Research for Teachers

Leading staff development in primary mathematics

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In this TLA research summary we feature some of the findings from a major five-year study into the teaching and learning of mathematics in British primary schools.

The work is derived from the Leverhulme Numeracy Research Programme, a six-strand study which began in 1997 to investigate primary school mathematics teaching at a time of national and international concern about standards of children's achievement in the subject. It coincided with the introduction, in England and Wales, of the National Numeracy Strategy (NNS) in 1999/2000 and therefore offered a unique perspective on what it was like for teachers on the ground as they began to implement the new requirements.

The first volume in a set of four is:

Millet, A., M. Brown and M. Askew (eds). *Primary Mathematics and the developing professional*. Dordrecht: Kluwer, 2004.

The book focuses on the professional development of teachers in mathematics and includes insights into the successes and challenges for effective practice encountered by primary mathematics co-ordinators and school leaders in a variety of primary settings.
Most primary practitioners are full-time class teachers with a particular subject responsibility.

This summary will be of interest to primary teachers in their roles as subject co-ordinators, a role that has gone through marked changes over the past decade, from that of supportive colleague to that of recognised 'expert', responsible for monitoring the standard of teaching and learning in their subject. It offers insights into more (and less) effective ways of supporting the professional development of colleagues.

It will also be of interest to school leaders, as it clarifies the nature of support that subject co-ordinators need

from their head teacher in order to pursue their roles effectively. The summary also includes insights into effective aspects of practice in the teaching of primary mathematics in both the main text and the case studies.

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Overview

Why is the issue important?

The implementation of the National Numeracy Strategy (NNS) required mathematics co-ordinators to play a pivotal role in ensuring changes were understood and followed by their colleagues. To achieve such changes in practice and raise attainment, co-ordinators need to know how to be effective at leading and supporting the professional development of colleagues.

What did the research show?

With the NNS, the role of maths co-ordinator changed from supportive colleague to recognised 'expert', responsible for monitoring the standard of teaching and learning in mathematics. Co-ordinators introduced their colleagues to the new ideas from the NNS through whole school in-service training (INSET) meetings and encouraged their colleagues to begin to make changes to classroom practice by providing demonstration lessons and mentoring. Co-ordinators supported their colleagues by creating opportunities for group and individual discussion and by providing new materials and resources, such as number fans and individual whiteboards for pupils.

How was this achieved?

Key to the success of co-ordinators in negotiating change was the level of support offered to them by the school. The most important form of support was the availability of non-contact time, which enabled co-ordinators to observe and work alongside their colleagues. Specialist expertise (from teachers within the school and from external experts, such as LA subject consultants and academic researchers in mathematics education) was important too. The ease with which mathematics co-ordinators were able to bring about changes in their colleagues' practice depended upon their colleagues' expectations and previous practice at the school, as well as on the co-ordinators' own self-confidence and experience.

How was the research designed to be trustworthy?

The study formed part of the four-year Leverhulme Numeracy Research Programme which investigated low achievement in numeracy and effective strategies for improvement. This part of the research involved six primary schools. Interviews were conducted with headteachers, twenty-four class teachers and twelve mathematics co-ordinators. The researchers also examined trends in the schools' Key Stage 2 SATs results and observed nearly 60 maths lessons.

What are the implications?

The study showed the importance of:

- headteachers providing subject co-ordinators with support in the form of a working relationship of mutual trust and respect, and non-contact time to observe colleagues and model good practice
- subject co-ordinators working collaboratively with colleagues and discussing teaching strategies with them
- incorporating specialist expertise into staff development
- greater use of tactile and visual apparatus in mathematics teaching.

What do the case studies illustrate?

The case studies show, for example:

- how one teacher was supported within a context of collaborative research with colleagues to change how he listened to students
- strategies teachers have used to get the best out of debriefing (plenary) sessions in which pupils had the opportunity to discuss their learning
- ways schools successfully improved pupil attainment in maths through the use of multi sensory equipment and implementing whole school change.

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Study

How was the National Numeracy Strategy intended to change mathematics teaching?

In the late 1990s, international comparisons of mathematical achievement intensified political concerns about low standards of calculation skills shown by children in English primary schools. The government's desire for rapid enhancement to teaching and learning in schools culminated in the introduction in 1999 of the National Numeracy Strategy (NNS).

The key features of the NNS were as follows.

An increased emphasis on number and on calculation (especially mental calculation)

- Pupils could choose from a range of mental strategies.
- Written calculation was postponed in the early years.
- Use of calculators was discouraged.

A three-part template for daily mathematics lessons

- 5-10 minutes of oral/mental skills practice.
- Direct, interactive teaching of whole class.
- Direct, interactive teaching of groups.
- 10-15 minutes of review at a plenary session.

Detailed planning using week by week sets of objectives

- The objectives were listed with detailed examples to explain them
- Teachers were expected to reduce their dependency on textbooks, using them only as a source of examples

A systematic national training programme

- Local consultants ran three-day courses for mathematics co-ordinators, head teachers, one other teacher from each school and a governor
- The co-ordinator was expected to cascade learning to other staff in the school
- Some schools 'in need of intensive support' received an external, five-day course and were given additional support through school visits - this was later extended to include other schools.

The concept of numeracy was a key part of the strategy. The aim was for children to achieve an ease with numbers: to understand numbers and numerical relationships, to be comfortable using numbers and calculating and to be able to use numbers to solve problems in everyday life. To meet this aim, the strategy identified and organised lists of number skills into a complex framework, specifying when and how teachers

were to teach them to pupils. Mathematics co-ordinators were expected to play a pivotal role in ensuring that the new framework was understood and followed by their colleagues.

The study found a number of changes commonly made to classroom practice and reported by a variety of staff. These were:

- changes to the structure of the lesson
- changes in the teaching of mental mathematics
- changes in the provision and use of commercially produced resources, especially practical apparatus, but also sometimes in the use of mathematics schemes
- changes to planning.

What was the role of the mathematics co-ordinator?

During the period of the study, the researchers found that the role of the subject co-ordinator in primary schools changed quite fast in response to external expectations of the role and pressures (from Ofsted inspections, for example) for greater accountability. The role changed from a supportive, developmental model to one with strong elements of monitoring and evaluation. Subject co-ordinators might be expected to undertake the following duties:

- organisation of materials and resources
- subject leadership and consultancy
- production of curriculum documents
- organisation and delivery of CPD activities
- initiation of the school response to initiatives for reform
- in-class support
- monitoring and evaluation of teaching and learning in the subject.

Thus, in addition to responsibility for teaching their own class and initiating and implementing curriculum changes there, mathematics co-ordinators also had to act as a mediator of change for others. They had to negotiate simultaneous but different roles, such as colleague, expert and evaluator.

How did the co-ordinators respond to these changes in their role?

The researchers found that the level of support offered by the school was key to co-ordinators successfully negotiating this change. Most schools offered financial support to buy new apparatus and textbooks, but the most important form of support for co-ordinators was the provision of non-contact time which enabled them to observe and work alongside colleagues.

