APPENDIX A

Numeracy Practices: 'Framework 2'

Numeracy Practices: criteria for identification (somewhere between 'maths as everything' and maths as schooled cognitive)	
Source of VIEWS /visions (perceptions) of NP	Evidence/examples of views /understandings/ perceptions
Research-based: *conceptions of numeracy based on research theory and methodology* eg'Funds of Knowledge' (Moll) eg Adult learners/ Parent Learners (Civil) eg Home/ school Discourses (Freebody) eg Home measurement, approximation (Massingila) eg Cultural systems of representation (Abreu) eg Material values, money, poverty (Walkerdine) eg Home socialisation/ school learning programmes (Cairney) eg Literacy research - events and practices (Heath, Street, Barton) eg 'Variables' literature (mother's education; reading to children; books at home, WPPSI etc) descriptions of Numeracy practices & social Baker Street Johnson pedagogical practices constructivist situated cultural resources Bourdieu Pollard	**RELATIONS Analysis, interpretations BETWEEN VIEWS OF PARTIES (contrast within and between homes, schools - MATRIX?)** **eg content/ pedagogy different pedagogies eg salience/ visible eg mobilise/ demobilise eg switching (mode; h/s)** **DIRECTION/ STRENGTH OF LINKS** **eg determination eg authority**
Mathematicians: essentialist, fallibilist, social linear hierarchical, ordered well defined, subject knowledge, pedagogical subject knowledge etc. Importance values and social relations.	**EXPLANATORY**

Correctness minimalist, compliance Explanations for achievement in maths **Carer-based:** *Home/school relations as context for perceptions of numeracy practices*: eg definite/ less definite views of school eg conceptions of parenting, discipline, 'work', 'prospects', eg comparison with other parents. *Understanding of maths re own uses and history* *Interpretations of /demands from current school practices* eg working with children re school requirements eg homework eg Teaching and learning numeracy practices at home. *What numeracy practices are described at home: what is valued, selected* eg 'Salience' and visibility of different maths practices eg hidden/ overt eg may count only what is 'difficult' *Explanations for achievement in maths* **Child-based:** What they bring from home to school; their view of relationships; what they see as school demands their roles in numeracy practices what children do or could do in numeracy terms **Policy**: **a) National** National Curriculum; Agencies eg Ofsted; TTA Maths Education and Teacher Education Public Discourses **b) School-based** school definitions of 'numeracy': cognitive skills eg NNS eg tests eg metacognitive awareness eg 'two-ness', place value (relation to	**POWER** ***similarities / differences between parties 'explain' children's underachievement?*** ***cultural resources***

metalinguistic awareness?) modes of representation. conceptions of numeracy embedded in school/ home relations eg homework eg schemes (Impact) School and National policies towards numeracy curriculum and pedagogy linear, hierarchical, absolutist Explanations for achievement in maths **c Teacher-based** Teacher conception of maths; relation to policy and school versions. notions of importance, valued. Selection. Roles and social relations. Purposes, contexts Teachers' numeracy pedagogical practices. Explanations for achievement in maths Teacher images of home maths practices, carers' & children's experiences at home what they use maths for at home. How they see carers' roles in "teach" children maths at home Teacher's perception of children's responses to maths Teacher images of home as context for numeracy practices eg deficit constructing relations with carers - discipline, 'cosy' **Researcher-based models:** *Emerging from/ synthesis of the observations and analysis of models of parties above - research, mathematicians, school, teacher, carer, child: re our prior expectations/ models* Separate strands for descriptive purposes? Comparison for analytic purposes eg 'matrix' of parties' positions? Home numeracy practices and schooled numeracy practices Salience/visibility axis; eg 'mobilisation/ resistance Contrasts of practices within and between homes and schools	

Modes of representation eg reformulations/ switching between oral/ written; notation, sign, words; visual, objects Switching between home and schooled numeracy practices **Key concepts emerging from data:** dis/continuities; barriers/links support/ tensions consonant/ dissonant; compensate/ complement dis/engagement; mis/trust; value, valorise; accept/ reject mis/communicate; identities; insiders outsiders status, authority, relations	

Numeracy Practices: 'Framework 2'
(note)

For working purposes we begin observations with some of the conceptions of numeracy practices listed above, held by different parties, noting the differences that each set generates. We started with school and research based, moved into classrooms and thence to homes, moving backwards and forwards between this empirical work and the theoretical and research literature. The model of 'numeracy practices' is thus not an ontological claim to a given but is constructed out of description of different models held by different parties. We might follow through the implications of each position/ view for how we observe/ make sense of the activities of home and school and their relationship eg how far does one party take account of views of others eg on 'homework' eg what are relationships between different parties' models - does one 'determine/ influence' another, are they independent, which has authority? We might then begin to develop/ refine our own model as a way of delimiting the field of enquiry with respect to the research questions raised by the project. This model too is a construct not a given, but its validity/ value will rest on its ability to help us observe what might otherwise be missed and to begin to offer explanations (eg for 'success'/ underachievement) that are not apparent from other perspectives. The framework can provide a basis for observation and interview schedules and to make explicit what is taken for granted in the situations we describe. Team discussions of data will lead to occasional revisions of this framework.

BS 19.10.01

APPENDIX B

LEVERHULME NUMERACY PROGRAMME
FOCUS 4: SCHOOL AND COMMUNITY NUMERACIES

Checklist for conversations with parents/ carers

Home practices

Uses of numeracy/ number /maths practices at home? for example helping around the house, setting the table, games, TV, video, mobile phone, shopping, pocket money, dates, time, behaviour? data handling e.g. labels on videos, computer discs. How important is it at home?
'*Relationships'* of carer/ child around NP e.g. negotiable? control? home/ outside agendas?
Varied uses of number/ numeracy eg numbers on video/ buses/ that could functionally be letters; measurement, estimation, range, interval etc.
Smith's books - does carer buy/ use commercial books to help child's numeracy? which ones? in what ways does carer/ another adult work with them?
Engagement: distinction between things (real and imaginary) that do and do not engage child's intentions and attention ie not distinction between 'everyday' and 'abstract' maths but what engages them.

