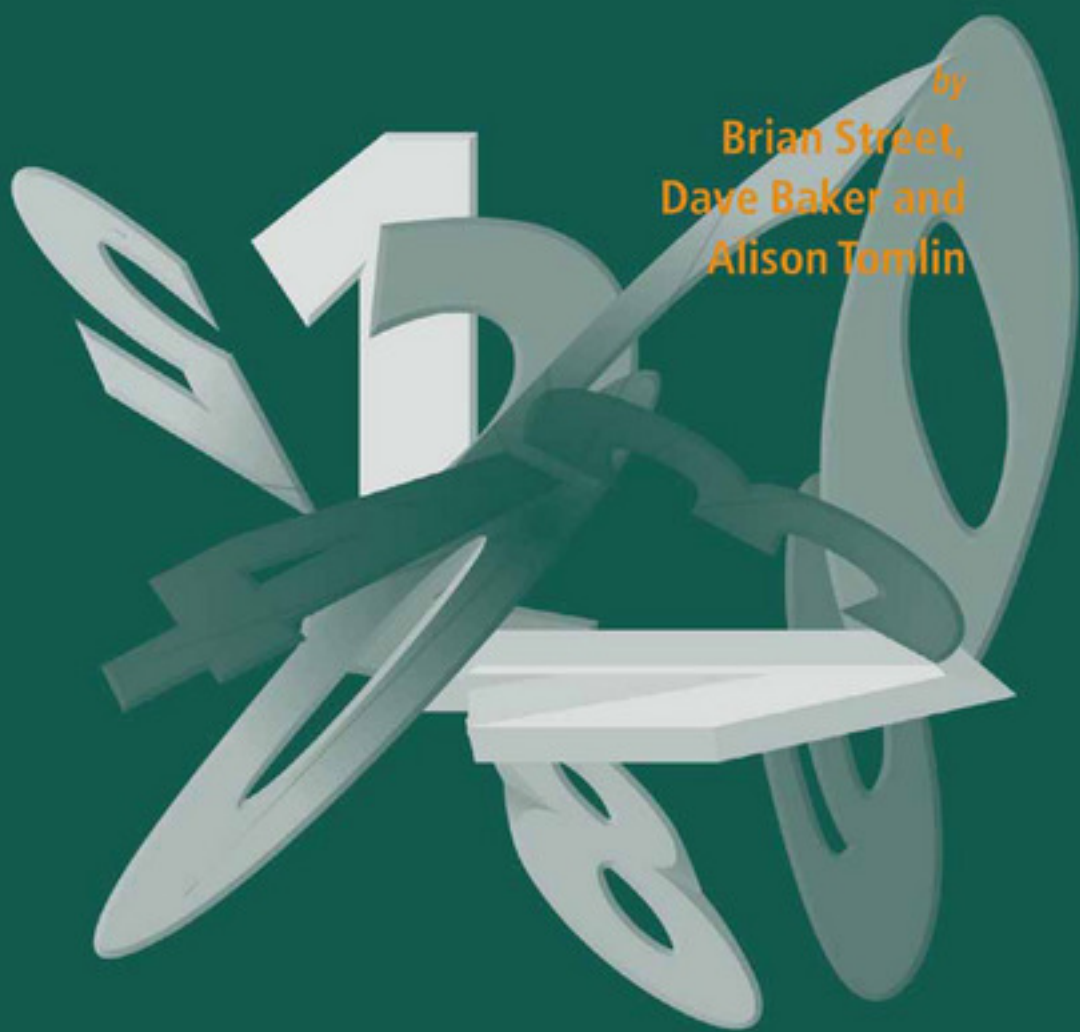


MULTIPLE PERSPECTIVES ON ATTAINMENT IN NUMERACY

NAVIGATING NUMERACIES

Home/School Numeracy Practices

by
Brian Street,
Dave Baker and
Alison Tomlin



 Springer

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by

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A C.I.P. Catalogue record for this book is available from the Library of Congress.

ISBN 10 1-4020-3676-0 (HB)
ISBN 13 978-1-4020-3676-7 (HB)
ISBN 10 1-4020-3677-9 (e-book)
ISBN 13 978-1-4020-3677-4 (e-book)

Published by Springer,
P.O. Box 17, 3300 AA Dordrecht, The Netherlands.

www.springeronline.com

Printed on acid-free paper

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Printed in the Netherlands.

