TECHNICAL REPORT

Mathematics education

A systematic review of strategies to raise pupils' motivational effort in Key Stage 4 Mathematics

Review conducted by the Mathematics Education Review Group

Technical report written by Chris Kyriacou and Maria Goulding

EPPI-Centre
Social Science Research Unit
Institute of Education
University of London

June 2006

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Report by Chris Kyriacou (Department of Educational Studies, University of York)
Maria Goulding (Department of Educational Studies, University of York)

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

This report is dedicated to the memory of Gillian Hatch, who died in November 2005. Gill had been an enthusiastic member of the Review Group from its inception. Over the course of her career, she made a massive contribution to mathematics education. She will be remembered by many people as a marvellous friend and colleague.

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/**

This report should be cited as:

Kyriacou C, Goulding M (2006) A systematic review of strategies to raise pupils' motivational effort in Key Stage 4 Mathematics. Technical Report. In: *Research Evidence in Education Library*. London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

CONTENTS

List of abbreviations

BEI	British Education Index
CAME	Cognitive acceleration in mathematics education
CPD	Continuing professional development
DfEE	Department for Education and Employment
DfES	Department for Education and Skills
EPPI-Centre	Evidence for Policy and Practice Information and Co-ordinating Centre, Social Science Research Unit, Institute of Education, University of London
ICT	Information and communication technology
KS 1	Key Stage 1 (aged 5 to 7 years)
KS 2	Key Stage 2 (aged 7 to 11 years)
KS 3	Key Stage 3 (aged 11 to 14 years)
KS 4	Key Stage 4 (aged 14 to 16 years)
NNS	National Numeracy Strategy
OECD	Organisation for Economic Co-operation and Development
OfSTED	Office for Standards 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

Summary

Background

This review was undertaken in the context of (i) the drive to raise standards of pupil attainment in schools; (ii) the reform of 14-19 Mathematics Education; (iii) the move towards personalised learning; and(iv) the extension of the National Numeracy Strategy into key stages 3 and 4.

Aims

The aim of this review is to consider the research evidence regarding strategies that can raise motivation in Key Stage 4 Mathematics among pupils in the mid-below-average to average range of mathematical attainment.

Review question

What strategies can raise motivational effort in Key Stage 4 Mathematics among pupils in the mid-below-average to average range of mathematical attainment in England?

Methods

Identifying relevant studies involved carrying out an electronic search using keywords with bibliographic databases, handsearching through key journals and conference proceedings, citations, and publications recommended by contacts. This resulted in 25 studies being identified for the in-depth analysis.

Results

The in-depth analysis of the 25 included studies led to the identification of four key areas: (i) grouping; (ii) pupil identity; (iii) teaching for engagement; and (iv) innovative methods.

Grouping

This area looked at the use of grouping by ability (i.e. setting) and the use of single sex classes in co-educational schools. The studies here did not collectively indicate any clear and consistent impact of setting on motivational effort *per se*, although it does appear that, if the whole class knows that being in a lower set will deny them access to higher GCSE grades, this can make it very difficult to sustain their motivational effort. In addition, the use of boys only classes in co-educational schools can sometimes enhance rather than undermine the 'laddish' culture that it is in large measure designed to combat.

Pupil identity

This area looked at the extent to which pupils have a positive pupil identity of themselves as 'mathematicians': that is, as people who can understand and do mathematics, and feel a sense of belonging in their mathematics class. The studies here indicate that the key to raising motivational effort for the target group of pupils is to help pupils to develop a more positive pupil identity of themselves as 'mathematicians'. Studies here indicated that raising motivational effort through developing a more positive pupil identity involves the use of strategies characterised by (i) providing a caring and supportive classroom climate; (ii) providing activities which pupils find challenging and enjoyable; (iii) enabling pupils to gain a deeper understanding of the mathematics; (iv) providing opportunities for pupils to collaborate; and (v) enabling the pupils to feel equally valued.

Teaching for engagement

This area looked at how teachers' decision-making regarding their choice of teaching and learning activities, the way they interact with pupils, and the type of classroom climate they establish, are intended to enhance pupils' engagement. The findings here echoed the five elements in the picture emerging in the previous section. However, in this section (teaching for engagement), the emphasis was more on the importance of the teacher being caring and supportive, and making the mathemat-

ics enjoyable; on the other hand, in the previous section (pupil identity), the emphasis was more on the importance of pupils gaining a deeper understanding of the mathematics they were doing as being crucial to the development of a more positive pupil identity.

Innovative methods

This area was subdivided into innovative teaching methods based on information and communication technology (ICT) and other innovative teaching methods. The studies here indicate that strategies making use of ICT (ranging across methods involving the use of interactive whiteboards, videoconferencing, supportive software packages for pupils, and graphical calculators) can have a powerful effect on raising motivational effort. However, in using ICT an important distinction needs to be made between two stages: (i) the motivating effect of using ICT, based on its novelty, stimulating visual appearance and the opportunity it affords to work in different ways, including working in groups; and (ii) the motivating effect of using ICT in a way that enhances deeper understanding of the mathematics. While both the above two stages involved in the use of ICT are important, the long-term impact of using ICT as a means of motivating pupils and thereby enhancing their pupil identity needs to make use of the second stage experience.

Other innovative methods included the use of cognitive acceleration in mathematics education (CAME) or CAME-type lessons, the teaching of self-regulation strategies, teaching based on extending features of the NNS in primary schools into secondary schools (such as the use of mental/oral starters and whole class interactive teaching) and the use of formative assessment. The studies here indicated that such innovative methods can play a part in raising motivational effort.

However, for strategies based on both ICT-based and other innovative methods of teaching to be effective in raising pupils' motivational effort, teachers need to have a good understanding of the theoretical basis concerning why and how the innovation can be effective, and to develop the skills and techniques required for its effective practical implementation, as the effectiveness of any innovative teaching method is highly sensitive to the way in which it is implemented.

Conclusions

The main strengths of this review are that the review process has followed a publicly visible procedure, and has benefited from the collaboration involved between the Review Group, the EPPI-Centre, and many other individuals who offered comment, help and advice. The close scrutiny of the procedures involved means that each stage of the review process involved discussion and justification.

The main limitations of the review are that the constraints involved in terms of time, cost and access to relevant papers, inevitably means that decisions about the focus of the review question and the conduct of the review process had to be taken in the context of keeping the review manageable; many of the studies included samples which did not precisely match the target group (that is, KS 4 pupils in the mid-below average to average range of attainment); and none of the studies employed a research design which was ideal for addressing the review question.

Our main conclusions are as follows:

The issues identified here are very much in line with the DfES' own analysis of how pupils' motivational effort in school can be raised and is well reflected in the policies the DfES has developed in recent years, including the advocacy of personalised learning. There is little doubt that recent policy developments by the DfES, in conjunction with its response to *The Smith Report*, have now recognised and incorporated the importance of encouraging pupil engagement in mathematics. The section on personalised learning in the recent White Paper (DfES, 2005) is very much in tune with the findings of this review.

There is a vast array of initiatives that are current taking place in schools, many of which are already indicating ways in which rasing pupils' motivational effort can be achieved. What is clearly needed is for more teachers to be given the freedom to adopt what is emerging to be effective practice. The strategies considered in this review, ranging across the use of interactive whiteboards, videoconferencing, opportunities for peer collaboration, and providing a supportive classroom climate, all require a high level of skill and expertise. These are not strategies that teachers can simply implement without ongoing support and training. The evidence here indicates that enabling teachers to work together in collaborative groups with external support to explore and evaluate together innovations in their practice can make a major contribution to enable changes in practice to be effective in raising pupils' motivational effort.

There is a need for researchers to make greater use of measures and indicators of pupils' motivational effort in order to draw firmer conclusions about the effectiveness strategies designed to raise the motivational effort of the target group of pupils in KS 4 Mathematics. However, what is needed is not just evidence of whether a strategy works or not, but much more detail about what features of how a strategy is used contribute to its effectiveness or otherwise. Guidance to teachers on how to make use of these strategies, requires a fuller understanding of such features, which can only come from a rich research literature based on a mixture of study types, ranging from studies based on large scale testing of outcomes to studies based on qualitative in-depth case studies of the practice adopted by particular teachers, classes and schools.

CHAPTER ONE

Background

1.1 Aims and rationale for current review

The aim of this review is to consider the research evidence regarding strategies that can raise motivation in Key Stage 4 Mathematics among pupils in the mid-below-average to average range of mathematical attainment.

This review arises from a discussion held at the DfES in March 2005. It was felt at the meeting that a systematic review with a focus within mathematics education on Key Stage 4 would be particularly useful in the light of (i) *The Smith Report* on post-14 mathematics education; (ii) the carrying-forward of the principles underlying the numeracy strategy through key stages 1, 2 and 3 into Key Stage 4; and (iii) the standards agenda for mathematics attainment at the end of Key Stage 4.

It was felt at the meeting that pupils whose attainment level in mathematics at the start of Key Stage 4 ranges between the 20th and 50th percentile could achieve significantly higher grades in GCSE Mathematics through the use of more effective strategies to raise their motivation, and that a systematic review could usefully focus on the research evidence on the effectiveness of strategies to raise such pupils' motivation.

This review would thus identify research studies which had looked at the use of strategies to raise the motivation level of this group of pupils. The discussion explored a number of subsidiary questions that could be included in the review.

While it was agreed that the focus of the review would be on pupils in Key Stage 4, the review would also include research studies which dealt with strategies implemented during Key Stage 3, as long as these studies provided evidence regarding their impact on pupil motivation in Key Stage 4. In addition, while the focus of this review is on raising pupil motivation, evidence of a link between raising motivation and a subsequent increase in attainment will also be evaluated, whenever this is available.

The findings of this review will have important implications for policy and practice, particularly in terms of considering how well any successful strategies identified are in line with strategies being advocated to raise standards and with strategies underpinning reforms in the 14-19 curriculum. The review will also have important implications for the implementation of 'personalised learning' in schools.

1.2 Definitional and conceptual issues

Research on pupil motivation makes up a massive international literature (Alderman, 2004; Aronson, 2002). Indeed, a Review Group has been established specifically to explore pupil motivation (see Smith et al., 2005), and aspects of pupil motivation also appear in the work of other Review Groups, most notably in the review of the impact of summative assessment on pupil motivation carried out by the Assessment and Learning Review Group (Harlen and Deakin Crick, 2002).

Research on pupil motivation has contributed to the development of many conceptual frameworks, within which the various factors which influence motivation and the key elements that make up the notion of motivation itself have been located. While the exact relationship between these factors and elements is the subject of much ongoing debate, the key features which have been prominently highlighted in recent research are reasonably clear, and have been utilised in the development of a conceptual framework for this review.

What do we mean by motivation towards mathematics?

Motivation towards mathematics is a complex concept which involves a mixture of: (i) attitudes towards the subject; (ii) beliefs about self-efficacy; (iii) intention; and (iv) action.

When we say that a pupil is highly motivated towards mathematics, this typically includes the following:

i. **Positive attitudes towards mathematics:** The pupil finds mathematics interesting, enjoyable, important, do-able and relevant.
ii. **Positive beliefs about self-efficacy:** The pupil believes that making an effort will lead to success.
iii. **Positive intention**: The pupil has a desire to learn more and to do well in attainment tests.
iv. **Positive action**: The pupil displays effort and perseverance, and positively seeks out new challenges.

Research on pupil motivation towards school subjects has, however, indicated that the relationship between these four elements is complex. While in general, positive attitudes, beliefs, intentions and effort, do go together, the picture is not always consistent. For example, some pupils who display all the signs that they enjoy mathematics may nevertheless display a lack of effort towards learning mathematics; some pupils who display a great effort in learning mathematics may state they have little interest in the subject of mathematics *per se*.

In order to understand fully the impact on pupils of strategies employed by mathematics teachers in the classroom to elicit and sustain a high level of pupil motivation, we need to be sensitive to the different elements that make up the notion of motivation.

Motivational effort

For the purpose of this systematic review, the focus will be on pupils' **motivational effort** towards mathematics: in effect, how hard pupils work in lessons. This focus has been adopted because this is the sense in which motivation is used when we are exploring strategies to increase pupil motivation in the classroom. The other elements of motivation will be considered in terms of their role as factors which can have an influence on motivational effort.

We have to be sensitive in considering the notion of motivational effort to an important distinction that needs to be made between two different sources of motivational effort: the first is based on a pupil's **desire to learn** more about the subject and the second is based on a pupil's **desire to perform** well in the subject. This distinction between learning goals and performance goals has been extensively developed by a number of researchers, including most notably Dweck (2004). How exactly a pupil's motivational effort is deployed will in part be reflected by the relative influence of their desire to learn and their desire to perform, and pupils' motivational effort may well be influenced by whether the classroom climate established by the teacher is perceived by pupils to be learning-oriented or performance-oriented (Kaplan et al., 2002).

The role of pupil appraisal

In the mathematics lesson, the pupil needs to decide how much effort they will deploy towards the work at hand. This involves a consideration of the reasons for making an effort and/or for not making an effort. For example, one reason for making an effort may be that the pupil needs to get a good grade in GCSE Mathematics in order to continue with the subject at A-level; one reason for not making an effort is that the work is so difficult that any effort would simply be wasted. The pupil's decision about how much effort to deploy will be influenced by their attitudes towards school mathematics and by the context.

This appraisal by a pupil is seen by a number of researchers (e.g. Boekaerts, 1995) to lie at the heart of a process which can lead to the pupil either **responding positively** to the academic demands being made upon them in the lesson (by making an effort which then leads to success and sets up a virtuous cycle for the future: sometimes referred to as 'an adaptive-mastery cycle'), or **responding negatively** (by minimising effort which leads to failure and sets up a vicious cycle for the future: sometimes referred to as 'a maladaptive-helplessness cycle'). The challenge often facing teachers who wish to raise motivation among lower attaining pupils in the mathematics classroom is to break a vicious cycle that has already been well established and offers the pupil some protection from the pain of failure, since failing if you have not made an effort is much less painful than failing if you have made an effort (Galloway et al., 1998).

Pupils' attitudes towards school mathematics: to what extent do they find mathematics enjoyable, interesting, important, do-able and relevant?

In examining pupils' attitudes we need to make a distinction between five categories of their perceptions regarding school mathematics:

i. **enjoyment**: the extent to which they find doing the subject is 'fun'
ii. **interest**: the extent to which they find the subject elicits their curiosity and their desire to learn more about the subject
iii. **importance**: the extent to which the subject is seen by the pupil to have high status in the school and in the wider society, and to be

to a prerequisite for accessing a variety of opportunities in life

iv. **do-able**: the extent to which it is possible to understand the subject and perform well

v. **relevance**: the extent to which doing well in the subject is seen to be relevant to their personal short-term and long-term needs.

An important distinction needs to be made here between, on the one hand, the extent to which pupils find mathematics interesting and want to learn and understand more about the mathematics they are doing (that is, being **intrinsically motivated and learning oriented**) and, on the other hand, the extent to which pupils want to do well in mathematics in order to achieve a variety of goals contingent on doing well, such as getting a good job, receiving praise from their parents, and enhancing their self-esteem (that is, being **extrinsically motivated and performance oriented**).

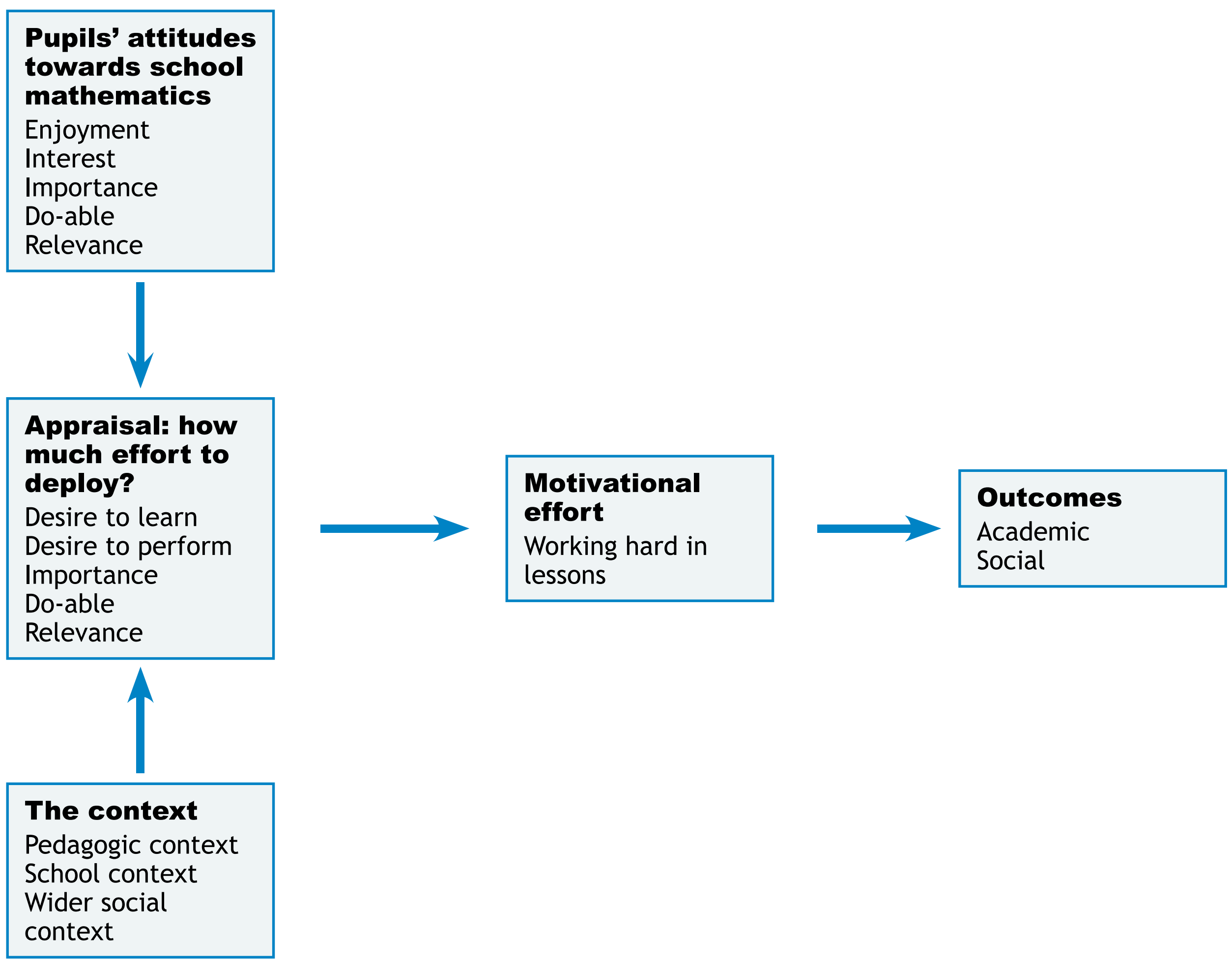
A further distinction also needs to be made here between pupils' attitudes towards the **subject matter** of mathematics *per se* and towards the **way it is being taught**.

Of particular importance here concerning pupils' views of the extent to which school mathematics is do-able is the pupils' **self-efficacy beliefs**: the extent to which they think they will be able to achieve success if they expend effort. Self-efficacy beliefs encompass a number belief orientations, such as the extent to which they hold the belief that doing mathematics is dependent on ability rather than effort, and the extent to which they hold the belief that ability is 'fixed and unchangeable' or is 'malleable' and can be expanded through 'experience and practice' (Chaplain, 2003; Dweck, 2004). Self-efficacy beliefs underpin pupils' sense of confidence or anxiety about undertaking tasks in mathematics (Ma, 1999; Ma and Xu, 2004). As such, in the framework developed below (Figure 1.1), self-efficacy beliefs specifically concerning school mathematics (rather than those concerning learning more generally) are located within category of 'do-able' regarding pupils' attitudes towards school mathematics.

The context

There are the following three major facets to the context:

Figure 1.1 The overall theoretical framework



i. **The pedagogical context**: What particular topic is being taught, how and by whom? (Pupils' attitudes towards this particular topic, this teacher, this teacher's expectations, and this type of teaching method, will have a major influence on the appraisal process regarding the decision about how much motivational effort to deploy.)

ii. **The school context**: What is the school ethos and, in particular how do teachers and school friends value different subjects and academic success?

iii. **The wider social context**: How do parents view mathematics and what influence do they have on the pupil? What career opportunities are available which may depend on success in mathematics?

The overall framework

Figure 1.1 illustrates the overall theoretical framework which underpins this review. Pupils attitudes towards school mathematics together with the context will influence the pupils appraisal regarding how much effort to deploy in the lesson. This appraisal will in turn influence the pupil's motivational effort. The degree of effort exerted will in turn have outcomes (both academic and social) which will then feed into the pupil's future attitudes and decision-making.

There is an implicit link in this theoretical framework between motivation and achievement, although it is clear from research studies which have explored the nature of this link that it is a complex one (Aronson, 2002; Elliot et al., 2005); this complexity is particularly evident in research studies of motivation undertaken in the context of the drive to raise standards of attainment through raising pupil motivation in order to meet nationally assessed attainment targets (Gardner, 2006; Smith, 2005).

Strategies to raise pupil motivation

This review is concerned with the action that has been taken to raise pupil motivation. Such action may have been taken by a teacher explicitly to raise motivation in their own classroom. However, some action may have been taken by the school as a whole, as a result of its own initiative or in response to educational reforms more generally; such wider action may have been taken with aims other than raising motivation in mind, but may nevertheless have had a direct impact on pupil motivation in the classroom. In addition, evidence concerning practices that can raise motivation may be identified as a byproduct of naturally occurring changes, such as when differences in a pupil's experiences appear to have impacted on their motivation (e.g. when they change from one teacher to another teacher). In order to maintain a broad coverage of strategies that can raise pupil motivation, three categories of activity have been identified:

i. **Ongoing strategies used by a teacher to raise pupil motivation**. These refer to everyday techniques that teachers use to elicit and sustain pupil motivation. Such strategies may be directed with particular frequency and sensitivity towards a class or pupil whose motivation the teacher feels needs to be raised. Such strategies may be adjusted to accommodate the different needs of different pupils. Examples might be the use of small group work investigations, the use of fortnightly tests and setting short-term targets.

ii. **Intervention strategies used by a teacher to raise pupil motivation.** These refer to specific strategies that the teacher has introduced on an experimental basis to see if they are effective in raising pupil motivation. Such an intervention strategy may have been adopted by the teacher on their own initiative, or following outside encouragement or recommendation. Examples might be the use of single-sex class in a co-educational school, the use of an increased level of formative feedback, and the use of televised programmes.

iii. **School wide practices.** These refer to practices decided at a departmental or school level that appear to impact on pupil motivation, whether intended or unintended. Examples might be the use of setting, the use of homework clubs, the use of learning skills workshops, and implementing the Key Stage 3 national strategy.

In considering how and why certain strategies are effective or not, reference will need to be made to the overall framework illustrated in Figure 1.1.

1.3 Policy and practice background

There are four key elements to the policy background relevant to this review:

i. the drive to raise standards of pupil attainment in schools

ii. the reform of 14-19 mathematics education

iii. the move towards personalised learning

iv. the extension of the National Numeracy Strategy into key stages 3 and 4

The DfES (2004a) has set demanding targets for pupil attainment in Mathematics: by 2007, 85% of 14-year-olds should achieve level 5 or above nationally; and, by 2008, in all schools, at least 50% of pupils should achieve level 5 or above.

In addition, by 2008, 60% of those aged 16 should achieve the equivalent of 5 GCSEs at grades A*-C nationally, and in all schools, at least 30% of pupils should do so (p 8). The DfES (2004a) has noted the progress that has been made to date (see table 1.1). The targets for 2004 were as follows:

Table 1.1 Pupil attainment 1998-2004 (percentages for each year)

	1998	1999	2000	2001	2002	2003	2004
Mathematics level 5 or above for 14-year-olds	59	62	65	66	67	71	73
5 or more GCSEs A*-C for 16-year-olds	46.3	47.9	49.2	50.0	51.6	52.9	53.4
5 or more GCSEs A*-G (including English and Mathematics) for 16 year olds	83.8	85.8	86.8	86.9	87.1	86.6	86.4

Table 1.2 Ofsted assessment of mathematics lessons in Key Stages 3 and 4 (percentages)

	Key Stage 3	Key Stage 4
Excellent/very good	13	14
Good	56	51
Satisfactory	25	29
Unsatisfactory/poor	6	6

- 75% of 14-year-old pupils should attain level 5 or above.
- The proportion of 16-year-olds who gain five GCSEs at grades A*-C should increase by 2 percentage points over the previous year.
- 92% of 16-year-olds should obtain five or more GCSEs at grades A*-G , including English and Mathematics.