Home practices taken into school

Does child take number activities into school from home eg times, calendars, festivals, problems, puzzles, games, dice, Pokemon?

School practices taken into homes.

Homework does child bring home work set in class, (eg learning tables), does carer help, how long do they spend on it, do they have opinions about children doing homework? Do they help him/her? Does she/he use SNP at home? eg puzzles, games, problems. when? why/why not? Does carer model school practices at home? eg naming and practising on clock eg numbering steps as child goes up/ down

Complementing/ compensating: in what ways do carers represent their engagement in maths activities at home with child? eg as complementing what school does? as compensating for gaps in what school does? relate to those of school?

Literacy: there is a book bag for literacy but is there any equivalent for numeracy sent home? Do they see literacy as different from numeracy from the point of view of the child's learning and of what the school does?

Home/school sharing of experiences/information

Does carer know about what goes on in school? how, when where? Do they get letters/ information home from school - general/ re numeracy? Do teachers ask what goes on at home (or only communicate when there are problems?). Do they have a role in child's education/ numeracy or is that just for the school? How different is HNP and SNP? Why? What changes in the relationship to school have they noticed from R to Year 1? eg distancing of parents at school door eg child's maths work less familiar to parents/ carers?

Parents' concepts of numeracy

Views of HNP

What is carer's own history, views etc about numeracy? Do they use it? context, How important is it at home? Why? What are the implications of their own maths history for their child's numeracy? What counts as maths? what remains 'invisible'? Views of child's maths?

Views of SNP

Value of SNP why?. What content of SNP are important? why, who decides?.

Views of numeracy teaching and learning

best ways of teaching/ learning it? why do some children do well others not? What do they hope child will get from school numeracy?

Links with other institutions

Do they have contacts/ get help from e.g. Sure Start; Play Link; EAZ; Hill View; etc.?

APPENDIXC

LEVERHULME NUMERACY PROGRAMME
FOCUS 4: SCHOOL AND COMMUNITY NUMERACIES
CHECKLIST FOR CLASSROOM VISITS

Reference Framework 2 for school's or teacher's explanation for numeracy achievement eg School-based: a. policy b teacher; eg Home/school relations as context for perceptions of numeracy practices

Home/school

- What is the teacher's view of NP at home?
- relationship of homework (if any) to classroom activities eg whether homework grows out of class activities, includes writing/setting of homework, as well as aftermath. her perceptions of purposes value role of HW is there evidence of drawing on home NP and experience in the classroom? eg non-teacher led use of home approaches/experiences. *:* Does T know about/ make use of NP that children use at home? eg puzzles, games, problems? Does T ask parents to help children with numeracy at home eg naming and practising on clock eg numbering steps as child goes up/ down.
- parents/carers arriving with children – in playground/allowed in class?
- any evidence of relationships of F4 parents/carers with teacher. Communication and access. Separation. Beliefs about roles parents can play, mobilising? Role of documents parents evenings and meetings; tensions or conflicts with parents' purposes and roles of homework. Perceptions of cultural resources of homes and children

Classroom & school

focus on numeracy

- Displays of children's work; role play changes; table layouts etc e.g. role play re 'topic' maths. Relevant school displays e.g. photos *Schooled NP:* numeracy work - content and form; relation to NC and school programmes of work; eg number, shape, eg counting in twos, odd /even, measuring weighing and time;, number

bonds; Purposes of numeracy activities: educational; embedded in other tasks, e.g. school meals, register, games, contexts for SNP; values and social relations

School numeracy

Building blocks of what we might then analyse as schooled numeracy practices.
aspects to do with school vision towards numeracy, what things are valued selected stressed etc. How they relate to NNS and NC and Pandas. School vision towards numeracy pedagogy. Does it set?

Numeracy work: teacher focus

- Teacher's pedagogical practices in maths;
- role of the teacher/ children in classroom
- relation to maths insider outsider
- intended learning outcomes, e.g. from teacher's plan, as told to children, or interpreted by researcher, including specialised vocabulary
- relation to national curriculum, NNS, schemes of work, where known
- values towards maths - correctness debate, autonomous, sitedness
- relationship of literacy work to numeracy
- mediating devices, procedures, techniques, technologies, tools, objects
- classroom organisation e.g. whole class, mat, small groups, does school/ teacher set? children volunteer to answer questions or called upon etc, individual worksheets
- whole class and individual 'engagement' including sanctions, 'noise'
- classroom language eg modality, narrative, vocabulary, interpersonal styles
- role of LSAs, SEN support staff, speech therapists etc eg how teacher/LSA/researcher time is distributed among children e.g. whether children usually work with same adult eg differences between LSAs
- beliefs about learning in pedagogical practices, building of children's experiences
- Reactions to Pandas and other data
- Teacher's explanations for achievement in maths; Teachers perceptions of different roles status; social relations;

- Teacher images of home eg constructing relations with parents - discipline, 'cosy'; deficit; compensating complementing

Numeracy work: focus on children

- children's choices (where they have any), e.g. choices of numeracy work, who to sit with
- social relations around numeracy work e.g. sharing, competition, friends; who they ask for help
- detail of 'what happens' in particular work: mediating devices, procedures, literacy issues, talking
- dis/engagement in numeracy tasks
- any evidence of dis/continuities with home experiences, or relating of classroom and home experiences

Wolcott's framework for analysing field data:

The framework suggested by Wolcott, for representing research data involves dividing the account into: Description (mainly accounts of data eg literacy events); Interpretation (mainly insights, knowledge you bring to bear from elsewhere, theoretical perspectives); and Analysis (in his terms this means doing systematic trawls through Description in relation to Interpretation, to check whether you can validate/ support your insights: this forces you to be selective, i.e. to recognise that interesting though some insights are, you can't actually follow them up sufficiently to make valid and sustainable claims in the outside world...). The categories are, of course, not water tight and they are contestable, but the framework provides a starting point for discussion of the issue involved in doing qualitative research. I will provide an example of how I have tried to work this through in relation to my own current research on home/ school numeracy practices. My methodological questions are - what goes in the 'Analysis' column and how does it relate to the other two? Does this approach/ procedure help/ what are its limitations?

