

National Centre
for Excellence in the
Teaching of Mathematics

Primary Mathematics Host Schools Project

Prepared by the National Centre for Excellence in the Teaching of Mathematics

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1 Glossary

AfL: assessment for learning i.e. formative assessment

ARE: age related expectations

Arithmetic Proficiency: achieving fluency in calculating with understanding

AST: Advanced skills teacher

CPD: continuing professional development

CTP: Collaborative Teaching Project: an initiative funded by the NCETM to support schools in undertaking collaborative work across several schools with the support of an expert outsider

Evaluation event: second national event for participating schools held in March 2013

HLTA: Higher level teaching assistant

Host School: school which acted in role of group leader of a network group

LA: Local authority

Launch event: first national event for participating schools held in November 2012

Lesson Study: a Japanese model for professional development that involves collaboratively planning a lesson with colleagues, one of the group teaching it with the others observing. The group consider possible the basis of the children's learning and responses to the Study Lesson. The group then go on to adapt the lesson plan and reteach it to another group of children, again with observers. The cycle ends with a final discussion about what the group has learnt from the study before embarking on a new cycle.

MaST: Mathematics Specialist Teachers: course for primary teachers at Masters level

Project Administrator: supporter of the project dealing with administrative and financial aspects of the initiative

Project Lead: leader of the project dealing with educational and mathematical aspects of the initiative

TA: Teaching assistant

Visiting School: participating school which was part of a network group

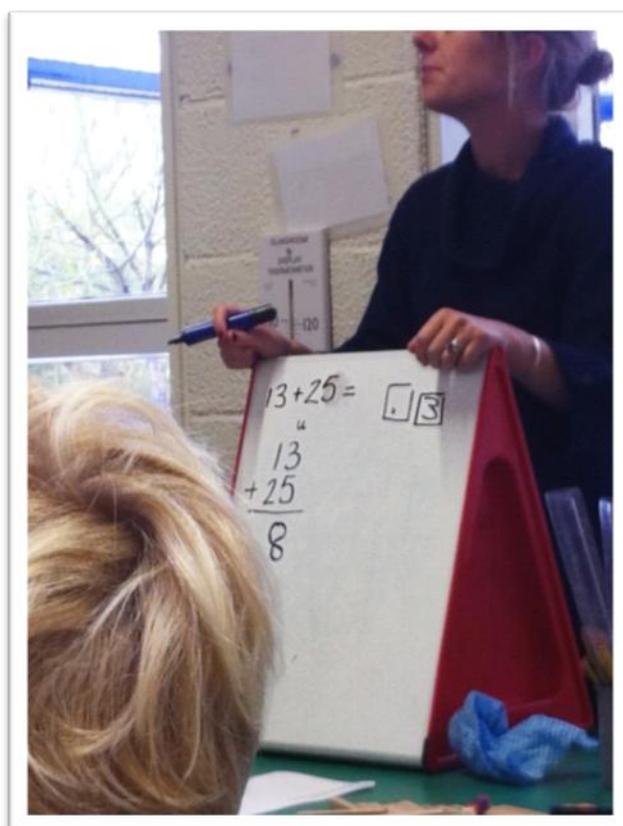
2 Key Findings

1. Primary schools have an appetite for collaborative professional development.

There was considerable interest from primary schools in the Host Schools Project and no trouble recruiting suitable Host Schools to lead the project.

2. A key to the success of the project was having a local expert mathematics champion in each network.

The local mathematics champions were predominantly those who have engaged in the MaST programme: 77 local expert mathematics champions were involved. 64 experts were MaST alumni or participants, 8 were ASTs and 5 were other local experts.



3. The network groups involved are optimistic about sustaining their work after the projected time frame of the project.

In many cases school management teams are keen to support the continuation, either as part of their schools' CPD programmes or, in some cases, related to their work in the developing teaching schools alliances.

- 4. The quality of the work undertaken by many of the groups has been of an exceptionally high standard and teachers involved are convinced that it will enhance the progression of their children in arithmetic.**

Case studies outlining this will be available as part of the NCETM external evaluation process and network groups have also been invited to tell their own stories about their involvement. These stories offer other teachers examples that might help them to engage in similar ways of working.

- 5. Teachers report a deeper understanding of ideas about the teaching of arithmetic and greater expertise in their understanding of strategies for supporting their children to deepen their understanding and increase their fluency.**



- 6. A key feature that has been highly valued by the project schools has been the support that they have been offered by the Host Schools Project Lead.**

The model of the Host Schools Project networks uses an expert outsider as a catalyst. Research findings (2009 RECME) suggest that networked groups can provide supportive relationships that encourage risk taking, but external challenge is needed. The schools involved had the freedom to shape the nature of the external support. The expertise of the Project Lead in terms of identifying resources for teaching, supporting teachers in developing their mathematical subject knowledge and considering the issues related specifically to the teaching of primary arithmetic has been an important contributing factor in the success of the project. The Host Schools also valued the support offered by the Project Lead, both during a face-to-face day with each network group and through on-going dialogue in discussion forums on the NCETM portal.

