified for the review (Back, 2005; Black, 2004a, 2006; Bold, 2002; Coles, 2002; Hadjidemetriou and Williams, 2003; Jones and Tanner, 2002; Mercer and Sams, 2006; Myhill, 2006; Pratt, 2006; Ryan et al., 2003; Smith et al., 2004; Smith and Higgins, 2006; Tanner and Jones, 2000; Wilson et al., 2006).

Of the main papers, six were identified as a result of the electronic search strategy of BEI and nine were identified as a result of handsearching. Eight of the 15 main papers were published in journals and seven were published as conference papers. All the studies were written in English, 13 included data collected in England, and two presented data from Wales.

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.

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?'. 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. It is thus disappointing, from the point of view of addressing the review question, 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.

No study received an overall weight of evidence rating of 'high'; five studies were rated 'medium', and ten studies were rated 'low'; full details can be found in the Technical Report. 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.



CHAPTER FOUR

What were the findings of the studies?

All 15 studies indicated that the use of initiation-response-feedback (IRF) sequences remained 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) and Wilson et al. (2006).

In considering this finding, one needs to bear in mind that the included studies cannot be said to have investigated a representative sample of mathematics lessons in England. However, the finding is in line with the wider research on mathematics in England that has been published recently, some of which is highlighted in the Technical 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, 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 national numeracy strategy (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 of evidence 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.

Three of the studies provided evidence that such characteristics actually led to an

improvement the conceptual understanding of mathematics (Jones and Tanner, 2002; Mercer and Sams, 2006; Tanner and Jones, 2000). 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 of these reported an effect size. In the case of Mercer and Sams (2006), an effect size of 0.59 was reported for the 'Thinking Together' programme on standard assessment test (SAT) scores; in the case of Tanner and Jones (2000), an effect size of 0.21 was reported for the Mathematics Thinking Skills Project for reflective scaffolders on cognitive development. As the third study did not present an effect size, it was not possible to combine the results from the three studies using a meta-analysis.

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. 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 inter-connected and to some extent also overlapped.

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). 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. The study by Back (2005) 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.

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 in just getting correct answers. A number of studies addressed this characteristic (Back, 2005; Coles, 2002; Hadjidemetriou and Williams, 2003; Jones and Tanner, 2002). 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 (generalising, reasoning, and argument). For example, Back notes that asking a 'why question' focuses pupils on the mathematics and away from focusing solely 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 explaining or demonstrating 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 the study by Jones and Tanner (2002), which notes that the quality of discourse is enhanced when teachers provide pupils with opportunities for reflection.

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 work 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). 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 teacher's confidence to 'go with the pupils' by allowing the pupils to develop their ideas and to follow the pupils' thinking, even if it appears to be taking the teacher in a direction that they did not anticipate or intend.

Black (2004a, 2006) noted that only those pupils (usually the more able ones) who regularly had productive exchanges with the teacher saw themselves as being engaged in developing a shared understanding of the mathematics with their teacher; for this reason, 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.

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). 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) responding to pupils' suggestions; (iii) asking for feedback from the whole class; and (iv) 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.

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, 2000). 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 (2000) 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.

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 using talk and listening to teachers and other pupils talking 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, 2000).

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. The study by Black (2006) 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) gives 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 being asked to explain their answer and 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 (2006) 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 (2000) 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 talk, 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 engaging in talk of itself can enhance their understanding.

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). These studies point to the need for teachers to be open towards pupils' contributions, to encourage pupils to develop their contributions further, and indeed, to allow the direction of a lesson to follow the pupils' contributions.

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

Smith and Higgins (2006) identified ways in which teachers convey to pupils that their contributions were valued. These included incorporating the pupil's response into a discussion or a framework for 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'.

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, 2004). 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.