Wolcott,H 1994 Transforming Qualitative Data: Description, Analysis and Interpretation Sage: CA esp chapter 2 'Description, Analysis and Interpretation in Qualitative Inquiry' pp. 9-53

APPENDIX D; Layout for Recording Classroom Data

Leverhulme Numeracy programme: F4 'School and Community Numeracies'

Brian Street Report on Mountford home visits: Mar 14th 2000
Lenny in Pamela's Class (Reception). Mother (M) and Sister (Z).

DESCRIPTION	INTERPRETATION	ANALYSIS
Lenny is in Pamela's reception Class at Mountford. First visited March 00. Spring child. He is in the top band according to the teacher's baseline. Lives with Mother (Mrs W), Sister (Samantha; in year 7 at F Secondary School, 11 years old). Grandfather (G) often present and helps out e.g. buying computer e.g. supporting Lenny in maths work.		
Met M and Lenny at school and went to the house in her car, Lenny had only just returned to school yesterday after two weeks off following having his adenoids out. His mother hoped that his nasal passages would be unblocked and he could breathe through his nose not just his mouth and thereby speak more clearly. He had been a little subdued in class and wasn't quite so hyped up at home as before. They had bought a new computer with lots of educational games and software so that when he came out of hospital he had plenty to do and also to contribute to his educational development.		

DESCRIPTION	INTERPRETATION	ANALYSIS
New computer game - Encyclopaedia of Nature: Dorling Kindersley, typical quality of picture from their books with computer graphics, moving images, hot spots etc.. They had only played with it once or twice so were learning the keys and the procedures. Lenny in charge of mouse and keys, M and Z watching and asking/advising/ cajoling. He opened up a nature information piece, with fish swimming around an a po-faced American voices in 'scientific' register framing the video with pieces of 'knowledge' e.g. 'flat fish as they move across the ocean bed allow the water to flow over their fins and a gap beneath allows them to sweep up small creatures which are their food'. He then scanned a world map and from it opened up pictures of a Rain Forest in S. America and then found a way of individually magnifying the animals/ plants depicted there (this procedure was new as we went along and his M and Z remarked on this, they had not done it last time they opened the programme). He moved around the forest space focusing upon individual objects/ animals and his M and Z tried to encourage him to then find out information on them by clicking: it took him a while to find the way to do this (outside the magnification, by double clicking - he had at first tried a small complex window with arrows and images that was hard to focus on or to link to the larger picture). He then occasionally responded to their requests and brought up text or other images and sometimes a moving image was available or a sound. M was highly impressed and said she loved this kind of activity and information - she had bought a Human Body CD for herself and hoped now to apply to it some of	On a different plane from classroom activities, including classroom computer (old BBC with simple tasks e.g. click on numbers, get them right, a clown dances). Need to establish links between children's home activities and those of school? Lenny's M keen to offer him support and has bought the computer and software with this in mind. But she has no idea what goes on in school and how her home activities relate. For him the excitement of the high quality graphics and moving images and control are light years ahead of the school computing. But at present he just surfs about clicking and jumping images, without much structure or direction: meanwhile, the school activity has structure and direction but lacks the excitement and sheer visual and image excitement or pupil control. Mother keen to help child - how can school build on this e.g. Teachers to be trained in what children are doing at home e.g. re computers. Teachers could send home activities e.g. number line, bonds, that parents could practice via the computer games or via everyday activities. But teachers afraid 'a little knowledge is a dangerous thing' (A. in staff room)	check out other examples of home/ school practices around computers interview teacher/ parent re pedagogies associated with computer use Policy implications - follow up

the procedures she had learned this afternoon. She kept asking me whether this activity was 'educational' and how. I occasionally commented on what Lenny might be 'learning' e.g. manipulating computer mouse and procedures e.g. bits of information about the world e.g. routes to knowledge e.g. different discourses associated with 'knowledge' in the world.	ie don't trust parents with this level of complexity. meanwhile parents out of touch with school activity so go for 'educational' books and software but children jump around in them without structure and without clear link/ cohesion with what is happening in class. Shirley Heath in a meeting on Fri comment on the 'frames of knowledge' that she identified urban youths deploying and bringing to school. She was concerned that schools ignore these/ have no conceptual framework for recognising them and has prepared TT materials to bridge this gap. Thinking of Lenny on his computer one might identify emerging frames of knowledge regarding computer representations of knowledge (e.g. the 'scientific voice'), perhaps some maths context, certainly some serendipitous knowledge of the natural world that might hook into more structured knowledge later. The pedagogic implications of all of this are enormous but the school's interest is mainly in inculcating the children into its routines and into fairly limited discourses/ voices. How far should we pursue these policy questions at this stage?	

ANNEX 1

CORE PROJECT: TRACKING NUMERACY

The aim of the core project of the Leverhulme Numeracy Research Programme was 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
- assess relative contributions to gains in numeracy of the different factors to be investigated in the programme.