7. The opportunity to share experiences with schools from across the country, as well as to learn more about approaches and aspects of arithmetic proficiency was valued.

The national events were valued by the participating schools. Attendance was approximately 50 delegates at each: roughly half from the Host Schools and half from Visiting Schools.

8. The schools involved expect their relationships in the Host Schools Network groups to support their preparation to implement the new curriculum.

The draft new primary programmes of study for mathematics are very ambitious and many primary teachers will need expert support to implement the new curriculum successfully. Network groups can help schools to share expertise effectively between schools.

Note:

A significant proportion of Host School Network groups were in rural settings, which does not reflect the predominantly urban and suburban settings of primary schools nationally.

Of the 29 Host Schools Network Groups, 13 were in a rural setting, 8 in urban areas and 8 in suburban areas. This may reflect the difficulty that rural schools have in accessing quality professional development, due to their size, budget and geographical situation. The opportunity to develop a funded network group was one that these schools particularly welcomed.

3 Introduction

The overarching aim of the project was to support the effective teaching of arithmetic in primary schools, with a specific focus on Years 3 and 4, and also to raise teachers' awareness of the importance of developing pupils' arithmetic proficiency.

A national network was established of 29 Host Schools which had been identified as centres of excellence in the teaching of calculation by the project team with support from DfE and Ofsted.

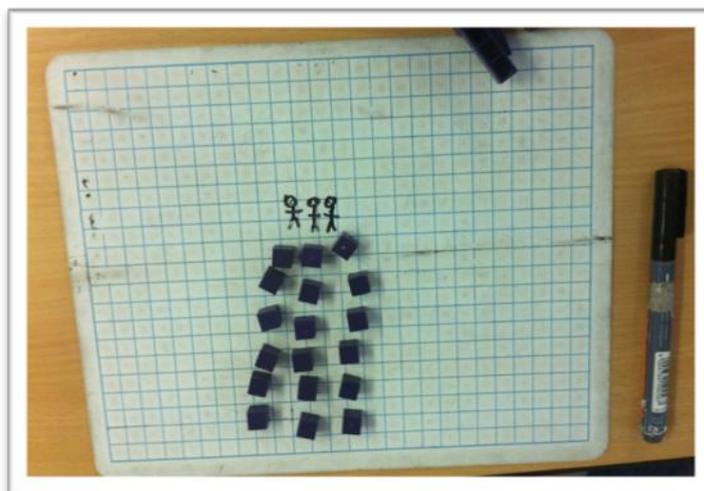
The criteria for the selection of the Host Schools were that they:

- had a story to tell about improving and sustaining attainment in mathematics over the last five years;
- could demonstrate an interest in teaching arithmetic;
- were able to exhibit an approach to teaching calculation that was in line with government policies and priorities;
- were able to articulate a story about working, or wanting to work, with other schools in their neighbourhood to develop practice in teaching arithmetic;
- had calculation policies in place or well into development;
- were experienced in supporting their own staff to develop both their understanding of mathematics and their knowledge of ways of teaching it to children;
- had an identified 'mathematics champion' who led their involvement on the project;
- were able to produce examples of excellent practice in the teaching mathematics.

The schools were also selected to offer a geographical spread across England. See map on page 7.

The Host Schools worked with the Project Lead and Project Administrator to identify an additional 157 Visiting Schools, all of which expressed a wish to improve their teaching of arithmetic particularly in Years 3 and 4, where a dip in performance had been identified nationally.

The focus of the work of all the network groups was on arithmetic proficiency, comprising fluency with understanding of calculation strategies. This involved looking at calculation policies and practices across each of the schools and examining issues in relation to their current practices.



Map showing Host School Network groups:



Key:
Rural (green)
Urban (blue)
Suburban (yellow)

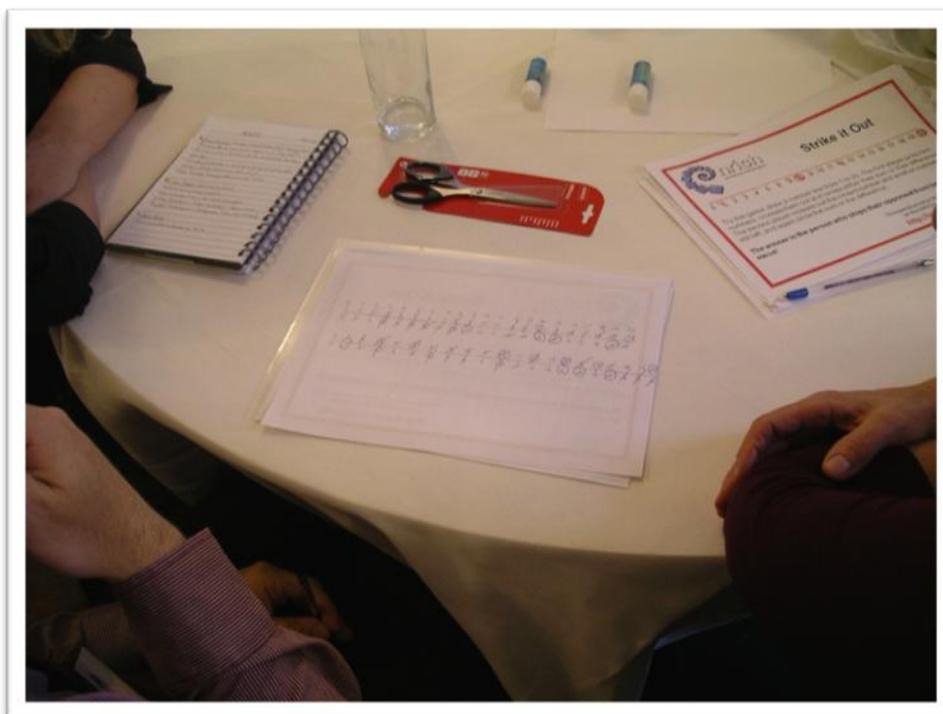
4 Events and support for links between Host Schools

