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REVIEW OF MATHEMATICS TEACHING IN PRIMARY SCHOOLS AND EARLY YEARS SETTINGS

Area 1: Pedagogy

Q1. What are the effective pedagogies for maths teaching? Is there a single, most effective pedagogy? What would you like the Review team to recommend in this area?

Your [ATM's] comments:

Primary Schools

Teachers are well aware that children need to be taught facts, skills, and understanding of mathematical concepts, and that this complexity requires different teaching strategies. In addition, children learn in different ways and account needs to be taken of this. The Cockcroft Report (HMSO, 1982) made recommendations for primary and secondary schools based on research, about the need for a range of teaching styles. The messages of the Cockcroft Report are as pertinent today as in 1982. Paragraph 243 of Cockcroft states:

Mathematics teaching at all levels should include opportunities for

- *exposition by the teacher;*
- *discussion between teacher and pupils and between pupils themselves;*
- *appropriate practical work;*
- *consolidation and practice of fundamental skills and routines;*
- *problem solving, including the application of mathematics to everyday situations;*
- *investigational work.* (HMSO, 1982; p71)

These recommendations were sound at the time and remain so. Cockcroft made recommendations about teaching rather than learning. A range of teaching styles should lead to a range of learning opportunities, as learners need a varied range of experiences. Reliance on, say, exposition by the teacher does not give the learner the opportunity to make decisions about the mathematics to use and apply. In addition to the teaching styles identified by Cockcroft, it is useful to identify some characteristics of good/effective practice. We identify the following principles:

Teaching for understanding

- Teaching children how to obtain an answer and this is all s/he can do (if s/he can remember it)
- Teaching to understand the mathematics and you teach her/him for life.

Teaching children a method to obtain an answer may well lead to facility in the short term, but a single method will only work in particular situations. Teachers know that children need to be taught to transfer and apply their knowledge in a variety of contexts and situations. For example, many teachers report that children are unable to solve a mathematical problem when it is worded differently.

Making connections

- Askew, Brown, Rhodes, Wiliam and Johnson (1997) identify that teachers who were able to help learners make connections between mathematical areas, were particularly effective.
- Developing a recall of number facts is not an alternative to developing strategic thinking, but a necessary complement to it.
- An emphasis on the problem-solving aspects of mental calculation.

Using a range of models and images to support understanding

- Although the NNS produce resources and guidance in this field, more research needs to be done to support, complement and extend this range. Many teachers do not make enough use of these. For example, teachers would find support for the use of the 'Empty Number Line' most helpful.
- Support needs to be given for the appropriate use of ICT, particularly Interactive Whiteboards, in learning to use their power effectively to enhance learning, rather than as a classroom management device. In addition, teachers would welcome clear guidance on the effective use of calculators at all stages, not just as instruments to check calculations.

Early Years Settings

It seems particularly inappropriate to talk of "a single, most effective pedagogy" for primary schools and early years settings together. Children between the ages of 0 to 5 are part of the Statutory Early Years Foundation Stage – EYFS (DfES, 2007) with its particular set of principles and research guiding good practice.

'*The EYFS sets standards to enable early years providers to reflect the rich and personalised experience that many parent give their children at home.*' (DfES, 2007, p9).

The EYFS outlines six interrelated areas of learning and development; one of which being 'Problem solving, reasoning and numeracy'; and none of which is to be tackled in isolation from the others. This has particular implications for planning effective mathematical experiences for children at this stage. In addition, there is an emphasis on play as a teaching and learning strategy for all areas: '*All the areas must be delivered through planned, purposeful play, with a balance of adult-led and child-initiated activities.*' (DfES, 2007, p11).

This document is influenced by the seminal EPPE / REPEY research into early years practice (Siraj-Blatchford et al, 2002). This research contains clear and compelling pedagogical messages for effective teaching and learning in early years settings. The EPPE/REPEY research found most effective settings encouraged 'sustained shared thinking', although this did not happen very frequently. 'Sustained, shared, thinking' relies on time being taken to maintain and nourish dialogues between children and children and children and adults. In addition, as well as teacher-directed, programmed learning, the authors identify effective early years pedagogy as a balance of this with an open framework where children are provided with free access to a range of instructive learning environments. Talk of "lesson designs" is thus unhelpful in the early years context.