Our objectives were:

- to assess longitudinally the numeracy attainment of two overlapping cohorts of primary pupils so that a picture of year-on-year achievement in a variety of schools was obtained from Year 1 (pupils aged 5-6 years) up to Year 6 (pupils aged 10-11 years), with some limited extension both into Reception (pupils aged 4-5 years) and into Year 7 (pupils aged 11-12 years)
- to match the year-on-year value-added attainment data against data relating to *classroom practice*, including, but not limited to, teaching method, teaching organisation, and curriculum in order to investigate the influence of these factors on attainment
- to match the year-on-year value-added attainment data against data relating to each *teacher*, in particular to teachers' subject knowledge and expectations, as well as other factors, in order to investigate the influence of these factors on attainment
- to match the year-on-year value-added attainment data against data relating to each *school,* in particular to data on the existence of clear policies and agreed practices, as well as other factors (such as the experience of the headteacher and the mathematics co-ordinator), in order to investigate the effect of these factors on attainment
- to match the year-on-year value-added attainment data against data relating to individual *pupils* (in particular social class), in order to investigate the effects of these factors on attainment at different stages of schooling
- to generate hypotheses from large-scale quantitative analyses which can be further explored in the Focus Projects, in particular in Focus Project: *Case Studies of Pupil Progress*, and in addition to provide data which will allow hypotheses which arise from case study samples in the focused projects to be validated on a larger scale.

No longitudinal data is available in the United Kingdom to indicate the ways, or the rate, at which primary pupils develop over time the understanding and skills

which together constitute competence in numeracy, nor of how this is related to a broader range of school and other factors.

The long-term nature of the Leverhulme Numeracy Research Programme gave an opportunity to track the progress of pupils in numeracy over five years. By selecting two overlapping cohorts, the first starting with Reception (pupils aged 4-5 years) and the second with Year 4 (pupils aged 8-9 years), this covered the full primary age range and allowed one group to be followed through to Year 7 in secondary school as shown in Table A.1.1. This provided for the first time a unique set of longitudinal year-on-year data on a large primary sample.

Table A.1.1. The two cohorts

	1997-1998	*1998-1999*	*1999-2000*	*2000-2001*	*2001-2002*
Cohort 1	Reception	Y1	Y2	Y3	Y4
Cohort 2	Y4	Y5	Y6	Y7	

The fact that Year 4 data was available for both the second cohort in 1997/98 and from the first in 2001/02 has also made it possible to evaluate the effect of the National Numeracy Strategy which was implemented across all years in all primary schools in the UK during 1999/2000.

By selecting a sample which was relatively large and covered schools drawing pupils from a variety of different social backgrounds, with differences in teaching style and organisation, it was possible to determine the effects of the different factors listed below (and the interactions between them), together with others which were later suggested.

Classroom practice factors
- (a) teaching methods
- (b) teaching organisation
- (c) curriculum

Teacher factors
- (d) teacher subject knowledge
- (e) low teacher expectations

School factors
- (f) school leadership

Social context factors
- (g) home contexts

One important feature of the relatively long time-span of the project was that it enabled hypotheses which arose from the analysis of early rounds of data to be investigated further.

The 40 schools that took part in the longitudinal study were chosen from four Local Education Authorities, and the 10 schools in each of them included inner city schools in deprived areas, racially mixed schools and schools in pleasant suburbs with expensive housing. Two authorities were from the London area; the other two authorities were both large counties, one in the South East of England and the second in the North of England. In the North of England authority, some of the schools were in an urban area with a large population of South Asian origin. Some

schools in one of the Local Education Authorities in the sample had been involved in the National Numeracy Project (See Introduction).

School sample

Within each of these Local Education Authorities the selection of 10 schools was made with the assistance of the professional advisory staff and the available performance and intake data. In this programme the focus was on the effect of particular factors and therefore a quota rather than a representative or random sample was appropriate. The aim within each Local Education Authority was to choose 10 primary schools so that they included:

- relative to the socio-economic circumstances of the population in each Local Education Authority, at least two schools from relatively advantaged, two from intermediate and two from less advantaged catchment areas
- at least two church schools
- relative to the balance within the Local Education Authority, at least two large and two small schools
- at least three schools which were identified (according to available value-added data) to be effective in teaching numeracy, together with at least two which were identified as average and two weak
- in addition to primary schools (ages 4-11 years), some linked infant (ages 4-7 years) and junior (ages 7-11 years) schools where these were a common form of school organisation within a Local Education Authority.

At the point at which the older cohort of pupils in the study transferred into secondary schools at age 11, there was no attempt to trace the progress of all the pupils. However, at least one secondary school in each Local Education Authority which received a substantial number of the pupils in the cohort, including some from different primary schools, was selected and agreed to collaborate in the study, providing some information on the achievements of the pupils at the end of the first year of secondary school. In one of the two Local Education Authorities in London, two further secondary schools were also included, and in the other one additional school was selected, making a total of seven secondary schools in the study, with over 180 pupils. It was believed that these seven schools constituted a reasonable range of types of secondary school.

37 out of the original 40 primary schools (seven of which were linked infant and junior schools) remained as participants in the project over this five year period. There was less attrition than expected, especially given the pressures on primary schools and teachers over the years 1997-2002 which included the introduction of both the National Literacy and National Numeracy Strategies (see Introduction). This meant that with students joining and leaving schools over the five years, there were more than 2000 pupils on the database for each of the two cohorts. However, in any one year, at least 1300 pupils in over 70 classes had taken part for each of the two cohorts.

Data Sources and Instruments

Pupil Data: Numeracy assessment. To enable progress in each year to be measured, pupils in the two cohorts were tested at the beginning and end of each year between Year 1 and Year 6, using a class test of numeracy. There was no formal testing in the Reception year, although results of baseline and other tests were collected.

Children were tested towards the beginning and end of each school year, within a designated two weeks towards the end of October and the beginning of June. A sequence of tests, one for each year group, was used which were derived from instruments developed from earlier research by members of the team (Hart (Ed.), 1981; Denvir & Brown, 1986; Askew et al., 1997). The items had in almost all cases been designed for one-on-one diagnostic interviews and based on reviews of related research; Denvir and Bibby (2002) have updated in a format usable by teachers and teaching assistants a diagnostic interview for low attaining primary pupils from which many of the items were drawn. These items were later adapted for whole class settings, and were thus extensively trialled in both formats. The reliability (using Cronbach's alpha) was found to be very high (of the order of 0.94). Denvir and Brown (1987) had earlier compared pupils performance on interviews and class tests using many of the items. Items were designed to assess conceptual understanding and cognitively based skills. They include contextual as well as purely numerical items. Most items required short open responses but a small number were in multiple choice format. Many items were linked with others assessing similar concepts/skills but often of varying facility. The same test was used at the start and end of the year, and was orally administered by teachers from a provided script with pupils answering in specially designed booklets. The emphasis was on mental rather than written processes. For some cases teachers were asked to display a poster for a fixed number of seconds. The number of items in the test varied from 41 in Year 1 to over 80 in older age groups.