One of the highlights of the project for the teachers was the opportunity to participate in two national events for the whole network. The first event was held in November 2012 in London and was over-subscribed.

At this event the teachers were introduced to some of the core ideas and principles underlying the aims of the project and some data were gathered about the teachers' views of arithmetic and its teaching.

Feedback from the event identified the following aspects as the most useful:

- The task that illustrated the mathematical development of arithmetic and notions of fluency, developed through meaningful practice;
- Network groups sharing ideas, including descriptions of how they structured meetings;
- Range of exceptional speakers with different experiences to share;
- Exploring key educational ideas;
- Helping to consolidate our network aims.



Another national event was held in March 2013 and this one was not quite as well attended, even though each network was offered up to 4 places. This is possibly because the event was near the end of a short Spring Term, which added pressure when the groups had to complete various pieces of work before the end of term and in many cases had already planned other events.

Feedback from this event identified the following aspects as the most useful:

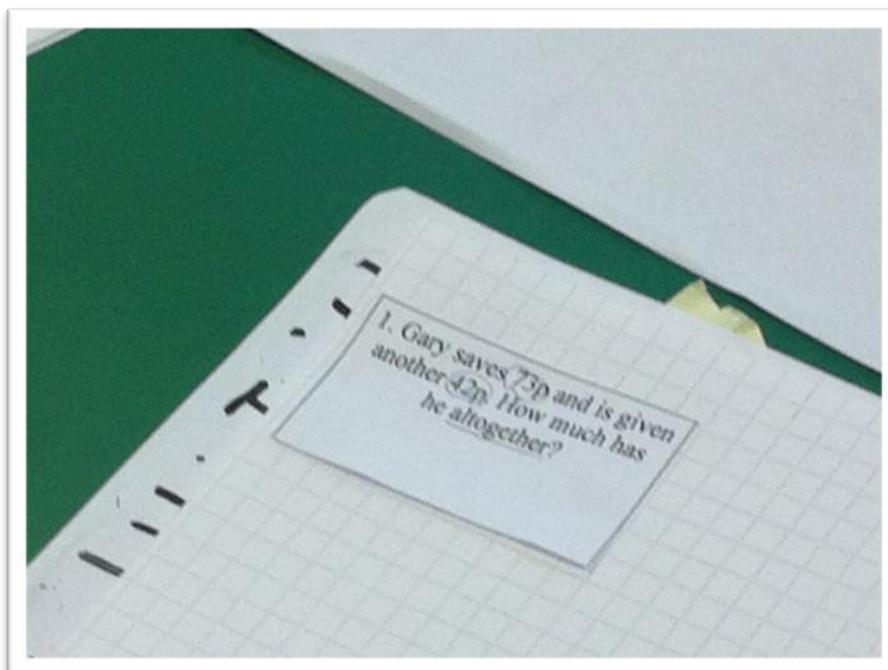
- Discussion about the new curriculum, with its focus on raising achievement in arithmetic;
- Exploring multiplication and division;
- The balance of presentations and discussion;
- Practical workshop in which teachers explored aspects of teaching division;
- Fresh ideas/concepts and the chance to consider 'big ideas' about teaching mathematics and working collaboratively;
- Time to think and consider concepts that have worked or could be developed.

The programmes for these two events are available in Appendix 11.3.

5 The work of the network groups

Each network group was required to submit their plan for its work to the project team as a prerequisite for the release of funding. This strategy proved effective in ensuring that the project team was fully informed about the activity of each group. These plans varied considerably, even though the focus of them all was on improving the arithmetic proficiency of children in Years 3 and 4. These were the main approaches and topics:

- One of the four operations (with subtraction and division being the favourites).
- Undertaking a Lesson Study cycle, either focused on a mathematical topic such as subtraction or on a pedagogic approach such as using problem solving to provoke learning.
- Working with the linked secondary schools to communicate the kinds of approaches to arithmetic found in primary schools, with a view to ensuring that secondary teachers would be able to acknowledge them and build on the children's prior learning. This transition work often involved the scrutiny of calculation policies for consistency and coherence in progression from Key Stage 1 through to Key Stage 3.
- Focusing on developing strategies for using problem solving and rich tasks in teaching arithmetic, including opening up arithmetic problems beyond 'word' problems.