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MARGARET BROWN

FOREWORD

Abstract. This introduction sets the scene for the remainder of the book by considering first the international context of widespread concern about the improvement of numeracy skills. This is related to reform movements in the UK, the US and other countries aimed at modernising primary (elementary) school mathematics curricula. A detailed account is given of the National Numeracy Strategy in England, a systemic government-imposed response to concern about standards implemented in 1999/2000. This includes a discussion of the alternative meanings of numeracy. An earlier initiative sponsored by a UK charitable trust reacting to concern about primary numeracy was the Leverhulme Numeracy Research Programme. This large-scale longitudinal study and linked set of case-study projects, focusing on reasons for low attainment, took place during 1997-2002. This book, and each other in the same series, is based on results of that research. The timescale fortuitously enabled the research team to also report on some effects of the systemic reform in the National Numeracy Strategy.

1. THE INTERNATIONAL CONTEXT

In many countries, there are recurring periods of national concern about the low standards of calculation skills shown by children in primary (elementary) schools. Recently these concerns have become more urgent and more political with the publication of international comparisons of mathematical achievement, first at secondary and more recently at primary level (e.g. Lapointe, Mead et al. 1992; Mullis et al., 1997). Dismay at a low position in the international league tables has in some cases triggered a programme of systemic reform (National Commission for Excellence in Education, 1983; Brown, 1996).

A further reason for government concern over mathematical standards is the realisation that countries in the developed world will require a highly skilled numerate workforce to maintain their economic competitiveness, while developing nations will need to improve the mathematical skills of their population as a basis for building technical and financial capacity. South Korea, a country which is close to the top of every mathematical league table, provides an example to demonstrate that high attainment is possible, even for countries with relatively low Gross National Product.

In many English-speaking countries, and some others, the concern over low attainment in number skills has led to a desire by governments for increasing control of the content, teaching and assessment of primary mathematics. In some countries such increasing government control has come after, and to some extent as a response to, curriculum changes aimed at modernising the primary curriculum and emanating from mathematics educationists and teachers.

For example in the United States the National Council of Teachers of Mathematics Standards (1989; 2000) authorised a primary curriculum which was broad, going well beyond number to statistics and geometry, and emphasised

problem-solving, reasoning and mathematical communication. Understanding and appreciation of numbers and number operations, mental strategies and the ability to estimate, i.e. 'number sense' (Reys, Reys et al., 1993) were seen as more important than proficiency in pencil-and-paper algorithms in a society which had ready access to calculators and computers. Informed by constructivist (e.g. Carpenter and Peterson 1988; Steffe and Gale, 1995; Davis, 1984; Maher and Davis, 1990) and social constructivist (e.g. Cobb and Bauersfeld, 1995) results and beliefs about learning, 'reform' initiatives incorporating the Standards have aimed at making learning more participatory and discussion-based, and teachers more knowledgeable about, welcoming of, and responsive to, pupils' own methods and ideas. Such reform initiatives in fact built on a variety of earlier projects since the 1950s, aimed at active and investigatory learning, including problem-solving. Although evaluation of children's learning in the various reform projects has been overwhelmingly positive, there has been some vocal opposition among religious fundamentalists, conservative mathematicians and other right wing groups which has given rise to the 'math wars'. Such groups, who saw the changes as undermining social control and traditional computational standards, have won control in some states, and have persuaded the federal government to impose a comprehensive programme of statewide recurrent testing of mathematical standards.

A very similar pattern has taken place in the UK. A series of initiatives from the 1950s onwards, led by people such as Edith Biggs, Geoffrey Matthews with the Nuffield Project, Elizabeth Williams and Hilary Shuard, were aimed at broadening the primary curriculum and making it more child-centred and investigatory. Changes had been at least partially implemented in most schools by the mid-1980s, encouraged by the relatively progressive report of the national Cockcroft Committee (Department of Education and Science/Welsh Office, 1982). Hilary Shuard's work in the 1980s on the Calculator Aware Number (CAN) curriculum, which emphasised investigation, mental strategies and calculator methods and avoided pencil-and paper algorithms, received international recognition. However after further panic about the role of mathematical standards in industrial decline in the 1980s, and concern that the Cockcroft Committee, set up originally to investigate this, had been subverted by educationist agendas, further moves were made towards government control. These included the imposition of a national curriculum in 1989 followed by a programme of national testing (Department of Education and Science/Welsh Office, 1988). In spite of government pressure, educationists responsible for the detail maintained a broad and modern curriculum and testing programme with only minor concessions in the direction of pencil-and-paper calculation.