The impact of testing and performance related pay

High stakes testing has a range of impacts on pupils' attainment in mathematics. The sharp focus on particular forms of assessment undoubtedly leads to pupils being prepared for such forms of assessment. If what is being assessed is that which represents the full scope of desired attainment, then assessment can perform a valuable reinforcing function. It is damaging in so far as it deflects teaching and learning in mathematics away from more lasting styles of teaching and learning. The emphasis on performance in tested dilemmas – with constant checking of attainment of a specific subset of mathematics competence – means there is little incentive for primary teachers to engage their pupils in mathematical dilemmas – i.e. to develop the mathematical curiosity and to think as mathematicians.

We would like the Review team to recommend that in order to move from where we are now to where we might want to be in five years time, the focus now needs to be on:

- how we develop teachers' pedagogical subject knowledge, of the kind referred to above, effectively and lastingly,
- how we affect teachers confidence and aptitude in teaching mathematics, and
- what kinds of ongoing CPD are effective in achieving this.

Area 2: Provision

Q2. What range of provision best supports children across the full ability range? How about the most gifted pupils? And what about those who are not progressing fast enough to reach national expectations? And what about pupils with special educational needs? What would you like the Review team to recommend in this area?

Your [ATM's] comments:

Provision should be about teachers being more imaginative for all abilities. In addition to children needing support and 'gifted and talented' children, there is a large group of children in the middle of the mathematical range of attainment that need to be inspired, intrigued and challenged.

Setting and Grouping

We strongly believe that setting or grouping children by some notion of mathematical 'ability' is flawed as there is no research basis for suggesting that setting and/or grouping within the primary classroom raises standards; although it may simplify planning and monitoring from the teacher's point of view.

In reality, setting and grouping for mathematics are now sadly facts-of-life in many primary schools. This is a result of factors other than that of promoting children's effective mathematical development. Following the introduction of the NNS, schools sought to make direct teaching more manageable by organising classes so that teachers teach more homogeneous groups of children. Many teachers feel they do not have much choice in this. It is a school with a robust philosophy on equality of opportunity combined with both strong and competent leadership and teaching that withstands this drive to set or group by perceived mathematical ability.

The problems with setting and grouping are long established and focus on the fact that such descriptions are perceived as a permanent description of ability. Thus research evidence shows that children's image of themselves as learners is affected by such grouping, and thus labelling. As Askew and Wiliam (HMSO, 1995) point out *'One of the most important things that a teacher can do is to foster a view of ability in mathematics as changeable rather than fixed'*. (p28). It is difficult to see how this is attainable in fixed 'ability' sets. In *Learning without Limits* (Hart, Dixon, Drummond and McIntyre, 2004), the authors, with nine collaborating teachers, note that all forms of ability labelling, whatever the intentions, give implied messages to pupils and teachers about the pupils' potential for future achievement.

In the widespread use of ability labelling, educational practice in England differs markedly from the practice in other countries notably more successful in measured mathematical attainment; eg. in Finland, grouping by ability was abolished 20 years ago (Askew, 2005) and yet, in a 2005 Organisation for Economic Co-operation and Development (OECD) study, Finland came out top in pupil performance across 40 counties.

We believe that effective teaching is dependent upon the teacher offering accessible starting points, which can be extended by different children at different rates and to different depths. The skill for the teacher is to find such accessible starting points and plan for structured extension work (in contrast to doing more of the same). The ATM, as well as the other mathematical subject associations, have developed such materials over 50 years.

This approach has implications for CPD and for developing the mathematical subject knowledge of teachers, who need to understand the progression within and connections between the various

strands of mathematics.