None of these three targets for 2004 was met.

The DfES (2004b) has highlighted the major challenges facing the education system, and in the area of 14-19 year olds expressed the concern that 'too many pupils drift, become disenchanted with school or get into trouble and drop out at 16' (p 6). The DfES (2004b) noted that attainment at 16 was highly linked to attainment at 14: 95 per cent of those who fail to reach the expected level at the age of 14 will not get five good GCSEs. Ofsted (2005) also noted that, in 2004, the proportion of pupils gaining five or more GCSE (or equivalent) grades A*-C in maintained secondary schools serving disadvantaged areas was less than one-third compared with the national proportion of over 50%. Ofsted attributed this achievement gap in part to the effects of these pupils' 'low educational ambition' and 'attitudes to learning that lack determination and resilience' (p 37).

The drive to increase the quality of teaching mathematics in secondary schools, as reflected in Ofsted's (2005) report of its annual assessment of observed lessons (see Table 1.2), is an important feature of the policy context for raising pupil attainment.

The DfES (2004b) argued that meeting the challenge of enabling more pupils to succeed can in part be met by schools doing more 'to tailor or personalise what is taught to get the most from each pupil, and particularly to help groups of children who have traditionally underperformed' (p 58), and also by offering pupils 'teachers who are masters of their subject, and who can enthuse and inspire'. (p 59).

Personalised learning involves two aspects: firstly, tailoring the teaching to take account of each pupil's individual need, interest and aptitude; and secondly, helping the pupil to develop the skills needed to access learning activities to better effect. The DfES (2004c) notes that personalised learning involves the regular assessment of pupil progress to identify each pupil's learning needs in order to teach them accordingly ('assessment for learning'), a variety of curriculum options, and enabling pupils to participate in a variety of learning experiences and styles. The essence of personalised learning is for the pupil to experience learning as something that is relevant to their needs and which they can readily engage in with success. The DfES (2004c) claims that personalised learning has 'the potential to make every young person's learning experience stretching, creative, fun and successful' (p 3). Pollard and James (2004) have outlined some of the ways in which recent research evidence can inform the concept of personalised learning as an approach to school

Table 1.3 GCSE Mathematics attainment 1999-2003

	1999	2000	2001	2002	2003
Numbers sitting GCSE Mathematics (thousands)	536.8	539.9	563.8	568.9	585.0
% of 15-year-olds in schools in England attempting GCSE Mathematics	92	94	93	84	94
% of 15-year-olds-cohort gaining grades A*-C	45	47	48	49	48

Table 1.4 Percentage of all pupils achieving each level in the National Curriculum Key Stage 3 Tests and Teacher Assessments in Mathematics in 2004 (Source: DfES website on national performance tables)

	Absent	1	2	3	4	5	6	7	8
Test: boys	6			7	15	20	28	19	5
Teacher assessment: boys	1		1	7	17	25	25	18	5
Test: girls	5			6	14	22	30	19	3
Teacher assessment: girls	1		1	6	16	26	27	18	4

Table 1.5 National GCSE Mathematics Results in 2004 (cumulative percentages by grade) (Source: DfES website on national performance tables)

	Number sat	A*	A	B	C	D	E	F	G
Male	367,518	4.5	12.1	28.7	50.9	68.5	83.3	92.0	95.9
Female	374,164	4	11.6	29.8	52.9	70.7	84.9	92.9	96.2

education, with particular reference to the ESRC's teaching and learning research programme.

The DfES (2004b) singled out mathematics for particular attention in its drive to increase effective subject teaching, in recognition of 'the particular importance of mathematics' (p 61). It notes that 'better teaching, and a more interesting curriculum, have a part to play in engaging pupils more effectively' (p 62) and highlights the particular importance of using ICT to support personalised learning as a tool which enables pupils to engage more easily when faced with difficult concepts.

The Smith Report (Smith, 2004) on post-14 mathematics education made a number of observations concerning 'the failure of the curriculum to excite interest and provide appropriate motivation' (p 4) and has called for the development of 14-19 pathways that will 'provide motivation, challenge and worthwhile attainment across the whole spectrum of abilities and motivation' (p 8). Smith also noted that the proportion of 15-year-old pupils gaining grades A*-C in Mathematics (see Table 1.3) in 2003 was 48 per cent of the age cohort (51 per cent of those entered) and the proportion of 15-year-old pupils gaining grades A*-G in Mathematics was 90 per cent of the age cohort (96 per cent of those entered).

Smith (2004) noted that, in terms of the appeal of the subject at GCSE to pupils, evidence from focus groups revealed that, for many pupils, 'GCSE Mathematics seems irrelevant and boring and does not encourage them to consider further study of mathematics' (pp 86-87).

The inquiry listed a number of principles that should guide the approach to Mathematics provision 14-19, which included the call that 'all learners should be provided with a positive experience of learning mathematics and should be encouraged to realise their full potential' (p 96). The importance of this was related to the inquiry's concern regarding 'the relatively low numbers of school pupils continuing mathematics post-16 through to the age of 19 and beyond' (p 105).

Smith also noted the key role of continuing professional development (CPD) for teachers in addressing its concerns, and noted the need for teachers 'to become increasingly aware of key ideas and new approaches to promoting mathematical reasoning in ways appropriate to the diverse range of students with differing abilities and motivation' (p 112).

The most important reform in Mathematics Education in recent years was the introduction of the National Numeracy Strategy into primary schools in September 1999 (DfEE, 1999). One aspect of this strategy, the use of daily mathematics lesson, was the subject our first systematic review (Kyriacou, 2005; Kyriacou and Goulding, 2004). The principles underpinning the NNS have since been extended into secondary schools as part of the Key Stage 3 Strategy for Mathematics (DfES, 2001), and are now beginning to be extended into Key Stage 4. A particular feature of the NNS has been the use of a three part-lesson structure (comprising an oral and mental starter, followed by the main teaching activity, and ending with a plenary), coupled with the use of interactive whole class teaching and objectives-led lesson planning based on a highly specified curriculum.

The Key Stage 3 Strategy for Mathematics (DfES, 2001) has identified the importance of '**engagement**: promoting approaches to teaching and learning that engage and motivate pupils and demand their active participation' (p 2). Approaches to improve pupil motivation have been elaborated in the training materials, which provide guidance for secondary school teachers, both in terms of the subject teaching (DfES, 2002), and in terms of improving behaviour and attendance (DfES, 2005).

In QCA (2004) a major concern has also been expressed 'that a large proportion of key stage 4 students say they do not enjoy mathematics very much' (p 31). Particular interesting, in terms of this review, is are the QCA's observations that:

> A slight majority of pupils in year 8 focus groups enjoy mathematics. This is likely to be due to the impact of the key stage 3 national strategy. Pupils in year 8 and 9 say they enjoy group work and the use of technology and mini-whiteboards. Algebra continues to bring out strong feelings, Most pupils dislike it and either find it boring, difficult or both; some like it and find it easy. As last year, there are pupils who find mathematics both challenging and satisfying.' (pp 25–26)
>
> Students value the GCSE mathematics qualification, and for some their motivation to learn mathematics is entirely focused on that goal. Many in year 10 report that the qualification is useful for a university place or a job, but not the mathematics itself. All agree that basic number is useful for everyday life and work. Half of the year 10 students questioned think that statistics is useful for business management. Some recognise the value of what they learn about percentages, for example.' (p 26)

The figures for mathematics attainment at the beginning and end of Key Stage 4 in 2004 are shown in Table 1.4 for SAT mathematics levels for 14-year-olds and in Table 1.5 for GCSE grades for 16-year-olds.

It will be evident from the above that the policy context can, in essence, be described as a drive towards meeting challenging targets for pupil attainment in GCSE Mathematics, which can be met by extending the principles underlying the NNS into key stages 3 and 4, and by the raising the motivation of pupils who at the start of Key Stage 3 are likely to gain a GCSE grade C, D or E (that is, those in the attainment range of between the 20th and 50th percentile at the start of Key Stage 3, which is the focus of the review question) through the use of variety of strategies, particularly those aimed at personalised learning.

While it has not been made clear to what extent the policy drive to raise pupil motivation as a means of raising achievement has been evidence based, it is noteworthy that such a link between the two is supported by the research literature (Luiselli et al., 2005) and indeed this link was one of the findings of the Harlen and Deakin Crick (2002) systematic review.

It will be evident from tables 4 and 5 that the target group for this review (that is, those in the mathematics attainment range of between the 20th and 50th percentile at the start of Key Stage 3) largely comprises those pupils gaining a level 5 at the age of 14 years, together with those performing at the top end of level 4. This group equated in 2004 with gaining a grade D or E in GCSE Mathematics at the age of 16 years.

1.4 Research background

Research evidence can be identified in several ways, including the following:

i. **Teacher and pupil perceptions** about what has or could raise pupil motivation

ii. **Observational or documentary evidence** of the extent to which pupils have displayed increased motivation (e.g. pupils work harder in lessons, and produce work of greater quality)

iii. **Measurement tests of motivation** based on pupil self-reported or teacher-reported estimates of how hard the pupil is working

A number of studies on pupil motivation have been reported which look at pupils' attitudes or effort towards mathematics. These include three broad types of studies (although, of course, the data for a particular study may cover more than one of these types):

i. Studies which have compared pupils' attitudes and/or effort towards mathematics with other subjects, typically producing overall rankings of subjects in terms of attributes, such as liking, importance, and usefulness (e.g. Colley and Comber, 2003; Francis, 2000; Miller et al., 1999)
ii. Studies which have sought to identify what factors pupils report have influenced their attitudes or effort towards different school subjects, including mathematics. One particularly common finding regarding reasons for liking a subject is that the pupil likes the teacher, so a further level of enquiry here has sought to identify the reasons for liking the teacher in order to identify the origins for the consequent liking of the subject (e.g. Hendley et al., 1996; Lightbody et al., 1996; Morgan and Morris, 1999; Norwich, 1999)
iii. Studies which have looked at pupils' attitudes or effort towards particular content areas within mathematics (e.g. algebra, number), or particular teaching methods and activities (group work, investigations, use of ICT), or particular approaches to assessment (e.g. coursework, formative feedback) (e.g. Boaler, 1997; Gage, 1999; Hyde, 2004; Nardi and Steward, 2003; Smith and Gorard, 2005)
iv. Studies which have looked at the influence of pupils' attitudes and context factors (see Figure 1.1) on motivational effort or achievement in mathematics (in the latter case, with or without explicit reference to raising motivational effort as an intervening link in the causal pathway) (Alerby, 2003; Benmansour, 1999; Boaler et al., 2000; Galloway et al., 1998; Kaplan et al., 2002; Ma, 1999; Ma and Xu, 2004; Noyes, 2004; Pietsch et al., 2003; Seegers and Boekaerts, 1993; Turner et al., 1998)

It is important to bear in mind here that the focus in this systematic review is on pupils' motivational effort, and the research evidence concerning what strategies can increase pupils' motivational effort. In considering studies for this review, it is crucial to extract the research evidence that bears a closely as possible on the link between strategies on the one hand and motivational effort on the other hand within the framework illustrated in Figure 1.1. For strategies to influence effort, they will need to work through the influence of attitudes and context factors on the pupil appraisal process.

This review is also undertaken with an awareness of a wider research context, most notably the research literature which draws on international comparisons of pupil attainment, attitudes, images and behaviour regarding school mathematics (e.g. Elliot et al., 1999; Picker and Berry, 2000), and which includes the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMMS) surveys (e.g. OECD, 2004; Ruddock et al., 2004; Shen, 2002; Shen and Pedulla, 2000).

1.5 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 and policy-makers. Most of the group are also parents.

All members of the group have 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 progresses, a core group will be 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 policy-makers, although parents of school-aged children and other members of general public will also have an interest in this review question. It is the intended to disseminate the findings of the review through internet access to the review report, publication in an academic journal, and conference papers.

This review is timely in the light of *The Smith Report* (2004), which has recognised both the importance of the NNS and the importance of systematic reviews in mathematics education to provide an evidence base to inform policy and practice.

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. Conference papers presenting the interim findings of this review were presented at two national conferences (the annual conference of British Psychological Society Education Section in November 2005, held in Durham; and a day conference of the British Society for Research into Learning Mathematics in November 2005, held in Lancaster) and at a international conference (The InterLearn Conference in December 2005, held in Helsinki).

1.6 Review questions

The review question is as follows:

> *What strategies can raise motivational effort in Key Stage 4 Mathematics among pupils in the mid-below-average to average range of mathematical attainment in England?*

The objectives of the review are as follows:

i. to identify relevant studies reported in England in the period from the introduction of the NNS in September 1999 until May 2005

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 on the extent to which particular strategies can raise motivational effort in Key Stage 4 mathematics among pupils in the mid-below-average to average range of mathematical attainment

In order to address this review question, the following more specific questions need to be considered:

i. What strategies do teachers currently employ that are successful in motivating pupils towards mathematics in Key Stage 4?

ii. What changes or intervention strategies in teachers' practices in the classroom have led to improvement in pupil motivation towards mathematics in Key Stage 4?

iii. What changes or intervention strategies used outside the classroom (e.g. homework clubs, catch-up workshops) have led to improvement in pupil motivation towards mathematics in Key Stage 4?

It important to note here that the use of the phrase 'motivational effort' in the review question serves to make a distinction between two aspects of motivation - the desire, willingness or intention to make an effort on the one hand, and actual behavioural effort on the other hand. The focus of this review is on the latter, but it is important to note that writing and research data on motivation sometimes fails to make this distinction explicit and sometimes uses the former as an indicator of the latter. The reader thus needs to be alert to this distinction when the research data presented is being considered.

CHAPTER TWO

Methods used in the review

2.1 User involvement

2.1.1 Approach and rationale

User group involvement is reflected in the composition of the Review Group itself, which includes parents, primary and secondary school teachers, school governors, teacher educators, academic researchers and policy-makers.

2.1.2 Methods used

User perspectives on the review process and the provisional report were sought and written user perspectives are included in the final report. Details of this review have been circulated to a number of professional organisations, teacher educators, researchers and policy-makers. Meetings were held with users to consider and reflect upon the interim findings, which has informed the final report.

2.2 Identifying and describing studies

2.2.1 Defining relevant studies: inclusion and exclusion criteria

For a paper to be included in the systematic map, it had 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 September 1999 to May 2005.

ii. It reports a study presenting original data collected by the author(s).

iii. The study deals with the classroom-based teaching and learning of KS 3 or KS 4 school mathematics in mainstream classes in England.

iv. The study is relevant to considering strategies for increasing KS 4 pupils' classroom-based motivational effort towards learning mathematics.

These inclusion criteria were reformulated as four exclusion criteria (see Appendix 2.1) and placed in the hierarchical order, as indicated below, for ease of exclusion and, importantly, to act as a system of gradual filtering, so that the papers that are 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.

2.2.2 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.

On the other hand, 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 be 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. While the arguments specifically concerning the publication bias which can occur if unpublished studies are not included in a systematic review have been particularly well rehearsed (e.g. Thomas and Harden, 2003; Torgerson, 2003), the problem of publication bias is felt to be much more applicable to studies involving randomised controlled trials than to the type of studies that are relevant to the review question here.

Nevertheless, in order not to exclude important studies reported in the form of a conference paper, the search for relevant publications included conference papers which are relevant to the review question and which, in particular, have appeared as full-length papers in edited conference proceedings; conference papers, where appropriate, were included in the in-depth analysis.

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 (2004).

The period September 1999 to May 2005 was chosen for this review to cover the period following the introduction of the NNS in September 1999 (Askew, 2002; Ofsted, 2002), as this period provides an appropriate educational and policy context for considering these strategies.

This enables the research evidence obtained during this period to be more readily applicable to this specific pedagogical context of teaching mathematics that pertains at the time that this review is taking place. Research studies of the teaching of mathematics prior to 1999 deal with a different pedagogical context. By focusing on studies which deal with journal and conference papers from September 1999 to May 2005, 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 September 1999 to May 2005. Five strategies will be involved here.

i. Electronic search of BEI: The key search terms to be used: motivation, effort, attitudes, self, and mathematics
   Subject: Mathematics
   Population: Key stages 3 and 4 pupils in mainstream classes
   Limits: English Language, September 1999 to May 2005
ii. Electronic search and/or handsearch of 11 key journals in Mathematics Education (September 1999 to May 2005) looking at every title and where appropriate and available the abstract and/or the full-paper (see Appendix 2.3)
iii. Electronic searches and/or handsearching issues of the following 17 selected key UK journals in Educational Research (September 1999 to May 2005) looking at every title and, where appropriate and available, the abstract and/or the full-paper (see Appendix 2.3)
iv. Handsearch and/or electronic search of key recent conference proceedings looking at every tile and where appropriate and available the abstract and/or the full-paper (see 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 secondary mathematics
vii. Contacting researchers working in this field for their recommendations

2.2.3 Screening studies: applying inclusion and exclusion criteria

We applied the inclusion/exclusion criteria at three points:

i. to the title and abstract of papers from searching electronic databases
ii. to a full-paper 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

2.2.4 Characterising included studies

The included studies were mapped (characterised) using the *EPPI-Centre's Data Extraction Guidelines (Version 0.9.7)* together with its data-extraction software, EPPI-reviewer (see section 2.3.2).

Because 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 (see Appendix 2.4), prior to data extraction, as all the questions in the keyword sheet are answered in the data-extraction.

2.2.5 Identifying and describing studies: quality-assurance process

Application of the exclusion criteria to titles (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 judgements 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 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 and 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 studies, and any differences were discussed and resolved.

2.3 In-depth review

2.3.1 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.

2.3.2 Detailed description of studies in the in-depth review

Studies identified as meeting the inclusion criteria were 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.

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

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

A Soundness of studies (internal methodological coherence) based upon the study only

B Appropriateness of the research design and analysis used for answering the review question

C Relevance of the study topic focus (from the sample, measures, scenario, or other indicator of the focus of the study) to the 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 (scored 1 to 3 respectively) and an overall weighting for the study (composite D) was arrived at by taking the arithmetic mean of the three component assessments (rounded to the nearest whole number), so that a mean of 1, 2 and 3 yielded an overall weighting of low, medium and high respectively. A discussion of this method of arriving at the overall weighting can be found in section 4.1.

2.3.4 Synthesis of evidence

The responses to the generic questions used for the data extraction, together with a consideration of the weight of evidence assessments were then used as a basis for producing a narrative synthesis 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.

2.3.5 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 and coming to a consensus. As part of the quality-assurance process, a member of the EPPI-Centre 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 were discussed and resolved.

CHAPTER THREE

Identifying and describing studies: results

3.1 Studies included from searching and screening

262 papers were identified by an electronic search, 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 218 exclusions. The exclusion codes applied to each of these excluded papers are shown in Figure 3.1.

Full copies of the remaining 44 papers were then screened, using the inclusion/exclusion criteria (see Appendix 3.2). In addition, a further 36 papers were identified as a result of handsearching (see Appendix 3.3) and were added to the main review database.

The four exclusion codes were then applied to a full-length copy of 75 of these 80 papers; a full-length copy of five papers were not available - these were conference papers that had been presented orally without a written version. This resulted in a further 41 papers being excluded (see Figure 3.1). As can be seen, the majority of these further exclusions were the result of applying exclusion code 4. While exclusion code 3 specified the study should involve data collected in England, three papers conducted in Wales were included on account of their particular relevance to the review question.

This resulted in 34 papers reporting 25 studies being identified for the systematic map. For each of the 25 studies, one main paper was identified (listed in Appendix 3.4) and 9 subsidiary papers were identified (listed in Appendix 3.5). 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 a published in a major journal; or it could be an enhanced version of the main paper which adds new data which is not relevant to the review question and omits some of the old data which is relevant.

3.2 Characteristics of the included studies (systematic map)

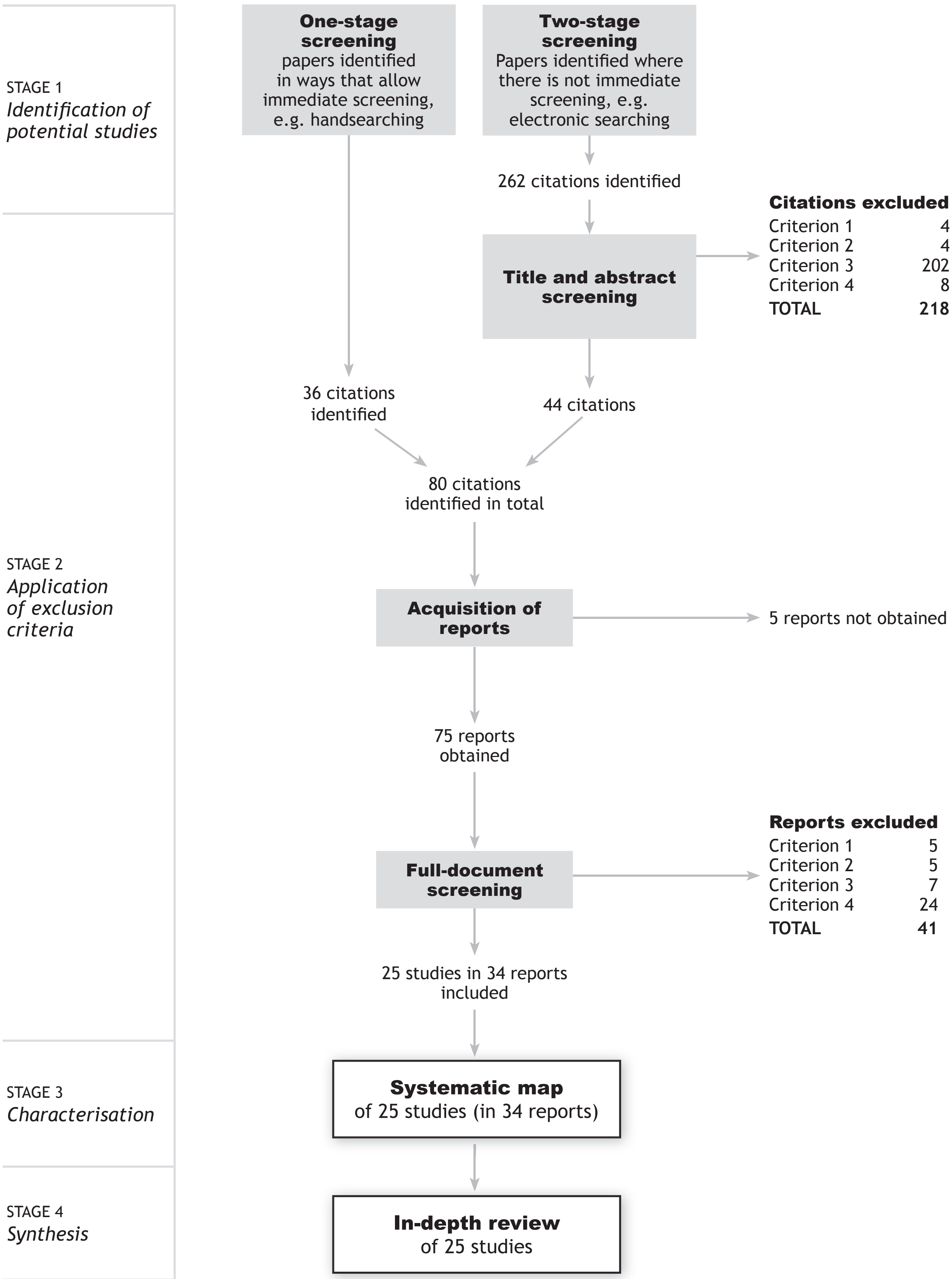
The data-extraction of the 25 main papers was used to develop the systematic map. The data-extraction also took account of the subsidiary papers. Tables giving the characteristics of the 25 included studies are shown in Appendix 3.1. 14 studies were identified as a result of the electronic search strategy of BEI. It is interesting to note, however, that over two-fifths of the included studies (11 studies) came from handsearching. This supports Black's (2004) observation that an over-reliance on an electronic search strategy based on keywords will almost certainly miss a number of important papers.

20 of the 25 papers were published. 17 of the papers were journal papers and 8 of the papers were conference papers. The journal papers ranged from those published in high quality research-oriented journals (where the emphasis is on presenting an academically rigorous account of the study) to those published in journals which are aimed at a practitioner audience (where the emphasis is on highlighting the implications of the study for practice).

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

Indeed, because large scale studies published in major journals often have a long timelag between the start of the research and its publication, the

Figure 3.1 Filtering of papers from searching to map to synthesis



inclusion of small scale studies published in practitioner journals or 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.

All the studies were written in English. 22 of the studies included data collected in England and three presented data from Wales (Jones and Tanner, 2002; Smith and Gorard, 2005; Tanner and Jones, 2003).