Ways of working varied too, with some of the Host Schools leading a series of twilight or half day sessions focusing on different aspects of calculation in Years 3 & 4 and some groups developing and sharing resources for the teaching of arithmetic across their network.

6 Visits to the network groups

One aspect of the work of the Project Lead involved spending a day with each of the Host Schools network groups to support their work. Each group was offered the opportunity to identify the kind of

support from the Project Lead that would be most helpful to them, and the Project Lead tailored her input and programme for the day to their needs. This input varied from group to group, depending on the focus of their work, and involved a variety of activity. Examples included:

- Leading professional development days, half days and twilight session for audiences of teachers, teaching assistants, local advisers and even, on one occasion, parents.
- Observing lessons, both in the Host Schools and the Visiting Schools, and offering support guidance and feedback.
- Teaching classes of children, both in their mathematics classes and also in several groups of children created especially for the purpose. These lessons were observed by audiences of professionals numbering up to twenty and on one occasion the taught lesson was videoed. In some cases the observations were followed by discussions about what had been seen.
- Involvement in Lesson Study cycles and providing advice, guidance and feedback for this model of professional development.
- Focusing on children who were failing to make the expected progress in arithmetic, working with them to identify their problems and then suggesting ways of moving them on to the teachers involved.
- In some groups the focus of the day was on developing a calculation policy and so the policies of the various schools involved were scrutinised for inconsistencies and errors. The Project Lead supported the teachers in developing a coherent and clear plan that their colleagues would be able to work with.

Resources used in, and produced for, these sessions were shared with the individual communities through their community space on the NCETM portal and participants were encouraged to engage in discussion about their use. Further details of the visits are available in Appendix 11.4.

Vignette 1: The Eleanor Palmer Network Group, Camden, London

This group was jointly led by three primary schools in the London Borough of Camden. The four mathematics champions in these schools included MaST teachers and they were very enthusiastic about all they had learnt and keen to pass on this knowledge to their colleagues. They involved eight other schools in their group and led a series of four meetings, which culminated in a whole day conference. The meetings focused on the key issues in teaching arithmetic in years 3 and 4 and looked at children's misconceptions, as well as strategies and resources to support arithmetic proficiency. The meeting which the Project Lead attended focused on multiplication and division and strategies for supporting children with developing understanding of, and fluency with, multiplication tables, as well as ways of calculating using multiplication and division. The atmosphere within the group was one of cheerful collaboration and the teachers engaged in discussion about pedagogy, the mathematical ideas involved and ways of supporting and identifying children's understandings of multiplication and division.



Vignette 2: Carleton Endowed Network Group, Skipton, North Yorkshire

This group of five rural primary schools was led by the teaching head of the Host School. None of the schools involved had more than 200 children on roll and all were set in villages in North Yorkshire. The focus of the group's activity was on developing calculation policies for all the schools that would work to support the children's learning and would be consistent and coherent across the school, as well as preparing children for the mathematics teaching they will receive in secondary school. The network group built on a local cluster group of small primary schools, so they were familiar with one another's contexts and able to support one another in developing the plans for their schools. The day that the Project Lead spent with the group focused on developing a strategy for the work of the project that the group went on to implement. This strategy incorporated working with the teaching assistants in all the schools to support their subject knowledge and understanding of the calculation policies that were developed.

Vignette 3: Harleston CEVA Primary School, Harleston, Norfolk

This was another network of rural schools, centred on Harleston, a small market town about thirty miles south of Norwich. Harleston CEVA was the Host School and the largest of the five schools in the network. The teachers involved engaged in a lesson study cycle, focused on teaching division. The day that the Project Lead spent with the group began with a session in which she worked with groups of children who were perceived by the teachers to be 'stuck' at a lower level than they should be. The Project Lead undertook some diagnostic testing of the groups of children concerned and suggested strategies to support them in moving on in their thinking. The Project Lead then taught a lesson on using word problems with division as a demonstration lesson, with an audience of teachers and teaching assistants. In the afternoon the group of teachers watched a Study Lesson which they had jointly developed and which one of them taught. The focus of the lesson was on solving word problems using division. This was followed by a discussion about the Study Lesson. The group were engaged in the project and were developing as a group of thoughtful and reflective practitioners.