All the way through the book, the researchers used a model they called the 'zone of enactment' that was a bit like a sphere of learning. It is a social model of learning, insofar as it is based on the idea that people learn by talking to one another and by trying out new ideas in different contexts. These spheres of learning or zones of enactment can be expanded by interaction with others and by a variety of experiences. The researchers were particularly interested in how co-ordinators' spheres of influence could affect their colleagues' spheres of learning. They found that different co-ordinators' ability to influence their colleagues' zones of enactment and thus their classroom practice varied and depended on the provision of time and opportunities for:

- discussion
- modelling or seeing how new ideas could work in practice
- experimenting with new ideas and subsequent discussion
- working alongside and mentoring colleagues.

The concept of a zone of enactment or sphere of learning seemed to have some parallels with Vygotsky's concept of the zone of proximal development (see our earlier RfT about Vygotsky's work).

How did co-ordinators set about introducing new ideas?

The researchers looked at some of the decisions made by the co-ordinators about facilitating colleagues' change and the ways they set about putting those decisions into operation. The researchers found the co-ordinators:

- provided new materials and resources
- created opportunities for group and individual discussion
- modelled new ideas in the classroom for colleagues.

The NNS promoted the use of a variety of practical equipment. Subject co-ordinators were required to provide, organise and ease the use of resources. They introduced materials such as number lines, counting sticks, 100-squares, number fans and individual whiteboards to their schools and sometimes used these artefacts to start conversations about teaching practices.

All six schools in the study used whole school in-service training (INSET) meetings, conducted by the co-ordinator, as one way to introduce classroom teachers to new ideas. The best of these encouraged discussion by all staff present; for example, by displaying resources and discussing their use, or by exploring practical ideas for a range of year groups. Other INSET sessions were felt to be less helpful. For example, when two individuals dominated the discussion to the exclusion of other staff or when the co-ordinator merely read through the transparencies supplied by the NNS training pack and offered few opportunities for interaction.

Some co-ordinators were clear that they needed to provide a variety of contexts and ways in which they could engage colleagues in discussion. They were sensitive to the fact that some colleagues preferred to discuss issues on an individual basis and were less likely to speak out in a group. So, as well as providing opportunities for group discussion of mathematics teaching during in-school training sessions, they made themselves available for individual discussion with colleagues. Some held 'mathematics surgeries' at regular intervals and invited colleagues to use these to discuss their queries or to work together on any difficulties. Readers may like to refer to a case study illustrating how one school used collaborative action research (case study 1) to transform the quality of listening and whole class discussion in mathematics lessons.

The researchers identified four conditions that promoted effective professional development:

- time, including both non-contact time to support and coach colleagues and sufficient time for continuing to learn and reflect on the outcomes of trying new approaches
- talk, especially discussion with colleagues focused on the teaching and learning of mathematics
- expertise, both from teachers within the school and from external experts such as LEA subject consultants and academic researchers in mathematics education
- motivation to improve practice and understanding.

Co-ordinators worked hard to mentor and support their colleagues. As discussed below, co-ordinators invited colleagues to watch either them or an expert from elsewhere demonstrate a new style numeracy lesson.

How did co-ordinators help colleagues to use new ideas in the classroom?

Co-ordinators supported their colleagues to move forward from discussion of ideas and to begin to make changes to classroom practice by providing demonstration lessons and mentoring. The ease with which mathematics co-ordinators were able to implement these practices depended upon colleagues' expectations and previous practice at the school, as well as on the co-ordinators' own self-confidence and experience and the type and extent of support available to them.

Modelling and demonstrating

The NNS entitled all classroom teachers to see a numeracy lesson actually being taught by either a 'leading mathematics teacher' from the LEA, from another school or from within their own school. The co-ordinators had received either three or five days of training about the NNS, but many found having to lead these demonstration lessons stressful. Their discomfort increased if they:

- had little experience in the role of mathematics co-ordinator
- felt that other staff were relying on them as the 'resident expert'
- had to teach an unfamiliar age group.

Some co-ordinators lessened the strain by using the expertise of others. For example:

- co-ordinators for schools that needed particular support in mathematics could ask staff from the LEA to model lessons for them
- some co-ordinators only demonstrated the new techniques with their own classes and then discussed with colleagues how these might be modified for different age groups.

More experienced and confident co-ordinators were clear about the importance of using the modelling process as a basis for later discussion. This enabled staff to:

- ask why the teacher did particular things
- gain a deeper understanding of the process
- consider as a group how an activity could be modified to better suit particular individuals or age groups.

Mentoring

The NNS provided funding for co-ordinators to monitor others' classroom practice and act as mentors. The successful use of classroom visits varied according to:

- the priority given by school leaders to providing non-contact time for mentoring to take place
- the extent to which teachers were used to watching one another's lessons and being watched before the advent of the NNS.

Almost all primary mathematics co-ordinators in the study had full-time responsibility for teaching a class of their own. Their effectiveness in influencing practice and improving the teaching and learning of mathematics across the school depended upon having time away from their own class (non-contact time) so as to work with and mentor others. School leaders differed in how successfully they planned and guarded this non-contact time, which was sometimes lost due to staff absences and other demands.

Schools varied in the amount of non-contact time they made available to mathematics co-ordinators to observe other colleagues both before and after the introduction of the NNS. In schools where lesson observation had been well established before the advent of the NNS, co-ordinators were happy to act as 'a critical friend'. In half of the schools in the study, co-ordinators had never observed their colleagues prior to the NNS and knew little about how mathematics was taught in other classrooms. These co-ordinators in these schools were aware that their colleagues felt anxious and threatened about the proposed observation and monitoring of their teaching. They also struggled to balance their roles of support and accountability for raising standards. As one co-ordinator commented:

We made sure that when everybody went into another class it wasn't going to be critical - it was going to be looking for the positive and helping each other. I think I've got to make sure that my monitoring is like that as well, but you've also got to pick up on things that aren't going well.

Several co-ordinators in schools that were wary of classroom observation deliberately scheduled their demonstration lessons before visiting other teachers' classes to show that they were willing to be observed.

How did teachers put whole class interactive teaching into practice?

The NNS placed great emphasis on interactive whole class teaching. Numeracy sessions were split into three parts, each of which featured interactive teaching. There was evidence that teachers readily adopted the three-part lesson structure. Nevertheless, they lacked opportunities to explore their understanding of certain issues, such as:

- the nature of interactive teaching
- the nature of the learning process itself
- how to develop pupils' understanding of mathematical concepts.

As a result, many teachers adopted a relatively simplistic response to, for example, demands for a swift lesson pace. This study observed particular teachers in detail and over time. This account of one teacher's struggles with the guidance from the strategy highlights issues which also affected many others.

Lesson pace and pupil engagement - learning from misunderstandings

Frankie was a motivated and enthusiastic teacher. Her beliefs about the nature of learning and her understanding of lesson pace and the nature of interactive teaching affected her attempts to implement the NNS. She was in her third year of teaching when the study began in a mixed Year 4/Year 5 class with many children of low ability. She became the school's mathematics co-ordinator in 2000, the first after a break of a year during which the school was without one. She wanted her pupils to understand, and often asked them to demonstrate on the board, how they reached an answer. This process was time consuming and the NNS advocated a brisk lesson pace, so Frankie (like many other teachers in the study) decided to increase the pace of her whole class teaching. She did so by using quick-fire question and answer sessions, which she thought helped her pupils to get through a lot of work.

Frankie included as many pupils as possible in her whole class teaching. She distributed the questions widely and used resources that involved all of the children. The observers noted that when children were given questions they could easily answer, their level of attention was good, but that the low achievers lost interest during more demanding work and more able pupils were 'somewhat passive' during extended periods of listening and observing. Video evidence showed that attention wavered during a whole class exercise in which pupils took turns to place fractions or decimal cards on a number line, but that:

Once Frankie went back to ask less difficult questions of the whole class and distributed the questions around, the whole class sat up and took notice.