16 studies had a population focus on pupils (Bartholomew, 2000; Boaler et al., 2000; Cramp and Nardi, 2000; Dorman and Adams, 2004; Edmiston, 2003; Gage, 1999, 2003; Gage et al., 2002; Gkolia and Jervis, 2003; Hallam and Deathe, 2002; Ireson et al., 2001; Jackson, 2002; Nardi and Steward, 2003; Smith and Gorard, 2005; Tanner and Jones, 2003; Watson and De Geest, 2005); the remaining 9 papers had a population focus on teachers (Andrews and Hatch, 2000, 2002; Bills and Husbands, 2005; Crisan, 2004; Goulding, 2003; Hallam and Ireson, 2005; Hyde, 2004; Jones and Tanner, 2002; Miller et al., 2005).

Of the 16 studies which had a population focus on pupils, only 7 included data from KS 4 pupils (Bartholomew, 2000; Cramp and Nardi, 2000; Dorman and Adams, 2004; Gage, 1999; Gage et al., 2002; Gkolia and Jervis, 2003; Hallam and Deathe, 2002).

16 studies were categorised in terms of study type as an 'evaluation'; 13 of these were 'naturally occurring evaluations' (Boaler et al., 2000; Cramp and Nardi, 2000; Edmiston, 2003; Gage, 1999; Gage et al., 2002; Gkolia and Jervis, 2003; Goulding, 2003; Hallam and Deathe, 2002; Hyde, 2004; Ireson et al., 2001; Jones and Tanner, 2002; Miller *et al.*, 2005; Watson and De Geest, 2005) and three were 'researcher-manipulated evaluations' (Gage, 2003; Jackson, 2002; Smith and Gorard, 2005).

The remaining nine studies comprised one study categorised as 'description' (Nardi and Steward, 2003) and eight studies categorised as 'exploration of relationships' (Andrews and Hatch, 2000, 2002; Bartholomew, 2000; Bills and Husband, 2005; Crisan, 2004; Dorman and Adams, 2004; Hallam and Ireson, 2005; Tanner and Jones, 2003).

3.3 Identifying and describing studies: quality-assurance results

Quality assurance for the first stage of screening

A ten per cent sample of the 262 papers (26 papers) identified in the first stage of screening were screened by a second member of the Review Group. There were three 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 may 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 10 papers out of the 262 papers identified by electronic searching was then screened by a member of the EPPI-Centre in London. The member of the EPPI-Centre was more uncertain about deciding which code to use without further information regarding five 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, but 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 that warranted an appropriate exclusion code. The details available on the database for all these 10 papers did not include an abstract, which meant that the EPPI-Centre reviewer was having to reach a decision based solely on name of the author, title and publication details. On the other hand, the first reviewer was able to consult an abstract and/or a full copy 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 (i.e. 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 sometimes 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. In the case of these 10 papers, on further checking, it was established that none of these papers had been incorrectly excluded by the first reviewer.

Quality assurance for the second stage of screening

The four exclusion codes were applied to a full-length copy of these 75 papers by two members of the Review Group, working independently and then comparing their codes. There were only three cases of disagreement, which were resolved after further consideration of the papers involved. A random sample of 5 of these 75 papers identified for second-stage consideration was sent to the EPPI-Centre reviewer for quality-assurance purposes. In all five cases, the code applied by the EPPI-Centre reviewer agreed with the code applied by the two internal reviewers.

Quality assurance for keywording

As it was decided that all 34 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 (see section 4.3).

CHAPTER FOUR

In-depth review: results

4.1 The in-depth studies

34 reports of 25 studies met the inclusion criteria for the in-depth review. Details of these studies are shown in Appendix 4.2.

Key findings of the included studies

This section presents key details of the nature of the findings and conclusions presented in each of the 25 studies together with a summary of each of the studies. In the following section, the studies are considered in terms of six key areas which were identified. A continuous narrative style of reporting has been adopted.

A summary of included studies tables is shown in Appendix 4.2. The summary tables deal with four key aspects of each of the 25 studies:

i. the focus of the study
ii. the data collected
iii. key claims/evidence regarding the classroom teaching of early mathematics
iv. key claims/evidence regarding raising target group pupil motivation in KS 4

Andrews and Hatch (2000) explored Hungarian and English teachers' conceptions of mathematics and its teaching. The English data was based on a questionnaire completed by teachers in 200 schools in three regions of England teaching 11-14 year-olds. 577 responses were obtained, although only 108 of these were used in the factor analysis to match a sample of 108 responses from Hungarian teachers. The factor analysis identified five conceptions of teaching mathematics: (i) the formal teaching of skills and fluency through regular practice of routine procedures; (ii) pedagogic variety; (iii) task differentiation, (iv) the creation of a mathematically enriched and challenging classroom; and (v) the development of pupil autonomy through facilitation in an open and cooperative environment. Although a consideration of KS 4 pupils in the target ability group not explicitly mentioned, it seems highly probable that they are included. The English teachers seem to have a belief that pupils lack intrinsic motivation for mathematics and that teachers thus need to stimulate pupils by providing an enriched and challenging classroom, and by using informal forms of classroom management, including small group activities, where learning is subordinate to the maintenance of pupils' self-esteem. No explicit evidence is provided that such practice is effective in raising pupil motivation. This study was assessed as having medium weight of evidence.

Andrews and Hatch (2002) explored teachers' conceptions of mathematics and its teaching, and the elements of the mathematics curriculum they think are most important. The data was based on interviews with 45 teachers teaching in 11-16 or 11-18 schools in two regions of England (Greater Manchester and southern Hampshire). The majority of the schools were urban or semi-urban. These teachers had volunteered to be interviewed following completion of the questionnaire used in Andrews and Hatch (2000). The interviews were semi-structured. The data on teachers' conceptions of mathematics and its teaching fell into three broad stands: (i) the self; (ii) the learner; and (iii) mathematics. Within each of these strands, two or three themes were identified. The data from the subsidiary paper (Andrews, 2002) on the curriculum fell into five categories: (i) the importance of numerical skills; (ii) the importance of utility; (iii) the curriculum as a given (iv) mathematics as problem-solving; and (v) taking account of pupil ability and need. A consideration of KS 4 pupils in the target ability group are explicitly mentioned. The teachers emphasised the importance of pupils enjoying mathematics and promoting confidence with numbers. While the practical utility of mathematics was recognised for the 'middle to less able', the mathematics curriculum still needed to be broad and include investigations. The teachers reported that the problem-solving aspect of mathematics has the power to enthuse pupils, and that GCSE coursework, particularly involving statistics, had enthused lower attaining pupils. This study was assessed as having medium weight of evidence.

Bartholomew (2000) explored the impact of ability grouping practices on pupils' achievement in, and attitude to, mathematics. The study tracked pupils in six schools from year 8 until they took their GCSEs in year 11. The schools were all non-selective and were located in and around London.

Five schools were mixed; the other was a girls' school. The percentage of pupils in each school gaining 5 A*-C grades ranged from 13% to 74%. All six schools grouped by ability in years 10 and 11. The data collected comprised: a questionnaire completed at the end of years 8, 9 and 10; interviews during years 9 and 11; lesson observations; and pupil attainment. This paper focused mainly in the interview data with pupils in year 11. The mathematics lessons, generally emphasise the learning of procedures rather than encourages pupils to think things through for themselves. Although the paper focuses on year 11 pupils, the quotations presented only include pupils in sets 1 or 2; that is, pupils in the target ability group are not explicitly mentioned. Many pupils felt the mathematics they were doing for GCSE had very little relevance to their lives outside school, and its importance is largely based on it being an important qualification. Some pupils, however, got a boost to their motivation by being considered as being good at mathematics. Some pupils are reluctant to try hard to understand because they feel understanding is too hard; instead, they rely on learning procedures. This study was assessed as having medium weight of evidence.

Bills and Husbands (2005) explored values issues in the teaching of mathematics through one teacher's articulation of her practice. The teacher is a secondary school teacher with four years' experience. The data comprises an interview and four hours of lesson observation. Specific reference is made to lessons in years 9, 10 and 11. The teacher's account of her teaching is highly values-dependent. KS 4 lessons are included, but pupils in the target ability group are not explicitly mentioned. The teacher's approach to teaching is characterised by the use of strategies to protect pupils from the rigours of mathematics and to build up their confidence. She makes use of pupils' mistakes in order to protect pupils from a sense of failure. No explicit evidence is provided that such practice is effective in raising pupil motivation. This study was assessed as having low weight of evidence.

Boaler et al. (2000) explored the influence of ability-grouping practices on pupils' attitudes and achievement in mathematics, based on a two-year longitudinal study of pupils moving from year 8 to year 9. The study involved the full cohort of about 1,000 pupils in six schools in greater London who completed a questionnaire at the end of year 8 (943 pupils) and 9 (977 pupils), of whom 843 pupils in the sample completed both questionnaires. In addition, 72 pupils were interviewed (6 pupils per school each year) and there were120 hours of lesson observation. Pupils in four of the six schools moved from mixed ability groups to sets. Many pupils in the higher sets were disadvantaged by being taught at too fast a pace for understanding. Many pupils in lower sets were disadvantaged by a restricted opportunity to learn. Setting in comparison to mixed ability groups was linked to a more restricted range of teaching approaches. KS 3 pupils in the target ability group are included. Pupils in the lower sets became disaffected by working at too slow a pace and by knowing they would only have access to lower grades at GCSE. This study was assessed as having medium weight of evidence.

Cramp and Nardi (2000) explored the use of a short lesson starter (about 5 to 10 minutes in length). The short lesson starter ('snappy') was based on using mental arithmetic to revise a topic

The study is described as being a qualitative research project. The data presented is based on interviews with four teachers at a 13-18 Suffolk high school, who developed this innovation, together with some comments from interviews with pupils, including two pupils in year 9, two pupils in year 10 and two pupils in year 12. The teachers felt that snappies offered a useful opportunity to check pupils' understanding and previous knowledge. KS 4 pupils in the target ability group are included. The teachers felt snappies were powerful lesson starters that got pupils to settle down with a work ethic and attitude in the first few minutes of the lesson. The pupil data contained some examples of how snappies had increased their confidence and motivation. The authors claim they have strong evidence to suggest that the use of snappies improved pupils' attitudes towards mathematics lessons. This study was assessed as having low weight of evidence.

Crisan (2004) explored secondary school mathematics teachers' use of ICT. The data was based on seven teachers (four females, three males) teaching in three secondary schools in the same city. The teachers were at different stages in the career and in their use of ICT. Each teacher was interviewed twice and observed teaching at least one lesson in which ICT was used. Post-lesson comments and informal conversations were noted. Written documents, such as lesson plans and handouts, were also collected. Factors influencing teachers' implementation of ICT into their classroom practice were divided into two broad categories: contextual factors and personal factors. Neither KS 4 nor the target ability group are explicitly mentioned, but it seems highly probable that they are both included. Some of the teachers perceived the benefits of ICT use in terms of enhancing pupils' enjoyment of mathematics lessons, rewarding hard work, and addressing learning difficulties. No explicit evidence is provided that such practice is effective in raising pupil motivation. This study was assessed as having low weight of evidence.

Dorman and Adams (2004) explored the association between classroom psychosocial environment and academic efficacy in Australian and British secondary schools. The British data was based on questionnaires completed by pupils in year 8 (656 pupils), year 10 (715 pupils) and year 12 (225 pupils) mathematics classes in 16 British schools. The British and Australia data was aggregated in the analysis. Mean scores are presented for 11 scales: student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, equity, personal relevance, shared control, student negotiation and academic efficacy. The study includes KS 4 pupils, but no separate breakdown is given for the target ability group. Classrooms characterised by high levels of cooperation, harmony, genuine teacher support, student cohesiveness, task orientation and equity are more likely to enhance pupil confidence. The authors express the concern that the standardised, regimented approach associated with the National Curriculum in England is unlikely to provide the level of freedom and independence in classroom necessary for the academic efficacy of pupils to be enhanced. This study was assessed as having medium weight of evidence.

Edmiston (2003) explored the use of cognitive acceleration in mathematics education (CAME) lessons. The researcher was a support teacher who makes regular use of 30 CAME lessons. The data presented is based on his own teaching of one year 7 lesson in a challenging school, where pupils tend to have negative attitudes towards mathematics. The lesson presented was on functions to explore ratio and proportion (CAME lesson 12, 29 pupils in the class - 12 boys, 17 girls). The researcher states that the CAME materials seek to sow the seeds of mathematical reasoning skills needed in KS 4. KS 3 pupils in the target ability group are included. The teacher's experience of CAME lessons is that this approach can be used to develop a culture of co-operation and to see learning as a collaborative process. He claims the CAME approach led to these year 7 pupils gaining in confidence and motivation throughout the year. The study does not deal with KS 4 or provide evidence of its claimed benefits for KS 4. This study was assessed as having low weight of evidence.

Gage (1999) explored the use of a graphic calculator with a year 10 mathematics class in relation to doing an open-ended piece of GCSE coursework. The researcher was a teacher and the data is based on her own teaching. The class was the top set of four in one half of year 10 at a girls' grammar school. The pupils were told they were going to use a graphic calculator to investigate connections between some of the graphs, sequences and equations that had been covered in the previous term. The data is based on the teacher's observations of pupils during lessons; eight pupils were also interviewed at the end of the term. Use of graphic calculator led to enhanced understanding and insight. KS 4 pupils are included, but not in the target ability group. Learning how to use a graphic calculator effectively can cause frustration which would discourage some pupils. Open-ended tasks are harder and require confidence as independent learners. Using the graphic calculator to undertake an open-ended task generated a high degree of anxiety, although some pupils enjoyed having to be self-motivated and having more ownership over their own learning. This study was assessed as having low weight of evidence.

Gage (2003) explored the use of videoconferencing in school mathematics teaching (the Motivate Project) in a normal classroom setting. The data was based on four year 8 classes from two different schools; one class at each school was the experimental group and the other class was a control group. The data was described as being qualitative: semi-structured interviews, questionnaires with open-ended questions (post-treatment), videotapes of classroom discussion and accompanying written work (pre-treatment and post-treatment). The two schools held four videoconferences of about 30 minutes each at fortnightly intervals. Using videoconferencing in normal lessons required new thinking about content and management but had proved possible without increasing teacher workload unacceptably. Videoconferencing had improved pupils' communication skills in both their oral and written and work. This study involved KS 3 pupils; pupils in the target ability group are explicitly mentioned (one of the experimental classes is described as of 'below average ability'). Videoconferencing had enhanced pupils' motivation. Pupils found the interaction involved in videoconferencing was motivating. Some pupils were critical of some of the logistical and technical problems involved. This study was assessed as having low weight of evidence.

Gage et al. (2002) explored the use of videoconferencing in school mathematics teaching (the Motivate Project). The data is based on evaluation forms completed by over 50 teachers and 250 pupils in primary and secondary schools; 13 teachers were interviewed and some teachers emailled comments. The conferences have involved 10 primary and over 50 secondary schools from 16 different parts of the UK. The project has tried to involve schools where there is some degree of disadvantage. Pupils undertake project work in the classroom that they then present at the videoconference. Videoconferencing enabled many pupils to develop ICT skills in the use of spreadsheets, powerpoint and the electronic whiteboard. Although no KS 4 pupils in the target ability group are explicitly mentioned, it seems highly probable that they have been included. The teachers and pupils reported that the pupils had found the experience enjoyable and that it had motivated them and boosted their confidence. 60% of the secondary school pupils reported that their confidence in their ability in mathematics had increased. 60% of the secondary school pupils reported that the experience had encouraged them to consider studying mathematics at a higher level. Some pupils were critical of some aspects of the experience, such as sitting passively for long periods. This study was assessed as having low weight of evidence.

Gkolia and Jervis (2001) explored the use of integrated learning systems (ILS) in English and Mathematics education in secondary schools. The data was based on semi-structured interviews of six teachers from four different 11-16 secondary schools and seven pupils from three different schools; four teachers were IT teachers, one a mathematics teacher and one an English teacher. Three of the schools used *Successmaker* and the fourth used *Global*. The teachers felt ILS can benefit pupils from the whole range of ability. Pupils were enthusiastic about making unusually fast learning gains using ILS. Neither KS 4 pupils nor target ability group are explicitly mentioned. Teachers felt ILS can be particularly useful in helping low achieving pupils to catch up, increasing motivation for learning and enhancing confidence. Both teachers and pupils reported that ILS raised motivation, with some evidence that this transferred back to the 'normal' classroom. The teachers felt the instant feedback ILS provided on every attempt kept pupils more motivated and active. Teachers reported that pupil motivation decreased as the novelty value of using ILS wore off, but pupils did not report this, although pupils reported that motivation could wane when a task was too long or repetitive. This study was assessed as having low weight of evidence.

Goulding (2002) explore how the cognitive acceleration in mathematics education (CAME) project was being implemented in schools. 21 teachers involved in the CAME project in seven schools were interviewed concerning the implementation of CAME in their school; their attitudes to the project; their understanding of the project's theoretical base; and their explanations of learning gains. The 21 teachers included three student teachers. Data was also collected in the form of fieldnotes of a CAME in-service session, and of a student and teacher discussing a videoed lesson. Five of the seven schools responded to a follow-up questionnaire a year later. 11 teachers were classified as having positive attitudes towards CAME, 8 as cautious, and 2 as negative/resistant. A distinctive contribution of CAME was the role of discussion as a means of involving pupils in co-operative activity. The focus is implicitly on KS 3; the target ability group are not explicitly mentioned. Teachers felt CAME had a positive effect on pupils' disposition towards doing mathematics: it encouraged them to be confident and to 'have a go'. CAME was felt to be of particular use for those boys who did not like writing things down. This study was assessed as having low weight of evidence.

Hallam and Deathe (2002) explored year group differences in pupils' self-concept and attitudes towards school as influenced by ability grouping. Questionnaires were used to collect data on pupils' attitudes towards mathematics and school, on pupils' mathematics self-concept, school self-concept, and on pupils' preferences for different kinds of grouping. The sample comprised 234 pupils from years 7 to 10 at a mixed comprehensive school. In year 7, mixed ability groups were used; in years 8 and 9, pupils were setted within parallel bands; in year 10 setting was across the whole year group. Pupils' perceptions of teacher skills and support was not influenced by pupils' set placement or year group. The study included data on KS 4 pupils in the target ability group. The mean mathematics self-concept for each year group gradually increased from year 7 to 9, and then decreased to its lowest level for year 10 (largely due to a marked drop for the bottom set in year 10). Pupils' attitudes towards mathematics did not differ between year groups, but high sets were the most positive, and low sets least positive. The data indicates that being in a lower set in year 10 has a negative impact on mathematics self-concept and attitudes to mathematics. 66% of pupils in year 10 were happy with their set placement, but some pupils in middle and lower sets found the work too easy and wanted to be in a higher set, which might lead to underachievement. This study was assessed as having low weight of evidence.

Hallam and Ireson (2005) explored the effects of structured ability grouping on secondary school teachers' pedagogical practices. A questionnaire was used to collect data teachers' pedagogical practices. The sample comprised over 1,500 teachers from 45 mixed gender secondary comprehensive schools in London, southern counties, East Anglia and south Yorkshire. The sample of teachers included all heads of department, all lower school teachers of English, mathematics and science and a sample of lower school teachers of other subjects. The schools comprised 15 schools in each of three categories of ability group practice in years 7 to 9: mixed ability, partially set, and set. Only aggregated data is presented (i.e. the data completed by teachers of mathematics is not shown separately). The curriculum was more differentiated in ability grouped classes by content, depth, activities undertaken and resources used. Less able pupils were given more opportunities for rehearsal and repetition, more structured work, more practical work, less opportunities for discussion, less access to the curriculum, less homework with less detailed feedback, while work proceeded at a slower pace and was easier. KS 3 pupils in the target ability group are included. The authors claim that the practices that are more evident when low ability pupils are taught in ability group classes may be likely to be perceived by pupils as 'boring'. As the data for mathematics teachers is not presented separately, it is not possible to tell how well (if at all) the general findings hold true for mathematics lessons. This study was assessed as having low weight of evidence.

Hyde (2004) explored teachers' views about the impact of ICT on pupils learning mathematics. The data, collected by the researcher, is based on a questionnaire completed by 38 secondary school teachers of mathematics, each from a different school. The questionnaire covered the use of different 11 ICT resources and the impact of ICT on pupils' learning in KS 3 and KS 4. Using a four-point scale (labelled: very little, some, significant, and substantial), 18% of the teachers reported ICT had a substantial impact in KS 3 and 21% of the teachers reported ICT had a substantial impact in KS 4. The percentage of teachers reporting using the 11 different ICT resources ranged from 100% for using websites to 64% for using the interactive whiteboard. This study relates to KS 4 and includes the target ability group. The teachers reported that interactive whiteboards had a high level of positive impact on pupils' motivation. No other ICT resource was explicitly linked to motivation, but the notion of impact on pupils' learning may, for some teachers, have implicitly included an impact on pupil motivation. The impact of ICT on pupils appears to be related to teachers' confidence in using ICT. This study was assessed as having low weight of evidence.

Ireson et al. (2001) explored the effects of structured ability grouping on year 9 pupils' self-concepts. Questionnaires were used to collect data on five scales of self-concept: mathematics, English, science, general and self-esteem; data on the pupils' KS 3 test marks in English, mathematics and science were also collected from school records. The sample comprised over 3,000 year 9 pupils from 45 comprehensive schools in England. The schools were divided into three categories of ability group practice in years 7 to 9: mixed ability, partially set, and set. Twenty-nine of the 45 schools rigorously divided their students into sets for mathematics in year 9. (The sample base of the schools for this study is linked to that for the study by Hallam and Ireson reported above, which focused on teachers.) Academic self-concept was related to KS 3 attainment in each curriculum area (0.30 for mathematics). Academic self-concept in mathematics was higher for boys even when their attainment was similar to that of girls. KS 3 pupils in the target ability group are included. Setting in mathematics did not appear to have an impact on pupils' self-concept in mathematics. The authors argue that the lower academic self-concept in mathematics for girls is a cause for concern, as it could impact negatively on their motivation and later mathematics course choices. This study was assessed as having medium weight of evidence.

Jackson (2002) explored the perspectives of boys and girls in a co-educational school on the use of single-sex mathematics classes. The school was a mixed-sex inner-city comprehensive school in the south-west of England, where pupils spent year 7 and the first two terms of year 8 in single-sexed mathematics classes before moving to mixed-sexed mathematics classes. Data was collected from pupils by questionnaire administered to all pupils at the end of year 7 (79 responses: 40 girls and 39 boys) together with interviews of 11 pupils (5 girls and 6 boys) in the summer term of year 8 (about three months after entering mixed-sex mathematics classes). The classroom climate reported by girls in single-sex classes was more relaxed and supportive, while for boys it was more competitive and aggressive. KS 3 pupils in the target ability group are included. 80% of year 7 girls expressed being more confident in single-sex classes, while 33% of year 7 boys expressed being less confident in single-sex classes. 55% of year 7 girls reported that they enjoyed mathematics in single-sexed classes, while 72% of year 7 boys said they enjoyed mathematics more in mixed-sex classes. The author notes that girls only classes seemed to have many positive effects for girls, but single-sexed classes do not appear to be helpful for boys: they may do nothing to challenge the laddish culture inherent in schools and may actually exacerbate it. This study was assessed as having low weight of evidence.

Jones and Tanner (2002) explored the impact of introducing whole-class interactive teaching strategies into mathematics lessons. The data was based on a teacher inquiry group comprising eight mathematics teachers from four secondary schools in South Wales. The data comprised lesson observations, interviews and discussion at group meetings. The pupils taught were in years 7 and 8.

This paper focuses on the quality of the discourse developed within classrooms and the strategies teachers used to encourage pupils' reflection. Pupils were encouraged to contribute ideas and to explain their methods to the class. The legitimation of pupils' own mathematical thinking was explicitly emphasised. Despite every teacher trying to finish with a plenary, they were often omitted. The quality of interaction varied between teachers, depending on the types of scaffolding used, the opportunities created for reflection, and the degree of pupil ownership. The focus here was on KS 3 pupils; although pupils in the target ability range are not explicitly mentioned, it seems highly probable that they are included. Every teacher considered their pupils to have become far more confident about their mathematics. This study was assessed as having low weight of evidence.

