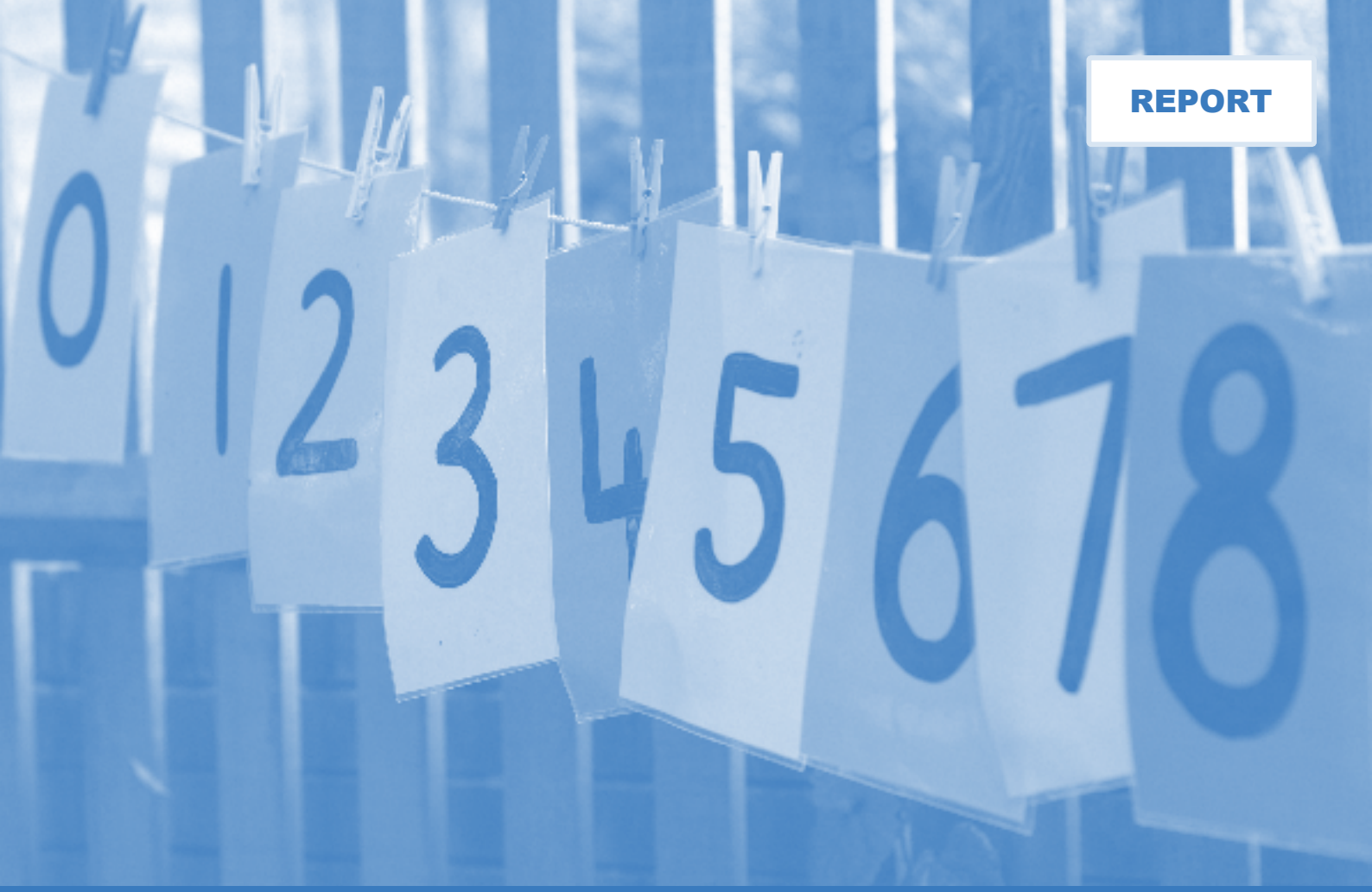

REPORT

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

Report written by Chris Kyriacou and Maria Goulding

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

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EPPI CENTRE
SSRU Social Science Research Unit
INSTITUTE OF EDUCATION UNIVERSITY OF LONDON

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REPORT

Review conducted by the Mathematics Review Group

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/**

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CONTENTS

Abstract

The 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?

Who wants to know and why?

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 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.

Methods of the review

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 mathematics 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.

Implications

The issues identified here are very much in line with the analysis by the Department

for Education and Skills (DfES) 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 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 towards enabling 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 Key Stage 4 Mathematics. What is needed, however, 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

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.

The review question adopted was 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?

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.

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).

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:

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 fully understand 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.

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).

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

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 by-product 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).

Policy and practice context

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

Research context

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

i. Sudies 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

ii. Sudies 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.

iii. Sudies 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)

iv. Sudies which have looked at the influence of pupils' attitudes and context factors 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)

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 Fgure 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, and which includes the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMMS) surveys.

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.

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 intended to disseminate the findings of the review through internet access

CHAPTER TWO

Methods of the review

to the review report, publication in an academic journal, and conference papers.