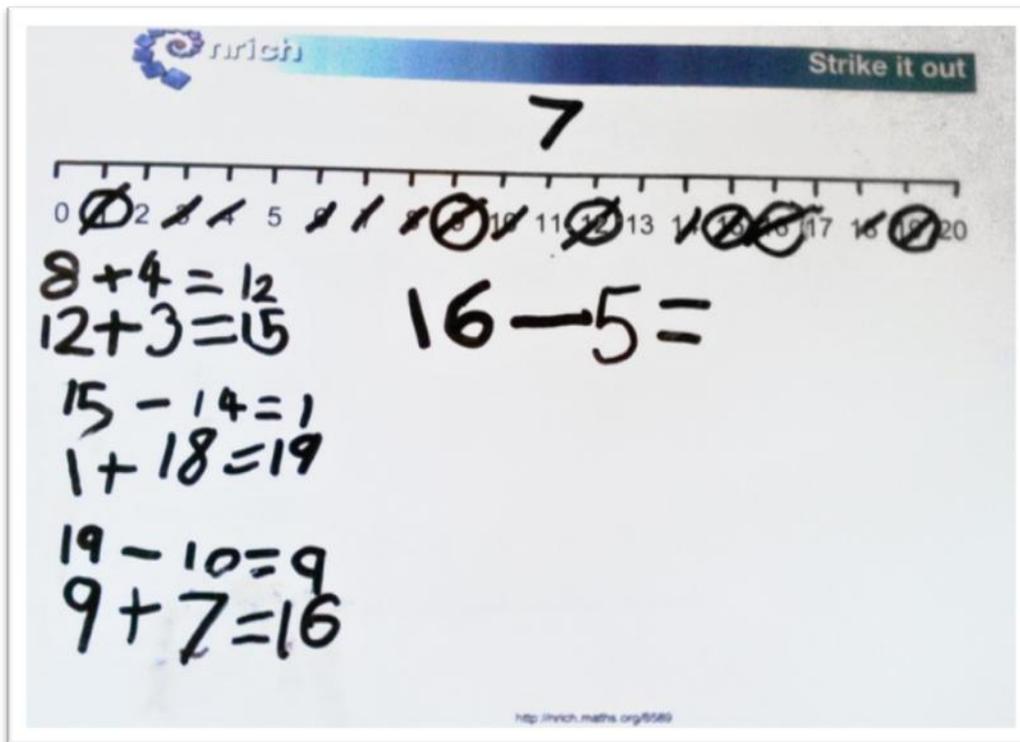
We have received the following feedback from the Project Lead's visits:

Carol Cato, Mathematics Subject Leader, Fleetville Junior School (Host School)

I just wanted to drop you a quick note to say thank you for coming to Fleetville today and leading the sessions. I think that the day was a great success - I know that I definitely appreciated the chance to step back and observe the children during your teaching session. Everyone went away with great ideas about how to apply the project to their particular setting and I am looking forward to hearing from them via the portal.

Chris Johnson, Assistant Headteacher, Chilham St Mary's CEP Primary (Visiting School to Wye Host School Network)

I just wanted to write a quick e-mail regarding Monday's training and discussion from Jenni Back. I was very grateful for Wye hosting the day and especially for teachers and children who had agreed to be part of it. The children were a real credit to the school. I thought those teachers who had agreed to let someone else teach their class, under the gaze of many other professionals, should be given a huge amount of credit. Children never act in exactly the same way as they would do in the comfort of their class, with their usual teacher, but I thought that watching them work really made the morning. I wonder how many of the audience would be so brave?



Secondly I wanted to say a thank you to Jenni, through you as the hosts. The aim was to really engage professionals in a reflection on what is working with our calculation teaching and what can further improve. As a teacher and leader who loves mathematics (and hopefully a reflective teacher) I got an awful lot out of it and it has helped me to explore what deep learning is taking place and where the learning is more superficial. I am so glad that it was not designed to be an 'observation' lesson with bells and whistles but rather something that allowed the debate about teaching of calculation to be opened up and explored. I then really enjoyed the afternoon discussion, especially the comparison with the Hungarian system, with opportunities to debate with colleagues. Those practitioners with a truly open and progressive outlook will have soaked in the day's activities and discussions with a mirror on their own practice and how to improve it further.

Donna Langley, Ripley Endowed Primary (Host School)

... one of our 'visiting schools' had Ofsted the week before Christmas. In an email from her, she said she was so motivated and inspired by our session together the week previously, that she opted to 'do' problem solving for Ofsted week. The Ofsted inspector said that it was one of the best mathematics sessions seen! Woo hoo!

Tim Bannister, Lakenham Primary School (Host School)

Just wanted to thank you for the fantastic twilight yesterday. It was really interesting and you explained your thinking so clearly and precisely. I know that teachers really appreciated hearing what you had to say. It gave a real lift to our network.

Tim Mills, Latchmere Primary School (Host School)