Differentiation
In those schools that do not set for mathematics, teachers are encouraged to differentiate the work for classes for at least three different levels of attainment. Sadly, in much published material, often these three different levels of work bear very little resemblance to each other. Teachers need help to realise that differentiation does not necessarily mean different. Indeed, for many they need to be given permission not to have at least three different tasks. The idea of layering an objective so that the children can opt for the most appropriate for them is useful. Clarke (2006) uses the idea of 'must', 'should' and 'could'. For example in Year 5:

You **must** multiply a two-digit number by a single-digit number
You **should** multiply a two-digit number by a two-digit number
You **could** multiply a three-digit number by a two-digit number

In addition, more open-ended tasks allow children to work at a variety of levels within a problem-solving task, and paired working and discussion are essential for all children.

We would like the Review team to recommend that teachers and schools are supported in developing mathematical tasks that allow access for all children to work mathematically, by both, making teachers aware of available rich resources, and further developing accessible starting points together with support for planning structured extension work.

Perhaps the most we can hope to achieve in the near future in the current climate, is increased support for teachers in teaching *some* mathematics in mixed groupings; as well as the development of research and advice on how we as mathematics teachers can affect all children's self-confidence and belief in themselves as competent mathematicians; for example, Clarke (2006) suggests that children learn best when they are given some control over how they learn.

Developments such as these would positively support all children across the full mathematical attainment range.

Area 3: Intervention

Q3. Are you aware of any numeracy intervention programmes for Year 2 pupils? What should the key features of a successful intervention programme look like? How do you identify if a child needs additional support? How do you measure a child's starting points, the progress the child is making and whether the child has reached the desired level of attainment? How long should the intervention last? And how intensive / frequent should it be? What would you like the Review team to recommend in this area?

Your [ATM's] comments:

Currently, the impact and pressures of performance data on schools, particularly at Y6, is leading to teachers not focusing on the 'routines and vital essentials', nor using the '*Booster'* programmes appropriately. The *Springboard* programmes that have been available for years 3 – 6 contain some useful material. However the way they have been implemented in many schools has been as follows:

- Children 'fall behind' on a topic
- Children are taken out of the next mathematics lesson to' catch up'
- Children miss the beginning of the next topic
- Children 'fall behind' on this topic.

This model has serious shortfalls. The intervention programmes were always intended to be used

before the topic was addressed in the classroom, hence allowing those children to access the lesson. Essentially, the model is to identify pupils who 'slip behind' in a specific area, and intervene so that they can re-join the class. However, often these pupils remain permanently in 'booster classes' for all areas of mathematics, which suggest that the 'catch-up' is not targeted enough. There are important implications for the rest of the curriculum: children must miss another lesson (P.E? Art?), or children attend extra sessions outside normal school hours. It has serious repercussions on the narrowing of the curriculum for these children, as well as an adverse affect on their motivation, interest and application in all subjects, not least mathematics.

There is scope for being more creative, with targeted 'catch up or consolidation' for 30 minutes each day/week where children are working specifically on a subject that they find difficult, or an enrichment activity in a subject in which they feel confident.

It will be by routinely and persistently ensuring that *all* children learn the vital essentials – as is the case in many Pacific Rim and Eastern European countries – that the need for additional intervention-type programmes can be eliminated.

Four essential topics at KS1 for children to understand if they are to make progress in KS2 might be:

- The principles of counting
- Knowing the name and position on the number line of numbers from 1 to 100
- Partitioning and recombining numbers (not just into 10s and 1s) leading to a confident manipulation of calculations (e.g. calculating 13 + 8 as 18 +3)
- Number bonds within 20 and confident use of doubling and near doubling strategies.
- Opportunities to problem-solve, including the application of mathematics to everyday situations and investigational work.

Any planned intervention programmes would need to take into account the shortcomings of those already having been implemented (eg *Booster*, *Springboard*) as well as containing good diagnostic materials, high quality classroom material, and be accompanied by high quality training and clear guidance as to how they should be implemented. Further, they should be given adequate funding which should be ring-fenced. It goes without saying that any initiative that labels such young children as 'below' some perceived level is destructive and counter-productive.

We would like the Review team to take into account the following when considering numeracy intervention programmes for Year 2 pupils:

- the shortfalls of current initiatives,
- broadening, rather than narrowing the curriculum for children who need long term support, as well as for the most gifted pupils,
- creative ways of targeting specific areas needing support.