Review methods

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

User involvement

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

Identifying and describing studies

Identifying relevant studies involved carrying out an electronic search using keywords of bibliographic databases, handsearching through key journals and conference proceedings, citations, and publications recommended by contacts. The scope of the research was limited to publications dated 1999 or later, and focused on pupils in key stages 3 and 4 (i.e. aged 11 to 16 years). Explicit inclusion/exclusion criteria were applied in two stages. The first stage of filtering was based on a consideration of titles and, where available, an abstract. The second stage involved applying the inclusion/exclusion criteria to a full copy of each of these papers. 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 key stages 3 or 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.

The included studies were mapped using the EPPI-Centre's data-extraction guidelines together with its data-extraction software, EPPI-reviewer.

In-depth review

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

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

CHAPTER THREE

What research was found?

25 papers were identified for the systematic map: Andrews and Hatch, 2000, 2002; Bartholomew, 2000; Bills and Husbands, 2005; Boaler et al., 2000; Cramp and Nardi, 2000; Crisan, 2004; Dorman and Adams, 2004; Edmiston, 2003; Gage, 1999, 2003; Gage et al., 2002; Gkolia and Jervis, 2001; Goulding, 2002; Hallam and Deathe, 2002; Hallam and Ireson, 2005; Hyde, 2004; Ireson et al., 2001; Jackson, 2002; Jones and Tanner, 2002; Miller et al., 2005; Nardi and Steward, 2003; Smith and Gorard, 2005; Tanner and Jones, 2003; Watson and De Geest, 2005 (details of nine subsidiary papers are also listed in the references.

20 of the 25 papers were published, of which 17 were journal papers and 8 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 time lag between the start of the research and its publication, the 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 25 studies were written in English: 22 of the studies included data collected in England, and 3 presented data from Wales. 16 studies had a population focus on pupils; the remaining 9 papers had a population focus on teachers. Of the 16 studies which had a population focus on pupils, only 7 included data from KS 4 pupils. 16 studies were categorised in terms of study type as an 'evaluation'; 13 of these were 'naturally occurring evaluations' and three were 'researcher-manipulated evaluations'. The remaining nine studies comprised 1 study categorised as 'description' and 8 studies categorised as 'exploration of relationships'.

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 and 3 were based on interview data. Most of the studies (15 studies), however, used a mixture of data. These included three studies that were case studies of one teacher's practice.

Only one study (Watson and De Geest, 2005) received an overall weight of evidence rating of 'high', 8 studies were rated 'medium'; 16 studies were rated 'low' (see technical report).

CHAPTER FOUR

What were the findings of the studies?

The analysis of the 25 included studies led to the identification of the following four key areas:

i. Grouping

ii. Pupil identity

iii. Teaching for engagement

iv. Innovative methods

The analysis focused 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 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 below.

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 overarching category within which other categories could be subsumed. 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'.

It will be evident from the synthesis 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'. However, 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 here 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 so as 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 the 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 score for each of the included studies 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 weight of evidence 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). Since 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 may impact on pupils' attitudes differently. These four studies essentially employed this paradigm. However, it is worth noting here that, 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 in a higher or lower set may differ. 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 here 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. So the same teachers could be seen to adopt very different approaches with sets and mixed ability groups, rather than adapting and carrying 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 here 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 set-

ting *per se,* as some degree of misplacing in 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, they 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, of 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 might 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, which 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 also a mixed ability group, 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 here, 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 here the current preoccupation with strategies to raise motivational effort across the school curriculum for boys. It is important in the current context 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 here: 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 pre-dominance 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).

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 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 - 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 here 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 overrepresented in the top set, because high ability girls are more likely also to display mathematics anxiety than high ability boys. As such, strategies than 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 being primarily related to motivational effort (rather than ability), many of these pupils 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: that is, 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 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 the class.

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 (Elliot et al., 2005; Elwood, 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 (particu-

larly 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.

The potential influence of ethnicity was not addressed by the included studies, but the influence of gender was. 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) 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' (p 7).

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 shared 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, longer on participation and concentrating on learning as much as possible, rather than focusing on finishing tasks. Another principle, 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: 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 effort.

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 to note here 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 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. Interestingly here, 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 reflect better 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 (2003).

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 (Elliot et al., 2005; Elwood, 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, of course, 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 point 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) and 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 to gain a deeper understanding of the mathematics they are doing and also by enabling them to develop self-regulation strategies that will be more effective in improving the quality of their own learning, and in preparing for an assessment and making use of feedback following the assessment.

Tanner and Jones's (2003) study on pupil self-regulation strategies shows that helping 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

However, 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 indicate 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.

Tanner and Jones study 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 (2003). Certainly, the wider international research literature does 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.

CHAPTER FIVE

Implications

Strengths and limitations of this systematic review

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 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 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. 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; 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 in which strategies can be developed and subjected to rigorous evaluation.

Implications for policy and practice

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 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.

There is also little doubt that there is a vast array of initiatives that are current taking place in schools, many of which are already indicating ways in which raising 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.

Implications for 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.

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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.

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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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