Miller et al. (2005) explored the use of interactive whiteboards (IAWs) in mathematics lessons. Teachers in 18 secondary schools who make extensive use of IAW technology were identified and 37 mathematics lessons were videorecorded. The teachers were interviewed using a semi-structured interview schedule. The teachers also took part in five discussion sessions based upon summaries of the evidence collected. IAW teaching can enhance presentations and manipulations that can enliven understanding and learning. Teachers who had consistently used IAWs for at least the previous year were inclined to use manipulations to foster interactivity rather than use IAWs simply to enhance presentation. The six most common manipulations were labelled: drag and drop; hide and reveal; colour, shading and highlighting; matching items; movement or animation; and immediate feedback. KS 3 pupils are included: explicit mention is made of data regarding years 7, 8 and 9; no mention is made of pupil ability but pupils in the target ability group are probably included. Pupil motivation was enhanced by three major features of IAW teaching, which were labelled: intrinsic stimulation; sustained focus; and stepped learning. IAW teaching enhanced pupils' attention through interactivity, pace and differentiation. In the initial stages of using IAW teaching, pupils need to develop a range of skills to use this medium, and their self-esteem may be undermined if they are unable to do this. This study was assessed as having low weight of evidence.

Nardi and Steward (2003) explored disaffection among year 9 pupils in mathematics lessons. The data was based on a one-year study of three year 9 mathematics classrooms (each in a different school) in Norwich. The data comprise lesson observations and interviews with all 70 pupils in these three classes. The focus was on middle ability sets (i.e. sets whose pupils who are projected in two years' time to a achieve a grade C or D at GCSE). A profile of quiet disaffection in mathematics lessons is identified which comprises five characteristics (*TIRED*): *tedium* (irrelevant and boring), *isolation* (little opportunity to work with peers), *rote-learning* (rule-and-cue following), *elitism* (only exceptionally intelligent pupils can succeed) and *depersonalisation* (alienation resulting from an absence of work tailored to their needs). The study focuses on KS 3 pupils in the target ability group. Pupils' engagement in mathematics lessons is based on a sense of obligation, with little expectation of joy. The pupils called for activities which are useful, enjoyable, better tailored to individual needs, and based on collaboration and group work. The authors hope these findings can form the basis for developing re-engagement strategies. This study was assessed as having medium weight of evidence.

Smith and Gorard (2005) explored the effects of a 'formative feedback only' intervention on pupil progress. The data was collected at one comprehensive school in Wales. Year 7 pupils were divided into four mixed ability groups (26 pupils each), of which one was given enhanced formative (written comments only) feedback on their work for one year, but no marks or grades. The data collected covered assessment, prior attainment, pupil attitudes and background information. The data included observation of the process, a questionnaire completed by all 104 pupils, and group interviews with treatment pupils. The attainment data covered the four core subjects of English, mathematics, science and Welsh. Pupils in the treatment (formative feedback only) group made less progress overall compared with the control group (the difference being clear in English, mathematics and Welsh but unclear in science). Many of the pupils in the treatment group expressed negative views about not getting marks or grades, and about the usefulness of the formative comments. In particular, pupils complained that the formative comments tended to focus on enhancing self-esteem or self-image, and did not provide them with information on how they could how to improve. The consensus among pupils in the treatment group was that they would prefer to receive both marks and comments together. The study considers KS 3 pupils. Pupils in the target ability group are included. The use of formative feedback only seems to have caused confusion and a lack of motivation. No extracts from the pupil interview data presented, however, explicitly refer to mathematics. The evidence here is that providing feedback comments only was not effective in raising pupil motivation or attainment. This study was assessed as having medium weight of evidence.

Tanner and Jones (2003) explored pupils' beliefs about themselves as learners of mathematics and the strategies they use before and after assessment. The data was based on a questionnaire comprising 47 statements and a Likert-type response scale completed by 303 year 9 pupils (two classes in each of six comprehensive schools in Wales). The questionnaire covered (i) pupils' self-efficacy in mathematics, (ii) pupils' metacognitive knowledge, and (iii) strategies which pupils might use for learning mathematics. The vast majority of pupils thought it was worthwhile to try hard in mathematics (93%) and to revise for examinations (90%). Pupils generally attribute success in mathematics to hard work (84%) and doing lots of revision (71%). The more effective learning strategies were used by pupils with good metacognitive knowledge. Most pupils lack effective strategies for revision. The focus here was on KS 3 pupils; although pupils in the target ability group are not explicitly mentioned, it is highly probable that they are included. Some pupils are in a virtuous circle where metacognitive knowledge leads to the use of effective learning strategies and an increase in self-efficacy beliefs. Some pupils are in a vicious circle where their failure to apply effective learning strategies leads to failure in assessments and a lowering of self-efficacy beliefs. The authors argue that teachers need to teach pupils self-regulated learning strategies that will break this vicious circle. This study was assessed as having low weight of evidence.

Watson and De Geest (2005) explored the use of innovative practices in the teaching of low-attaining secondary pupils in mathematics. The data was based on action research with 10 teachers over two years and involved over 250 year 7 pupils. The effects of the innovative practices on pupils' learning was evaluated using national test scores, teachers' reports, non-routine tasks and other performance indicators. All the teachers were teaching lower secondary mathematics sets in which at least half the class were achieving below the government standards for entry to secondary school, and the others were only barely achieving. The teachers employed a variety of changes in their practices and activities which involved a greater emphasis on pupil learning, rather than simply completing tasks. Pupils were encouraged to engage in discussion, and were given more choice, freedom, challenge (with support), responsibility and time. A set of principles characterising the shared beliefs of the project teachers were identified, which generated the changes in practices the teachers initiated and evaluated. These were labelled: establishing working habits which may have been lost through disaffection and low expectations; providing tasks which generate concentration and participation, taking the view that 'doesn't concentrate' is not the same as 'cannot concentrate'; developing routines of meaningful interaction; choosing how to react to correct and incorrect answers; giving pupils time to think and learn; working explicitly or implicitly on memory; using visualisation; relating pupils' writing and learning; helping pupils be awareness of progress; giving a range of choice; being explicit about connections and differences in mathematics; offering, retaining and dealing with mathematical complexity; and developing extended work on mathematics. This study focused on KS 3 pupils in the target ability group. The teachers and pupils in the project moved from 'short-termism' to 'long-termism'. 'Long-termism' was characterised by the following:

i. Longer was spent on each topic than was recommended nationally, but content coverage was still important; coverage without understanding and memory was seen as pointless - understanding and memory needed time to develop.
ii. Longer was spent on establishing good work habits, which might mean undoing previously developed habits; if this took substantial amounts of lesson time, it was worth it.
iii. Longer was spent on thinking and on particular tasks, to establish participation, reasoning, understanding and a sense of connectedness.
iv. The focus was on learning as much as possible, rather than on finishing tasks.

The teachers reported that pupils became more enthusiastic, more willing to work and more engaged mathematically. This study was assessed as having high weight of evidence.

Characteristics of the included studies

As noted in Chapter 3, 15 studies focused on pupils and 10 on teachers. 16 studies were categorised in terms of study type as an 'evaluation', eight as an 'exploration of relationships' and one as 'description'.

The data extraction and the details included in the summary of included studies tables show that the 25 studies used a range of different methods for data collection.

10 of the studies were dominated by or exclusively used one particular type of data collection method; 7 of these were based on questionnaire data (Andrews and Hatch, 2000; Dorman and Adams, 2004; Hallam and Deathe, 2002; Hallam and Ireson, 2005; Hyde, 2004; Ireson et al., 2001; Tanner and Jones, 2003) and three of these were based on interview data (Andrews and Hatch, 2002; Cramp and Nardi, 2000; Gkolia and Jervis, 2001).

Most of the studies (15 studies), however, used a mixture of data (Bartholomew, 2000; Bills and Husbands, 2005; Boaler et al., 2000; Crisan, 2004; Edmiston, 2003; Gage, 1999, 2003; Gage et al., 2002; Goulding, 2002; Jackson, 2002; Jones and Tanner, 2002; Miller et al., 2005; Nardi and Steward, 2003; Smith and Gorard, 2005; Watson and de Geest, 2005). These included three studies that were case studies of one teacher's practice (Bills and Husbands, 2005; Edmiston, 2003; Gage, 1999).

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

Weight of evidence results

Only one study (Watson and De Geest, 2005) received an overall weight of evidence rating of 'high'; 8 studies were rated 'medium', and 16 studies were rated 'low' (see 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. Moreover, a simple algorithm of taking an average of the three component grades (scored 3, 2 and 1 respectively) was used to arrive at the composite overall weight of evidence grade.

The lack of studies receiving an overall weight rating of 'high' was due to the paucity of studies which explicitly included all three of the following elements in its report:

i. the evaluation of an intervention strategy which aimed to raise pupil motivation
ii. collected data on motivation before and after the intervention strategy
iii. presented data specifically dealing with KS 4 pupils in the target group (i.e. pupils mid-below-average to average range of mathematical attainment)

4.2 Synthesis of evidence

The purpose of the synthesis of evidence section is to present an overall synthesis of the data

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 questions	**Component B** Appropriateness of design and analysis for the review question	**Component C** Relevance of the focus of the study for the review question	**Composite D** Overall weight taking account of A, B and C
Andrews and Hatch (2000)	High	Low	Low	Medium
Andrews and Hatch (2002)	High	Low	Low	Medium
Bartholomew (2000)	Medium	Low	Medium	Medium
Bills and Husbands (2005)	Medium	Low	Low	Low
Boaler et al. (2000)	High	Medium	Medium	Medium
Cramp and Nardi (2000)	Low	Low	Low	Low
Crisan (2004)	Medium	Low	Low	Low
Dorman et al. (2004)	High	Medium	Medium	Medium
Edmiston (2003)	Low	Low	Low	Low
Gage (1999)	Low	Medium	Low	Low
Gage (2003)	Medium	Low	Low	Low
Gage et al. (2002)	Low	Low	Low	Low
Gkolia and Jervis (2001)	Low	Low	Low	Low
Goulding (2002)	Medium	Low	Low	Low
Hallam and Deathe (2002)	Medium	Low	Low	Low
Hallam and Ireson (2005)	Medium	Low	Low	Low
Hyde (2004)	Low	Low	Low	Low
Ireson et al. (2001)	High	Low	Low	Medium
Jackson (2002)	Medium	Low	Low	Low
Jones and Tanner (2002)	Medium	Low	Low	Low
Miller et al. (2005)	Low	Low	Low	Low
Nardi and Steward (2003)	High	Medium	Medium	Medium
Smith and Gorard (2005)	High	Medium	Medium	Medium
Tanner and Jones (2003)	Medium	Low	Low	Low
Watson and De Geest (2005)	High	High	Medium	High

contained in the included studies which address our review question. The essence of a systematic review of the literature lies in a rigorous consideration of the evidence that bears upon the review question as indicated exclusively by the included studies. However, at a progress meeting held at the DfES (September, 2005), it was agreed that the report would be more helpful if links with the wider research literature (including the international research literature) and with recent policy developments were made in this section, so that the synthesis could be read in a broader context.

What follows is a synthesis of the evidence in which links are made to the wider research literature and to policy developments, where it was felt that such links were important in terms of the consideration of the evidence presented in the included studies.

There is a danger that a synthesis of evidence section that includes such wider references may confuse the reader if it is not clear whether a point being made is evidenced by the data presented in the included studies, or whether that point is based on, or takes accounts of, the wider literature. Great care has been taken to make it explicitly clear when a point is evidenced by the included studies, and when a point draws on other sources.

The analysis of the included studies led to the identification of four key areas which were identified as a result of cross-referencing between the summary tables (shown in Appendix 4.1) in order to group together themes and issues arising for the included studies in a way that would add some structural coherence to the synthesis of evidence. The stages of this process involved discussion between members of the Review Group, and incorporated feedback and discussion at two progress meetings held at the DfES (September and November 2005), a meeting between members of the Review Group and schoolteachers (November 2005), and presentations and discussion about the emerging findings held at two conferences (November 2005: a day conference of the British Society for Research into Learning Mathematics, and the annual conference of the British Psychological Society Education Section), as well as advice and guidance from staff at the EPPI-Centre.

The four key areas are as follows:

i. Grouping

ii. Pupil identity

iii. Teaching for engagement

iv. Innovative methods

The synthesis of evidence will focus on the role played by each of these four areas in strategies to raise motivational effort in KS 4 Mathematics for the target group of pupils. The main studies which address each of these four areas are shown in Appendix 4.1. However, it is important to note that the data in some studies addressed more than one key area. This is reflected in the synthesis which follows.

The identification of these four areas provides a useful framework within which to consider the evidence emerging from the included studies. However, no strong claims are made here for these four labels, or for the order in which they are presented here. The issues arising from the included studies are highly inter-related. The first briefing meeting (September) held at the DfES highlighted the emerging category of 'pupil identity' as appearing to be an over-arching category within which other categories could be subsumed. However, further work on the analysis of evidence indicated that strategies could impact on raising pupil motivational effort either directly (bypassing pupil identity) or indirectly through its effect on pupil identity. As such, it was decided not to make pupil identity an overarching category. For those interested in the causal mechanisms that may be involved here, it may be possible, once more evidence of the effectiveness of different intervention strategies is available, to make use of structural modelling equations in order to assess the relative importance of these four categories and the direction of causation involved.

The category of 'teaching for engagement' was also influenced by the discussion at the DfES (September) meeting, and led to the merging of a separate category which had been initially labelled 'classroom climate', a separate category which had been initially labelled 'effective teaching', and a dividing up of papers in a separate category which had been initially labelled 'assessment' between the categories of 'teaching for engagement' and 'innovative methods'.

However, it will be evident from the synthesis presented below that elements of the notion of classroom climate in particular feature within the category of 'teaching for engagement', and there was some debate about whether the notion of 'classroom climate' might work as a better organising category than 'teaching for engagement'. A further analysis of the issues covered in the included studies indicated that the label 'teaching for engagement' better conveyed the thrust of key issues being addressed by this set of papers.

The process of refining the identification of the key areas, also led to a subdivision of the category 'innovative methods' between 'ICT-based' and 'other' innovative methods.

What is particularly noteworthy is that the included studies cover a range of features, from macro-features of organising school learning, such as the use of ability grouping to form the class units for teaching, to micro-features of teaching mathematics, such how to make effective use of graphic calculators during lessons. In considering how the research evidence presented in these studies bears upon strategies for raising the target group of pupils' motivational effort in KS 4 Mathematics, the pedagogical issues highlighted below appear to come together in one form or another across the whole range of studies.

Moreover, these issues very closely reflect the DfES' own analysis of the issues that need to be addressed if pupil engagement in mathematics is to be raised, and which have been outlined in its policy documents (see Chapter 1 of this review), particularly in relation to its advocacy of the importance of personalised learning (DfES, 2004c).

This synthesis also takes account of the weight of evidence (WoE) score for each of the included studies (Table 4.1) in order to arrive at a balanced view of the evidence concerning each of the trends identified in which greater weight was given to those studies which had a higher overall WoE score. However, the range of study types, as noted earlier, means that arriving at a balanced view was sometimes difficult. This problem was exacerbated by the fact that most studies did not include data from KS 4 pupils and, where they did, the data for pupils in the target ability group (i.e. pupils in the mid-below-average to average range of mathematical attainment) was not presented separately, and most studies did not evaluate an intervention specifically designed to increase pupils' motivational effort. Only one of the 25 included studies received an overall weight of evidence score of 'high' and the majority of studies were scored as 'low'. This means that the evidence presented here must be viewed as tentative. While the included studies taken as a whole are very effective in identifying a raise of ongoing developments in schools, and the issues and possible directions in developing strategies for raising pupils' motivational effort, the actual evidence for the effectiveness of particular strategies is not strong.

(i) Grouping

Background

There has been a long tradition of research in mathematics education which has explored the impact on pupils of being taught in a class grouped by ability (i.e. set by ability for mathematics or in a class streamed in terms of general ability) compared with the effects of being taught in a mixed ability group (see, for example, Boaler, 1997). The practice in secondary schools varies a great deal, depending on the extent to which they use streaming and/or setting for a range of subjects (including mathematics) and at what age such streaming and/or setting occurs. Four of the included studies in this review focused on the use of grouping by ability to explore the impact this has on pupils, with a particular focus on pupils' attitudes regarding their experience (Boaler et al., 2000; Hallam and Deathe, 2002; Hallam and Ireson, 2005; Ireson et al., 2001). As a number of schools at the time of this research used mixed ability groupings in year 7 and then started setting for mathematics in year 8, pupils could comment on their experience of the change from mixed ability to setting. In addition, the views of pupils in schools which rigorously set from the outset of year 7 could be compared with those of pupils in schools which did not. From such comparisons, researchers can infer to some extent how being taught in sets and mixed ability groups might impact on pupils' attitudes differently. These four studies essentially employed this paradigm. However, in recent years, schools have increasingly set by ability, so that the vast majority of schools now rigorously set for mathematics from year 7 onwards. This paradigm also has a number of limitations, so the conclusions drawn must be treated with caution.

Findings of studies in this review

The picture that emerges from the included studies is a complex one. There are two facets to this.

First, there is the differential impact on pupils of simply being in a higher or lower set. Typically, the concern is that pupils being taught in a lower set feel stigmatised by this to some extent, and that this will of itself undermine their self-concept regarding mathematics, and thereby reduce their motivational effort towards mathematics.

Second, there is the differential impact on pupils based on the extent to which the way mathematics is taught may differ in a higher or lower set. For example, the pace of teaching in a higher set may be faster, and pupils in lower sets may experience more repetitive tasks. It is also interesting to note that the included studies indicate that the way teachers teach a class appears to be influenced by whether the class is an ability set or a mixed ability class, over and above differences attributable to whether the set is a higher or lower set. The same teachers could be seen to adopt very different approaches with sets and mixed ability groups, rather than adapt and carry over similar methods as appropriate.

Discussion

The evidence from these four studies regarding the impact of being in a higher or lower set on pupils' motivational effort is not clear-cut. While, generally speaking, pupils in a higher set tend to be more positive and more motivated towards mathematics, one could speculate that the direction of causality may well be more in the direction of pupils who exert greater motivational effort tending to get into a higher set, rather than in the direction of being in a higher set contributing to increased motivational effort.

The evidence from these four studies regarding the impact of setting on how mathematics is taught, and thereby on their motivational effort, indicates that work in higher sets is more likely to be perceived by pupils as challenging and is taught at a faster pace, sometimes inducing anxiety, while the work in lower sets is more likely to be perceived by pupils as being too easy and too repetitive.

However, the issue here seems to be in part about the correct set placement. Average ability pupils who find themselves in too high a set may complain about the fast pace and greater difficulty of the work, while those average ability pupils who find themselves in too low a set may complain about the work being too easy. In other words, some of the critical comments made by pupils may be telling us more about the effects on pupils of being misplaced rather than the effects of setting *per se*, as some degree of misplacing is inevitable.

Generally speaking, most pupils (particularly pupils of average ability) seem to be happy with the set they are in, and it is not clear that being in a lower set (if it is the 'correct set' for the pupils) will, of itself, reduce their motivational effort. Indeed, one could speculate that, in principle, work set at the correct level for pupils (whatever set they are in) should heighten their motivational effort. However, the included studies also indicate that even those pupils who accept the set they are in is the correct one for them, are not all happy with the way setting seems to produce a particular style of teaching; this is particularly true for pupils in the middle ability sets. The included studies also beg the question, to some extent, how well pupils can be allocated to teaching groups on the basis of their level of attainment.

There is also an issue here regarding teachers' expectations. Teachers are caught in a dilemma between wanting to make the work interesting and challenging for pupils, and being aware that pupils in middle and in lower sets may be more vulnerable than pupils in higher sets to having their confidence undermined by finding the work too difficult. It is clear that some teachers' attempts to avoid undermining pupils' confidence may, in part, account for them providing work at a level which some pupils in the class will find too easy; this issue is also evident in the area on 'pupil identity' which follows.

Data exploring the views of pupils' who move from mixed ability classes in year 7 to sets in year 8 or 9 indicates that some pupils enjoyed mathematics more when they were in mixed ability classes. However, it is difficult to tell whether this reflects the changes in mathematics teaching that occur as these pupils move through KS 3 rather than the effect of the different type of grouping *per se*. What we do not have is data on pupils who moved from sets in KS 3 to mixed ability classes in KS 4. Evidence of an increase in motivational effort for such pupils would indeed indicate that the use of mixed ability teaching in KS 4 may be a worthwhile strategy to explore further.

The four included studies here did not collectively indicate any clear and consistent impact of setting on motivational effort *per se*. However, the studies by Boaler et al. (2000) and Hallam and Deathe (2002) both noted a marked increase in disaffection towards mathematics among pupils in the bottom set as they moved from year 9 to year 10, which was largely attributed to the effect on pupils whose set in KS 4 means that they will not be able to be entered for a GCSE examination tier that will provide them with access to the top grades. We need to bear in mind, however, that this 'tiering' effect may appear to be larger than it really is, unless we can account for the extent to which the attitudes of lower attaining pupils may decline from KS 3 to KS 4 for other reasons. Pupils may well cite 'tiering' as a reason for their declining motivational effort in mathematics, in part because it is a salient aspect of their situation and enables them to attribute the cause to an external factor rather than to themselves.

Nevertheless, this effect has been well recognised in other studies (e.g. Burghes et al., 2001; Elwood, 2005; Küchemann and Hoyles, *submitted for publication*). Recent moves to modify tiering at GCSE in order to allow pupils in lower sets to gain access to a grade C may offset this effect to some extent. Nevertheless, more research is needed on the impact on pupils of being in a low set for mathematics where the whole class knows that they will be denied access to the highest grades at GCSE. For the motivational effort of such pupils to be raised in such circumstances, new strategies will need to be developed.

Indeed, the House of Commons Education and Skills Committee Report (2005) has argued that this may require a recognition that not all pupils are suited to the GCSE examination in mathematics as currently operating, and some may flourish much better if the mathematics they undertake in KS 4 is linked to another type of award of some sort, or perhaps a modified form of the GCSE, which comprises a core plus vocational options and the new functional mathematics components; this could be particularly attractive if it is related to the world of work and can be seen to have much clearer relevance for such pupils' needs and aspirations. However, such strategies may have both potential benefits and potential drawbacks for raising motivational effort.

The included studies also highlight the extent to which teachers may allow the teaching of a set group to restrict their use of teaching methods: the point is often made that a set group is a mixed ability group too, and it is important that, when teaching a particular set, the teacher uses differentiation strategies in the same way that they would do if the group was a mixed ability group. What really matters here is not so much what set a pupil is in, so much as the teaching is well matched to their needs, whatever set they are in.

As well as looking at grouping by ability, some studies not included in this review have begun to look at the use of single-sex classes in co-educational schools as a means of raising motivational effort in mathematics for boys. The included study by Jackson (2002) found that boys only mathematics classes were not a panacea to raise their motivational effort. Indeed, some evidence from her study indicated that being in a boys only class may to some extent exacerbate the 'laddish culture' that such classes are largely intended to undermine. In contrast to the majority of boys, a majority of girls preferred being taught in the single sex groups and would have liked to continue with this arrangement.

It is important to note, however, that Jackson's study looked at one co-educational school. All evaluations of a particular initiative conducted at one school need to be very sensitive to how the initiative was actually put into practice at that particular school, and the context and circumstances pertaining to that particular school. Other evaluations of this initiative (of boys only mathematics classes in co-educational schools) could provide evidence of a successful impact on motivational effort. Before reaching any conclusions about this particular initiative, we need to know more about what features of such an initiative have a major bearing on its likely success or otherwise.

It is also interesting to note the current preoccupation with strategies to raise motivational effort across the school curriculum for boys. In the current context, it is important not to overlook the continuing concern regarding girls and mathematics. Evidence from the wider research literature on girls and mathematics still points to a number of areas of concern (Gallagher and Kaufman, 2005), most particularly how a greater proportion of those girls who achieve higher grades at GCSE can be encouraged to continue with the further study of mathematics at A-level and beyond (Mendick, 2005). Strategies aimed at increasing the motivational effort of girls through finding the subject more interesting and enjoyable can make an important contribution to addressing this concern.

What is also relevant here, from the wider research literature looking at grouping, is the research on the 'big fish little pond' effect: the tendency for pupils' academic self-concept (and consequent motivational effort) to be enhanced if they are one of the more able pupils in their class, than if they are in a class where they are one of the less able pupils (Harker and Tymms, 2004; Marsh, 1987, 2005; Tymms, 2001). This effect suggests that a pupil of average ability might be more motivated if they are in a set of slightly below average pupils than if they were in a set of slightly above average pupils.

In addition, research on the 'student composition effect' is also relevant: the tendency for the composition of pupils in the school to have an effect on pupils' motivational effort and attainment in the school over and above that which can be accounted for by taking account of each individual pupil's ability and motivation. Van Damme (2005) argues that this effect exists, in part, because pupils are not randomly assigned to schools or classes within schools; for example, some schools may have a predominance of pupils from under-resourced families, which may be associated with reduced levels of motivation towards achievement in school. He thus argues that, when comparing classes within or between schools that appear to be equivalent, we have to be aware of the composition effect in accounting for any differences, as illustrated in a recent study looking at mathematics classes in Belgium (Opdenakker and Van Damme, 2005).