Area 4: Subject Knowledge, CPD, ITT

Q4. What conceptual and subject knowledge of mathematics should we expect of primary school teachers and early years practitioners? What do you see as the key issues for teachers / practitioners CPD and why is it so important? What do you see as the key issues for teachers / practitioners ITT and why is it so important? What would you like the Review team to recommend in this area?

Your [ATM's] comments:

This is not really about the subject knowledge demonstrated at GCSE level, so much as the willingness and ability to make connections between areas of mathematical knowledge and be

creative in teaching these. Practitioners also need to be aware of why different teaching approaches work, how they can be explained and why they are appropriate.

It has been well documented that both practising and in-service primary teachers may have poor subject knowledge as well as negative attitudes to mathematics (eg. Cockcroft, 1982; Fennema & Franke, 1992). Teachers of primary mathematics need to know and understand the subject in a different way to the subject specialist. Teachers' knowledge of mathematics should be of sufficient depth to enable them to represent it in a variety of ways and to be flexible enough to enable them to interpret children's ideas and address misconceptions. This requires not only knowledge of concepts and procedures but also the understanding of underlying principles and meanings and the appreciation of connections between mathematical ideas.

Thirty years ago the psychologist Richard Skemp coined a distinction between two sorts of understanding. He described and contrasted what he called relational understanding and instrumental understanding. His distinction can help us grasp the nature of knowledge of mathematics we should be seeking as primary teachers (Skemp, 1989).

Mathematics subject knowledge in Initial Teacher Training.
Although the DfEE circular 4/98 gave a useful overview of subject knowledge for training teachers, it used unhelpful topic classifications. In addition, the level of competence demanded that trainees had to be taught in a procedural way that encouraged them to 'jump through hoops'. This is in direct conflict with how they are encouraged to teach, i.e. with understanding.
Trainees need to be very good at basic mathematics – by very good we mean have a thorough understanding of – the following:

- The ability to use and understand the mathematics that you have in order to construct other mathematics;
- Deep understanding of place value;
- Confidence in transforming calculations based on understanding of the four rules of numbers.

Trainees need to be taught to ask 'Help me to understand …' rather than 'Show me how to do …'

From this they need to practise selecting appropriate models and representations, examples, analogies, resources and activities – and to understand *why* the chosen models, representations, examples, analogies, resources or activities are appropriate for learning and teaching the aspect of mathematics being taught.

Training for in-service teachers
Only with *sustained*, ongoing engagement in a mathematics course over a long period of time might you begin to make an impact on teachers with weak subject and conceptual knowledge, and so positively affect teaching and hence mathematical learning. Engagement in longer courses has been life-changing for many teachers; for example, the twenty-day course. The cascade model is not only unsuitable but detrimental for improving teacher subject knowledge.

We fully support the recommendations made in the ACME report *'Ensuring effective Continuing Professional Development for teachers of mathematics in primary schools'* (ACME, September 2006).

Role models can play a vital part in developing teaching. In school situations, maths enthusiasts can be off-putting as they may heighten a sense of inadequacy. Developing a relationship with a role model in a supportive training environment over a long period of time changes attitudes and affects confidence, enabling people to allow themselves to make changes to their practice and to reflect on

these changes. In short, to become a thinking professional. It is unlikely that competent secondary mathematicians, who have had neither experience of sustained teaching in a primary school, nor appropriate preparation for, or interest in, being a trainer, would understand the issues faced by an inadequate-feeling primary mathematics teacher.

Early Years CPD

The EPPE / REPEY research demonstrates that a grasp of appropriate 'pedagogical content knowledge' is just as important in early years settings as at any later stages of education, (Siraj-Blatchford et al, 2002). We understand 'pedagogical content knowledge' to refer to knowledge and understanding of a subject (in this case, mathematics) coupled with effective teaching and learning approaches. This combination has implications for appropriate continuing professional development for early years practitioners. It is simply not enough to work on improving subject knowledge in isolation.