However in the 1990s government control tightened once again through publication of test results in league tables, a programme of frequent inspections by the Office for Standards in Education (Ofsted) which put pressure on all schools, but especially those with poor test results. As in the US such schools were initially entitled to additional support but could in the long term be closed. A desire to focus on number skills and revert to traditional teaching methods culminated in the National Numeracy Strategy which, because it forms an important part of the context of the research reported in this book, is described in detail later in this chapter.

As in the US, these moves towards greater government control have been followed by teacher shortages, especially in London and the prosperous South East of England. Vacant posts are sometimes filled by teachers on temporary contracts from private employment agencies, who are often recruited from other countries.

In Australia and New Zealand similar moves were made by governments, first imposing a national curriculum which was relatively vague and progressive, and then with a further tightening and re-focusing on number. Nevertheless the moves have stopped well short of the degree of government control that has occurred in the US and UK, and have involved much greater co-operation with educationists in developing new programmes which are research-based and properly evaluated

It is interesting to compare these changes with national reform of the primary mathematics curriculum and assessment in Holland. Here the 'Realistic Maths' programme, developed by the Freudenthal Institute (Streefland, 1991; Treffers 1991; Gravemeijer, 1997) has many features in common with reform programmes in other countries but with a greater emphasis on the development of mathematics out of models of real world situations. Perhaps because of good performances in national tests, the programme seems to have been allowed to go ahead with minimal political interference, and has achieved a coherence of vision that is probably unique. It has also influenced developments in several other countries, such as the US and UK, and South Africa.

It should be noted that some other countries which have had a tradition of a much greater degree of government control are moving in the opposite direction. Countries like Singapore, Japan and China where there has been great emphasis on number skills are trying to shift the focus to individual creativity and problem-solving skills.

Thus it is clear that all over the world governments and educationists are examining their curricula and teaching methods in primary mathematics and comparing them with those in other countries to see if higher standards in a range of objectives can be achieved.

This means that although this series of books deals with research from the UK, the results are likely to be of interest and use in many other countries, whether they are like other Anglophone countries already moving in similar directions or whether they are simply considering a range of alternative models.

2. THE MEANING OF NUMERACY

In some countries numeracy is a synonym for mathematical literacy, and hence includes areas of mathematics beyond number, for example, geometrical properties, algebra and logical reasoning. In this book however we will restrict numeracy to dealing only with numbers and operations on numbers, recognising that this to some extent includes application of number in work on measures, statistics and metric geometry.

Numeracy is now generally understood as a competence in interpreting and using numbers in daily life, within the home, employment and society. Thus the meaning of numeracy must relate to the social context of its use and the social practices that

are adopted in that context (Baker, 1999). The definition of numeracy therefore must be relative and differ not only between different national cultures, but between different subcultures and local circumstances within the same national culture. For example within one household numeracy might be judged by the ability to purchase appropriate quantities of materials and successfully complete household decorations and repairs, such as constructing and putting up a set of book shelves, whereas in the next door household numeracy might be conceptualised in relation to ability to participate intelligently in a family discussion of changes in government economic policy. It is even clearer that different forms of employment involve different practices. Moreover the mathematics underlying employment practices such as those used by nurses can be subtle and difficult to ascertain (Noss, 1997). And even participation as an active citizen in a democratic society might be thought to range from the ability to interpret bar graphs of mean income by region presented in the popular media, to the ability to critique government scientific policy, for example on genetic modification of crops, with reference to papers in scientific journals.

Thus it is not easy for those with the power to make to decisions over mathematics curricula and assessment, whether in schools, local areas, states or countries, to agree what constitutes a minimal competence in numeracy required for social survival, what should be expected of most citizens and what additional aspects of numeracy over and above this level should be aimed for.