The possible influence of the big-fish-little-pond effect and the student composition effect are two examples of the sensitivity needed in interpreting the data presented in these included studies and the difficulty involved in trying to make any estimates about effect sizes. Indeed, the complexities involved in assessing the effects of pupil grouping are well illustrated in the recent report for the DfES on this topic (Kutnick et al., 2005) and in a range of studies which have considered how best to approach the teaching of pupils who are taught in lower ability groupings (Lewis and Norwich, 2005; Smith, 2005).

Summary

Overall, the five included studies considered in this section did not offer clear support for the notion that strategies based on making use of mixed ability teaching rather than rigorous setting for mathematics or the use of single-sex classes for boys in co-educational schools would be successful in raising the target group pupils' motivational effort in KS 4 mathematics.

(ii) Pupil identity

Background

Perhaps the most important area that has emerged from a consideration of the 25 included studies is that of pupil identity. Pupil identify concerns the extent to which pupils see themselves as 'mathematicians': as people who can understand and can do mathematics, and feel a sense of belonging in their mathematics class. The term 'mathematicians' is being used here not in the sense of professional mathematicians. The key point being made here is that pupils, regardless of their level of ability and set placement, who enjoy mathematics, are interested in mathematics, and can do the mathematics set for them, can properly see themselves as 'mathematicians'. A number of studies in the wider research literature have explored how pupils see mathematicians and how they see themselves as mathematicians. One of the barriers facing pupils in terms of motivational effort in mathematics is that they do not see themselves as 'mathematicians' in the sense being used here. They may take the view that mathematics is a subject that only clever people can do well in (what Nardi and Steward refer to as 'elitism') and that any effort they expend will have only a very limited return (as is clearly evidenced in Nardi and Steward's analysis of pupil disaffection). A number of very interesting case studies in other countries have highlighted the way in which helping pupils to understand and succeed in mathematics can lead to a seismic shift in pupils' perception of themselves as mathematicians and a marked upsurge in the amount of motivational effort they are then prepared to expend in mathematics lessons (Hannula, 2002; Williams and Ivey, 2001).

It is worth pointing out here that the wider research literature has highlighted the importance of pupils understanding the mathematics they are doing if their view of themselves as 'mathematicians' is to develop and thrive (Hoyles, in press; Kilpatrick et al., 2005).

The dilemma referred to in the previous section - between wanting to make the work interesting and challenging for pupils, but also being aware that pupils in middle and in lower sets may be more vulnerable than pupils in higher sets to having their confidence undermined by finding the work too difficult - is also evident in the way teachers try to promote a more positive pupil identity towards mathematics. Many teachers take the view that promoting a more positive identity requires pupils to be challenged by the mathematics they are doing so that the success in understanding can breed both confidence and motivational effort. The study by Bills and Husbands (2005) illustrates how some teachers, mindful of wanting to shield their pupils from experiencing failure, are careful to adopt strategies in which they are quick to build on pupils' mistakes to protect them, sometimes to the point of being 'over-protective'.

It is interesting to note that evidence from the wider research literature not included in this review (e.g. Elwood, 2005) indicates that 'mathematics anxiety' among pupils can lead teachers to underestimate the ability of pupils because they tend to associate confidence with ability, and that this can lead to boys being over-represented in the top set, because high ability girls are more likely to also display mathematics anxiety than high ability boys. As such, strategies that can enable pupils to become more confident in mathematics can offset this effect.

There is some evidence in the wider international research literature, however, that, among those pupils who see their performance in mathematics as being primarily related to motivational effort (rather than ability), many are not energised by this to maximise their motivational effort because, in large measure, they are content with the notion of being 'average' rather than better than their peers for the class they are in. For such pupils, their pupil identity is based on exerting sufficient motivational effort to maintain their academic position in their class as average rather than above average (Elliot et al., 2005). Such research suggests that raising pupils' motivational effort will thus be partly dependent on needing to raise the motivational effort of the class as a whole if it is to have an impact on such individuals. This has implications for the notion of personalised learning, as it suggests the teachers need both to view their class as a whole as well as to consider each individual in it.

The wider international research literature also indicates that ethnic and gender differences may be involved in different aspects of pupil identity, and that such considerations will need to be taken into account if strategies based on personalised learning are to have a positive impact on raising pupils' motivational effort. In particular, ethnicity and gender may influence the extent to which pupils of similar ability differ in their level of confidence (Elwood, 2005; Elliot et al., 2005; Gallagher and Kaufman, 2005).

Findings of studies in this review

Although three included studies will be highlighted here (Bartholomew, 2000; Nardi and Steward, 2003; Watson and De Geest, 2005), the issues raised in these studies are also connected with findings of several other included studies (particularly that of Bills and Husbands, 2005). The included studies by Bartholomew (2000) and Nardi and Steward (2003) highlighted that many pupils felt the mathematics they were doing for GCSE held very little interest or relevance for them; they were strategically compliant rather than engaged with the mathematics.

The three included studies in this section all indicate how the effectiveness of strategies to raise motivational effort largely work through their effects on improving pupils' identity of themselves as mathematicians. Taken as a whole, the included studies in this section present an approach to enhancing pupil identity and motivational effort based on teachers adopting a caring attitude towards how the pupils feel about themselves, coupled with a supportive framework for learning which emphasises helping pupils to understand the mathematics they are doing.

Although the potential influence of ethnicity was not addressed by the included studies, the influence of gender was considered. For example, Ireson et al. (2001) noted that boys held a higher academic-self concept in mathematics compared with girls of matched ability; Bartholomew (2000, p 7) noted that boys are frequently over-represented in top sets and that top sets were places where the set of values promoted 'speaks to a particular middle class masculinity'; and that, while boys appear 'to derive some meaning and motivation from competing with their classmate, many girls - unable or unwilling or compete on these terms - withdraw in lessons'.

The study by Watson and De Geest (2005) is particularly interesting in providing strong evidence that highlights how a collaborative action research project can be used as an effective way of supporting teachers to develop and evaluate strategies intended to enhanced pupils' identity towards mathematics and their sustained engagement in mathematics. What is also particularly noteworthy in their study is that the different teachers used different approaches. What they had in common was a commitment to helping pupils to develop a deeper understanding of the mathematics they were doing. One of the principles adopted, that of 'long termism', involved spending longer on topics, longer on thinking, and longer on participation, and concentrating on learning as much as possible rather than focusing on finishing tasks. Another, that of 'self-questioning', involved pupils making up their own hard questions, using repetition but with variation, and reflecting on easy and hard tasks. While this study was the only included study which specifically looked at the use of collaborative work among teachers as a vehicle for them to explore and evaluate changes in their classroom practices, it was a study which was assessed as having a high weight of evidence.

Discussion

This use of creating small groups (or communities) of teachers collaborating together to better engage their pupils in mathematics is reflected in the wider research literature, both specifically regarding mathematics (Jaworksi, 2004) and more generally (Cordingley et al., 2005), and can be advocated with some confidence as a form of continuing professional development (CPD) for teachers that could provide a basis for helping teachers to develop strategies that enhance pupils' motivational effort. The emphasis by these teachers on helping pupils to develop a deeper understanding of the mathematics they were doing indicates that we need to be alert to the dangers of teachers making use of an objectives-led lesson if this treats the mathematics in a superficial way as isolated fragments of knowledge and rule-following procedures.

Again, looking at the wider research literature, there is little doubt that pupil identity based on their self-belief and self-confidence regarding how they view a particular subject plays a crucial role in pupils' decision-making about whether or not to continue with the study of that subject post-16 and beyond into higher education (Archer et al., 2003).

(iii) Teaching for engagement

Background

A number of studies have been published over the years about how teachers view mathematics education in schools, and in particular how they see their role as teachers of mathematics in terms of helping pupils to engage in, and successfully learn, mathematics. Four of the included studies deal with the notion of teaching for engagement: that is, how teachers' decision-making regarding their choice of teaching and learning activities, the way they interact with pupils, and the type of classroom climate they establish are intended to enhance pupils' engagement (Andrews and Hatch, 2000, 2002; Bills and Husbands, 2005; Dorman and Adams, 2004). These studies are particularly relevant for this review in terms of the light certain aspects of their findings cast on how teachers view their role in eliciting and sustaining pupils' motivational efforts.

Findings from studies in this review

The two studies by Andrews and Hatch compared the views of teachers of mathematics in England with those in Hungary. For the purpose of this review, we are primarily interested in the views of the teachers in England, but the comparative element offers additional value, and it is interesting that the Hungarian teachers evidently take pupils' motivational effort for granted and see their main role as being to get on with the teaching of the mathematics *per se* (largely through whole class teaching), whereas the teachers in England feel they very much have to sell the subject to their pupils by referring to its practical utility, often in terms of lower order skills, and by making the lessons interesting in order to win them over to engaging in the subject. The teachers in England very much see an important, if not the major part, of the their role as having to provide a stimulating, enriching and challenging classroom environment, coupled with the sort of support and encouragement that will foster pupils' self-esteem and motivational effort. One simple example of this is the attention the teachers in England pay to features such as wall displays in the mathematics classroom.

The teachers in England (in this sample) clearly think that eliciting and sustaining pupils' motivational effort through establishing a supportive classroom climate means that the learning of mathematics may sometimes need to be subordinate to the maintenance of pupils' self-esteem. For example, activities such as small group discussion may help pupils to feel more comfortable about themselves as learners of mathematics and to enjoy the mathematics more, and this may take precedence over whether such activities are the most efficient in terms of covering the mathematics in hand. The need to incorporate more opportunity to work with peers during lessons as a means to increase motivational effort was clearly highlighted by the disaffected pupils in the included study by Nardi and Steward (2003), considered in the previous section. While using small group discussion to help pupils feel more comfortable in mathematics lessons has its place in raising motivational effort, what is equally important is that the small group discussion should enhance their engagement in mathematics in a way that will promote a more positive pupil identity.

The importance of providing a supportive classroom climate in which the activities are challenging and enjoyable is also highlighted in the study by Dorman and Adams (2004) and has strong similarities with the types of strategies employed by the teachers in the study by Watson and De Geest (2005). The degree to which teachers are trying to achieve a balance between on the one hand providing pupils with activities which are challenging and on the other hand providing pupils with the support is well illustrated in the case study reported by Bills and Husbands (2005).

Discussion

These ideas clearly overlap with the picture emerging in the previous section concerning the promotion of a more positive pupil identity. However, whereas in this section (teaching for engagement) the emphasis was more on the notion of caring, support and enjoyment, the section on pupil identity had more of an emphasis on the importance of pupils gaining a deeper understanding of the mathematics they were doing as being crucial to the development of a more positive pupil identity. It could be that the first emphasis without the second may make pupils feel comfortable but not challenged mathematically, and hence not given the chance for deeper learning.

The picture which emerges here is in line with the wider international research literature not in this review (Chouinard and Karsenti, 2005), and shares a number of features in common with Hatch's (1999) notion of the 'high energy classroom' as a means of fostering motivational effort. This picture is also in line with the ideas underpinning the development of the DfES's policy for the adoption of personalised learning in schools, although the research evidence base for personalised learning still needs to be developed much further (DfES, 2004c).

The characterisation of the ways in which pupils view their experience of mathematics presented in the included study by Nardi and Steward (2003) has implications for teaching for engagement which are very much in line with the recent characterisation of six facets of personalised learning developed by Rudduck et al. (2005). They describe these facets of personalised learning as the personalising of: feedback; target-setting; rewards; teaching and course design; mentoring; and participation in school organisation. Their exploratory research of a group of secondary schools' use of personalised learning indicates that the main effect of personalised learning appears to arise from the way it enables teachers to listen to, understand and take account of pupils' needs and perspectives better, and the way it enables pupils to better reflect on their learning. The findings emerging from Rudduck et al.'s study offer some positive signs regarding the ways in which personalised learning can offer a basis for strategies to raise pupils' motivational effort in KS 4 Mathematics for the target group which address the issues identified in the included study by Nardi and Steward.

The wider international research literature not included in this review also indicates that ethnic and gender differences may be involved in different aspects of pupil identity, and that such considerations will need to be taken into account if strategies based on teaching for engagement are to have a positive impact on raising pupils' motivational effort. In particular, ethnicity and gender may influence pupils' preferences for and/or ability to learn from certain types of teaching and learning activities and methods of assessment (Elwood, 2005; Elliot et al., 2005; Gallagher and Kaufman, 2005); this point also relates to the next section on 'innovative methods'.

Summary

Taken together, these studies point to the importance of basing strategies aimed at increasing the motivational effort of the target group of KS 4 pupils on providing a classroom climate in which (i) the teacher is highly supportive; (ii) the work is both challenging and enjoyable; (iii) there is a high level of cooperation among pupils; and (iv) all the pupils in the class feel equally valued by the teacher.

(iv) Innovative methods (of what?)

Background

This fourth section comprises a range of included studies which have evaluated particular initiatives occurring in schools in recent years that are relevant to the review question. These range from the evaluation of the practice of a particular teacher (Edmiston, 2003) or a particular school (Smith and Gorard, 2005) to the evaluation of practice involving a large number of teachers and schools (Gage et al., 2002). The included studies also range from those looking at the use of particular teaching tools, such as the graphic calculator (Gage, 1999), to those involving much broader initiatives, such as the use of whole class interactive teaching (Jones and Tanner, 2002).

This section will be subdivided into two parts. The first part will look at those initiatives which are ICT-based. These cover the use of videoconferencing (Gage, 2003; Gage et al., 2002), supportive software packages for pupils (Gkolia and Jervis, 2001), interactive whiteboards (Hyde, 2004; Miller et al., 2005) and graphic calculators (Gage, 1999). It is interesting to note here the absence of studies looking at the use of the internet, despite the fact that all the schools in Hyde's (2004) study reported making use of websites. A study looking at teachers' reasons for using ICT is also included here (Crisan, 2004).

The second part of this section will look at other initiatives involving broader approaches. These cover the use of starter sessions (Cramp and Nardi, 2000) and whole class interactive teaching (Jones and Tanner, 2002), the development of thinking and learning skills (Edmiston, 2003; Goulding, 2002; Tanner and Jones, 2003), and the use of formative assessment (Smith and Gorard, 2005).

(a) ICT-based innovative methods findings of studies in this review

One of the main reasons given by teachers for making use of ICT in studies outside this review is the powerful effect this can have on increasing pupils' interest and enjoyment in mathematics, and the way in which it can elicit and sustain their concentration and motivation for long periods (Crisan, 2004; Gkolia and Jervis, 2001). The included studies, however, have also highlighted a number of key issues concerning the use of ICT which have implications for raising pupils' motivational effort.

First, ICT can have a short-lived novelty effect based on its stimulating aspects, such as its visual appearance (e.g. the use of colourful displays and eye-catching representations at the press of a button); the opportunity it affords for a degree of control over the activities; and the opportunity to work in collaboration with other pupils. The included studies indicate that this novelty effect can gradually start to wane, although, for some pupils, these features may be welcome enough to act as a motivator for a substantial period of time (Gkolia and Jervis, 2001; Miller et al., 2005); the attractiveness of working in collaborating with peers, noted earlier (Nardi and Steward, 2003) may be a particularly important factor here. This raises the issue of the extent to which some of the impact of ICT-based methods may be more to do with the ways in which it provides an opportunity for different collaborative working methods (including peer-tutoring, cross-age collaboration, cooperative learning) than the impact of ICT-based methods structuring the way the mathematics itself is being investigated.

Second, ICT can be particularly demanding as pupils need to develop the skills needed to use the ICT and this can easily discourage those pupils who do not master these skills easily. Evidence regarding the use of interactive whiteboards, graphic calculators and videoconferencing all involve pupils needing to develop new ICT skills. Pupils who lack confidence at the outset in their ability to develop the necessary ICT skills may find this phase of development frustrating and threatening (see Gage, 1999, regarding graphic calculators; Miller et al., 2005, regarding interactive whiteboards).

Third, a very important distinction has been drawn between two stages for pupils regarding the use of ICT. The first stage refers to pupils' mastery of the ICT skills needed to make use of the stimulating aspects of using ICT (such as its visual appearance) as indicated in the first point above. The second stage refers to the effective use of ICT to elicit and sustain a deeper understanding of the mathematics being learnt. The included studies (particularly, Miller et al., 2005, in relation to interactive whiteboards) have pointed out that it is only when pupils reach this second stage that their learning and motivation really take off. However, the included studies indicate that teachers need inservice training and support in order to be able to help their pupils to make use of this second stage effectively; otherwise, their pupils will simply remain at the first stage of ICT use. (This is in line with the findings of the recent DfES research report on the motivational effect of ICT in pupils; see Passey et al., 2004.)

While remaining at this first stage has many benefits in its own terms regarding providing pupils with stimulating activities and enabling pupils to develop a range of ICT skills, it will place a threshold on the way using ICT can link motivational effort to the actual learning of mathematics, and it is establishing this link for pupils which may have an important influence in shaping pupils' identity of themselves as mathematicians, as considered in section (ii) above.

Fourth, the use of ICT can often involve time appearing to be wasted as pupils have to wait patiently for equipment to work properly or to deal with logistical or housekeeping arrangements involved in the setting up and use of ICT. This was particularly evident regarding the use of videoconferencing (Gage, 2003; Gage et al., 2002).

Discussion

The issues concerning the effective use of ICT-based methods are reflected in the wider research literature (Leask and Pachler, 2005; Passey et al., 2004), and there is a growing recognition now that ICT does provide a powerful learning environment, but we need to know more about how to use ICT-based teaching effectively and to support teachers' continuing professional development in this area (Johnston-Wilder and Pimm, 2005; Hennessy et al., 2005), as well as how to employ the types of research designs that can enable researchers to quantify the effect sizes involved for ICT-based teaching.

(b) Other innovative methods findings from studies in this review

The introduction of the National Numeracy Strategy in England in 1999 included the adoption of a three-part daily mathematics lesson in primary schools (often referred to as 'the numeracy hour') which was characterised by (i) a mental or oral start to the lesson lasting about 5 to 10 minutes; (ii) the main teaching phase lasting about 30 to 40 minutes; and (iii) finishing with a plenary lasting about 5 to 10 minutes. This approach also placed an emphasis on the use of whole class interactive teaching (Kyriacou and Goulding, 2004).

A number of secondary school teachers anticipated (correctly) that such features of the NNS would be extended to secondary schools (DfEE, 2001), and thus introduced such features into their own teaching as an innovation to be evaluated. Two of the included studies report an evaluation of this: one looking at the use of mental/oral starters (Cramp and Nardi, 2000) and the other at the use of whole class interactive teaching (Jones and Tanner, 2002). Both studies indicated that these two features had a positive effect on pupils' motivational effort. These studies suggest that the introduction of such features into secondary schools as part of the National Secondary Strategy for Mathematics may have had a beneficial effect on pupils' motivational effort.

Three of the studies dealing with the development of thinking and learning skills indicate that such activities can contribute to improving pupils' motivational effort by enabling them (i) to gain a deeper understanding of the mathematics they are doing, (ii) to develop self-regulation strategies that will be more effective in improving the quality of their own learning, and (iii) to prepare for an assessment and make use of feedback following the assessment.

Tanner and Jones's (2003) study on pupil self-regulation strategies that help pupils to improve the quality of their self-regulation strategies when faced with a challenging task in mathematics (and the emotions which are generated) can have a very beneficial impact on pupils' ability to sustain motivational effort.

The study by Smith and Gorard (2005) looked at one school's attempt to evaluate the impact on pupils of using written comments only as formative assessment. While the study itself did not provide evidence of the beneficial effects of only using written comments in assessment feedback, what it does highlight is that the adoption by schools of innovations advocated as part of national policies need to be based on providing teachers with an understanding of the innovation, both in terms of its underlying theoretical basis and in terms of its practical application in schools. Indeed, the pupils in the study provide evidence that the written comments provided by teachers were often not formative. The study by Smith and Gorard does not show that formative (written comments only) assessments are ineffective, so much as the way this particular school's implemented regime of formative only assessment was ineffective (Black et al., 2005).

Discussion

Evidence collected by teachers or others regarding an innovation that the teachers themselves have freely chosen to introduce are notoriously biased in terms of apparent success, since teachers who choose to introduce an innovation often teach it with a degree of commitment and enthusiasm that is unlikely to be typical of other teachers who adopt the innovation once it becomes mandatory. Moreover, evidence from other research studies indicates that the type of teaching methods which can successfully engage pupils in say year 7 may not be so successful at year 9, or indeed for pupils in Key Stage 4, and *vice versa* (e.g. Venkatakrishnan, 2005). As such, the impact of innovative methods contained within the National Secondary Strategy for Mathematics on the motivational effort of target pupils in KS 4, as part of innovations in pedagogy and practice outlined by the DfES (2003) for the KS 3 National Strategy as a whole, will require comprehensive research.

Despite the promise shown by the two included studies looking at CAME (Edmiston, 2003; Goulding, 2002), there is surprising little evaluative research reported on CAME, although the massive research data available regarding its larger and older sister, cognitive acceleration through science education (CASE), with whom it shares a number of features, together with other recent research on CAME itself (Shayer and Adhami, 2005), indicates that CAME or CAME-type lessons and activities can make mathematics lessons more interesting and enjoyable, and contribute to the challenge and success need to improve pupil identity.

The study by Tanner and Jones is particularly noteworthy given the vast international research literature that has developed over the last ten years pointing to the importance of pupils' self-regulation in contributing either to a positive cycle (in which effective self-regulation contributes to increased self-confidence and better performance) or to a negative cycle (in which ineffective self-regulation contributes to decreased self-confidence and worse performance) which thereby sustains or hinders the maintenance of motivational effort during lessons (Vollmeyer and Rheinberg, 2005; Zirngibl et al., 2005). Effective self-regulation during revision included learners making notes, highlighting important points, doing lots of questions, setting their own questions, and predicting questions that could be asked. The most popular ineffective strategy was reading through the mathematics book. Evidence of the positive and negative cycles, well evidenced in the international research literature, is evidenced in the included study by Tanner and Jones. Certainly, the wider international research literature supports the findings advocated by Tanner and Jones,

The study by Smith and Gorard (2005) is particularly noteworthy, given the prominence of formative assessment as part of the assessment for learning strand in current DfES (2003, 2004b, 2004c) policy and the recommendation to use only written comments rather than grades only, or grades plus comments, on pupils' work. The same point has been made in relation to the use of CAME (Shayer and Adhami, 2005) and whole class interactive teaching (Kyriacou and Goulding, 2004): namely that, unless teachers understand how and why the innovation may have beneficial effects, they are unlikely to implement it successfully.

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 and coming to a consensus. Five 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 centred on questions dealing with the reliability and validity of the studies, the generalisability of findings, and the weight of evidence assessments.

4.4 Nature of actual involvement of users in the review and its impact

The membership of the Review Group includes a variety of user groups, 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 policy-makers, 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.

CHAPTER FIVE

Implications

5.1 Summary of principal findings

This review set out to answer the question:

> *What strategies can raise motivational effort in Key Stage 4 Mathematics among pupils in the mid-below-average to average range of mathematical attainment in England?*

5.1.1 Identification of studies

The review identified 34 reports of 25 studies which met the inclusion criteria for producing the systematic map.

5.1.2 Mapping of all included studies

The mapping of these studies indicate the following:

- Just over half of the studies were identified in the BEI electronic database and a number of important papers were identified through hand-searching.
- The vast majority of the studies were published.
- About two-thirds of the studies had a population focus on pupils, and the remaining one-third on teachers.
- About two-thirds of the studies were classified as involving an evaluation.

5.1.3 Nature of studies selected for in-depth review

No studies in the map were excluded from the in-depth review.

5.1.4 Synthesis of findings from studies in in-depth review

The in-depth analysis of the 25 included studies led to the identification of four key areas: (i) grouping; (ii) pupil identity; (iii) teaching for engagement; and (iv) innovative methods.

Grouping

This area looked at the use of grouping by ability (i.e. setting) and the use of single sex classes in co-educational schools. The studies here did not collectively indicate any clear and consistent impact of setting on motivational effort *per se*, although it does appear that, if the whole class knows that being in a lower set will deny them access to higher GCSE grades, this can make it very difficult to sustain their motivational effort. In addition, the use of boys only classes in co-educational schools can sometimes enhance, rather than undermine, the 'laddish' culture that it is in large measure designed to combat.