The tests were designed both to contain a large number of common items from one year to the next (including three items which were assessed in each year from Year 1 to Year 6), and to have the same uniform distribution of facility within each test. This means that equal numerical gains were made by children at different attainment levels.

The inclusion of common items has allowed the facilities across several years of the primary school to be plotted for each item and compared for the linked sets of items. An index of difficulty has been calculated for each item which indicates the estimated age at which 50% of the cohort can succeed on it. The Rasch procedure allows children to then be assigned a 'numeracy age' for each sitting of the test.

The test was given orally by the teacher to avoid reading problems and to enable a time limit on some questions to focus on mental numeracy skills and prevent pupils from using ineffective methods. The test had been successful in differentiating within year groups and was clearly appropriate in the level of attainment it tested.

A problem solving task was developed and trialled and was administered to Year 4 pupils in the first year. However as it was found in the assessment that pupils' strategies were heavily influenced by their teachers, it was decided that the data was

not sufficiently valid or reliable to justify the considerable marking costs in later years.

The Year 6 test was repeated at the end of Year 7 in the seven secondary schools included in the study.

Pupil Data: Other sources. In addition to numeracy assessment, we collected additional data on pupils in the sample. This included:

- national test data on mathematics and English for Year 2 pupils (aged 6-7 years) and Year 6 pupils (aged 10-11 years); in some cases results of nationally set tests were also available in Year 4
- reading age data where available
- baseline data where available (for pupils aged 4-5 years at the start of Reception class
- social class data (using post-code analysis as a proxy)
- gender and ethnicity data
- any relevant data from the seven secondary schools e.g. mathematics sets allocated.

These data assisted especially with the exploration of factors relating to pupil social background.

School data: interviews and school statistics. We visited each school in each year of the project, for a minimum of one day, and more than this in the case of larger schools. In the first year we interviewed the headteacher and the mathematics co-ordinator, collected relevant school data on the size and characteristics on the school population and relevant documents including curriculum policies for mathematics. This gave some information on factor (f) school leadership, in particular, clear policies and agreed practices for numeracy teaching. It also provided information on factor (e) of low teacher expectation. In later years brief interviews were held with the head teacher and co-ordinator to update information. In the final year there were again longer interviews with the headteacher and co-ordinator. Only one year-group was involved in primary schools for the fourth and fifth year of the study (Cohort 2 had by that time moved into secondary school). In the fourth year, visits were made to each of the three selected secondary schools in each Local Education Authority, to interview the head of the mathematics department.

Classroom data: observations. Lessons were observed in the classrooms of the pupils in each year of the two cohorts, starting with Reception and Year 4 classes in 1997/98. Aspects of classroom organisation, resources and teaching methods, and also brief conversations with pupils were recorded in fieldnotes. In the fourth year, visits were made to each of the seven secondary schools to observe one or more Year 7 lessons.

Teacher data: questionnaires. Over the five years, each teacher of a class in either cohort was also asked to provide brief data relating to several other factors under investigation, and where possible, this was triangulated with data from field observations. These data included:

- range of teaching methods
- classroom organisation
- curriculum materials
- assessment and recording methods

- own mathematical experience, qualifications and training (initial and in-service).

As well as information on the above factors this also included brief items on teachers' beliefs and priorities in teaching numeracy. There was about an 80% return each year on teacher questionnaires.

Teacher data: interviews. Teachers of the classes in both cohorts, starting with Reception and Year 4 in 1997/98, were interviewed each year. Interviews were semi-structured and were tape-recorded and transcribed. Protocols for teacher interviews were modified each year to take account of national developments, like the National Numeracy Strategy and targetting.

Data analysis

Tests were marked centrally by students onto optical mark reading forms which were scanned into the computer. All questions were marked simply as correct, wrong or omitted, using a marking schedule. Various checks were made on the reliability of this process. Data analyses were undertaken using Excel and Datadesk.

The responses to the closed questionnaire items were also coded for optical mark reading, and joined with manually keyed in open questionnaire items and the other data, in order to provide the most comprehensive possible dataset.

Transcripts of interviews and other qualitative data were also stored in a database. Classroom observations were in the form of fieldnotes taken either longhand or entered into an electronic notebook.

Several methods of analysing both quantitative and qualitative data were developed. Where relevant these are described in the main text.

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ANNEX 2

FOCUS PROJECT: TEACHERS' KNOWLEDGE, CONCEPTIONS AND PRACTICES

This project was part of the Leverhulme Numeracy Research Programme funded by The Leverhulme Trust at the School of Education, King's College London. The aim of this project was to investigate the relationship between teachers' beliefs about, knowledge of and practices in teaching numeracy and whether changes in beliefs, knowledge and/or practices raise standards. Our objectives were:

- To understand and document the effect of the National Numeracy Strategy's programme of five day training in terms of changes in teachers' beliefs, knowledge and practices in teaching numeracy
- To examine the impact of any changes in beliefs, knowledge and practice upon pupil attainment
- To further develop understanding of which aspects of teachers' beliefs, knowledge and practices are most salient in promoting effective teaching of numeracy and raising standards.

The research tracked a group of 12 teachers and their pupils over a two year period (spanning three school years) in order to identify changes over time in teacher beliefs and practices, pupil attainment and possible reasons for changes occurring.