Early years practitioners may be under-confident mathematicians. It is thus essential that any continuing professional development for mathematics should address issues of personal confidence and attitude. Only with sustained engagement in mathematics that early years practitioners see as relevant, might you begin to make any impact on negative subject attitudes and self confidence, and thus on the confidence of practitioners to nourish in-depth and sustained dialogues with young children about mathematics.

To summarise:
All primary/early years/trainee teachers should:

- Realise that differentiation does not always mean children will be doing different tasks;
- Be able to plan for more open-ended tasks to allow children to work at their own level within a problem-solving task, and assist children as appropriate;
- Create opportunities for lots of paired working and talking/discussion for all children;
- Be able to use, and have a deep understanding of, their own mathematics and the relationship of each area, in order to construct other mathematics and to understand the progression of each strand,
- Be confident in transforming calculations based on an understanding of the four rules of numbers;
- Use a variety of resources and images in their numeracy lessons, including the Empty Number Line and place value cards.

We would like the Review team to take account of the following when considering the development of primary school teachers' and early years practitioners' conceptual and subject knowledge:

- the development of the term 'pedagogical content knowledge' - referring to knowledge and understanding of a subject coupled with effective teaching and learning approaches;
- the development and funding of long-term (10 and 20-day) CPD courses for serving teachers;
- a need, in some cases, for ITT providers to increase the hours given to mathematics pedagogy *and* subject knowledge during PGCE courses;
- creating opportunities for developing learning networks, many of which already exist, many through subject associations.

Area 5: Curriculum

Q5. What is the most effective design and sequencing of the mathematics curriculum? Are there

any gaps / problems in the current design? How should and could these issues be rectified? What would you like the Review team to recommend in this area?

Your [ATM's] comments:

Mathematics learning is not sequential but complex, although many of the mathematical 'big ideas' have identifiable roots. Curriculum design should not oversimplify mathematics learning by breaking this down into small blocks or steps; instead a curriculum should outline the broad sweep of mathematical big ideas, allowing all teachers time to pursue threads in depth while maintaining an overview of where the threads lead as well as where they interlink.
In addition to below, please refer to our response to question 1 as much of this is relevant here.

The Early Years Curriculum
Early years learning of mathematics should not be divorced from the five other areas of learning identified in the EYFS (DfES, 2007). Curriculum design that encourages planning mathematical activities solely as separate entities runs contrary to all current advice. Early years practitioners need support in recognising, and then further developing, the mathematical significance of rich learning environments; e.g. how to use a classroom shop to both support and extend mathematical learning and understanding in a variety of ways and at a variety of developmental levels.
In addition, although early years mathematics should be linked to other areas of learning, current research points to the fact that some number-focused activities can be appropriate (Gifford, Peters, Zur and Gelman). For example, parents often teach children to count and children often enjoy learning to do this, the key issue is that the teaching is sensitive and playful and children are enjoying the activities. The New Zealand summary of effective maths pedagogy for the early years also points out that maths focused activities are not only helpful, but enhance the confidence of practitioners (Anthony and Walshaw, 2007).

The current guidance for the EYFS is mathematically inaccurate and unhelpful for practitioners. For example, the section on 'Shape, space and measures' mixes shape and space with early data handling with no explanation; *'match sets of objects to numerals that represent numbers of objects'* is in Shape, space and measures, EYFS, p72. In addition, there is no link between the mathematical ideas, the assessment pointers and 'effective practice' examples, and thus the mathematical ideas are not exemplified sufficiently.

It is unsatisfactory that the word 'mathematics' has been removed as a heading from the EYFS. This leads to a lack of continuity between the Foundation Stage and KS1, as well as not contributing to practitioners' knowledge of mathematics as a subject. It is unclear what positive effect this was intended to achieve.

The EYFS already identifies a broad sequence of *learning and development* for early years practitioners for all six interrelated areas of learning. The primary curriculum should clearly build on this by linking development with learning.