Pupil identity

This area looked at the extent to which pupils have a positive pupil identity of themselves as 'mathematicians': that is, as people who can understand and do mathematics, and feel a sense of belonging in their mathematics class. The studies here indicate that the key to raising motivational effort for the target group of pupils is to help pupils to develop a more positive pupil identity of themselves as 'mathematicians'. Studies here indicated that raising motivational effort through developing a more positive pupil identity involves the use of strategies characterised by: (i) providing a caring and supportive classroom climate; (ii) providing activities which pupils find challenging and enjoyable; (iii) enabling pupils to gain a deeper understanding of the mathematics; (iv) providing opportunities for pupils to collaborate; and (v) enabling the pupils to feel equally valued.

Teaching for engagement

This area looked at how teachers' decision-making regarding their choice teaching and learning activities, the way they interact with pupils, and the type of classroom climate they establish, are intended to enhance pupils' engagement. The findings here echoed the five elements in the picture emerging in the previous section. However, in this section (teaching for engagement) the emphasis was more on the importance of the teacher being caring and supportive and making the mathematics enjoyable; while, in the previous section (pupil identity), the emphasis was more on the importance of pupils gaining a deeper understanding of the mathematics they were doing as being crucial to the development of a more positive pupil identity.

Innovative methods

This area was subdivided into ICT-based innovative teaching methods and other innovative teaching methods. The studies here indicate that strategies making use of ICT (ranging across methods involving the use of interactive whiteboards, videoconferencing, supportive software packages for pupils, and graphical calculators) can have a powerful effect on raising motivational effort. However, in using ICT an important distinction needs to be made between two stages: (i) the motivating effect of using ICT based on its novelty, stimulating visual appearance, and the opportunity it affords to work in different ways, including working in groups; and (ii) the motivating effect of using ICT in a way that enhances deeper understanding of the mathematics. While both stages involved in the use of ICT are important, the long-term impact of using ICT as a means of motivating pupils, and thereby enhancing their pupil identity, needs to make use of the second stage experience.

Other innovative methods included the use of cognitive acceleration in mathematics education (CAME) or CAME-type lessons, the teaching of self-regulation strategies, teaching based on extending features of the NNS in primary schools into secondary schools (such as the use of mental/oral starters and whole class interactive teaching), and the use of formative assessment. The studies here indicated that such innovative methods can play a part in raising motivational effort.

However, for strategies based on both ICT-based and other innovative methods of teaching to be effective in raising pupils' motivational effort, teachers need to have a good understanding of the theoretical basis concerning why and how the innovation can be effective, and to develop the skills and techniques required for its effective practical implementation. The effectiveness of any innovative teaching method is highly sensitive to the way in which it is implemented.

5.2 Strengths and limitations of this systematic review

The main strengths of this review have been that the review process has followed a publicly visible procedure, and has benefited from the collaboration involved between the Review Group, the EPPI-Centre, and many other individuals who offered comment, help and advice. The close scrutiny of the procedures involved means that each stage of the review involved discussion and justification.

The main limitations of the review are that the constraints involved in terms of time, cost and access to relevant papers, inevitably means that decisions about the focus of the review question and the conduct of the review process have to be taken in the context of keeping the review manageable. Such decisions involve trade-offs. For example, the decision to focus on recent research and research conducted in England (with three exceptions) meant that the included studies were highly relevant to the current context of policy and practice in England, but meant that studies from the wider international research literature, or studies conducted in England published prior to 1999 could not be included in the data-extraction.

Another limitation of the review is that many conference papers (including those which are published in conference proceedings) and papers which appears in journals aimed at a practitioner audience do not appear in a polished and full-length form, so the material presented in the paper sometimes omits details that would normally be required if the paper were to be accepted for publication in a major research-oriented journal. As such, the fact that some such papers were included in this review meant that, during data-extraction, a number of questions about such papers had to be coded as unclear or not stated in the paper.

Another limitation was that many of the studies included samples which did not precisely match the target group (that is, KS 4 pupils in the mid-below average to average range of attainment). Many studies had a population focus on pupils did not include data from pupils in KS 4. This may reflect the difficulty of doing research which involves pupils in KS 4, given the current pressure on pupils to focus their attention in KS 4 on achieving success in the GCSE examinations. In addition, many of the studies aggregated data together from a broad range of attainment, so that the data dealing specifically with pupils in the mid-below-average to average range of mathematical attainment was not presented separately.

In addition, none of the studies employed a research design which was ideal for addressing the review question, and hence any findings need to be regarded as tentative. The studies in the review were not evaluation studies specifically designed to provide evidence about how to increase or improve motivational effort. However, the included studies have identified areas where strategies can be developed and subjected to rigorous evaluation.

5.3 Implications

5.3.1 Policy

The issues identified here are very much in line with the DfES' own analysis of how pupils' motivational effort in school can be raised, and is well reflected in the policies the DfES has developed in recent years, including the advocacy of personalised learning. There is little doubt that recent policy developments by the DfES in conjunction with its response to *The Smith Report*, have now recognised and incorporated the importance of encouraging pupil engagement in mathematics. The section on personalised learning in the recent White Paper, *Higher Standards, Better Schools for All* (DfES, 2005) is very much in tune with the findings of this review. There is little doubt, however, as is recognised in the White Paper, that effective continuing professional development (CPD) for teachers will have an important role to play in enabling teachers to adopt strategies that will successfully raise the motivational effort of KS 4 pupils in the mid-below-average to average range of mathematical attainment.

5.3.2 Practice

There is also little doubt that there is a vast array of initiatives that are currently taking place in schools, many of which are already indicating ways in which rasing pupils' motivational effort can be achieved. What is clearly needed is for more teachers to be given the freedom to adopt what is emerging to be effective practice. The strategies considered in this review - ranging across the use of interactive whiteboards, videoconferencing, opportunities for peer collaboration, and providing a supportive classroom climate - all require a high level of skill and expertise. These are not strategies that teachers can simply implement without ongoing support and training. The evidence here indicates that enabling teachers to work together in collaborative groups with external support to explore and evaluate together innovations in their practice can make a major contribution to enable changes in practice to be effective in raising pupils' motivational effort.

5.3.3. Research

There is a need for researchers to make greater use of measures and indicators of pupils' motivational effort in order to draw firmer conclusions about the effectiveness strategies designed to raise the motivational effort of the target group of pupils in KS 4 Mathematics. However, what is needed is not just evidence of whether a strategy works or not, but much more detail about what features of how a strategy is used contribute to its effectiveness or otherwise. Guidance to teachers on how to make use of these strategies requires a fuller understanding of such features, which can only come from a rich research literature based on a mixture of study types, ranging from studies based on large scale testing of outcomes to studies based on qualitative in-depth case studies of the practice adopted by particular teachers, classes and schools.

CHAPTER SIX

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Passey D, Rogers C, Machell J, McHugh G (2004) *The Motivational Effect of ICT on Pupils (DfES Research Report RR523)*. London: DfES.

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Shen C, Pedulla JJ (2000) The relationship between students' achievement and their self-perception of competence and rigour of mathematics and science: a cross-national analysis. *Assessment in Education* **7:** 237–253.

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Turner JC, Thorpe PK, Meyer DK (1998) Students' reports of motivation and negative affect: a theoretical and empirical analysis. *Journal of Educational Psychology* **90:** 758–771.

Tymms P (2001) A test of the big fish in a little pond hypothesis: an investigation into the feelings of seven-year-old pupils in school. *School Effectiveness and School Improvement* **12:** 161–181.

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Instruction, University of Cyprus, 22–27 August.

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Appendix 1.1: Authorship of this report

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

The authors of this report are

Chris Kyriacou (Department of Educational Studies, University of York)
Maria Goulding (Department of Educational Studies, University of York)

They conducted the review with the benefit of advice 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, policy-makers) with an interest in the review question were invited to comment on the work of the Review Group at appropriate times. This was done through email and informal conversations at conferences. We are particularly indebted here to comments and advice we received from Margaret Brown, Celia Hoyles, Linton Waters and Anne Watson.

Conflict of interest

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

Acknowledgements

The Mathematics Education Review Group and this review are part of the initiative on evidence-informed policy and practice at the EPPI-Centre, Social Science Research Unit, Institute of Education, University of London, funded by the Department for Education and Skills (DfES). The Review Group acknowledges the financial support from the DfES via the EPPI-Centre.

We wish to thank staff at the EPPI-Centre for their advice, support and guidance throughout the various stages of carrying out this review, with particular thanks to Kelly Dickson, Zoe Garrett and Mark Newman.

Our thanks also go to members of the Review Group and the institutions to which they belong for their support. We are particularly grateful to those members of the Review Group who attended the various meetings in London and York and were involved in the screening and data-extraction stages of the review.

We would also like to thank numerous individuals who kindly sent us copies of their published and unpublished papers, together with their thoughts and comments on our work at various stages in the review process, and also kindly suggested references that we should consider for inclusion.

Appendix 2.1: Inclusion and exclusion criteria

For a paper to be included in the systematic map, it had 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 September 1999 to May 2005.
ii. It reports a study presenting original data collected by the author(s).
iii. The study deals with the classroom-based teaching and learning of KS 3 or KS 4 school mathematics in mainstream classes in England.
iv. The study is relevant to considering strategies for increasing KS 4 pupils' classroom-based motivational effort towards learning mathematics.

These inclusion criteria were reformulated as four exclusion criteria and placed in the hierarchical order, as indicated below, for ease of exclusion and, importantly, to act as a system of gradual filtering, so that the papers that are 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

ExC 1: Not an academic paper published in an academic journal or presented at an academic conference during the period September 1999 to May 2005 in English

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 symposium

ExC 2: Not a report of a research study presenting original data collected by the author(s)

Examples of exclusion: a review of the literature; or a paper which offers a critique of policy and practice

ExC 3: Not about the classroom-based teaching and learning of KS 3 or KS 4 school mathematics in mainstream classes in England

Examples of exclusion: a study based on data collected in another country; or a study which only has tangential or contextual relevance to the teaching and learning of mathematics in the classroom; or a study which looks at mathematics education in primary schools; or a study looking at performance in national examinations

ExC 4: Not relevant to increasing KS 4 pupils' classroom-based motivational effort towards learning mathematics

Examples of exclusion: a study dealing with the development of pupils' understanding of a specific topic; or a study dealing solely with pupils' mathematical attainment

Appendix 2.2: Search strategy for electronic databases

The British Education Index (BEI) was searched on 16 May 2004. The database was accessed via the Dialog interface and the search constructed as follows:

Database: British Education Index 1976 - March 2005

262 records retrieved using Dialog@Site on Monday 16 May 2005

Search:

1. (MATH?) AND (ATTITUD? OR EFFORT OR MOTIV? OR SELF)
2. Year of publication = ("1999" OR "2000" OR "2001" OR "2002" OR "2003" OR "2004")
3. Combine 1 and 2.

Appendix 2.3: Journals and conference proceedings handsearched

(i) Electronic search and/or handsearch of 11 key journals in Mathematics Education (September 1999 to May 2005) looking at every title and where appropriate and available the abstract and/or the full-paper:

Educational Studies in Mathematics
Equals
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
Teaching Mathematics and its Applications

(ii) Electronic searches and/or handsearching issues of the following 16 selected key UK journals in Educational Research (September 1999 to May 2005) 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

(iii) Handsearch and/or electronic search of key recent conference proceedings looking at every tile and where appropriate and available the abstract and/or the full paper:

British Congress of Mathematics Education 2005

British Educational Research Association Annual Conference 2003 and 2004

British Society for Research into Learning Mathematics, Day Conferences 1999-2005

European Conference on Educational Research 2003 and 2004

International Group for the Psychology of Mathematics Education Annual Conference 2003 and 2004

Scottish Educational Research Association Annual Conference 2003 and 2004

APPENDIX 2.4 EPPI-Centre keyword sheet

V0.9.7 *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
Mathematics
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 = 25 studies)

BEI searched journal paper	8
BEI searched conference paper	6
Handsearched journal paper	9
Handsearched conference paper	2
Total	***25***

Table A3.2 Status (N = 25 studies)

Published	20
Unpublished	5
Total	***25***

Table A3.3 Population focus of study (N = 25 studies)

Pupils (16 studies)	**Teachers (9 studies)**
Bartholomew (2000)	Andrews and Hatch (2000)
Boaler et al. (2000)	Andrews and Hatch (2002)
Cramp and Nardi (2000)	Bills and Husbands (2005)
Dorman and Adams (2004)	Crisan (2004)
Edmiston (2003)	Goulding (2003)
Gage (1999)	Hallam and Ireson (2005)
Gage (2003)	Hyde (2004)
Gage et al. (2002)	Jones and Tanner (2002)
Gkolia and Jervis (2003)	Miller et al. (2005)
Hallam and Deathe (2002)	
Ireson et al. (2001)	
Jackson (2002)	
Nardi and Steward (2003)	
Smith and Gorard (2005)	
Tanner and Jones (2003)	
Watson and De Geest (2005)	

Table A3.4 Type of study (25 studies)

Description (1 study)

Nardi and Steward (2003)

Exploration of relationships (8 studies)

Andrews and Hatch (2000)
Andrews and Hatch (2002)
Bartholomew (2000)
Bills and Husbands (2005)
Crisan (2004)
Dorman and Adams (2004)
Hallam and Ireson (2005)
Tanner and Jones (2003)

Evaluation (naturally occurring) (13 studies)

Boaler et al. (2000)
Cramp and Nardi (2000)
Edmiston (2003)
Gage (1999)
Gage et al. (2002)
Gkolia and Jervis (2003)
Goulding (2003)
Hallam and Deathe (2002)
Hyde (2004)
Ireson et al. (2001)
Jones and Tanner (2002)
Miller et al. (2005)
Watson and De Geest (2005)

Evaluation (researcher-manipulated) (3 studies)

Gage (2003)
Jackson (2002)
Smith and Gorard (2005)

Andrews P (2000) The influence of context on teachers' conceptions of mathematics and its teaching. Paper presented at the European Conference on Educational Research, University of Edinburgh, 20–23 September. **[ExC 4]**

Andrews P (2002) Which elements of the mathematics curriculum do teachers think are the most important? A comparison of English and Hungarian teachers' beliefs. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12–14 September. **[Inc.]**

Andrews P and Hatch G (2000) A comparison of Hungarian and English teachers' conceptions of mathematics and its teaching. *Educational Studies in Mathematics,* **43:** 31-64. **[Inc.]**

Andrews P and Hatch G (2002) Secondary mathematics teachers' rationales for the teaching of the subject. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12-14 September. **[Inc.]**

Bartholomew H (2000) Negotiating identity in the community of the mathematics classroom. Paper presented at the British Educational Research Association Annual Conference, Cardiff University, 7-10 September. **[Inc.]**

Berry J and Picker SH (2000) Your pupils' images of mathematicians and mathematics. *Mathematics in School* **29:** 24-26. **[ExC 4]**

Bills L (1999) Students talking: an analysis of how students convey attitude in maths talk. *Educational Review* **51:** 161-171. **[ExC 3]**

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 the British Educational Research Association Annual Conference, University of Exeter, 12-14 September. **[ExC 3]**

Appendix 3.2: Possible inclusions identified by electronic searching strategy (44 papers)

(This refers to using specificied keywords within BEI.)

Boaler J, Wiliam D and Brown M (2000) Students' experiences of ability grouping - disaffection, polarisation and the construction of failure. *British Educational Research Journal* **26:** 631-648. **[Inc.]**

Burghes D, Roddick M and Tapson F (2001) Tiering at GCSE: is there a fairer system? *Educational Research* **43:** 175-187. **[ExC 4]**

Cramp E and Nardi S (2000) A snappy start to a mathematics lesson. *Mathematics Teaching* **172**: 46-51. **[Inc.]**

Crisan C (2004) Mathematics teachers' learning about and incorporation of ICT into classroom practices. In: McNamara O(ed.) Proceedings of the Day Conference held on 12 June at the University of Leeds. *BSRLM Proceedings,* Vol. 24, pp 15-20. London: British Society for Research into Learning Mathematics. **[Inc.]**

Dorman J and Adams J (2004) Associations between students' perceptions of classroom environment and academic efficacy in Australian and British secondary schools. *Westminster Studies in Education* **27**: 69-85. **[Inc.]**

Dorman JP, Adams JE and Ferguson JM (2002) Psychosocial environment and student self-handicapping in secondary school mathematics classes: a cross-national study. *Educational Psychology* **22:** 499-511. **[Inc.]**

Duggan P (2002) TEAMWORK: involving secondary school students in the design of multimedia distance learning curriculum material in collaboration with a City Learning Centre. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12-14 September. **[ExC 3]**

Dunne M (1999) Positioned neutrality: mathematics teachers and the cultural politics of their classrooms. *Educational Review* **51:** 117-128. **[ExC 4]**

Edwards A and Ruthven K (2003) Young people's perceptions of the mathematics involved in everyday activities. *Educational Research* **45:** (249-260. **[ExC 4]**

Gage J (2003) Videoconferencing in the mathematics lesson. Paper presented at the British Educational Research Association Annual Conference, Heriot-Watt University, Edinburgh, 11-13 September. **[Inc.]**

Gage J, Nickson M and Beardon T (2002) Can videoconferencing contribute to teaching and learning? The experience of the Motivate Project. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12-14 September. **[Inc.]**

Gkolia C and Jervis A (2001) Teachers' and pupils' perceptions of the use of integrated learning systems in English and mathematics education. Paper presented at the British Educational Research Association Annual Conference, University of Leeds, 13-15 September. **[Inc.]**

Goulding M (2002) Cognitive acceleration in mathematics Education: teachers' views. *Evaluation and Research in Education* **16:** 104-119. **[Inc.]**

Grainger H (2003) Just a bit thick - or is there more to it? In: Williams J (ed.) Proceedings of the Day Conference held on 15 November at the University of Birmingham. *BSRLM Proceedings,* Vol. 23, pp 19-24. London: British Society for Research into Learning Mathematics. **[ExC 4]**

Hallam S and Deathe K (2002) Ability grouping: year group differences in self-concept and attitudes of secondary school pupils. *Westminster Studies in Education* **25:** 7-17. **[Inc.]**

Hogan S (1999) Raising of self-esteem through mathematical activity. In: Bills L (ed.) Proceedings of the Day Conferences held on 12-13 November at the University of Warwick. *BSRLM Proceedings,* pp 67-72. London: British Society for Research into Learning Mathematics. **[ExC 4]**

Hyde R (2004) What do mathematics teachers say about the impact of ICT on pupils learning mathematics? *Micromath* **20**: (11-13. **[Inc.]**

Ireson J, Hallam S, Mortimore P, Hack S, Clark H and Plewis I (1999) Ability grouping in the secondary school: the effects on academic achievement and pupils' self-esteem. Paper presented at the British Educational Research Association Annual Conference, University of Sussex at Brighton, 2-5 September. **[Inc.]**

Johnson M and Green S (2004) On-line assessment: the impact of mode on student performance. Paper presented at the British Educational Research Association Annual Conference, University of Manchester, 16-18

September. **[ExC 3]**

Johnson M and Green S (2004) On-line assessment: the impact of mode on students' strategies, perceptions and behaviours. Paper presented at the British Educational Research Association Annual Conference, University of Manchester, 16-18 September. **[ExC 3]**

Kidd H (2004) Winging it!: Control, structure and freedom in mathematics teaching. In: MacNamara O (ed.) Proceedings of the day conference held on 12 June at the University of Leeds. *BSRLM Proceedings,* Vol. 24, pp 51-56. London: British Society for Research into Learning Mathematics. **[ExC 4]**

Miller D, Parkhouse P, Eagle R and Evans T (1999) Pupils and the core subjects: a study of the attitudes of some pupils aged 11 - 16. Paper presented at the British Educational Research Association Annual Conference, University of Sussex at Brighton, 2-5 September. **[ExC 4]**

Nardi E, Iannone P and Cooker MJ (2003) Pre-eighteen students have lost something major: mathematicians on the impact of school mathematics on students' skills, perceptions and attitudes. In: Williams J (ed.) Proceedings of the Day Conference held on 15 November at the University of Birmingham. *BSRLM Proceedings,* Vol. 23, pp 37-42. London: British Society for Research into Learning Mathematics. **[ExC 3]**

Nardi E and Steward S (2003) Is mathematics TIRED? A profile of quiet disaffection in the secondary mathematics classroom. *British Educational Research Journal* **29:** 345-367. **[Inc]**

Norwich B (1999) Pupils' reasons for learning and behaving and for not learning and behaving in English and maths lessons in a secondary school. *British Journal of Educational Psychology* **69:** 547-569. **[ExC 4]**

Noyes A (2004) Learning landscapes. *British Educational Research Journal* **30:** 27-41. **[ExC 2]**

Picker SH and Berry JS (2000) Investigating pupils' images of mathematicians. *Educational Studies in Mathematics* **43**: 65-94. **[ExC 4]**

Rowland T (2000) Analysis of classroom mathematics discourse: shifting attention from transaction to interaction. Paper presented at the British Educational Research Association Annual Conference, Cardiff University, 7-10 September. **[ExC 2]**

Ruthven K and Hennessy S (2003) Successful ICT use in secondary mathematics: a teacher perspective. *Micromath* **19:** 20-24. **[ExC 1]**

Shen C (2002) Revisiting the relationship between students' achievement and their self-perceptions: a cross-national analysis based on TIMSS 1999 data. *Assessment in Education* **9**: 161-184. **[ExC 4]**

Shen C and Pedulla JJ (2000) The relationship between students' achievement and their self-perception of competence and rigour of mathematics and science: a cross-national analysis. *Assessment in Education* **7:** 237-253. **[ExC 4]**

Steward S and Nardi E (2002) I could be the best mathematician in the world... if I actually enjoyed it: part 2. *Mathematics Teaching* **180**: 4-9. **[Inc.]**

Swan M, Bell A, Phillips R and Shannon A (2000) The purposes of mathematical activities and pupils' perceptions of them. *Research in Education* **63:** 11-20. **[ExC 4]**

Taylor L (2000) How do secondary mathematics teachers view homework? In: Jaworski B (ed.) Proceedings of the day conferences held on 26 February at the University of Exeter and on 6 May at the University of Loughborough. *BSRLM Proceedings,* Vol. 20, pp 122-125. London: British Society for Research into Learning Mathematics. **[ExC 4]**

Venkatakrishnan H and Brown M (2004) National policy, departmental responses: the implementation of the mathematics strand of the Key Stage 3 strategy. In: McNamara O (ed.) Proceedings of the Day Conference held on 28 February at King's College London. *BSRLM Proceedings,* Vol. 24 , pp 75-81. London: British Society for Research into Learning Mathematics. **[ExC 4]**

Winter J (2000) Pupils doing algebra: interviews with year 7 pupils in an ESRC project. In: Jaworski B (ed.) Proceedings of the day conferences held on 26 February at the University of Exeter and on 6 May at the University of Loughborough. *BSRLM Proceedings,* Vol. 20, pp 24-29. London: British Society for Research into Learning Mathematics. **[ExC 4]**

(This refers to handsearching and electronic searching of key journals and conferences proceed-

Appendix 3.3: Possible inclusions identified by handsearching (36 papers)

ings, citations and personal contacts.)