The schools were selected from the cohort of schools identified by the Local Education Authorities as taking part in the National Numeracy Strategy Five-day training that took place in the second year of the implementation of the Numeracy Strategy (2000/01). Hence the schools fell outside the set of schools identified as requiring intensive support within the first year of implementation of the National Numeracy Strategy but nevertheless had been identified as being capable of improving their standards (as measured by national test results) in mathematics.

Within that overall cohort of schools, the four schools, two in the north of England and two in the south, were selected to represent a range in terms of pupil intake (see Table A.2.1). In each of the four schools, we opted to work with the two teachers who would be undergoing the National Numeracy Strategy Five-day training in 2000-2001, and a third teacher within the school who would not be directly engaged in the training. Three of this latter group of four teachers subsequently undertook the training the following year (see Table A.2.2).

Table A.2.1. Details of the schools involved in the research 1999-2002

School	*Characteristics of school*
School 1	One form entry, outer urban, high level unemployment and social deprivation, 10% pupil mobility, FSM 45%, EAL 0%
School 2	One and a half form entry, outer urban, varied socio-economic conditions, many parents on temporary contracts or from army base, 33% pupils have experience of several schools, FSM 8%, EAL 14%
School 3	One and a half form entry, outer urban, mainly social housing, below average socio-economic background, FSM 41%, EAL 22%
School 4	One form entry, inner urban, high level social deprivation, 25% pupil mobility at Key Stage 2 (ages 7-11), FSM 63%, EAL 40%

Note. FSM denotes free school meals; EAL denotes English as an additional language

Table A.2.2 Details of the teachers involved in the research 1999-2002

Teacher	*Teachers' mathematics qualification and teaching experience*
Sam	GCSE mathematics. Experience: 2 years, pupils aged 7-11 years
Chris	GCE 'O' Level mathematics. Experience: 12 years, pupils aged 4-7 years
Jules	GCSE mathematics. Experience: 3 years, pupils aged 7-11 years
Jo	GCE 'O' Level mathematics. Experience: more than 10 years, pupils aged 3-7 and 11-16 years
Andy	GCE 'O' Level mathematics. Experience: over 20 years, pupils aged 7-11, 11-16 years
Pat	GCE 'O' Level mathematics, studied physics to 'A' Level. Experience: 20 years, pupils aged 7-13 years
Jess	GCE 'O' Level mathematics. Experience: 7 years, pupils aged 4-7 years
Frankie	GCSE mathematics. Studied mathematics for an additional year post 16. Experience: 3 years, pupils aged 7-11 years. Mathematics Co-ordinator
Charlie	GCE 'O' Level mathematics. Teaching experience: 9 years, pupils aged 7-11 years
Clare	GCSE mathematics. Experience: 4 years, pupils aged 7-11 years. Mathematics Co-ordinator
Toni	Access mathematics course to higher education as a mature student. Experience: 2 years, pupils aged 5-7 and 7-11 years
Jenny	No mathematics qualification. Experience: 23 years, mainly pupils aged 4-7 years; two terms with pupils aged 8-9 years

Note. The post-16 qualification was known as General Certificate of Education (GCE) 'O' Level until 1985, then as the General Certificate of Secondary Education (GCSE). The post 18 qualification is known as Advanced ('A') Level.

	Denotes teachers who attended the Five-day course in 2000/01
	Denotes teachers who attended the Five-day course in 2001/02

The teachers were selected for the training by their headteachers. One teacher not initially engaged in the training was replaced early on in the project by the teacher who took over her class. One of the eight teachers engaged in the training in 2000-2001 did not take part in the final interview as she had left the school.

Table A.2.3. Details of the data sources

Interviews	*Focus of interview*
1. June/July 2000 (for the majority of teachers)	Teaching experience; experience of mathematics; description of own practice. Changes in practice since the introduction of the National Numeracy Strategy. Understanding of aspects of the National Numeracy Strategy. Knowledge of whole-school approach to mathematics
2. June/July 2000 (for the majority of teachers)	Understanding of selected aspects of mathematics through working through examples. Responses to pupils' misconceptions. Conceptions and beliefs about the teaching and learning of mathematics
3. September/ October 2000	Pre-course interview. Expectations of the course (omitted for the four teachers not attending the course)
4. November 2000	Post-course interview. Impressions and responses immediately following the course
5. June/July 2001	Responses to the course over time. Details of current practice and any changes noted
6. November 2001	Views of mathematics as a subject, both as a learner and as a teacher. Contrasting mathematics with other subjects in the curriculum
7. March 2002	Overview of changes in practice, beliefs and understanding over the course of two years. Return to selected mathematics questions from Interview 2. Return to conceptions of teaching and learning mathematics. This interview was missed for the teacher who left towards the end of the research
Observations	*Details of observations*
June 2000; March 2001; June 2001; November 2001; March 2002.	Lesson observations were recorded on video camera and supported by fieldnotes: The first observation was missed for the replacement teacher. The last observation missed for the teacher who left towards the end of the research
Tests	*Details of test administrations*
October 2000, June 2001; October 2001, June 2002	Administration by the class teacher of the Leverhulme Numeracy Research Programme assessments (see Introduction) for the appropriate year group at the beginning and end of the school year

In June or September 2000, baseline data was gathered on the 12 teachers in terms of profiles of their beliefs, knowledge and practices, prior to the training. Using methods developed in previous research at Kings' College (Askew et al., 1997) extended interviews and classroom observations probed teachers' understandings and beliefs. Each of the 12 teachers was interviewed twice (Interviews 1 and 2): once to explore their beliefs and practices, and once to elicit their understanding of aspects of mathematics. (This data was collected one term later for the replacement teacher.) The teachers were also observed teaching mathematics to establish teaching methods, styles of teaching organisation and curriculum emphasises prior to the National Numeracy Strategy training. Given the increased emphasis within the National Numeracy Strategy of aspects of mathematics that are based around understanding of multiplicative reasoning – ratio and proportion, rational numbers, models of multiplication and division – for the current study we chose to present to teachers specific mathematical problems related to these aspects. Sources for these problems were from previous research (for example, Ma, 1999) taken in conjunction with an analysis of key aspects of the National Numeracy Strategy Framework for Teaching Mathematics from Reception to Year 6 (Department for Education and Employment, 1999).