Issues with the new primary framework
The NNS framework was widely welcomed by schools as a tool to support their curriculum planning in mathematics. We now have identified objectives in mathematical development. It is difficult to see how this can be further developed to any real advantage. Many schools have been using the NNS framework with confidence and are now beginning to use it flexibly to suit the needs of their children and curriculum design. It is illogical to attempt to achieve a 'final' framework, and there is thus no reason for a one-off wholesale restructuring of this. Far better would be to develop additional guidance papers (such as the welcome additional paper on Using and Applying mathematics) using

the flexible potential of a website.
However, the new Primary Framework for Mathematics (PFM) consists of a rigid, illogical, and thus unhelpful, block structure for the organisation of the mathematics curriculum. Repeated inquiries about the rationale for this structure were met with the comment that the mathematics framework needed to "match the literacy framework". Why this is so is not clear. Thus we consider it essential that the new PFM block structure is dismantled and that schools are freely able to access the very valuable supportive resources secreted on the PFM site to devise the combinations and sequences of learning that best suit their learners' needs. There is no evidence that this will lead to any loss of rigour in the mathematics curriculum.

The place of mathematics in cross-curricular teaching
Mathematics has nearly always been taught as a distinct subject in primary schools. However, schools are increasingly combining subjects in order to ease curricular pressure (TES, 9/11/2007). The extent to which a school seeks to develop cross-curricular teaching and learning depends, to some extent, on what members of staff consider to be the purposes of education. There are three basic justifications for cross-curricular learning in mathematics:

1. Mathematics is an indispensable tool for other disciplines and human thought. Mathematics education must reflect the importance of mathematics, and what it can do.
2. The application of mathematical knowledge and understanding is essential if learners are to understand the power of mathematics.
3. Knowledge of the world is interconnected. Subject divisions are arbitrary at best, and possibly unhelpful.

If children's capacity for critical inquiry is to be furthered, topics being studied must be located in a broader societal context, and this would be better supported by cross-curricular activities. In addition, some mathematics skills act as 'servants' of work in several curriculum areas, such as measurement in science and data handling in many other areas. There are clear advantages in identifying the inherent overlaps between mathematics and other subjects at the medium term planning stage.

We would like the Review group to take into account the following when considering the effective design and sequencing of the mathematics curriculum:

- the current lack of coherence between the EYFS and the PFM,
- the desirability of working with what we have in terms of frameworks and sequences, and developing additional guidance and support in improving teachers' confidence and creativity in teaching mathematics,
- the need to creatively and rigorously support the development of cross curricular teaching.

Area 6: Parents and Families

Q6. What should the role of parents / families be in helping their children achieve in mathematics? What are the key obstacles / issues for parents and families in this regard? What more should and could we do to support parents and families in this area? What would you like the Review team to recommend in this area?

Your [ATM's] comments:

There is long history of parental involvement in the early years of their children's education. Rose Griffiths provided useful examples of this recently in *MT* (Griffiths, 2003). This can be drawn on for primary schools.
There is a strong body of evidence (e.g. Harris and Goodall 2006) to suggest that, whatever their

own educational levels and abilities, parents have an important influence over children's achievement through their impact on children's attitudes to learning and to school. Actions that help to overcome many parents' negativity about learning mathematics are likely to be particularly beneficial.

We would like the Review group to consider the following:

- Parents working alongside children can help to overcome not only children's resistance to maths but also the parents' resistance.
- Raising parents and families awareness that mathematics is about more than more than calculations.
- Guidance on ways of encouraging children to think and make decisions through open-ended questioning.
- Prompting parents to demonstrate the use of mathematics in our daily lives, for example, in measurements and money.
- Suggesting resources, games and activities which will make learning interesting and above all, fun, for everyone concerned.

Area 7: Primary Frameworks and EYFS

Q7. What assessment do you make of the Primary Frameworks / EYFS and its effectiveness? How can the Review team build upon the Primary Frameworks?

Your [ATM's] comments:

See Area 5 above.

Area 8: General thoughts / comments

Q8. Do you have other thoughts / comments that you would like to make? If so, please let us know here.

Your comments:

It would have been helpful if there had been more time to consult members who are busy working in schools. The timescale for such consultations should be longer than has been allowed for in this instance.

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