Many teachers in the study reported increases in pace, pupil engagement and enthusiasm, but the researchers' observation that pupil engagement in Frankie's lesson appeared to increase when she made the work less thought-provoking raised questions as to what was really happening in classrooms. The researchers questioned a widespread perception that a greater pace in question and answer sessions equated to more interactive teaching. Although Frankie had tried to put whole class interactive teaching into practice, her understanding of what it might look like differed from the researchers' understanding of what it might mean.

One case study taken from the Leverhulme Project on whole class interaction in mathematics (case study 2) raises the issue that a strong emphasis on producing a swift answer within a whole class context may promote young pupils' social participation in the lesson, but not their engagement with mathematical thinking. Practitioners may also like to read a case study of effective whole class teaching which we featured in our earlier RfT Effective teachers of numeracy.

Changing unconscious beliefs

Frankie assumed that learning took place through observation and this belief underpinned her teaching methods. She had a view of teaching as demonstrating and thought pupils' mathematical understanding would increase by watching her or a fellow pupil demonstrate a mathematical procedure. She disliked seeing pupils struggle to overcome difficulties. The researchers commented that Frankie would have benefited from knowing that children can learn through such struggles. Readers who wish to explore the area of learning through challenge might like to refer to the RfT on 'Improving learning through cognitive intervention'.

Whilst Frankie's beliefs remained unexamined, they affected her practice to the extent that, although she adopted some new teaching methods as a result of attending the NNS five-day course, her ability to support her pupils' learning remained relatively unchanged. The researchers noted that Frankie's willingness to

change led to small, but continuous changes in her practice. They concluded that she would have gained much more from a course that helped her to uncover her underlying beliefs about learning and extended her understanding of how children learn.

Before taking on the role of mathematics co-ordinator, Frankie experienced few opportunities for discussion with colleagues. She planned alone and had few chances to observe others' classes in the school. Staff did not discuss teaching experiences with one another. Once Frankie became mathematics co-ordinator, her opportunities for learning with and from others increased.

How did teachers help pupils' understanding through better teaching of mental arithmetic?

The NNS laid great emphasis on mental work in mathematics. A test of mental arithmetic had been introduced to the Year 6 SATs in 1998 and some schools practised mental arithmetic in response to this. In the early years of the NNS (1999 to 2000), mental arithmetic practice became more widespread and frequent. Each numeracy session was expected to start with a ten minute 'oral and mental starter' for pupils to practise their mental arithmetic skills. To monitor responses, teachers often asked pupils to write their answers on individual white boards or to indicate them using digit cards or fans.

Once the mental mathematics starter had been established as part of the numeracy lesson, co-ordinators focused on making it more varied and interesting:

'I'm trying to get through to people that they can cover areas other than just quick number bonds in that time. I've suggested that they actually do two short activities...[with] the emphasis on all the class joining in, rather than just one person coming up and writing things on the board...'

Teachers also actively taught strategies for mental calculation to a greater extent than previously. Teachers reported that they, as well as their pupils, enjoyed learning new strategies for mental mathematics. Some teachers saw improvements in their own ability to do mental mathematics, as well as in their pupils' ability.

The Strategy explicitly delayed the introduction of written methods of calculation to the later years of primary school. As a result, younger pupils spent less time on written work. Some teachers were anxious that the decreased amount of written work in children's books would lead parents to complain. Co-ordinators tried to reassure their colleagues that those responsible for planning the NNS understood this issue.

The plenary session

The NNS expected teachers to use the final part of the lesson to review what had been learned and to take the learning forward. This might have appeared straightforward to implement, but the study found that some teachers struggled to establish effective teaching and learning strategies for the plenary session. Its timing and content both proved problematic.

Some teachers had problems with time management, missing the plenary or spending too long on it:

'I spend a long time on the plenary sometimes... and you feel like you should sort out all their problems that they don't understand and then suddenly you've lost loads of time...' (Year 4 teacher)

Nevertheless, classroom observations showed that nine out of ten lessons included a plenary in 1999 - 2001, after the introduction of the NNS.

A more intractable issue was that of purpose and content. The plenary was intended to sort out misconceptions, identify progress, to summarise key facts and ideas worth remembering, to make links to other work and to discuss next steps. However, it was often used as an occasion when pupils described or explained in turn what they had done in the main part of the lesson. A focus on what pupils had done, rather than on what they had learned, was found in about half of the plenary sessions observed.'

In the more effective plenary sessions, teachers addressed problems that had arisen or drew out teaching points from the children's work. At its best, direct, genuinely interactive teaching in the plenary session drew explanations from pupils that helped them to gain a deeper understanding of what they had achieved in the lesson and to connect their learning to other work.

Readers may like to explore a case study on how pupils learn from effective debriefing (case study 3).

How did use of mathematics resources change?

Head teachers and mathematics co-ordinators in all schools commented on the increased need for and provision of practical equipment in order to implement the NNS. Teachers claimed to include more practical activities and games in their lessons, but lesson observations by the researchers led them to question how often some new practical equipment was actually used. Teachers reported favourably on the increased variety and availability of resources, but admitted not using them all.

'We've used the number lines quite a lot with the children... [but] haven't used a lot of cards and fans and so on.'

Readers may like to look at a case study of how a school greatly improved its pupils' SATS scores by using structured mathematics apparatus in a carefully planned multi-sensory approach to teaching mathematics (case study 4).

Some primary mathematics co-ordinators used the introduction of new practical resources as a starting point for discussion and staff development. Others used the opportunity presented by the implementation of the NNS to review their use of particular textbooks and written schemes. This is discussed further in the section entitled 'How did the NNS change the planning of mathematics teaching?'

Co-ordinators generally reported receiving many more requests for help and advice following the introduction of the NNS than was the case beforehand. In their roles as subject mentors, co-ordinators had to deal with more than just the pedagogical and structural changes required by the strategy. They also had to cope with resistance, anxiety and stress. Nevertheless, they reported some instances of positive responses from colleagues to the introduction of the NNS including:

- greater confidence in teaching mathematics
- higher expectations of pupils
- higher quality mathematics displays
- some instances of better questioning, including greater differentiation for pupils of different abilities in mental mathematics sessions.

How could the planning of schemes of work use textbooks most effectively?

It was common practice in England before the introduction of the NNS for primary teachers to use a mathematics 'scheme', a structured set of published materials for pupils and teachers that often included children's textbooks, teachers' books, assessment and resource materials. The ways in which schools used such schemes varied, but fell into two broad categories:

- scheme-assisted planning
- scheme-driven planning.

Scheme-assisted planners used a variety of source materials to set work for their pupils. Scheme-driven planners took more than 50 per cent of their pupils' work from a published scheme. In some scheme-driven classrooms, children worked independently through textbooks at their own pace.

The Cockcroft report of 1982 warned teachers to exercise discretion in their use of published schemes and not rely on them to provide a complete course in mathematics for pupils. Local education authority advisors

tended to promote scheme-assisted practice. Concerns were expressed when an Ofsted report (1993) noted that in about one third of classes inspected, teachers were very reliant on commercially produced mathematics schemes. This was not thought to be in the best interests of either their pupils' mathematical development or the teachers' own professional development.