Each mathematical problem was presented to the teachers on a separate piece of paper and the teachers were asked for their initial reaction to it. They were then encouraged to try and work out the solution and talk through what they were doing. Calculators were available and the teachers were free to record whatever they wished on the paper. The extent to which the interviewer probed a teacher on their methods, particularly where these were incorrect, depended partly upon the judgement of the interviewer of the extent to which the teacher perceived the questions as stressful. Although the main emphasis in the questions was on the teachers' understanding of the mathematics, in some of the questions the teachers were also asked to comment on the ways in which they might introduce the ideas to the pupils. The interviews were recorded and later transcribed.

Seven interviews were conducted with the teachers over the course of two school years, and video recordings were made of their practice on five occasions over that time. Details of the data sources are given in Table A.2.3. All interviews were recorded and transcribed. They were analysed in conjunction with the video-recordings of lessons around several themes:

- current classroom practice
- subject matter knowledge
- pedagogic content knowledge
- responses to the Five-day course of training
- conceptions and beliefs about mathematics as a subject
- conceptions and beliefs about the teaching of mathematics
- changes in classroom practice.

Pupils in the classes of nine teachers (Reception age pupils, 4-5 years, were not tested) completed the appropriate numeracy assessments developed for the Core longitudinal project of the Leverhulme Numeracy Research Programme (see Introduction), at the beginning and end of the school years 2000/01, 2001/02.

Askew, M., Brown, M., Rhodes, V., Johnson, D., & Wiliam, D. (1997). *Effective teachers of numeracy: Final report*. London: King's College.

Department for Education and Employment. (1999). *The National Numeracy Strategy: Framework for Teaching Mathematics from Reception to Year 6.* London: Department for Education and Employment.

Ma, L. (1999). *Knowing and teaching mathematics: teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, NJ: Lawrence Erlbaum Associates.

ANNEX 3

FOCUS PROJECT: WHOLE SCHOOL ACTION ON NUMERACY

Whole School Action on Numeracy (1997-2001) was one of six projects in the major research programme carried out at King's College London - the Leverhulme Numeracy Research Programme (1997-2002). The overall aim of the project was to identify whole-school and individual teacher factors, which appeared to facilitate or inhibit the development of strategies for raising attainment in numeracy.

Whole School Action on Numeracy focused on six schools as they prepared for, experienced and followed up an Office for Standards in Education (Ofsted) inspection, and continued for a total period of four years (See Table A.3.1).

Table A.3.1. Details of the six schools involved in the research 1997-2001

School	*Size*	*Characteristics*
1. Woodbury	600 pupils 3-form entry 21 classes	Suburban, mixed socio-economic, average special needs, above average free school meals, ethnic minorities
2. The Grove	70 pupils 0.5-form entry 3 classes	Rural, Low special needs, very low eligibility for free school meals, very low pupils from ethnic minorities
3. Maple	200 pupils 1 form entry 7 classes	Suburban, mixed socio-economic, average free school meals, above average pupils from ethnic minorities
4. Pennington	340 pupils 1.5-form entry 10 classes, Nursery	New town, high unemployment. About average special needs, free school meals. Few pupils from ethnic minorities
5. Sandmere	340 pupils 1.5- form entry 10 classes, Nursery	Outer urban, high special needs, high free school meals, substantial Asian and African-Caribbean minorities
6. Wolverton	200 pupils 1 form entry 7 classes, Nursery	Inner urban. High levels of pupil mobility, well above average free school meals, above average special needs and pupils from ethnic minorities

The schools (Schools 1-6, given the names Woodbury, The Grove, Maple, Pennington, Sandmere, Wolverton) were chosen to provide a range of contexts. Two schools experiencing inspection or re-inspection were added to the project each term, so that at the end of the first year work had begun in all six schools.

The schools varied in size; they were situated in inner urban, outer urban, suburban and rural environments; their populations had varied levels of economic status and spoke a range of languages other than English; their recent histories exhibited turbulence, moderate disturbance and stability; they were at different

stages in their experience of development planning and self-evaluation. However they shared a concern that they had themselves established - the need to develop their mathematics and, in particular, certain aspects of numeracy. In five out of the six schools, mathematics was on the school development plan before the inspection and in the sixth school it was due for priority action during the term following inspection. Interviews with key informants in the schools revealed that all were concerned about raising attainment in mathematics. Some of this concern stemmed specifically from recent poor national test results at ages 7 and 11.

Table A.3.2. The data set 1997-2001

Year	*School visits*	*Interviews*	*Observations*
1997-98	46	6 headteacher 10 co-ordinator 13 class teacher 1 governor	23 classrooms 12 meetings
1998-99	49	6 headteacher 9 co-ordinator 16 class teacher 1 governor	25 classrooms 19 meetings
1999-2000	29	7 headteacher 11 co-ordinator 11 class teacher	9 classrooms 10 meetings
2000-2001	13	6 headteacher 10 co-ordinator 3 class teacher	1 classroom 2 meetings

Data for the research included interviews with teachers, mathematics co-ordinators or subject leaders, headteachers and school governors (school board members), observations of the teaching of mathematics in selected classrooms and notes taken at whole-school and group meetings and in-service training (Inset), both in school and out, related to mathematics/numeracy (See Table A.3.2). School documents were also collected.

Data was collected on:

- Views about, and practice of, mathematics/numeracy prior to the inspection
- Intended development as identified in the School Development Plan
- Interpretations of the requirements of Ofsted
- Preparations made by the school prior to the inspection
- Reactions to the inspection report translated into preparations for the action plan
- Strategies identified for the development of numeracy
- Ways in which these strategies were implemented
- Changes in practice or beliefs (perceived and observed)
- Pupil levels of achievement (at ages 7 and 11 and non-statutory assessments)
- Interaction with the pressures of statutory assessment and the impact of new government emphases, in particular the National Numeracy Strategy.