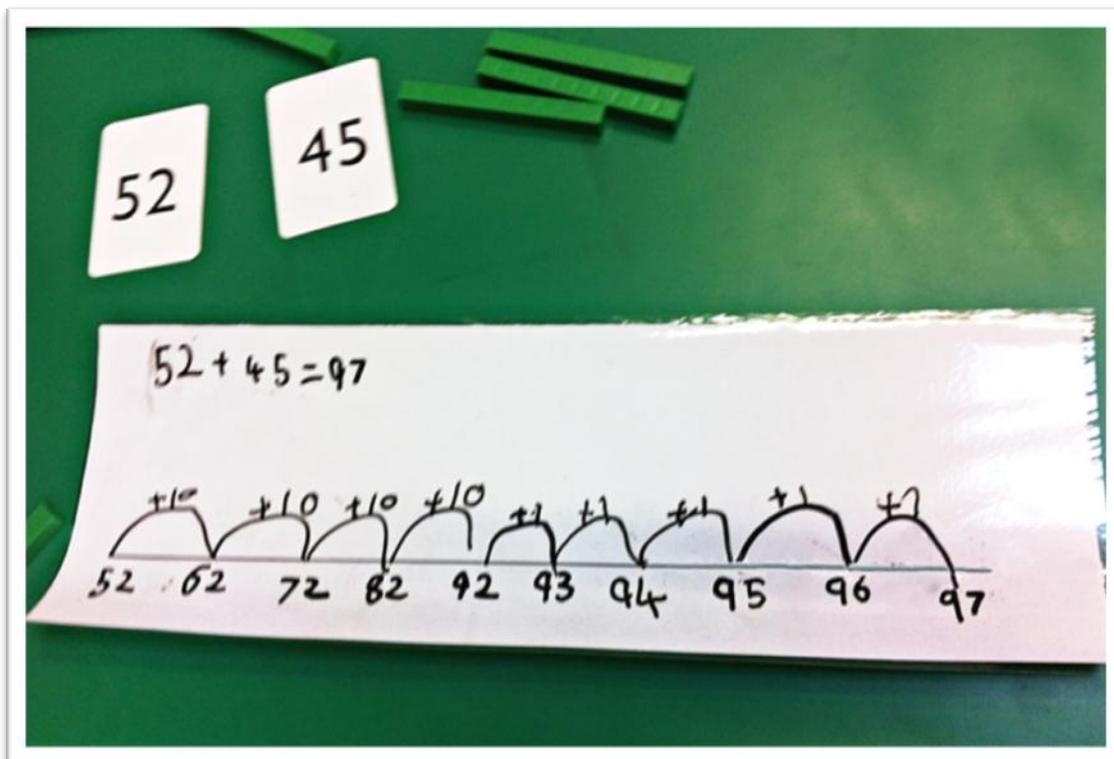
Just a very quick thank you for yesterday – feedback has been so positive and I feel it has really cemented the network. We all seem very keen to continue. Your input was inspirational, informative and useful.

7 Links with other NCETM opportunities and to wider support for mathematics teaching and learning

Throughout the project there has been a strong emphasis on linking the work of the Host Schools Network Groups with other areas of activity for which the NCETM is responsible. Each group has been allocated a community space on the NCETM portal, which they have been encouraged to use to share resources and hold online discussion. These have been used by the groups to varying degrees but an overall positive outcome is that the Host Schools Project led to 314 teachers signing up to their own Host Schools Communities on the portal. The community set up for the Host Schools themselves to communicate with one another had pretty steady usage and involved 55 participating teachers. In addition, the Project Lead has encouraged teachers who have the necessary capacity and profile to participate in the Professional Development Lead Support Programme; at the time of writing 7 have already done so.

So far two of the Host Schools Project's network groups have applied successfully for Collaborative Teacher Project grants and nominated the Host Schools Project Lead to be their improvement agent in this endeavour. A couple more are in the process of developing bids for this funding stream. In addition, many of the groups encouraged their members to use the self-evaluation tools on the NCETM portal to check on and support the development of their subject knowledge, and one or two of the groups are considering applying for the NCETM CPD Standard to support their sustained involvement in the professional development of their colleagues.

Many of the teachers involved in leading Host Schools network groups were graduates of the MaST programme and had been encouraged to take part because of their previous experience of, and success in, supporting the professional development of their colleagues in school. For these teachers the opportunity to work with wider groups of teachers from more schools was a natural next step in their professional learning journey and the success of the project has undoubtedly been due in part to their capacity to take on the challenge of leading a network group. Many of these teachers were also used to communicating with wider groups of teachers through their networks of fellow MaST teachers. For many of these teachers the MaST course had offered them the chance to engage with the opportunities offered by their local HEI and some were continuing their studies to complete their Master level qualification.



Another approach to ensuring the longevity of the groups has been through encouragement to join subject associations, such as the Mathematical Association or the Association of Teachers of Mathematics. Both of these associations have local branches and also a joint primary group that has a mailing list and meets three times a year. Membership of subject associations would also give them wider support for their continued development as teachers of primary mathematics.

One of the aims of the project was to establish network groups that would be able to continue their work in the longer term. For details of their intentions for continuation, see section 9.

8 Dissemination

Some of the work of the Host Schools Project has already been disseminated through workshops offered at the Easter 2013 subject associations' conferences. The Project Lead presented workshops at both the Mathematical Association conference and the Association of Teachers of Mathematics conference. Teachers from the Oakthorpe, Leicestershire and Heversham St Peters, Cumbria networks were involved in co-presenting and relating some of their experiences as Host Schools. Responses to the workshops were very positive and the delegates were interested to hear of the teachers' experiences, as well as the findings of the project.