Some experts believed that the process of choosing materials to exemplify and practise particular mathematics skills and concepts could be a valuable source of CPD for teachers. The researchers expected that the introduction of the NNS would lead groups of teachers to plan collaboratively and discuss which materials would best suit specific lesson objectives. Although this was the case for teachers in some schools, other schools avoided joint planning, seeing it as duplicated effort and an inefficient use of time.

How did the NNS change the planning of mathematics teaching?

The National Numeracy Strategy prescribed learning objectives and specified learning outcomes, but left teachers to decide how to fill the gaps between the two. Teachers were expected to use the strategy document to define a programme of study in mathematics and then to make their own detailed plans as to how to implement it.

'The way to teach it isn't really in there.' (Mathematics co-ordinator)

There was inevitably a mismatch between the content of existing commercial schemes and the new strategy. For example, the NNS proposed that teachers revisited different mathematics topics frequently during the year, rather than spending an extended block of time such as half a term on, for example, 'time' or 'shape and space'. This mismatch initially forced teachers to rely less on their existing scheme and to search for materials elsewhere. The initial NNS training encouraged teachers to use their professional judgement to use a variety of materials to support their work and to 'pick and mix' resources as they saw fit. The NNS encouraged teachers to become less dependent on textbooks, using them only as a source of examples.

Whatever their practice before the strategy, all schools appeared to go through at least a brief period when the NNS framework became the focus for their planning. However, searching several sources for suitable examples for children's work took time and energy and this added to the increased planning requirements of the Strategy for written details of learning objectives for each aspect of the new three-part lesson. Lengthy planning time was a considerable problem:

'I don't believe that you should be spending more time planning than delivering. That can't be right.' (Head teacher)

'Before I got this [newly published] scheme, I'd say it was taking me three to four hours just to plan my maths lessons and to prepare things for them which is just unworkable week in, week out. It was becoming a nightmare.' (Year 3 teacher)

The issue of time needed for planning persuaded some schools to adopt new mathematics schemes that did the work for them and offered highly detailed lesson plans, or even scripted lessons. As more commercially produced products that fitted the new Strategy became available, some schools dropped scheme-assisted practice in favour of a heavier reliance upon the new schemes. The DfES also eventually published detailed, ready-made lesson plans on their website. Some head teachers welcomed the advent of 'ready to use' lesson plans from a single source:

'[The new scheme] is just a total script for delivery in maths ... that frees you up because once you've got that knowledge of 'this is what concepts you'll be teaching' and this approach to it, you can then add flair...' (Head teacher)

'I'm loath to have teachers choosing between two and three schemes because otherwise things might get missed out or something like that...if you've got too many resources ... teachers go about looking at this one

and that one and the other one and deciding which one ... [it] is just time-consuming.' (Head teacher)

Most schools eventually returned to the general approach they had taken to the use of mathematics schemes before the NNS was introduced. Of the schools that did change their approach, a number became less, rather than more, flexible in their use of texts. The researchers thought this was a retrograde step, as it reduced the possibility of teachers learning from the process of using the Framework for collaborative planning.

What school conditions and personal qualities influenced co-ordinators' effectiveness?

All mathematics co-ordinators introduced their colleagues to the new strategy, but some were more successful than others in acting as catalysts for change. The researchers identified six factors which seemed to affect the speed and effectiveness with which change occurred in different schools in the study. The first two related to personal characteristics of the mathematics co-ordinator, including:

- their enthusiasm for the co-ordination role
- their clarity of vision about priorities for action, including their sensitivity to colleagues' needs for different ways of working with them.

The next four factors that influenced the way in which co-ordinators were able to carry out their role in effecting change lay beyond the co-ordinators themselves and in the wider situation of the school. Situations that promoted positive change showed:

- a balanced relationship between the head and mathematics co-ordinator - where the head's respect for the co-ordinator's judgement and expertise was matched by the co-ordinator's understanding of the head's priorities and recognition of their support
- a high priority given to resourcing the co-ordinator's role - where this included the provision of non-contact time for co-ordinators to observe or work with colleagues, as well as the purchase of mathematics equipment and texts
- coherence and consistency of colleagues' views within the school - including whether colleagues held consistent views towards school policies and actions in general, and whether they supported the innovations in the NNS, rather than being resistant to them
- the existence and appropriate use of external support - such as support from LEA advisors or the investment of substantial time in training courses in mathematics.

The first of the points above seemed to be the central and critical factor for success. Two of the three schools that were judged by the researchers to be in a positive position on at least five of these factors at the beginning of the study made early gains in pupil attainment results in national tests at the age of eleven. Schools with a negative position on some of the constructs were slower to make such gains. Three of the six schools were judged to have difficulties with four factors:

- the co-ordinator did not have a great deal of choice about taking on the role
- the coordinator had difficulty in clarifying goals and ways of working with colleagues
- the school allocated little or no non-contact time for the coordinator to work with colleagues
- the relationship between the head teacher and the co-ordinator was not characterised by mutual trust and respect, but by conflicting views and lack of trust.

In these cases, the three original mathematics co-ordinators relinquished the role, often in distress, as they were conscious of an atmosphere of disapproval, yet felt unable to take action to improve the situation. The degree of trust between head teachers and new co-ordinators that they had appointed was greater. This led to an improved balance of power between them and other factors also began to improve.

How did 'whole school factors' affect improvement in mathematics?

Schools work within a given context in which only some factors come within their control. They have no control over other aspects of the school, such as the socioeconomic circumstances or mobility of their pupils and the amount of basic funding they receive from the LEA. The researchers wanted to find out what effect such 'givens' had on improvement in mathematics compared with other, more controllable factors. They investigated this by studying the eight most and eight least successful schools from a sample of 35 primary

schools in varied circumstances. The measure of a school's 'success' was determined by the average gain in mathematics performance made by two cohorts of pupils over a three-year period. They searched for patterns that emerged on several factors over which schools had varying degrees of influence.

Three factors emerged as having an effect on improving mathematics scores:

- schools that had low levels of attainment at the start of the study tended to improve more - there was more potential for improvement in such schools
- schools with lower levels of staff mobility tended to be more successful in raising pupils' attainment
- schools in which more staff used opportunities for extended support in mathematics from external sources (such as use of support from LEA advisors or attendance at long training courses) were more likely to make larger gains in pupil attainment.

The effects of other factors were less clear cut. Some schools situated in deeply deprived areas were as successful as schools in more affluent areas in effecting improvements to pupils' SATs scores. This led the authors to conclude that school improvement depended more upon the attitudes of and actions taken by staff than upon their pupils' level of socioeconomic deprivation. The quality of teaching, the attitudes of teachers and the use of specialist expertise were the key to improvement.

The researchers also compared their own tests of pupil progress with comments from schools' Ofsted reports. They found that some schools with low levels of attainment in mathematics compared to national averages nevertheless had helped their pupils to make exceptional progress from their low starting points. Ofsted reports rarely recognised such value added gains. Given the profound effect that Ofsted reports can have on both the focus of school improvement and on teacher morale, this finding suggests that school self-evaluation processes might usefully pay careful attention to value added measures.

Readers of this RfT may like to read details of a case study that illustrates the process of whole school improvement in mathematics (case study 5) and the steps that led to dramatic and sustained improvements in pupils' mathematics performance.