It was accepted by educational policymakers in the UK that numeracy was to be defined broadly as the competence and inclination to use number concepts and skills to solve problems in everyday life and employment. Nevertheless it was felt necessary, for political and educational reasons, that the aspect of numeracy to be newly emphasised at primary level should be proficiency in a culturally neutral context-free set of number skills, underpinned by abstract visual models, such as the number line (Department for Education and Employment, 1998). In contrast to 1980s developments, there is now little reference in the primary numeracy guidance to applications or problem-solving, and those which occur are mainly traditional 'word-problems', with artificial contexts.

Because this series of books concerns numeracy in English primary schools in the period 1997-2002, we will generally use numeracy in this narrow and traditional sense. However this usage does not reflect the beliefs of the authors.

3. THE NATIONAL NUMERACY STRATEGY

The Conservative UK Government of 1992-97 had taken 'back to basics' as one of its slogans in education as in other policy areas. As part of this theme high profile National Literacy and National Numeracy Projects were launched in 1996, each in a group of local education authorities which mainly had poor results in national tests. The Labour Party under the leadership of Tony Blair fought the 1997 election with an education policy which differed little from that of the Conservatives, and again emphasised the need to raise standards of basic skills in primary schools, with specific targets for national test results in 2002.

The Labour Party when elected already had plans to extend the National Literacy Project into a National Literacy Strategy to be implemented in all schools in England during the school year 1998/9. They had also set up a Task Force to plan during 1997/8 the details of a National Numeracy Strategy, probably to be based on the National Numeracy Project, to be introduced in all primary schools in England during 1999/2000. This decision was made before any formal evaluation of the National Numeracy Project was available, although informally it was known to be welcomed by teachers and headteachers.

The key features of the National Numeracy Strategy were:

- *an increased emphasis on number and on calculation*, especially mental calculation, including estimation, with pupils being encouraged to select from a repertoire of mental strategies. Written calculation was postponed but informal and later standard written procedures were to be introduced. Calculators were discouraged, although use of them was to be taught in specific lessons starting from Year 5 (age 9/10)
- *a three-part template for daily mathematics lessons*, starting with 10-15 minutes of oral/mental skills practice, then direct interactive teaching of the whole class and groups, and finally 10 minutes of plenary review
- *detailed planning using a suggested week-by-week set of objectives*, specified for each year group. The objectives were listed, with detailed examples to explain them in a key document 'The Framework for Teaching Mathematics from Reception to Year 6' (Department for Education and Employment, 1999). This covered areas of mathematics other than number, but introduced many mental strategies earlier than previously. Teachers were expected to reduce their dependency on text books, using the Framework document as a day-to-day reference point and referring to published text book schemes only as a source of examples
- *a systematic national training programme* based on standard packages of training materials, providing timetables, overhead transparencies to illustrate key points, and videos to demonstrate 'best practice'. Training in each Local Education Authority was organised for teachers from each school by newly appointed trainers acting as consultants and working to regional directors, under a national director. In all schools the training was run by school mathematics co-ordinators, with additional support from consultants for low-performing schools, both in-school and via local courses.

Although not legally imposed, the Numeracy Strategy has been almost universally implemented, and is being extended in a slightly modified form to secondary schools. Most teachers and headteachers have welcomed the Strategy, although teachers found it very hard work to implement, since it required them to plan new introductions to many topics and to prepare new teaching material for each lesson. Previous to this many had been following either commercially produced textbook schemes directly or schemes-of-work written in the school which made reference to published schemes. Many publishers worked hard to issue new textbook schemes to match the Framework but few were ready in time for the first year of the implementation.

Ministers expressed disappointment that national test results for children at age 11 in 2000 and 2001 failed to improve as much as expected after the introduction of the Strategy in the school year 1999/2000. (The proportion gaining the expected result for this age-group, Level 4, had gone from 69% in 1999 to 72% in 2000 and dropped back to 71% in 2001, against a national target of 75% in 2002.) Hence during 2001/2 detailed lesson plans were developed by the central team for all lessons in Years 4 and 6 (pupils aged 8-9 and 10-11 years) and were circulated to all teachers. These were later extended to include Year 5 (pupils aged 9-10 years) and piloted for Years 1 to 3 (pupils aged 5-8 years). While again there was no requirement to implement these, it was known that inspectors would expect teachers to be teaching from these plans and that they would need to provide a sound explanation if they chose alternatives. In fact teachers welcomed the plans as they saved a lot of preparation time and were generally felt to be of good quality.