Two articles written by members of the network groups were submitted to Primary Mathematics, the Mathematical Association's journal for primary teachers, and these will be published in May 2013. It is anticipated that further articles will follow, which will relate some of the key outcomes of the work of the network groups. Members of the Host Schools Network groups have already contributed to two of the NCETM's national events very successfully. Claire Trehwella from the Camden group offered a short plenary session on using iPads to support mathematics teaching at the NCETM's Digital Technology Conference on February 27th 2013 and Clare Christie from the Bristol network led a workshop at the NCETM's event for CPD Standard holders on April 12th 2013. Further similar involvement is anticipated.

The Project Lead intends to make the resources from the project more widely available on the NCETM portal through a microsite.

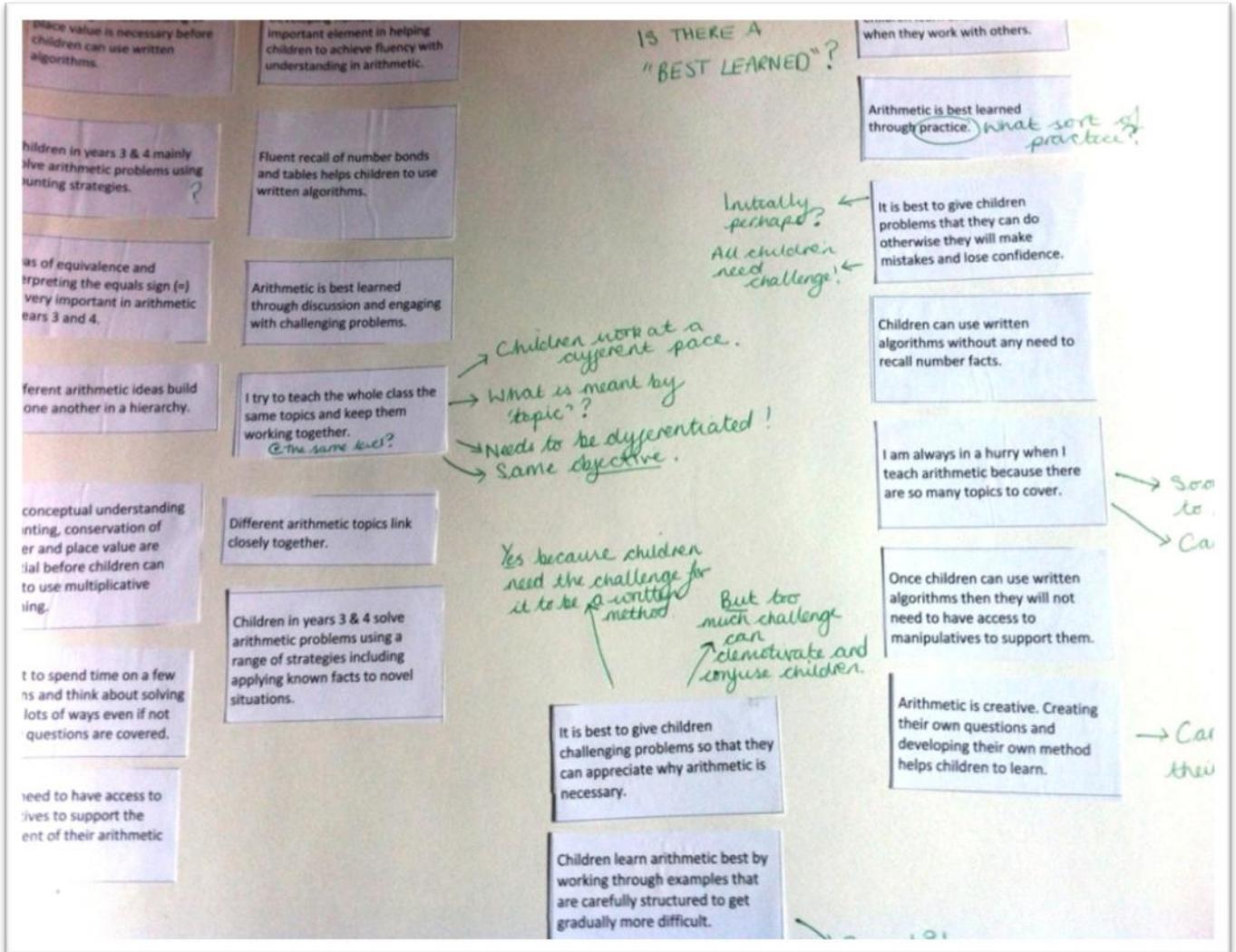


9 Evaluation

Data collection and analysis were built into the project, as explained below, and the team undertaking the NCETM's external evaluation will be looking at the longer term impacts and developing case studies. Overall the response rates and the commitment of the teachers to providing feedback were exceptionally high, with response rates of 100% on the first questionnaire and 89% on the second questionnaire being.

Data about the schools were collected by the project team through a questionnaire. Further, at the initial event in November, the teachers were given a task that involved expressing their beliefs about the teaching of arithmetic. Data gathered from this indicated that the teachers were open to considering difficult questions in relation to the teaching of arithmetic. The quality of reflection as they considered the statements they were offered was high. There was much discussion about the meaning of the statements and the teachers qualified their responses and sought to clarify the wording of the statements.