How was the research designed?

The data on the role of the mathematics co-ordinator were collected for the focus project 'Whole school action on numeracy'. The study involved six primary schools. The researchers collected evidence from interviews with head teachers, 24 class teachers and 12 mathematics co-ordinators (who had varied mathematical backgrounds) from the schools. They also examined trends in Key Stage 2 SATs (national test results of pupils aged 11 years) and made observations of lessons in mathematics (23 in 1997/98; 25 in 1998/99; 10 in 1999/2000).

The study investigated:

- how mathematics co-ordinators set about influencing a change in practice in their schools in response to changes in the curriculum for mathematics, including the introduction of national tests in Years 2 and 6 and the NNS in 1999
- the factors that influenced the effectiveness of mathematics co-ordinators in bringing about change.

The data on whole school change came from a large scale project 'Tracking numeracy'. This examined the numeracy attainment of two cohorts of primary pupils over four years in about 40 primary schools in a variety of contexts. It attempted to match year-on-year value added data against data related to classroom practice, to individual pupils, to each teacher and to each school.

Implications for practice

Subject co-ordinators may like to consider the following implications for their practice:

- The study was clear on the benefits of working collaboratively with colleagues and discussing teaching strategies. How can you and your colleagues maximise opportunities for learning together?
- Planning from the NNS framework was laborious, but the researchers were sceptical of the benefits of using detailed, prescriptive, published lesson plans. How can you work with colleagues to reduce the burden of planning and maximise the potential for professional learning from collaborative planning?
- The NNS has led schools to buy a wide range of equipment to improve teaching and learning in mathematics. What tactile and visual apparatus do your colleagues use in mathematics? Might further opportunities for staff discussion of their experiences with different equipment help to extend its usefulness?

Teachers may like to consider the following implications for their practice:

- Teachers in the study listened carefully to what pupils said, but did not always follow up pupils' ideas. To what extent are you able and/or confident to explore pupils' thinking and the assumptions that underlie their actions in mathematics? Do you think this is best done in a whole class, group or individual context?
- The study suggested that attempts to achieve a brisk lesson pace by using quick-fire questions and answers increased pupil involvement, but did not promote their deeper mathematical thinking. What activities, in your experience, tend to encourage pupils to think more deeply about mathematical concepts?

School leaders may like to consider the following implications:

- The expertise of most primary subject co-ordinators lies as much in teaching a particular age group as in their subject. How can you support them to work with colleagues to develop good subject practice for all age groups?
- The study found that co-ordinators needed support from their head teachers in the form of a working relationship of mutual trust and respect and non-contact time to observe colleagues and model good practice. What have you found to be effective ways of developing shared goals with, and demonstrating your support for, your subject co-ordinators?
- When many staff in a school had received extended support in mathematics from external sources, pupils' attainment was more likely to rise substantially. How can specialist expertise be drawn into staff development within your school?
- The study found that some schools in deprived areas made considerable value-added gains in pupil performance that were not always picked up during Ofsted inspections. How do you ensure that your school self-evaluation procedures communicate value-added achievements clearly?

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Case studies

The case studies we have chosen throw light on various aspects of introducing change to the teaching of mathematics in primary schools. The first illustrates how one teacher transformed his approach to listening to students and the mathematical ethos in his classroom through a reflective process of action research. Case study 2 focuses on the reasons why one young pupil chose to pretend to understand, rather than to truly engage in mathematical thinking. Case study 3 focuses on strategies that secondary teachers found helpful in debriefing pupils and this has useful parallels for primary teachers in the plenary session. Case studies 4 and 5 both focus on schools which have made major improvements to pupil attainment in mathematics: the former through the use of structured equipment in the Early Years and the second through a process of whole school change and effective partnership working between teachers in the school.

Listening: A case study of teacher change

We chose this case study because it illustrates how one teacher was supported within a context of collaborative research with colleagues to change how he listened to students. The change in the quality of this teacher's listening over several months transformed the nature of learning in his mathematics lessons. It resulted from his reflection on the learning conversations that took place in his Year 7 mathematics class.

What did the school do to promote deeper thinking about mathematics?

A teacher at the school had already undertaken some action research into developing 'a need for algebra' in mathematics. He encouraged his Year 7 students to develop and ask their own questions about complex mathematical situations and identified strategies that helped them to do so.

Four other teachers at the school decided that they wanted to work at developing 'a need for algebra' in their own Year 7 classes. They all believed:

- it was important for students to develop their own questions during whole class discussions
- the quality of listening used in the classroom would be a key factor.

They worked collaboratively to develop the quality of listening and questioning in their classes. The teachers agreed to be videotaped each half-term over an academic year. A camera was fixed at the back of the classroom, focused on the board with around half the students in view. The teacher-researchers then watched sections of videotape together and discussed what was happening. They thought about how future practice could be changed as a result of insights that arose from these discussions.

Transcribed sections of dialogue from the video recordings of whole class discussion offered evidence of three different types of listening:

- **evaluative listening** happened when a person judged what others said as either right or wrong, according to a predetermined idea. An example of evaluative listening would be an immediate response to another's suggestion with a judgement that it was correct or incorrect. Teachers who listened evaluatively rarely moved away from their intended plans
- **interpretive listening** happened when the listener reached out to try to understand the speaker, but was aware that he or she might not have understood the idea or meaning that the speaker intended to explain. An example of interpretive listening would be when someone offered an interpretation and asked for clarification
- **transformative listening** included both an awareness that what was heard might not be what the speaker intended and also an openness to change. Evidence of transformative listening in a classroom included a willingness to alter ideas in a discussion, to engage in dialogue and to consider other points of view as valid.

How did one teacher change his listening strategy?
Video tape transcripts for one of the teachers showed that the nature of the listening by both students and teacher in mathematics classes changed over time. Transcripts from different parts of the year illustrated a change from evaluative listening on the part of the teacher to interpretive and then transformative listening, when the students started asking their own questions about the mathematics.

Early transcripts showed evaluative listening: the teacher agreed with students' responses, or said "Thank you" when students made a 'correct' response. The teacher seemed to expect a particular response from students. He started with an open question: 'Any comments about those three numbers?' When students did not offer an expected response, the teacher directed students' attention to a specific aspect of the problem: 'What can you tell me about the first and the last?'

Later transcripts moved from interpretive to transformative listening. In one example, the teacher initially used an interpretive listening pattern, repeating each student's contribution and asking for further comments. The quality of listening changed after a student mentioned symmetry:

[Discussion of the properties of a rectangle]

S1: It's got six lines of symmetry.
T: Six lines of symmetry, right, we're talking symmetry. Where are your lines of symmetry then?
S1: Across the right hand top corner to the bottom left hand corner.
T: This is a line of symmetry? [T holds up a ruler along a diagonal of the rectangle.] [Pause] He's unsure. Who thinks it's a line of symmetry? Hands up. [Pause] A couple of you. [Pause] Who thinks it's not a line of

symmetry? [Lots of hands go up.] Oooh, okay, S3, convince those that think it is why is it not a line of symmetry do you think?
S3: You can only have diagonals in a square.
T: Oh right, okay.
S4: Or a circle.
T: Why is that one not a line of symmetry though? S5?
S5: Well, if you get A4 paper, that's a rectangle, you can fold it diagonally ...