The Numeracy Strategy was highly resourced in terms of training and training materials with an initial funding of £55 million and a later supplement of £25 million for the first three years. The initial training just prior to the school year 1999/2000 was a Three-day course run out-of-school by the local consultants for mathematics co-ordinators (subject leaders), headteachers, one other teacher from each school and a school governor. The co-ordinator was required to 'cascade' this training for other teachers and assistants in the school during three training days during 1999/2000. Additional training and support, in the form of both school visits by the consultant and a Five-day external course for two teachers, was given to schools identified as in need of 'intensive' support. This support was extended in subsequent years to a wider range of schools.

Some local teachers were designated as 'leading mathematics teachers' and given additional training and release time; teachers from their own and other schools were invited to observe them teach and discuss the lesson and other points with them afterwards.

Schools were provided with some additional money for resources but expected to spend it on equipment which was promulgated by the Strategy and shown in videos e.g. small white boards, number fans and digit cards for each pupil, 100-squares, counting rods, number lines and place value cards. They were also expected to provide release time for their mathematics co-ordinators to work with colleagues.

More details about the Strategy are available from its central offices (e-mail: nnswebeditor@cftb-hq.org.uk) and from reports by the official evaluators (Earl et al., 2000; Earl, Levin, Leithwood, Fullan & Watson, 2001) and from the inspectorate (Office for Standards in Education, 2000a; 2000b; 2001)

4. THE LEVERHULME NUMERACY RESEARCH PROGRAMME

The national concern about standards of numeracy in England in the late 1990s also led the Trustees of the Leverhulme Trust, a charitable foundation, to offer to fund a £1 million 5-year study on low attainment in basic skills at primary level. The competition for the funding was won by a team based at the Department of Education and Professional Studies, King's College London, for research focused on numeracy. The resulting programme, known as the Leverhulme Numeracy Research Programme, ran from 1997 to 2002 with the aim:

- to take forward understanding of the nature and causes of low achievement in numeracy and provide insight into effective strategies for remedying the situation.

We wanted to examine the contribution of many different factors to low attainment, in individual children, classes, schools or population groups, by studying, on both a large and small-scale, cases in which these factors varied. Two intervention studies were also planned as part of the Programme.

The research design, which included a large-scale longitudinal study (the Core Project) and five focus projects, is outlined below. (Further detail of data collection and analysis procedures on individual projects which contribute to the research reported in each book in the series is provided in the Annexes at the end of each volume. Findings are reported elsewhere.)

4.1. The Core Project: Tracking numeracy (Margaret Brown, Mike Askew, Valerie Rhodes, Hazel Denvir, Esther Ranson, Dylan Wiliam, Helen Lucey and Tamara Bibby; 1997-2002)

Aim: To obtain large-scale longitudinal value-added data on numeracy to:

- inform knowledge about the progression in pupils' learning of numeracy throughout the primary years, and
- to assess relative contributions to gains in numeracy of the different factors to be investigated in the programme.

Methods: Data on pupil attainment was gathered twice a year for 4 years, on two longitudinal cohorts each of about 1600 pupils, one moving from Year 1 (age 5-6 years) to Year 4 (age 8-9 years) and the other from Year 4 to Year 7 (age 11-12 years). Each cohort included all children of the appropriate age in 10 primary schools in each of 4 varied local education authorities (two groups of over 70 classes). Only a small subset of 180 pupils in seven secondary schools, including at least one in each of the four local education authorities, were followed into Year 7 and were tested only at the end of the year, because of the logistic problems of observing lessons and testing specific children in large numbers of secondary schools. Detailed data was collected annually on pupils, teachers and schools including lesson observations, teacher questionnaires and interviews with teachers, mathematics co-ordinators and headteachers. (This data relates also to the younger cohort in the Reception year (ages 4-5) although it was not practicable to test the pupils at that age). Many instruments were modifications of those designed for our 'Effective Teachers of Numeracy' project (Askew et al., 1997). This data formed the

basis for both statistical and qualitative analysis to investigate the relative contributions of different factors.

The core study provided a base for the case-study investigations in the focus projects, and both generated hypotheses to be explored in the focus projects and allowed hypotheses arising from those to be checked on a larger sample.