Bills L and Husbands C (2005) Values education in the mathematics classroom: subject values, educational values and one teacher's articulation of her practice. *Cambridge Journal of Education* **35**: 7-18. **[Inc.]**

De Geest E, Watson A and Prestage S (2003) Thinking in ordinary lessons: what happened when nine teachers believed their failing students could think mathematically. In: Pateman N, Dougherty B and Zilliox J (eds) *Proceedings of the 27th Annual Conference of the International Group for the Psychology of Mathematics Education held in Honolulu, Hawaii, 13-18 July* (Vol. 2, pp 301-308). **[Inc.]**

Dorman JP, Adams JE and Ferguson JM (2003) A cross-national investigation of students' perceptions of mathematics classroom environments and academic efficacy in secondary schools, *International Journal of Mathematics Teaching and Learning,* 15th April. [e-journal] **[Inc.]**

Edmiston A (2003) A tale of two cultures. *Equals* **9:** 4-8. **[Inc.]**

Edmiston A (2005) It's the way I tell them! *Equals* **11:** 3-5. **[ExC 1]**

Gabb J (1999) Thinking challenges across the ability range. *Equals* **5:** 5-7. **[ExC 3]**

Gage J (1999) Shifts in confidence: the graphic calculator as a space in which to do mathematics? *Micromath* **15:** 13-17. **[Inc.]**

Gage J (2001) What does MOTIVATE do? *Micromath* **17:** 22-25. **[ExC 1]**

Glatter, A. (2004) We're not bored playing board games! *Equals* **10:** 11-14. **[ExC 1]**

Francis B (2000) The gendered subject: students' subject preferences and discussions of gender and subject ability. *Oxford Review of Education* **26:** 35-48. **[ExC 4]**

Hallam S and Ireson J (2005) Secondary school teachers' pedagogic practices when teaching mixed and structured ability classes. *Research Papers in Education* **20:** 3-24. **[Inc.]**

Ireson J and Hallam S (2005) Pupils' liking for school: ability grouping, self-concept, and perceptions of teaching. *British Journal of Educational Psychology* **75:** 297-311. **[ExC 4]**

Ireson J, Hallam S and Plewis I (2001) Ability grouping in secondary schools: effects on pupils' self-concepts. *British Journal of Educational Psychology* **71**: 315-326. **[Inc.]**

Jackson C (2002) Can single-sex classes in co-educational schools enhance the learning experiences of girls and/or boys? An exploration of pupils' perceptions. *British Educational Research Journal* **28:** 37-48. **[Inc.]**

Jones S and Tanner H (2002) Teachers' interpretations of effective whole-class interactive teaching in secondary mathematics classrooms. *Educational Studies* **28:** 265-274. **[Inc.]**

Lord P (2005) Pupils' views of the curriculum: are you 'in the know'? *Topic* **33:** 9-14. **[ExC 2]**

Mendick HF (2004) Changing teachers, changing subjects: troubling transitions into AS mathematics. Paper presented at the British Educational Research Association Annual Conference, University of Manchester, 16-18 September. **[ExC 4]**

Mendick H (2005) A beautiful myth? The gendering of being/doing 'good at maths'. *Gender and Education* **17:** 203-219. **[ExC 4]**

Mendick H (2005) Mathematical stories: why do more boys than girls choose to study mathematics at AS-level in England? *British Journal of Sociology of Education* **26:** 235-251. **[ExC 4]**

Miller D, Glover D and Averis D (2005) Presentation and pedagogy: the effective use of interactive whiteboards in mathematics lessons. In: Hewitt D and Noyes A (eds) Proceedings of the Sixth British Congress of Mathematics Education held on 30 March to 2 April at the University of Warwick. *BSRLM Proceedings,* Vol. 25, pp 105-112. London: British Society for Research into Learning Mathematics. **[Inc.]**

Nardi E and Steward S (2002) I could be the best mathematician in the world... if I actually enjoyed it. *Mathematics Teaching* **179:** 41-44. **[Inc.]**

Ollerton M and Watson A (2003) I teach them but they don't learn. *Equals* **9:** 15-19. **[ExC 2]**

Pell A and Steward S (2004) Pupil attitudes at KS 3. Paper presented at the British Educational Research Association Annual Conference, University of Manchester, 16-18 September. **[no full paper available]**

Povey H and Angier C (2004) Girls' participation in some realistic mathematics: reflections from student teachers. In: Høines MJ and Fuglestad AB (eds) *Proceedings of the 28th Annual Conference of the International Group for the Psychology of Mathematics Education held in Bergen, Norway, 14-18 July* (Vol. 1, p 392). **[no full paper available]**

Prestage S, Watson A and De Geest E (2002) Developing ways of being mathematical with low attaining students. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12-14 September. **[ExC 2]**

Ransom P and Louch H (2000) A lesson with a difference. *Equals* **6:** 7-9. **[ExC 1]**

Rogers C and Passey D (2004) The impact of ICT on motivation for schoolwork: a multidimensional approach. Paper presented at the British Educational Research Association Annual Conference, University of Manchester, 16-18 September. **[no full paper available]**

Smith E and Gorard S (2005) 'They don't give us our marks': the role of formative feedback in student progress. *Assessment in Education* **12:** 21-38. **[Inc.]**

Solomon Y (2004) Maths histories: emerging mathematics identities in the classroom community of practice. Paper presented at the British Educational Research Association Annual Conference, University of Manchester, 16-18 September. **[no full paper available]**

Steward S and Pell T (2004) Changing students' attitudes to mathematics through small-group collaboration? In: Høines MJ and Fuglestad AB (eds) *Proceedings of the 28th Annual Conference of the International Group for the Psychology of Mathematics Education held in Bergen, Norway, 14-18 July* (Vol. 1, p 356). **[no full paper available]**

Tanner H and Jones S (2003) Self-efficacy in mathematics and students' use of self-regulated learning strategies during assessment events. In: Pateman NA, Dougherty BJ and Zilliox J (eds) *Proceedings of the 27th Annual Conference of the International Group for the Psychology of Mathematics Education held in Honolulu, Hawaii, 13-18 July* (Vol. 4, pp 275-282). **[Inc.]**

Watson A and De Geest E (2005) Principled teaching for deep progress: improving mathematical learning beyond methods and materials. *Educational Studies in Mathematics* **58:** 209-234. **[Inc.]**

Watson A, Prestage S and De Geest E (2002) Moving to the edge of the comfort zone: mathematical thinking and strategies used to promote it. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12-14 September. **[Inc.]**

Wiliam D and Bartholomew H (2004) It's not which school but which set you're in that matters: the influence of ability grouping practices on student progress in mathematics. *British Educational Research Journal* **30:** 279-293. **[ExC 4]**

Wiliam D and Bartholomew H (2005) It's the set you're in that counts. *Equals* **11:** 11. **[ExC 4]**

Wiliam D, Brown M and Boaler J (1999) 'We've still got to learn': low attainers' experiences of setting. *Equals* **5:** 15-18. **[Inc.]**

Appendix 3.4: The main papers

Andrews P and Hatch G (2000) A comparison of Hungarian and English teachers' conceptions of mathematics and its teaching. *Educational Studies in Mathematics* **43:** 31-64.

Andrews P and Hatch G (2002) Secondary mathematics teachers' rationales for the teaching of the subject. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12-14 September.

Bartholomew H (2000) Negotiating identity in the community of the mathematics classroom. Paper presented at the British Educational Research Association Annual Conference, Cardiff University, 7-10 September.

Bills L and Husbands C (2005) Values education in the mathematics classroom: subject values, educational values and one teacher's articulation of her practice. *Cambridge Journal of Education* **35:** 7-18.

Boaler J, Wiliam D and Brown M (2000) Students' experiences of ability grouping - disaffection, polarisation and the construction of failure. *British Educational Research Journal* **26:** 631-648.

Cramp S and Nardi E (2000) A snappy start to a mathematics lesson. *Mathematics Teaching* **172:** 46-51.

Crisan C (2004) Mathematics teachers' learning about and incorporation of ICT into classroom practices. In: McNamara O(ed.) Proceedings of the Day Conference held on 12 June at the University of Leeds. *BSRLM Proceedings,* Vol. 24, pp 15-20. London: British Society for Research into Learning Mathematics.

Dorman J and Adams J (2004) Associations between students' perceptions of classroom environment and academic efficacy in Australian and British secondary schools. *Westminster Studies in Education* **27:** 69-85.

Edmiston A (2003) A tale of two cultures. *Equals* **9:** 4-8.

Gage J (1999) Shifts in confidence: the graphic calculator as a space in which to do mathematics. *Micromath* **15:** 13-17.

Gage J (2003) Videoconferencing in the mathematics lesson. Paper presented at the British Educational Research Association Annual Conference, Heriot-Watt University, Edinburgh, 11-13 September.

Gage J, Nickson M and Beardon T (2002) Can videoconferencing contribute to teaching and learning? The experience of the Motivate Project. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12-14 September.

Gkolia C and Jervis A (2001) Teachers' and pupils' perceptions of the use of integrated learning systems in English and mathematics education. Paper presented at the British Educational Research Association Annual Conference, University of Leeds, 13-15 September.

Goulding M (2002) Cognitive Acceleration in Mathematics Education: teachers' views. *Evaluation and Research in Education* **16:** 104-119.

Hallam S and Deathe K (2002) Ability grouping: year group differences in self-concept and attitudes of secondary school pupils. *Westminster Studies in Education* **25:** 7-17.

Hallam S and Ireson J (2005) Secondary school teachers' pedagogic practices when teaching mixed and structured ability classes. *Research Papers in Education* **20:** 3-24.

Hyde R (2004). What do mathematics teachers say about the impact of ICT on pupils learning mathematics? *Micromath* **20:** 11-13.

Ireson J, Hallam S and Plewis I (2001) Ability grouping in secondary schools: effects on pupils' self-concepts. *British Journal of Educational Psychology* **71:** 315-326.

Jackson C (2002) Can single-sex classes in co-educational schools enhance the learning experiences of girls and/or boys? An exploration of pupils' perceptions. *British Educational Research Journal* **28:** 37-48.

Jones S and Tanner H (2002) Teachers' interpretations of effective whole-class interactive teaching in secondary mathematics classrooms. *Educational Studies* **28:** 265-274.

Miller D, Glover D and Averis D (2005) Presentation and pedagogy: the effective use of interactive whiteboards in mathematics lessons. In: Hewitt D and Noyes A (eds) Proceedings of the Sixth British Congress of Mathematics

Education held 30 March to 2 April at the University of Warwick. *BSRLM Proceedings,* Vol. 25, pp 105-112. London: British Society for Research into Learning Mathematics.

Nardi E and Steward S (2003) Is mathematics TIRED? A profile of quiet disaffection in the secondary mathematics classroom. *British Educational Research Journal* **29**: 345-367.

Smith E and Gorard S (2005) 'They don't give us our marks': the role of formative feedback in student progress. *Assessment in Education* **12:** 21-38.

Tanner H and Jones S (2003) Self-efficacy in mathematics and students' use of self-regulated learning strategies during assessment events. In: Pateman NA, Dougherty BJ and Zilliox J (eds) *Proceedings of the 27th Annual Conference of the International Group for the Psychology of Mathematics Education held in Honolulu, Hawaii, 13-18 July* (Vol. 4, pp 275-282).

Watson A and De Geest E (2005) Principled teaching for deep progress: improving mathematical learning beyond methods and materials. *Educational Studies in Mathematics* **58:** 209-234.

Appendix 3.5: The subsiary papers (9 papers)

Andrews P (2002) Which elements of the mathematics curriculum do teachers think are the most important? A comparison of English and Hungarian teachers' beliefs. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12-14 September.

De Geest E, Watson A and Prestage S (2003) Thinking in ordinary lessons: what happened when nine teachers believed their failing students could think mathematically. In: Pateman N, Dougherty B and Zilliox J (eds) *Proceedings of the 27th Annual Conference of the International Group for the Psychology of Mathematics Education held in Honolulu, Hawaii, 13-18 July* (Vol. 2, pp 301-308).

Dorman JP, Adams JE and Ferguson JM (2002) Psychosocial environment and student self-handicapping in secondary school mathematics classes: a cross-national study. *Educational Psychology* **22:** 499-511.

Dorman JP, Adams JE and Ferguson JM (2003) A cross-national investigation of students' perceptions of mathematics classroom environments and academic efficacy in secondary schools, *International Journal of Mathematics Teaching and Learning,* 15th April. [e-journal]

Ireson J, Hallam S, Mortimore P, Hack S, Clark H and Plewis I (1999) Ability grouping in the secondary school: the effects on academic achievement and pupils' self-esteem. Paper presented at the British Educational Research Association Annual Conference, University of Sussex at Brighton, 2-5 September.

Nardi E and Steward S (2002) I could be the best mathematician in the world... if I actually enjoyed it. *Mathematics Teaching* **179:** 41-44.

Steward S and Nardi E (2002) I could be the best mathematician in the world... if I actually enjoyed it: part 2. *Mathematics Teaching* **180:** 4-9.

Watson A, Prestage S and De Geest E (2002) Moving to the edge of the comfort zone: mathematical thinking and strategies used to promote it. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12-14 September.

Wiliam D, Brown M and Boaler J (1999) 'We've still got to learn': low attainers' experiences of setting. *Equals* **5:** 15-18.

Appendix 4.1: Key areas identified in the synthesis of evidence

Key areas	**Main papers** (with subsidiary papers in brackets) Paper numbers given in bold refer to Appendix 4.2
Grouping Grouping of pupils by ability or gender	*Re: ability* Baoler et al. **6** (Wiliam et al. 34) Hallam and Deathe **19** Hallam and Ireson **20** Ireson et al. **23** (Ireson et al. 22) *Re: gender* Jackson **24**
Pupil identity The extent to which pupils see themselves as 'mathematicians' – as people who can understand and do mathematics	Bartholomew **4** Nardi and Steward **27** (Nardi/Steward **28**; Steward/Nardi **30**) Watson et De Geest **32** (De Geest et al. **9**; Watson et al **33**)
Teaching for engagement Those aspects of teaching which motivate or demotivate	Andrews and Hatch **2** Andrews and Hatch **3** (Andrews **1**) Bills and Husbands **5** Dorman and Adams **10** (Dorman et al. **11**; Dorman et al. **12**)
Innovative methods The use of specific innovative methods recently introduced and evaluated in schools	***(i) ICT-based methods*** *Re: videoconferencing* Gage **15** Gage et al. **16** *Re: supportive software packages for pupils* Gkolia and Jervis **17** *Re: interactive whiteboards* Hyde **21** Miller et al. **26** *Re: graphic calculators* Gage **14** *Re: general ICT* Crisan **8** ***(ii) Other methods*** *Re: mental/oral starters* Cramp and Nardi **7** *Re: whole class interactive teaching* Jones and Tanner **25** *Re: Cognitive acceleration in mathematics education* Edmiston **13** Goulding **18** *Re: self-regulation* Tanner and Jones **31** *Re: formative assessment* Smith and Gorard **29**

Appendix 4.2: Summary of included studies

1. ANDREWS P (2002) Which elements of the mathematics curriculum do teachers think are the most important? A comparison of English and Hungarian teachers' beliefs. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12-14 September. (Papers 1 and 3 are part of the same study, and are also linked to paper 2; see paper 3.)

2. ANDREWS P, HATCH G (2000) A comparison of Hungarian and English teachers' conceptions of mathematics and its teaching. *Educational Studies in Mathematics* 43: 31-64. (See also papers 1 and 3 that are linked to this paper.)

Overall weight of evidence score = Medium

Focus of study

- To explore Hungarian and English teachers' conceptions of mathematics and its teaching

Data collected

- The English data was based on a questionnaire completed by teachers in 200 schools in three regions of England teaching 11-14 year-olds.

- 577 responses were obtained, although only 108 of these were used in the factor analysis to match a sample of 108 responses from Hungarian teachers.

Key claims/evidence regarding the classroom teaching of mathematics

- A factor analysis identified five conceptions of teaching mathematics: (i) the formal teaching of skills and fluency through regular practice of routine procedures; (ii) pedagogic variety; (iii) task differentiation; (iv) the creation of a mathematically enriched and challenging classroom; and (v) the development of pupil autonomy through facilitation in an open and cooperative environment.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- Although a consideration of KS 4 pupils in the target ability group are not explicitly mentioned, it seems highly probable that they are included.

- The English teachers seem to have a belief that pupils lack intrinsic motivation for mathematics and that teachers thus need to stimulate pupils by providing an enriched and challenging classroom, and by using informal forms of classroom management, including small group activities, where learning is subordinate to the maintenance of pupils' self-esteem.

- No explicit evidence is provided that such practice is effective in raising pupil motivation.

3. ANDREWS P, HATCH G (2002) Secondary mathematics teachers' rationales for the teaching of the subject. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12-14 September. (Papers 1 and 3 are part of the same study, and are also linked to paper 2.)

Overall weight of evidence score = Medium

Focus of study

- To explore teachers' conceptions of mathematics and its teaching, and the elements of the mathematics curriculum they think are most important

Data collected

- The data was based on interviews with 45 teachers teaching in 11-16 or 11-18 schools in two regions of England (Greater Manchester and southern Hampshire).

- The majority of the schools were urban or semi-urban.

- These teachers had volunteered to be interviewed following completion of the questionnaire used in Andrews and Hatch (2000).

- The interviews were semi-structured.

Key claims/evidence regarding the classroom teaching of mathematics

- The data on teachers' conceptions of mathematics and its teaching fell into three broad stands: (i) the self; (ii) the learner; and (iii) mathematics. Within each of these strands, two or three themes were identified.

- The data from the subsidiary paper (Andrews, 2002) on the curriculum fell into five categories: (i) the importance of numerical skills; (ii) the importance of utility; (iii) the curriculum as a given; (iv) mathematics as problem-solving; and (v) taking account of pupil ability and need.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- A consideration of KS 4 pupils in the target ability group are explicitly mentioned.

- The teachers emphasised the importance of pupils enjoying mathematics and promoting confidence with numbers.

- While the practical utility of mathematics was recognised for the 'middle to less able', the mathematics curriculum still needed to be broad and to include investigations.

- Teachers reported that the problem-solving aspect of mathematics has the power to enthuse pupils.

- GCSE coursework, particularly involving statistics, had enthused lower attaining pupils.

4. BARTHOLOMEW H (2000) Negotiating identity in the community of the mathematics classroom. Paper presented at the British Educational Research Association Annual Conference, Cardiff University, 7–10 September. (This paper is linked to papers 6 and 34.)

Overall weight of evidence score = Medium

Focus of study

- To explore the impact of ability grouping practices on pupils' achievement in, and attitude to, mathematics

Data collected

- The study tracked pupils in six schools from year 8 until they took their GCSEs in year 11.

- The schools were all non-selective and were located in and around London.

- Five schools were mixed; the other was a girls' school.

- The percentage of pupils in each school gaining 5 A*-C grades ranged from 13% to 74%.

- All six schools grouped by ability in years 10 and 11.

- The data collected comprised a questionnaire completed at the end of year 8, 9 and 10; interviews during years 9 and 11; lesson observations; and pupil attainment.

- This paper focused mainly on the interview data with pupils in year 11.

Key claims/evidence regarding the classroom teaching of mathematics

- The mathematics lessons, generally emphasize the learning of procedures rather than encourage pupils to think things through for themselves.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- Although the paper focuses on year 11 pupils, the quotations presented only include pupils in sets 1 or 2; that is, pupils in the target ability group are not explicitly mentioned here.

- Many pupils felt the mathematics they were doing for GCSE had very little relevance to their lives outside school, and its importance is largely based on it being an important qualification.

- Some pupils, however, got a boost to their motivation by being considered as being good at mathematics.

- Some pupils are reluctant to try hard to understand because they feel understanding is too hard; instead they rely on learning procedures.

5. BILLS L, HUSBANDS C (2005) Values education in the mathematics classroom: subject values, educational values and one teacher's articulation of her practice. *Cambridge Journal of Education* 35: 7–18.

Overall weight of evidence score = Low

Focus of study

- To explore values issues in the teaching of mathematics through one teacher's articulation of her practice

Data collected

- The teacher is a secondary school teacher with four years' experience.

- The data comprised an interview and four hours of lesson observation.

- Specific reference is made to lessons in years 9, 10 and 11.

Key claims/evidence regarding the classroom teaching of mathematics

- The teacher's account of her teaching is highly values-dependent.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- KS 4 lessons are included, but pupils in the target ability group are not explicitly mentioned.
- The teacher's approach to teaching is characterised by the use of strategies to protect pupils from the rigours of mathematics and to build up their confidence.
- She makes use of pupils' mistakes in order to protect pupils from a sense of failure.
- No explicit evidence is provided that such practices are effective in raising pupil motivation.

6. BOALER J, WILIAM D, BROWN M (2000) Students' experiences of ability grouping - disaffection, polarisation and the construction of failure. *British Educational Research Journal* 26: 631-648. (This paper is linked to papers 4 and 34.)

Overall weight of evidence score = Medium

Focus of study

- To explore the influence of ability-grouping practices on pupils' attitudes and achievement in mathematics

Data collected

- A two-year longitudinal study of pupils moving from year 8 to year 9
- The study involved the full cohort of about 1,000 pupils in six schools in greater London who completed a questionnaire at the end of year 8 (943 pupils) and 9 (977 pupils), of whom 843 pupils in the sample completed both questionnaires.
- In addition, 72 pupils were interviewed (6 pupils per school each year) and there were 120 hours of lesson observation.
- Pupils in four of the six schools moved from mixed ability groups to sets.

Key claims/Evidence regarding the classroom teaching of mathematics

- Many pupils in the higher sets were disadvantaged by being taught at too fast a pace for understanding.
- Many pupils in lower sets were disadvantaged by a restricted opportunity to learn.
- Setting in comparison to mixed ability groups was linked to a more restricted range of teaching approaches.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- KS 3 pupils in the target ability group are included.
- Pupils in the lower sets became disaffected by working at too slow a pace and by knowing they would only have access to lower grades at GCSE.

7. CRAMP S, NARDI E (2000) A snappy start to a mathematics lesson. *Mathematics Teaching* 172: 46-51.

Overall weight of evidence score = Low

Focus of study

- To explore the use of a short lesson starter (about 5 to 10 minutes in length)

Data collected

- The short lesson starter ('snappy') was based on using mental arithmetic to revise a topic.
- The study is described as being a qualitative research project.
- The data presented is based on interviews with four teachers at a 13-18 Suffolk high school, who developed this innovation, together with some comments from interviews with pupils. (These include quotes from two pupils in year 9, two pupils in year 10, and two pupils in year 12.)

Key claims/evidence regarding the classroom teaching of mathematics

- The teachers felt that snappies offered a useful opportunity to check pupils' understanding and previous knowledge.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- KS 4 pupils in the target ability group are included.
- The teachers felt snappies were powerful lesson starters that got pupils to settle down with a work ethic and attitude in the first few minutes of the lesson.
- The pupil data contained some examples of how snappies had increased their confidence and motivation.
- The authors claim they have strong evidence to suggest that the use of snappies improved pupils' attitudes towards mathematics lessons.

8. CRISAN C (2004) Mathematics teachers' learning about and incorporation of ICT into classroom practices. In: McNamara O (ed.) Proceedings of the Day Conference held on 12 June at the University of Leeds. *BSRLM*

***Proceedings* 24: 15-20. London: British Society for Research into Learning Mathematics.**

Overall weight of evidence score = Low

Focus of study

- To explore secondary school mathematics teachers' use of ICT

Data collected

- The data was based on seven teachers (four females, three males) teaching in three secondary schools in the same city.
- The teachers were at different stages in the career and in their use of ICT.
- Each teacher was interviewed twice and observed teaching at least one lesson in which ICT was used.
- Post-lesson comments and informal conversations were noted.
- Written documents, such as lesson plans and handouts, were also collected.

Key claims/evidence regarding the classroom teaching of mathematics

- Factors influencing teachers' implementation of ICT into their classroom practice were divided into two broad categories: contextual factors and personal factors.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- Neither KS 4 nor the target ability group are not explicitly mentioned, but it seems highly probable that they are both included.
- Some teachers perceived the benefits of ICT use in terms of enhancing pupils' enjoyment of mathematics lessons, rewarding hard work, and addressing learning difficulties.
- No explicit evidence is provided that such practice is effective in raising pupil motivation.

9. DE GEEST E, WATSON A, PRESTAGE S (2003) Thinking in ordinary lessons: what happened when nine teachers believed their failing students could think mathematically. In: Pateman N, Dougherty B, Zilliox J (eds) *Proceedings of the 27th Annual Conference of the International Group for the Psychology of Mathematics Education held in Honolulu, Hawaii, 13-18 July* (Vol. 2). (This paper is linked to this paper 32, and reports the same study; see paper 32.)

10. DORMAN J, ADAMS J (2004) Associations between students' perceptions of classroom environment and academic efficacy in Australian and British secondary schools. *Westminster Studies in Education* 27: 69-85. (This paper is linked to papers 11 and 12.)

Overall weight of evidence score = Medium

Focus of study

- To explore the association between classroom psychosocial environment and academic efficacy in Australian and British secondary schools

Data collected

- The British data was based on questionnaires completed by pupils in year 8 (656 pupils), year 10 (715 pupils) and year 12 (225 pupils) mathematics classes in 16 British schools.
- The British and Australia data was aggregated in the analysis.

Key claims/evidence regarding the classroom teaching of mathematics

- Mean scores are presented for 11 scales: student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, equity, personal relevance, shared control, student negotiation, and academic efficacy.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- Study includes KS 4 pupils, but no separate breakdown is given for the target ability group.
- Classrooms characterised by high levels of cooperation, harmony, genuine teacher support, student cohesiveness, task orientation and equity are more likely to enhance pupil confidence.
- The authors express the concern that the standardised, regimented approach associated with the National Curriculum in England is unlikely to provide the level of freedom and independence in classroom necessary for the academic efficacy of pupils to be enhanced.

11. DORMAN JP, ADAMS JE, FERGUSON JM (2002) Psychosocial environment and student self-handicapping in secondary school mathematics classes: a cross-national study. *Educational Psychology* 22: 499-511. (This paper adds Canadian data to the data reported in paper 10, and includes additional data based on a measure of self-handicapping.)

12. DORMAN JP, ADAMS JE, FERGUSON JM (2003) A cross-national investigation of students' perceptions of mathematics classroom environments and academic efficacy in secondary schools. *International Journal of Mathematics Teaching and Learning*, 15 April. [e-journal] (This paper adds Canadian data to the data reported in paper 10.)