The teacher's response, 'Where are your lines of symmetry then?' genuinely explored the meaning of the comment, because he did not know where S1's lines of symmetry were. The teacher then asked for the opinion of the rest of the class. After S5's comment, the teacher took an A4 piece of paper and started folding it in the ways S5 and other students suggested. The task for the class (in this case, deciding what was a line of symmetry and how many there were on a rectangle,) emerged from the interaction of students and teacher. The dialogue included collaboration and participation. During this discussion, over a quarter of the class spoke in a period of a few minutes. Students often talked directly to each other, responding to other students' suggestions and raising their own questions related to the mathematical activity in later transcripts, so the change in the quality of listening seemed to be lasting.

What teaching strategies helped to promote students' thinking about mathematics?
The study found that certain teaching strategies used in later discussions, but not used earlier in the year, encouraged the development of more productive classroom discussion. These strategies included:

- asking a question to which students did not know the answer
- responding to students' suggestions
- asking for feedback from the whole class
- asking a student to explain their idea to the class.

These strategies slowed down and opened up discussion. They were strategies that encouraged and allowed different students to engage in dialogue with each other and they required a quality of genuine and flexible listening on the part of the teacher.

Reference
Coles, A. (2001) 'Listening - a case study of teacher change.' In Rowland, T. (Ed.) Proceedings of the British Society for Research into Learning Mathematics 21(1) March 2001. Available online at: www.bsrlm.org.uk/IPs/ip21-1/index.html

One pupil's participation in numeracy lessons: Performing but not learning?

We have chosen this case study because it offers a cautionary tale about the ways in which some pupils participate within the numeracy lesson. The study, which came from the Leverhulme Numeracy Research Programme, found from extensive observations that, although some children seemed to participate in whole class interactive teaching in mathematics, they were not necessarily thinking about the mathematics. Instead, they were putting on a performance.

The researchers observed many lessons in a variety of primary schools and were particularly interested in finding out:

- how pupils presented themselves during whole class sessions
- what motivated pupils to take part
- if pupils' participation was fruitful in terms of mathematical learning.

A classroom example of how one child performed, rather than thought, during whole class sessions

The teacher in the study followed the usual NNS lesson structure. She used questioning as a major teaching tactic and tried to inject 'pace' into the lessons. All pupils were expected to take an active part in the questions and answers: they showed their answers to oral questions on individual white boards or by choosing digits from a set of cards or a number fan. The teacher often asked individual pupils to explain how they reached their answer. Meg, aged seven, responded to these demands by putting on an act.

Episode 1
As part of a whole class session, the teacher was working on halving numbers. Each child had an individual white board and marker pen with which to display answers.

Teacher: Half of 36?
Meg started to lift her board up to show the teacher. She had written '15', but before she showed it, she noticed that others around her had '18'. She quickly changed it. The teacher did not notice and said, 'Well done, Meg.'

Teacher: Half of 72?
Meg took the top off her pen, pushed it back again and looked puzzled. She appeared to be counting - her lips were moving, but it was not clear what she was saying. She turned round and saw what George had written, then turned back again and wrinkled her face (as if to say, 'I'm concentrating hard'). She looked around at several boards and saw what answers others had got. She closed her eyes and screwed up her face. After a time, her face lit up as if she had just made a big discovery and she wrote down '36'.

Episode 2
The teacher was using a counting stick (a metre length rod, with ten divisions, but no numbers marked) to count on from zero in 10s, 5s, 2s going up to 100, 50 or 20 respectively. The children each had a number fan to show their answers.

Meg seemed to rely a lot on counting from zero, which slowed her down. She looked at the rod and nodded her head as she worked her way to an answer and was often still searching for the two digits on her fan with which to show her answer when the teacher had moved on to the next question. After two counting on in 10s questions (where Meg was not quick enough to show her answer) the teacher changed to counting in 2s...The teacher pointed to the 9th division. Meg counted from zero, nodding as she looked at each division on the rod, then put 18 on her fan. The teacher asked her how she got the answer.

Meg: You count in ones to nine and then go backwards and then it's like double again. Teacher: Meg is using what we did last week, like doubling and halving.

The researchers argued that it was unlikely that Meg was using a doubling strategy: her actions and explanation suggested otherwise. They stated that during the four years that they had been observing Meg, they frequently heard her offer explanations with great conviction which did not match what she did and were sometimes mathematically incorrect. They suggested that Meg was not trying to explain her method, but only taking part in the 'game' of providing an explanation.

How might teachers help such pupils?

Meg's teacher set up activities to involve everyone and monitor participation, yet Meg still managed to put on a show without actually thinking through the mathematical tasks set. She was motivated less by an interest in the mathematics content than by a wish to maintain a perception that she could do the work and thus her status within the class. Her teachers described Meg as able, hardworking and reliable. Meg wanted to continue to appear like this to her teacher. She resisted admitting that she needed help.

The researchers cited another study which found that children were mainly concerned to do what was necessary to avoid being embarrassed or told off or having to do the work again. Young children may often be motivated by a need for approval from the teacher or acceptance from their peers. The researchers suggested

that what they called 'performative' behaviour was more likely to occur in situations where a) pupils were expected to offer public answers to closed questions and b) the lesson placed a strong emphasis on speed as well as correctness. They noted that this was the case in many lessons they observed and argued that some pupils' needs to perform satisfactorily in such a context were likely to prompt them to adopt classroom behaviours that prevented them from learning.

The researchers proposed that such pupils need encouragement to slow down and think about their work. When Meg was encouraged to take more time to think about her mathematics, she reached a correct response and showed great delight at doing so.

Reference

Denvir H. & Askew M., 'Pupils' participation in the classroom examined in relation to interactive whole class teaching'. In Rowland, T. (Ed.) Proceedings of the British Society for Research into Learning Mathematics 21(1) March 2001 Available online at: www.bsrlm.org.uk/IPs/ip21-1/index.html

How debriefing discussions with students help their understanding

We chose this case study because it throws light on strategies that teachers have used to get the best out of debriefing (plenary) sessions in which students have the opportunity to discuss their learning. This study is focused on geography lessons in secondary schools, but the general principles are relevant to a wide variety of contexts, including the Numeracy plenary session.

The study included lesson observations and student interviews at four secondary schools. The classes ranged from Year 7 (students aged 11 to 12) to Year 10 (students aged 14 to 15) and included mixed ability groups and setted classes of high, middle and low attainment.

What helped teachers to make debriefing more effective?

Plenary discussions were more likely to work well when the main activity of the lesson offered students a challenging and stimulating activity that made them think and gave them a focus for discussion. Students found it helpful if teachers:

- made the purpose of activities clear to students, so they knew why they were doing something, as well as what to do
- used the plenary session to gather information from many students that gave a variety of ideas and strategies for discussion
- persuaded students to explain their reasoning
- provided them with detailed and specific feedback on their solutions and thinking
  made connections between the lesson outcomes, other aspects of the curriculum and especially to everyday life.

Debriefing helped students see the point of the lesson:

Female student: We discuss everything.
Interviewer: And you think that helps?
Female student: Yeah, because then we understand what we're doing and why we're doing it.

Students felt more confident to share their thoughts if the teacher made it explicit that the purpose of the lesson was to encourage them to think and to share that thinking. It helped if the teacher listened attentively to groups and individuals throughout the lesson so that the discussion during the debriefing process became an integral part of the lesson.

She makes you feel more confident about answering questions.