Summary of results of the synthesis

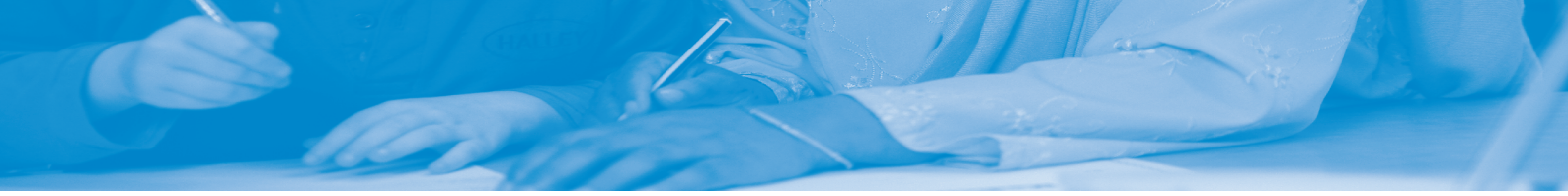
The Review Group's in-depth analysis of the included studies indicated the following:

- 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.



CHAPTER FIVE

Implications, or 'What does this mean?'

Strengths and limitations of this systematic review

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 in terms of this context 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 fifteen 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.

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. As such, 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 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 synthesis reported here was not able to assess the influence of such contextual factors.

It also needs to be noted that 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, the Review Group felt that attempting to do so would be 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.

Implications for policy and practice

The pedagogical approach embodied in the National Strategies includes the advocacy of dialogue to stimulate the quality of pupils' mathematical thinking. Nevertheless, the Review Group's view is that the studies included here indicate that the teaching of mathematics in Key Stages 2 and 3, 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, 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.

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 types of dialogue in their own practice. As such, attention needs to be given to how teachers can be supported to reflect upon their current practice so that they are able to appraise better the extent to which they are using high quality teacher-initiated teacher-pupil dialogue.

The development of classroom practice which incorporated more high quality teacher-initiated teacher pupil dialogue needs to consider 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 use 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 CPD experience to extend and develop their classroom practice in this direction. Aspects of personalised learning, assessment for learning, and the Every Child Matters agenda, considered in Chapter 1 of this review, 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.

Implications for 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.

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 need to be identified that can be drawn from international evidence on this topic, 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.

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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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They conducted the review with the benefit of active participation from the members of the review group.

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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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Appendix 2: The standard EPPI-Centre systematic review process

What is a systematic review?

A systematic review is a piece of research following standard methods and stages (see figure 1). A review seeks to bring together and 'pool' the findings of primary research to answer a particular review question, taking steps to reduce hidden bias and 'error' at all stages of the review. The review process is designed to ensure that the product is accountable, replicable, updateable and sustainable. The systematic review approach can be used to answer any kind of review question. Clarity is needed about the question, why it is being asked and by whom, and how it will be answered. The review is carried out by a review team/group. EPPI-Centre staff provide training, support and quality assurance to the review team.

Stages and procedures in a standard EPPI-Centre Review

- Formulate review question and develop protocol
- Define studies to be included with inclusion criteria
- Search for studies – a systematic search strategy including multiple sources is used
- Screen studies for inclusion
  - Inclusion criteria should be specified in the review protocol
  - All identified studies should be screened against the inclusion criteria
  - The results of screening (number of studies excluded under each criterion) should be reported
- Describe studies (keywording and/or in-depth data extraction)
  - Bibliographic and review management data on individual studies
  - Descriptive information on each study
  - The results or findings of each study

- Information necessary to assess the quality of the individual studies

At this stage the review question may be further focused and additional inclusion criteria applied to select studies for an 'in-depth' review.

- Assess study quality (and relevance)
  - A judgement is made by the review team about the quality and relevance of studies included in the review
  - The criteria used to make such judgements should be transparent and systematically applied
- Synthesise findings
  - The results of individual studies are brought together to answer the review question(s)
  - A variety of approaches can be used to synthesise the results. The approach used should be appropriate to the review question and studies in the review
  - The review team interpret the findings and draw conclusions implications from them

Quality assurance (QA) can check the execution of the methods of the review, just as in primary research, such as:

- Internal QA: individual reviewer competence; moderation; double coding
- External QA: audit/editorial process; moderation; double coding
- Peer referee of: protocol; draft report; published report feedback
- Editorial function for report: by review specialist; peer review; non-peer review

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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The EPPI-Centre was established in 1993 to address the need for a systematic approach to the organisation and review of evidence-based work on social interventions. The work and publications of the Centre engage health and education policy makers, practitioners and service users in discussions about how researchers can make their work more relevant and how to use research findings.

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The views expressed in this work are those of the authors and do not necessarily reflect the views of the funder. All errors and omissions remain those of the authors.

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