13. EDMISTON A (2003) A tale of two cultures. *Equals* 9: 4–8.

Overall weight of evidence score = Low

Focus of study

- To explore the use of cognitive acceleration through mathematics education (CAME) lessons

Data collected

- The researcher was a support teacher who makes regular use of 30 CAME lessons.
- The data presented is based on his own teaching of one year 7 lesson in a challenging school, where pupils tend to have negative attitudes towards mathematics.
- The lesson presented was on functions to explore ratio and proportion (CAME lesson 12).
- 29 pupils in the class (12 boys, 17 girls)

Key claims/evidence regarding the classroom teaching of mathematics

- The researcher states that the CAME materials seek to sow the seeds of mathematical reasoning skills needed in KS 4.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- KS 3 pupils in the target ability group are included.
- The teacher's experience of CAME lessons is that this approach can be used to develop a culture of co-operation and to see learning as a collaborative process.
- He claims the CAME approach led to these year 7 pupils gaining in confidence and motivation throughout the year.
- The study does not deal with KS 4 or provide evidence of its claimed benefits for KS 4.

14. GAGE J (1999) Shifts in confidence: the graphic calculator as a space in which to do mathematics. *Micromath* 15: 13–17.

Overall weight of evidence score = Low

Focus of study

- To explore the use of a graphic calculator with a year 10 mathematics class in relation to doing an open-ended piece of GCSE coursework

Data collected

- Te researcher was a teacher and the data is based on her own teaching.
- The class was the top set of four in one half of year 10 at a girls' grammar school.
- The pupils were told they were going to use a graphic calculator to investigate connections between some of the graphs, sequences and equations that had been covered in the previous term.
- Data is based on the teacher's observations of pupils during lessons; eight pupils were also interviewed at the end of the term.

Key claims/evidence regarding the classroom teaching of mathematics

- Use of graphic calculator led to enhanced understanding and insight.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- KS 4 pupils are included here, but not in the target ability group.
- Learning how to use a graphic calculator effectively can cause frustration which would discourage some pupils.
- Open-ended tasks are harder and require more confidence.
- Using the graphic calculator to undertake an open-ended task generated a high degree of anxiety, although some pupils enjoyed having to be self-motivated and having more ownership over their own learning.

15. GAGE J (2003) Videoconferencing in the mathematics lesson. Paper presented at the British Educational Research Association Annual Conference, Heriot-Watt University, Edinburgh, 11–13 September. (See also paper 16.)

Overall weight of evidence score = Low

Focus of study

- To explore the use of videoconferencing in school mathematics teaching (the Motivate Project) in a normal classroom setting

Data collected

- The data was based on four year 8 classes from two different schools; one class at each school was the experimental group and the other class was a control group.

- The data was described as being qualitative: semi-structured interviews, questionnaires with open-ended questions (post-treatment), videotapes of classroom discussion and accompanying written work (pre-treatment and post-treatment).
- The two schools held four videoconferences of about 30 minutes each at fortnightly intervals.

Key claims/evidence regarding the classroom teaching of mathematics

- Using videoconferencing in normal lessons required new thinking about content and management, but had proved possible without increasing teacher workload unacceptably.
- Videoconferencing had improved pupils' communication skills in both their oral and written and work.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- This study involved KS 3 pupils; pupils in the target ability group are explicitly mentioned here (one of the experimental classes is described as of 'below average ability').
- Videoconferencing enhanced pupils' motivation.
- Pupils found the interaction involved in videoconferencing was motivating.
- Some pupils were critical of some of the logistical and technical problems involved.

16. GAGE J, NICKSON M, BEARDON T (2002) Can videoconferencing contribute to teaching and learning? The experience of the Motivate Project. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12-14 September. (See also paper 15.)

Overall weight of evidence score = Low

Focus of study

- To explore the use of videoconferencing in school mathematics teaching (the Motivate Project)

Data collected

- The data was based on evaluation forms completed by over 50 teachers and 250 pupils in primary and secondary schools; 13 teachers were interviewed and some teachers emailed comments.
- The conferences involved 10 primary and over 50 secondary schools from 16 different parts of the UK.
- The project tried to involve schools where there is some degree of disadvantage.

Key claims/evidence regarding the classroom teaching of mathematics

- Pupils undertake project work in the classroom that they then present at the videoconference.
- Videoconferencing enabled many pupils to develop ICT skills in the use of spreadsheets, powerpoint, and the electronic whiteboard.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- Although no KS 4 pupils in the target ability group are explicitly mentioned, it seems highly probable that they have been included.
- The teachers and pupils reported that the pupils had found the experience enjoyable and that it had motivated them and boosted their confidence.
- 60% of the secondary school pupils reported that their confidence in their ability in mathematics had increased.
- 60% of the secondary school pupils reported that the experience had encouraged them to consider studying mathematics at a higher level.
- Some pupils were critical of some aspects of the experience, such as sitting passively for long periods.

17. GKOLIA C, JERVIS A (2001) Teachers' and pupils' perceptions of the use of integrated learning systems in English and mathematics education. Paper presented at the British Educational Research Association Annual Conference, University of Leeds, 13-15 September.

Overall weight of evidence score = Low

Focus of study

- To explore the use of integrated learning systems (ILS) in English and mathematics education in secondary schools

Data collected

- The data was based on semi-structured interviews of 6 teachers from four different 11-16 secondary schools and 7 pupils from three different schools; four teachers were IT teachers, one a mathematics teacher and one an English teacher.
- Three of the schools used *Successmaker* and the fourth used *Global*.

Key claims/evidence regarding the classroom teaching of mathematics

- Teachers felt ILS can benefit pupils from the whole range of ability.
- Pupils were enthusiastic about making unusually fast

learning gains using ILS.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- Neither KS 4 pupils nor target ability group are explicitly mentioned.
- Teachers felt ILS can be particularly useful in helping low achieving pupils to catch up, increasing motivation for learning and enhancing confidence.
- Both teachers and pupils reported that ILS raised motivation, with some evidence that this transferred back to the 'normal' classroom.
- The teachers felt the instant feedback ILS provided on every attempt kept pupils more motivated and active.
- Teachers reported that pupil motivation decreased as the novelty value of using ILS wore off, but pupils did not report this, although pupils reported that motivation could wane when a task was too long or repetitive.

18. GOULDING M (2002) Cognitive acceleration in mathematics education: teachers' views. *Evaluation and Research in Education* 16: 104-119.

Overall weight of evidence score = Low

Focus of study

- To explore how the cognitive acceleration in mathematics education (CAME) project was being implemented in schools

Data collected

- 21 teachers involved in the CAME project in seven schools were interviewed concerning the implementation of CAME in their school; their attitudes to the project; their understanding of the project's theoretical base; and their explanations of learning gains.
- The 21 teachers included three student teachers.
- Data was also collected in the form of field notes of a CAME in-service session and of a student and teacher discussing a videoed lesson.
- Five of the seven schools responded to a follow-up questionnaire a year later.

Key claims/evidence regarding the classroom teaching of mathematics

- 11 teachers were classified as having positive attitudes towards CAME, 8 as cautious, and two as negative/resistant.
- A distinctive contribution of CAME was the role of discussion as a means of involving pupils in co-operative activity.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- The focus is implicitly on KS 3; the target ability group are not explicitly mentioned.
- Teachers felt CAME had a positive effect on pupils' disposition towards doing mathematics: it encouraged them to be confident and to 'have a go'.
- CAME was felt to be of particular use for those boys who did not like writing things down.

19. HALLAM S, DEATHE K (2002) Ability grouping: year group differences in self-concept and attitudes of secondary school pupils. *Westminster Studies in Education* 25: 7-17.

Overall weight of evidence score = Low

Focus of study

- To explore year group differences in pupils' self-concept and attitudes towards school as influenced by ability grouping

Data collected

- Questionnaires were used to collect data on pupils' attitudes towards mathematics and school, on pupils' mathematics self-concept, school self-concept, and on pupils' preferences for different kinds of grouping.
- The sample comprised 234 pupils from years 7 to 10 at a mixed comprehensive school.
- In year 7, mixed ability groups were used; in years 8 and 9, pupils were setted within parallel bands; in year 10, setting was across the whole year group.

Key claims/evidence regarding the classroom teaching of mathematics

- Pupils' perceptions of teacher skills and support was not influenced by pupils' set placement or year group.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- This includes data on KS 4 pupils in the target ability group.
- The mean mathematics self-concept for each year group gradually increased from year 7 to 9, and then decreased to its lowest level for year 10 (largely due to a marked drop for the bottom set in year 10.
- Pupils' attitudes towards mathematics did not differ between year groups, but high, sets were the most positive, and low sets least positive.
- The data indicates that being in a lower set in year 10 has a negative impact on mathematics self-concept and attitudes to mathematics.
- 66% of pupils in year 10 were happy with their set

placement, but some pupils in middle and lower sets found the work too easy and wanted to be in a higher set, which may lead to underachievement.

20. HALLAM S, IRESON J (2005) Secondary school teachers' pedagogic practices when teaching mixed and structured ability classes. *Research Papers in Education* 20: 3-24. (This paper is linked to paper 23, which presents pupil data on their self-concepts.)

Overall weight of evidence score = Low

Focus of study

- To explore the effects of structured ability grouping on secondary school teachers' pedagogical practices

Data collected

- Questionnaires were used to collect data teachers' pedagogical practices.
- The sample comprised over 1,500 teachers from 45 mixed gender secondary comprehensive schools in London, southern counties, East Anglia and south Yorkshire.
- The sample of teachers included all heads of department, all lower school teachers of English, mathematics and science, and a sample of lower school teachers of other subjects
- The schools comprised 15 schools in each of three categories of ability group practice in years 7 to 9: mixed ability, partially set and set.
- Only aggregated data is presented; data completed by teachers of mathematics is not shown separately.

Key claims/evidence regarding the classroom teaching of mathematics

- The curriculum was more differentiated in ability grouped classes by content, depth, activities undertaken and resources used.
- Less able pupils were given more opportunities for rehearsal and repetition, more structured work, more practical work, less opportunities for discussion, less access to the curriculum, less homework with less detailed feedback, while work proceeded at a slower pace and was easier.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- KS 3 pupils in the target ability group are included.
- The authors claim that the practices that are more evident when low ability pupils are taught in ability group classes may be likely to be perceived by pupils as 'boring'.
- As the data for mathematics teachers is not presented separately, we are unable to tell how well (if at all) the general findings hold true for mathematics lessons.

21. HYDE R (2004) What do mathematics teachers say about the impact of ICT on pupils learning mathematics? *Micromath* 20: 11-13.

Overall weight of evidence score = Low

Focus of study

- To explore teachers' views about the impact of ICT on pupils learning mathematics

Data collected

- The data was collected by the researcher.
- The data is based on a questionnaire completed by 38 secondary school teachers of mathematics, each from a different school.
- The questionnaire covered the use of different 11 ICT resources and the impact of ICT on pupils' learning in KS 3 and KS 4.

Key claims/evidence regarding the classroom teaching of mathematics

- Using a four-point scale (labelled: very little, some, significant, and substantial), 18% of the teachers reported ICT had a substantial impact in KS 3 and 21% of the teachers reported ICT had a substantial impact in KS 4
- The percentage of teachers reporting using the 11 different ICT resources ranged from 100% for using websites to 64% for using the interactive whiteboard.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- This study relates to KS 4 and includes the target ability group.
- The teachers reported that interactive whiteboards has a high level of positive impact on pupils' motivation.
- No other ICT resource was explicitly linked to motivation, but the notion of impact on pupils' learning may, for some teachers, have implicitly included an impact on pupil motivation.
- The impact of ICT on pupils appears to be related to teachers' confidence in using ICT.

22. IRESON J, HALLAM S, MORTIMORE P, HACK S, CLARK H, PLEWIS I (1999) Ability grouping in the secondary school: the effects on academic achievement and pupils' self-esteem. Paper presented at the British Educational Research Association Annual Conference, University of Sussex at Brighton, 2-5 September. (This paper is linked to paper 23; it is an earlier version the same study, and includes some additional data and a larger sample; see paper 23.)

23. IRESON J, HALLAM S, PLEWIS I (2001) Ability grouping in secondary schools: effects on pupils' self-concepts. *British Journal of Educational Psychology* 71: 315–326. (This paper is linked to paper 20, which presents teacher data on their pedagogic practices.)

Overall weight of evidence score = Medium

Focus of study

- To explore the effects of structured ability grouping on year 9 pupils' self-concepts

Data collected

- Questionnaires were used to collect data on five scales of self-concept: mathematics, English, science, general and self-esteem; data on the pupils' KS 3 test marks in English, mathematics and science was also collected from school records.
- The sample comprised over 3,000 year 9 pupils from 45 comprehensive schools in England.
- The schools were divided into three categories of ability group practice in years 7 to 9: mixed ability, partially set and set.

Key claims/evidence regarding the classroom teaching of mathematics

- 29 of the 45 schools rigorously divided their pupils into sets for mathematics in year 9.
- Academic self-concept was related to KS 3 attainment in each curriculum area (0.30 for mathematics).
- Academic self-concept in mathematics was higher for boys even when their attainment was similar to that of girls.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- KS 3 pupils in the target ability group are included.
- Setting in mathematics did not appear to have an impact on pupils' self-concept in mathematics.
- Authors argue that the lower academic self-concept in mathematics for girls is a cause for concern, as it could impact negatively on their motivation and later mathematics course choices.

24. JACKSON C (2002) Can single-sex classes in co-educational schools enhance the learning experiences of girls and/or boys? An exploration of pupils' perceptions. *British Educational Research Journal* 28: 37–48.

Overall weight of evidence score = Low

Focus of study

- To explore the perspectives of boys and girls in a co-educational school on the use of single-sex mathematics classes

Data collected

- The school was a mixed-sex inner-city comprehensive school in the south-west of England, where pupils spent year 7 and the first two terms of year 8 in single-sexed mathematics classes before moving to mixed-sexed mathematics classes.
- Data was collected from pupils by questionnaire administered to all pupils at the end of year 7 (79 responses: 40 girls and 39 boys) together with interviews of 11 pupils (5 girls and 6 boys) in the summer term of year 8 (about three months after entering mixed-sex mathematics classes).

Key claims/evidence regarding the classroom teaching of mathematics

- The classroom climate reported by girls in single-sex classes was more relaxed and supportive, while for boys it was more competitive and aggressive.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- KS 3 pupils in the target ability group are included.
- 80% of year 7 girls expressed being more confident in single-sex classes, while 33% of year 7 boys expressed being less confident in single-sex classes.
- 55% of year 7 girls reported that they enjoyed mathematics in single-sexed classes, while 72% of year 7 boys said they enjoyed mathematics more in mixed-sex classes.
- The author notes that girls only classes seemed to have many positive effects for girls, but single-sexed classes do not appear to be helpful for boys: they may do nothing to challenge the laddish culture inherent in schools and, indeed may exacerbate it.

25. JONES S, TANNER H (2002) Teachers' interpretations of effective whole-class interactive teaching in secondary mathematics classrooms. *Educational Studies* 28: 265–274.

Overall weight of evidence score = Low

Focus of study

- To explore the impact of introducing whole-class interactive teaching strategies into mathematics lessons

Data collected

- The data was based on a teacher inquiry group comprising eight mathematics teachers from four secondary schools in South Wales.
- The data comprised lesson observations, interviews and discussion at group meetings.
- The pupils taught were in years 7 and 8.
- This paper focuses on the quality of the discourse developed within classrooms and the strategies teachers used to encourage pupils' reflection.

Key claims/evidence regarding the classroom teaching of mathematics

- Pupils were encouraged to contribute ideas and to explain their methods to the class.
- The legitimation of pupils' own mathematical thinking was explicitly emphasised.
- Despite every teacher trying to finish with a plenary, they were often omitted.
- The quality of interaction varied between teachers, depending on the types of scaffolding used, the opportunities created for reflection, and the degree of pupil ownership.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- The focus here was on KS 3 pupils; although pupils in the target ability range are not explicitly mentioned, it seems highly probable that they are included.
- Every teacher considered their pupils to have become far more confident about mathematics.

26. MILLER D, GLOVER D, AVERIS D (2005) Presentation and pedagogy: the effective use of interactive whiteboards in mathematics lessons. In: Hewitt D, Noyes A (eds) Proceedings of the Sixth British Congress of Mathematics Education held 30 March to 2 April at the University of Warwick. *BSRLM Proceedings* (Vol. 25). London: British Society for Research into Learning Mathematics.

Overall weight of evidence score = Low

Focus of study

- To explore the use of interactive whiteboards (IAWs) in mathematics lessons

Data collected

- Teachers in 18 secondary schools who make extensive use of IAW technology were identified and 37 mathematics lessons were videorecorded.
- The teachers were interviewed using a semi-structured interview schedule.
- The teachers also took part in five discussion sessions based upon summaries of the evidence collected.

Key claims/evidence regarding the classroom teaching of mathematics

- IAW teaching can enhance presentations and manipulations that can enliven understanding and learning.
- Teachers who had consistently used IAWs for at least the previous year were inclined to use manipulations to foster interactivity rather than use IAWs simply to enhance presentation.
- The six most common manipulations were labelled: drag and drop; hide and reveal; colour, shading and highlighting; matching items; movement or animation; and immediate feedback.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- KS 3 pupils are included. Explicit mention is made of data regarding years 7, 8 and 9; no mention is made of pupil ability but pupils in the target ability group are probably included.
- Pupil motivation was enhanced by three major features of IAW teaching, which were labelled intrinsic stimulation, sustained focus, and stepped learning.
- IAW teaching enhanced pupils' attention through interactivity, pace and differentiation.
- In the initial stages of using IAW teaching, pupils need to develop a range of skills to use this medium, and their self-esteem might be undermined if they are unable to do this.

27. NARDI E, STEWARD S (2003) Is mathematics TIRED? A profile of quiet disaffection in the secondary mathematics classroom. *British Educational Research Journal* 29: 345-367. (This paper is lined to papers 28 and 30.)

Overall weight of evidence score = Medium

Focus of study

- To explore disaffection among year 9 pupils in mathematics lessons

Data collected

- The data was based on a one-year study of three year 9 mathematics classrooms (each in a different school) in Norwich.
- The data comprises lesson observations and interviews with all 70 pupils in these three classes.
- The focus was on middle ability sets (i.e. sets whose pupils who are projected in two years' time to a achieve a grade C or D at GCSE).

Key claims/evidence regarding the classroom teaching of mathematics

- A profile of quiet disaffection in mathematics lessons is identified which comprises five characteristics (TIRED): *tedium* (irrelevant and boring), *isolation* (little opportunity to work with peers), *rote learning* (rule-and-cue following), *elitism* (only exceptionally intelligent pupils can succeed) and *depersonalisation* (alienation resulting from an absence of work tailored to their needs).

Key claims/evidence regarding raising target group pupil motivation in KS 4

- The study focuses on KS 3 pupils in the target ability group.
- Pupils' engagement in mathematics lessons is based on a sense of obligation, with little expectation of joy.
- The pupils called for activities which are useful, enjoyable, better tailored to individual needs, and based on collaboration and group work.
- The authors hope these findings can form the basis for developing re-engagement strategies.

28. NARDI E, STEWARD S (2002) I could be the best mathematician in the world... if I actually enjoyed it. *Mathematics Teaching* 179: 41–44. (This paper is linked to paper 27 and reports the same study; see paper 27.)

29. SMITH E, GORARD S (2005) 'They don't give us our marks': the role of formative feedback in student progress. *Assessment in Education* 12: 21–38.

Overall weight of evidence score = Medium

Focus of study

- To explore the effects of a 'formative feedback only' intervention on pupil progress

Data collected

- The data was collected at one comprehensive school in Wales.
- Year 7 pupils were divided into four mixed ability groups (26 pupils each) of which one was given enhanced formative feedback on their work for one year, but no marks or grades.
- The data collected covered assessment, prior attainment, pupil attitudes and background information.
- Te data included observation of the process, a questionnaire completed by all 104 pupils, and group interviews with treatment pupils.
- The attainment data covered the four core subjects of English, mathematics, science and Welsh.

Key claims/evidence regarding the classroom teaching of mathematics

- Pupils in the treatment (formative feedback only) group made less progress overall compared with the control group (the difference being clear in English, mathematics and Welsh but unclear in science).
- Many of the pupils in the treatment group expressed negative views about not getting marks or grades, and about the usefulness of the formative comments.
- In particular, pupils complained that the formative comments tended to focus on enhancing self-esteem or self-image and did not provide them with information on how they could how to improve.
- The consensus among pupils in the treatment group was that they would prefer to receive both marks and comments together.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- Considers KS 3 pupils; pupils in the target ability group are included.
- The use of formative feedback only seems to have caused confusion and a lack of motivation.
- No extracts from the pupil interview data are presented; however, explicit reference to mathematics.
- The evidence here is that providing feedback comments only was not effective in raising pupil motivation or attainment.

30. STEWARD S, NARDI E (2002) I could be the best mathematician in the world... if I actually enjoyed it: part 2. *Mathematics Teaching* 180: 4–9. (This paper is linked to paper 27 and reports the same study; see paper 27.)

31. TANNER H, JONES S (2003) Self-efficacy in mathematics and students' use of self-regulated learning strategies during assessment events. In: Pateman NA, Dougherty BJ, Zilliox J (eds) *Proceedings of the 27th Annual Conference of the International Group for the Psychology of Mathematics Education held in Honolulu, Hawaii, 13–18 July* (Vol. 4).

Overall weight of evidence score = Low

Focus of study

- To explore pupils' beliefs about themselves as learners of mathematics and the strategies they use before and after assessment

Data collected

- The data was based on a questionnaire comprising 47 statements and a Likert-type response scale completed by 303 year 9 pupils (two classes in each of 6 comprehensive schools in Wales).
- The questionnaire covered: (i) pupils' self-efficacy in mathematics, (ii) pupils' metacognitive knowledge, and (iii) strategies which pupils might use for learning mathematics.

Key claims/evidence regarding the classroom teaching of mathematics

- The vast majority of pupils thought it was worthwhile to try hard in mathematics (93%) and to revise for examinations (90%).
- Pupils generally attribute success in mathematics to hard work (84%) and doing lots of revision (71%).
- The more effective learning strategies were used by pupils with good metacognitive knowledge.
- Most pupils lack effective strategies for revision.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- The focus here was on KS 3 pupils; although pupils in the target ability group are not explicitly mentioned, it is highly probable that they are included.
- Some pupils are in a virtuous circle where metacognitive knowledge leads to the use of effective learning strategies and an increase in self-efficacy beliefs.
- Some pupils are in a vicious circle where their failure to apply effective learning strategies leads to failure in assessments and a lowering of self-efficacy beliefs.
- The authors argue that teachers need to teach pupils self-regulated learning strategies that will break this vicious circle.

32. WATSON A, DE GEEST E (2005) Principled teaching for deep progress: improving mathematical learning beyond methods and materials. *Educational Studies in Mathematics* 58: 209–234. (This paper is linked to papers 9 and 33, and reports the same study.)

Overall weight of evidence score = High

Focus of study

- To explore the use of innovative practices in the teaching of low-attaining secondary pupils in mathematics

Data collected

- The data was based on action research with 10 teachers over two years and involved over 250 year 7 pupils.
- The effects of the innovative practices on pupils' learning was evaluated using national test scores, teachers' reports, non-routine tasks and other performance indicators.
- All the teachers were teaching lower secondary mathematics sets in which at least half the class were achieving below the government standards for entry to secondary school, and the others were only barely achieving.

Key claims/evidence regarding the classroom teaching of mathematics

- The teachers employed a variety of changes in their practices and activities which involved a greater emphasis on pupil learning rather than simply completing tasks.
- Pupils were encouraged to engage in discussion, and were given more choice, freedom, challenge (with support), responsibility and time.
- A set of principles characterising the shared beliefs of the project teachers was identified, which generated the changes in practices the teachers initiated and evaluated.

Key claims/evidence regarding raising target group pupil motivation in KS 4

- This study focused on KS 3 pupils in the target ability group.
- Teachers reported that pupils became more enthusiastic, more willing to work and more engaged mathematically.

33. WATSON A, PRESTAGE S, DE GEEST E (2002) Moving to the edge of the comfort zone: mathematical thinking and strategies used to promote it. Paper presented at the British Educational Research Association Annual Conference, University of Exeter, 12-14 September. (This paper is linked to papers 9 and 32 and reports the same study; see paper 32.)

34. WILIAM D, BROWN M, BOALER J (1999) 'We've still got to learn': low attainers' experiences of setting. *Equals* 5: 15-18. (This paper is linked to papers 4 and 6, and reports the same study as paper 6; see paper 6.)

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

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First produced in 2006 by:

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