Female student

Many students mentioned that they were asked to expand on their first few words, to explain fully or "say a bit more". This process helped them to clarify their thinking.

You get a better idea of what you are talking about in your mind.

Female student

In the debriefing process the teacher drew together a range of ideas students had developed or strategies that they had used in tackling tasks so that they were available for all to consider. The teacher made links to everyday life to help improve students' understanding. In some lessons, debriefing took place in one episode at the end of the lesson, whilst in others it was spread over three shorter episodes. In all the debriefing episodes:

- the teacher asked many open questions
- the teacher made frequent references to learning skills and important concepts such as cause, effect and planning
- many students gave lengthy responses to teacher questions, sometimes after being asked to 'go on'
- in all of the lessons the teacher made connections between the learning outcomes and other contexts
- the students received evaluative feedback on their reasoning both from the teacher and other students
- the teacher summarised the discussion and learning for students.

How did students respond to the debriefing process?

Whole class debriefing helped students to learn. Students showed this in several ways:

- their ability to handle and process information improved
- their writing skills became more analytic
- their responses to questions were more extensive
- they asked probing open questions
- they gave evaluative feedback to one another
- they showed greater subject knowledge and enhanced skills.

The students took time to develop behaviour and language that supported debriefing - younger and less able groups took longer to develop this capacity. In most lessons, the resulting discussion was animated. The teacher remained in control of the direction of discussion, but students contributed fully and with confidence. In some lessons students reported improved social and co-operative learning skills:

She teaches [that] we need to talk...civilly to one another without having to shout.

Female student

You've got to co-operate to find things out, you cannot just do things on your own....cos you'll probably be wrong about it.

Male student

Students valued feedback on their thoughts and explanations as it helped them to improve their work. They also emphasised the value of discussion, both in small groups and in the whole class debriefing episodes:

What's good is ... when other people put up ... arguments (so) you can see everyone's different point of view.

Female student

Reference
Evans E., Kinninment D., McGrane J., Riches A. (1999) Debriefing: Students' Learning and Teacher Planning Available online at: www.tda.gov.uk/upload/resources/pdf/t/tta99-11.pdf

(This link downloads a PDF document)

A multi-sensory approach to teaching number at Key Stage 1

We have chosen this case study because it shows how mathematical equipment was used to help young pupils to develop visual images of number. The visually-based strategies for teaching mental arithmetic used at the Infant School and the tactile apparatus were very effective in raising achievement for children of all abilities. This included those with Special Educational Needs (SEN), especially children with Down's syndrome, who tended to be good visual learners, but had poor auditory memory.

The Infant School in the study had a high proportion of pupils who qualified for free school meals, had special needs and/or who entered the school with poor language skills. The school had become dissatisfied with various published mathematics schemes, all of which relied on counting as the basis for arithmetic and moved children very quickly from counting towards formal symbols in mathematics. Children used counting as a back up strategy when they could not apply learned procedures to solve arithmetic problems. The school felt this approach was not effective.

The school developed a structured programme of teaching activities that used visual structured images (and apparatus such as Numicon, Stern Patterns and number rods) to encourage children to develop a systematic mental imagery of number. The images were used to develop mathematical language and to help pupils apply their arithmetic to real life problems. The school wanted children to develop an understanding of number that related numbers to each other and could be generalised to solve new problems. This work was consistent with the National Numeracy Framework which expected children to employ relational understanding in mental arithmetic, although it did not explicitly promote the use of visual apparatus.

Pupils were not asked to record arithmetic until they had understood arithmetic symbols and could use addition and subtraction facts to ten in practical activities. The school found it was important that children developed pencil control before recording their number work, so that the writing process was not laborious for them. After that, children wrote arithmetic quickly and accurately.

How did teachers create a visually rich mathematics environment?

Children saw number being used in their classroom
For instance, drawers were numbered and storage pots were labelled to show how many items they should contain. Two 'number lines' were displayed in every classroom: a 'number line' showing numerals from 0-100 and a large 'number line' from 0-20, showing numerals, the corresponding visual structured image and the number word marked at regular intervals. The mathematics area offered children independent opportunities to explore and practise what they had learned. An interactive display included activities such as counting, numeral recognition games, pattern making, using construction apparatus and problem solving with puzzles.

In whole class or group teaching, the structured apparatus was used on a table top or a magnetic white board to illustrate teaching points. Children used the apparatus independently in group work and individually.

Daily mathematics lessons included practical, multi-sensory activities
Children saw and felt the structured images, whilst they said and heard connected mathematical language. Early activities taught children the shape associated with each number and how each related to other number shapes before the numerals were named. Activities were very simple: to practise addition children might

throw a number die and then feel in a 'feely bag' for two shapes that made that number. Children might arrange 1-10 rods in a 'staircase' pattern and fill the spaces with more rods to show all the combinations that made 10. Teachers found it helpful to remind children often to use mental imagery - they used phrases such as 'Let your fingers be your eyes' if pupils were feeling for shapes in a feely bag and 'Try to see the shapes in your mind's eye' when they were doing mental arithmetic. The programme of activities was carefully designed to built on and extend previous learning.

Teachers made connections to real life mathematics
Children working on addition would make up a story to apply the number bonds they had learned. Those working on subtractions sang number songs involving decrease like 'Five little firemen' to learn about '1 less'. Teachers used mathematics in daily activities. They asked questions like 'How many children are having a school dinner today? And how many are having a packed lunch?' Then the class would arrange counters into the Stern patterns to show the number in each group. Teachers also gave children opportunities to count larger sets of objects, which extended their understanding of higher numbers and the structure of the number system.

How did the use of visual apparatus in mathematics improve achievement?

The study found that children's performance in mathematics improved:

- children who had used visual structured imagery during the research project showed a dramatic improvement in attainment in Key Stage 1 SATs at the end of the year, compared with the results of the previous cohort whose learning had not been supported by the visual apparatus
- these higher levels of attainment at Key Stage 1 were sustained year on year at the school
- the first two cohorts of children also exceeded previous cohorts' scores in SATs when they reached the end of Key Stage 2.

In addition, the school found that:

- children were drawn to the apparatus, enjoyed working with it and used its structured patterns to show their understanding of number and arithmetic
- pupils developed confident and positive attitudes to mathematics
- pupils developed a range of strategies to solve arithmetic problems, rarely relying on counting
- parents recognised their children's success and began to see evidence of their children's understanding of arithmetic at home.

Reference
Tacon, R. and Wing A. (2004) An inclusive multi-sensory approach to teaching arithmetic Paper presented at the NTRP conference 2004.

Whole school improvement in mathematics

We have chosen this case study from the Leverhulme Numeracy Research Programme because it illustrates how one school brought about strong and sustained improvements in its pupils' performance in mathematics. Wolverton Primary School was situated in a socially and ethnically mixed inner-city area. It had high pupil mobility and many pupils were entitled to free school meals and/or spoke English as an additional language. The head teacher joined the school in 1996 when an Ofsted report found one third of teaching at the school to be unsatisfactory. Over the first three years of the research study, the school made dramatic improvements. In 1998, Ofsted found no unsatisfactory teaching and the Level 4 mathematics SATs results had risen from 33 per cent to 62 per cent. These results improved further in 1999 (78%) and 2000 (84%).