During the course of 1998, each school experienced an Ofsted inspection and a national initiative on literacy. In September 1999 the National Numeracy Strategy

was introduced (See Introduction). One school received intensive numeracy support during this year, the remaining five received this help the following year (2000/01).

Interviews were transcribed, and the transcripts returned to interviewees for validation. Observations were written up from fieldnotes and tape recordings (not transcribed) and also returned to classroom teachers; meetings were recorded in fieldnotes. Interview transcripts and observation notes were coded to identify key categories. These categories were subject to continuous interrogation and revision using the constant comparative method (Strauss, 1987). Interviews were analysed to compare and contrast perceptions within and across schools. Data collection and analysis were contiguous and on-going to enable the feedback of analysis into data collection. Data reduction techniques and memo-ing (Miles & Huberman, 1994) were used in the building up of constructs.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: an expanded sourcebook* (2nd ed.). Thousand Oaks, CA: Sage.

Strauss, A. L. (1987). *Qualitative analysis for social scientists*. Cambridge, UK: Cambridge University Press.

ANNEX 4

FOCUS PROJECT: COGNITIVE ACCELERATION IN MATHEMATICS EDUCATION IN THE PRIMARY SCHOOL (P-CAME)

The aim of this project was to investigate the effectiveness of an intervention programme with children aged 9-10 and 10-11 years (Years 5 and 6 of primary school). The programme consists of a series of mathematics lessons conducted over two consecutive years to the same classes by their own teachers. The lessons were to be designed around key cognitive challenges across the main conceptual strands of the mathematics curriculum. The classroom conduct by the teacher was to be structured to encourage verbal interactions and metacognitive activity in whole-class and various small group arrangements of children.

The main goals of the project were to:

- provide evidence on the effect of the programme on children's cognitive development and mathematical achievement
- create and describe a model of intervention-style teaching in primary school mathematics to serve as a basis for teachers' continuous professional development.

The implementation was carried out in two overlapping phases, each with specified personnel and tasks (see Table A.4.1). Minor pragmatic modifications were needed, mainly in enlarging the role of the teacher researchers and the elaboration of the professional development methodology.

Phase 1 continued throughout the three years by the full team comprised of teacher-researchers, the Local Education Authority maths adviser, three university researchers and an attached research student. The intensity of contact within the research team was at its greatest in the first year – 20 full day whole group formal meetings plus a similar number of school visits by researchers in various combinations. In the following two years this was nearly halved to 12 days a year, including the time allotted to the main study professional development sessions.

Table A.4.1. P-CAME research implementation

Tasks	*Year 1*	*Year 2*	*Year 3*
Phase 1 Development of lessons Support material Lesson observations Assessment instruments Revising materials Quantitative data	Full research team working with 2 Y5 and 2 Y6 classes in 2 lab schools) • Pre-tests in lab schools	Full research team working with 2 Y5 and 2 Y6 classes in 2 lab schools Post tests in lab schools Pre-tests in main study schools	Full research team working in main study schools and two additional lab schools Post tests in main study schools KS2 tests
Phase 2 Main research: lesson and Professional Development observations [Development of the Professional development methodology]		19 teachers in 9 main study schools Y5 classes only King's researchers and LEA adviser Teacher-researchers as peer tutors	19 teachers in 9 schools Y6 classes only King's researchers and LEA adviser Teacher-researchers as peer tutors

One teacher-researcher went on maternity-leave at the end of the first year, did not return to teaching, and was replaced by two teachers from different main study schools at the end of Year 2 of the project. The two teacher researchers in the other laboratory school became Local Education Authority numeracy consultants, one at the end of Year 1, the other during the second year, but both continued their involvement in the project voluntarily up to the present. It was felt that, despite the personnel and position changes, the research team was the strongest component of the project. That helped to compensate for large-scale staff turnover in the main study (Phase 2) cohort of teachers, and also helped to generate important theoretical and practical innovations in the approach.

Phase 2 started in the summer of the first year, with the introduction of main study teachers to the approach. Over the following six terms there were 12 formal half-day professional development sessions, and three times that number of in-class observations and tutorial support in various formal and informal arrangements, including team teaching and peer tutoring.

In total 24 lessons (out of the 34 considered) were fully developed and offered to the main study teachers, at a regular rate of four lessons a term. They addressed concepts and reasoning patterns in number and algebra, shape and space, and handling data, but with emphasis on number relations. On average 17 lessons were conducted in the main study classes.

PROFESSIONAL DEVELOPMENT IN PRIMARY MATHEMATICS

Additional work funded by Kings' College related to Primary CAME: Research Student Jeremy Hodgen

This additional research was funded as a research studentship by King's College London in order to investigate more fully the professional development aspects of the Primary CAME intervention. The initial aim of this attached project was to investigate the professional change of classroom teachers as they participated in the Primary CAME Professional Development programme.

As the project developed, the emphasis of the research shifted to focus more specifically on the teacher-researchers in the research and development team as practitioner teacher educators. The research explored the teacher-researchers' own knowledge and practice in primary mathematics and the tutoring relationship between the teacher-researchers and the classroom teachers. An additional, but secondary, aspect to the research was the teacher-researchers' involvement in the National Numeracy Strategy. Two teacher-researchers became numeracy consultants, whilst the others had led both Local Education Authority and in-school numeracy training sessions.

Early work emphasised the importance of collaboration and reflection with teacher change. A further aspect was an identification of some philosophical challenges that primary teachers faced in relation to school mathematics. The research explored ways in which these teacher-researchers' beliefs and understandings of big mathematical ideas had evolved. A major focus was on the impact of the teacher-researchers' engagement with the research and development activities of Primary CAME and subsequently through a consideration of their roles as consultants/tutors in the National Numeracy Strategy.

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