4.2. Focus Project: Case-studies of pupil progress (Mike Askew, Hazel Denvir, Valerie Rhodes and Margaret Brown; 1997-2002)

Aim: To obtain a clear and detailed longitudinal picture of the numeracy development of a range of pupils taught in a varied set of schools and to examine this in the light of their classroom experiences, to ascertain what works, what goes wrong, and why.

Methods: This project explored the classroom practice factors influencing pupil attainment, including school, teacher, teaching, curriculum and individual pupil factors. From the longitudinal core sample we selected 5 schools which presented interesting contrasts. In each of these schools we selected children of varied attainment, six from a Reception (age 4-5 years) and six from a Year 4 class (age 8-9 years) to provide longitudinal case study data, plotting progression in learning over 4 or 5 years. Children were observed and informally interviewed in two blocks of five lessons each year, and their written work collected. Longer interviews concerning perceptions of progress, attitudes and home support, and involving assessment questions, occurred at the end of Years 3 and 6.

4.3. Focus Project: Teachers' knowledge, conceptions and practices and pupils' learning (Mike Askew, Alison Millett & Shirley Simon; 1999-2002)

Aim: To investigate the relationships between teachers' beliefs about, knowledge of and practices in teaching numeracy and whether changes in beliefs, knowledge and/or practices raise standards.

Methods: The project followed twelve teachers before, during and after their experience of a short course of professional development as part of the National Numeracy Strategy. We adapted the methods of eliciting teachers' subject knowledge and beliefs in a series of interviews from our earlier work (Askew et al., 1997) in order to construct teacher profiles. Changes in teachers' practices were monitored using video recording of lessons, and changes in pupils' attainment by using the tests developed for the core project. The teachers' profiles, their classroom practices and their pupils' attainment were monitored over three years.

4.4. Focus Project: Whole school action on numeracy (Alison Millett & David Johnson; 1997- 2001)

Aim: To identify whole-school and teacher factors which appear to facilitate or inhibit the development of strategies for raising attainment in numeracy.

Methods: This research focused on six schools as they each experienced an inspection and then implemented the National Numeracy Strategy. Each school had identified the need for improvements in their teaching of numeracy and we have collected data both on the strategies schools used to develop the teaching of numeracy and the effect of these strategies on pupils' attainment. The research investigated the complex interplay of school factors, such as school policies and leadership, and teacher factors involved in the implementation of change over four years. The research used documentary analysis, observation in classrooms and at meetings, and interviews with a range of informants (headteachers, mathematics coordinators, classroom teachers, governors and parents).

4.5. Focus Project: School and community numeracies (Brian Street, Alison Tomlin, Dave Bake and Helen Lucey; 1998 - 2002)

Aim: To refine and establish the meanings and uses of numeracy in home and school contexts; to establish differences between practices in the two environments and to draw inferences for pedagogy.

Methods: This project investigated the influence of social factors on attainment, in particular differences between numeracy practices, and the linguistic practices associated with them, in the pupils' home and school contexts. Three schools were selected to provide a range of home cultures. Case-study pupils were then chosen from Reception classes (age 4-5 years) and followed through Year 1 (age 5-6 years) and into Year 2 (age 6-7 years). We used ethnographic methods including participant observation of classrooms and of informal situations in and out of school, and interviews with teachers, parents and pupils. The study extended previous work on literacy practices (Street, 1999) into numeracy, but retained a comparative element between the two.

4.6. Focus Project: Primary CAME (Cognitive Acceleration in Mathematics Education) (David Johnson, Mundher Adhami, Michael Shayer, Rosemary Hafeez, Sally Dubben, Ann Longfield & Jeremy Hodgen; 1997-2000)

Aim: To investigate the effect on the development of numeracy of managed cognitive challenge/conflict designed to encourage verbal interactions and metacognitive activity in whole-class and various small group arrangements of children in Year 5 (age 9-10 years) and Year 6 (age 10-11 years).

Methods: An experimental design was used to investigate whether intervention in classroom practices aimed at promoting intellectual development could be effective. It extended our earlier work on CAME (Cognitive Acceleration in Mathematics Education) in secondary schools (Adhami et al., 1998) which used Piagetian and Vygotskian paradigms. The research team, including teacher-researchers in each of two laboratory schools, first devised and trialled a sequence of mathematical problem situations designed to challenge children, and to promote teacher-child and child-child discussion in cooperative small group work and whole-class discussion. This led to the main fieldwork involving research with teachers in a further 8