What did the school do to improve attainment?
The 1996 negative Ofsted report made it clear that the school had to improve. The new head identified how

low teacher expectations of pupils led to low standards of attainment. He made good teaching and increased teacher expectations of pupils the school's top priority. He gave subject coordination a high profile, resourced it well and respected the expertise of the co-ordinator.

[The head teacher] lets me make decisions about what are the key issues that I then need to address in staff meetings or with individual teachers. So he's delegated to me a massive amount of freedom to do what I think is necessary ... but [there is] a minimum that he expects. If a lot of extra work is needed, then ... I've been given time to actually do it.

Mathematics co-ordinator

The mathematics co-ordinator was enthusiastic about the Numeracy Strategy and her role in spreading its message. She worked alongside colleagues as a critical friend, providing opportunities for peer coaching and classroom-based discussion about practice. Like all subject co-ordinators in the school, she regularly monitored lessons and also examined exercise books in staff meetings convened for that purpose. She responded to questioning and disagreement at meetings, allowing useful dialogue so that issues could be addressed in depth. An observer's field notes commented:

I said to her afterwards that it was very interesting that people felt able to raise all these issues - it showed a very informed staff. She said that a couple of years ago, they might have just sat there and said, 'OK, we'll tick against the key objectives,' but now they wanted to get at what these things really meant.

Observer's notes

The staff discussed their work together - they were not isolated in their classrooms. Teachers took collective responsibility and shared a similar approach. Interviews showed that professionals at all levels of the school held consistent views on the strategies they had used to raise attainment in mathematics. These included a focus on good behaviour, the setting of individual pupil targets and the importance of the subject co-ordinator role. Staff had supported the introduction of setting by ability and openly admitted 'teaching to the tests' - they knew they were being judged on SATs results and were strongly focused on helping their pupils to achieve the best results they could. Teachers agreed with the changes in mathematics teaching that had taken place: they had higher expectations of pupils, planned in more detail with a focus on learning objectives and had changed how they taught mental mathematics. They also commented on their pupils' increased confidence and enthusiasm.

The school was proactive in seeking out and using outside help. Both the head and mathematics co-ordinator attended a course (paid for by the school) by the National Director of the Numeracy Strategy to make sure they were well prepared in advance of its introduction nationally. The rises in attainment at end of Key Stage SATs enabled staff to use their professional judgement in agreeing the school's priorities for mathematics development and its response to the Numeracy Strategy.

How did change happen?

The study identified important steps of the process through which the head teacher worked with staff to drive up standards. These were:

- dissatisfaction with the status quo
- clarification of objectives
- promoting the acceptance of aims and objectives leading to coherence and consistency of views within the professional community
- raising expectations of the professional roles of co-ordinators within the school
- resourcing these roles through both internal and external provision
- expecting ongoing learning from all members of the professional community

- resisting complacency in order to sustain change.

This process of improvement seemed to be an intensely personal one in which the way in which actions were decided upon was as important as the actions themselves.

Reference

This case study is reported on pp. 62-74 in the first volume on the Leverhulme Numeracy Research Programme: Eds. Millett, A. Brown, M., Askew, M., (2004) Primary mathematics and the developing professional London: Kluwer Academic Publishers pp. 62-74

It is also published as: Millett, A., & Johnson, D.C (2003). Raising attainment in mathematics: the story of Wolverton School. Education 3-13, 31 (1), pp. 26-36.

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Further reading

What else might I enjoy reading?
Leverhulme numeracy project
http://www.kcl.ac.uk/schools/sspp/education/research/projects/leverhulme.html
Case studies
British Society for Research into Learning Mathematics (BSRLM)
http://www.bsrlm.org.uk/informalproceedings.html
Many case studies on a variety of mathematics topics.

Other studies
A systematic review of the impact of the Daily Mathematics Lesson
http://eppi.ioe.ac.uk/cms/Default.aspx?tabid=289&language=en-US
A summary of an EPPI systematic review: Kyriacou C, Goulding M (2004) A systematic review of the impact of the Daily Mathematics Lesson in enhancing pupil confidence and competence in early mathematics.

Summaries of Research
NERF: Summaries of research
http://www.eep.ac.uk/nerf/bulletin/indexe42d.html?version=1

The NERF Bulletin 'Evidence for teaching and learning' includes readable summaries of research into topics of interest to teachers. Articles related to mathematics include:
o How numeracy teaching has enhanced students' learning (Issue 1)
o Helping students with difficulties in mathematics (Issue 2); and
o Interactive whole class teaching in mathematics (Issue 3).

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Appraisal

Robustness

The research reported in this book formed part of the four-year Leverhulme Numeracy Research programme carried out by researchers at King's College London from 1997 to 2002, which set out to explore the nature

and causes of low achievement in numeracy and effective strategies for remedying the situation. 'Primary Mathematics and the developing professional' is the first of four books emanating from the project. It is concerned with the interplay of school factors, such as school policies and leadership and teacher factors involved in the implementation of change. The RoM summary focuses on exploring effective ways of leading and supporting the professional development of colleagues in mathematics at primary level and draws primarily from three chapters of the book.

The Leverhulme programme consisted of a large-scale longitudinal study (the core project) and five focus projects. The core project investigated the progression in pupils' learning of numeracy throughout the primary years. Data were collected twice a year for four years on two cohorts of about 1600 pupils, one moving from Year 1 to Year 4 and the other from Year 4 to Year 7. Each cohort included all the children of appropriate age in forty primary schools from four local education authorities. The data collected included lesson observations, teacher questionnaires and interviews with teachers, mathematics co-ordinators and head teachers and national test results. The core project provided a base for the case-study investigations in the focus projects.

Chapters 2 and 3 discuss the role of the mathematics co-ordinator and the school (Alison Millett and David Johnson) and were derived from the 'Whole school action on numeracy' focus project. The project set out to identify whole-school and teacher factors which appeared to facilitate or inhibit the development of strategies for raising attainment in numeracy. The research focused on six schools in varied locations as they prepared for, experienced, and followed up an inspection. The researchers collected data on the strategies the schools used from observations of individual teacher's numeracy lessons, and notes taken at whole-school and group meetings, and in-service training both in school and out of school related to numeracy. They also interviewed 24 teachers, 12 mathematics co-ordinators, school governors and the head teachers of each of the schools. Chapter 4 (Valerie Rhodes and Alison Millett), which explores the way that teaching materials were used and the impact they had on teacher's professional development, is based on another of the focus projects, which followed 12 teachers in four schools over two years, in addition to the core project.

Relevance

The book will particularly interest anyone with responsibility for mathematics in the primary sector, a role that has changed substantially in recent years - from supportive colleague to an 'expert' with responsibility for monitoring the teaching and learning in mathematics. The book will also interest head teachers because it explores the nature of support subject co-ordinators need from them to help them fulfil their role effectively. All primary teachers will find the insights into effective practice in the teaching of mathematics helpful.

Applicability

The book contributes to the body of knowledge on professional development in primary mathematics - how schools can make a difference in encouraging individual classroom teachers to make and sustain effective changes in their practice. It highlights the successes and challenges for effective practice encountered by primary mathematics co-ordinators and school leaders in a variety of primary settings.

Writing

The book is presented in the form of a collection of academic papers. Each chapter draws on a particular strand of the research programme and is divided into useful and appropriate sections: an abstract, an introduction, sub-sections, a summary and discussion, and a list of references. Although this is an 'academic' book, it is written in a style that colleagues interested in the development of mathematics teaching will enjoy dipping into.

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