Below is an example of the posters they made:



The data gathered from the initial questionnaire revealed the following:

- Participants involved in the project

802 practitioners were involved in the network groups altogether. Some will have identified themselves as belonging to more than one category.

These practitioners were:

Type of Practitioner	Number
Advanced Skills Teachers	7
Early Years Foundation Stage Practitioners	56
Lead Practitioners	37
NQTs	61
Numeracy Coordinators/Leaders/	188

Primary Teachers	589
Teaching Assistants	230
Head teacher	65
Deputy head teachers	51
Early years Foundation Stage Teachers	42
MaST teachers	64
Year 3 Teachers	223
Year 4 teachers	208
Higher level teaching assistants	29
Specialist Leaders in Education/ Advanced Skills Teachers	8
National Leaders in Education	5

- Profiles of the schools:

The majority of schools were either small (47% with single form entry or less) or medium (41% with 2 form entry). The majority of the schools (70%) had a majority of white British pupils with 25%, with mixed ethnic groups and 5% majority 'minority ethnic'. Over 80% of the schools felt that the parents of the children in their schools were either supportive or very supportive. 70% of the schools had some experience of working with other schools on professional development prior to the project. 8% had no previous experience of networking with other schools.

- The expectations of the teachers involved and their fulfilment

When asked about their expectations for the project, the teachers identified the following as the most significant features:

1. To collaborate with other teachers in exploring some of the issues that are key to developing fluency and understanding of arithmetic in years 3 and 4.
2. To learn from other schools who have been successful in teaching arithmetic in years 3 and 4.
3. To develop a supportive network group with the potential to support our long term professional development as teachers of mathematics.
4. To see other schools' practice in teaching arithmetic.

Comments made links to the priority that schools place on raising standards:

'We are aware that we need to raise the standards of mathematics in our school and we believe fluency and understanding of arithmetic is key to that.'

Other comments talked about the benefits of collaborative working and learning from other schools' practices.

The final questionnaire revealed that the focus of most of the groups had been on calculation, with over 70% concentrating on multiplication or division and others focussing on subtraction.

- Classroom practice in teaching arithmetic

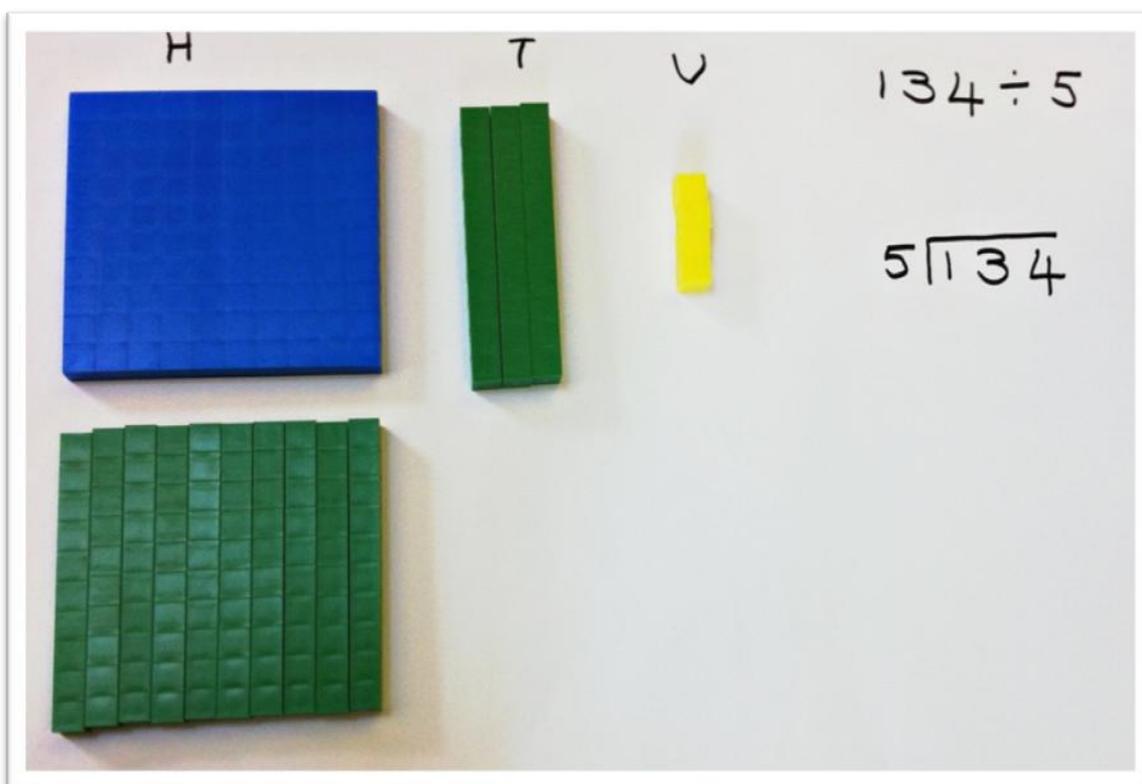
When asked about the artefacts and images used in teaching arithmetic at the start of the project, the teachers revealed a preference for Numicon, number lines and Dienes apparatus in most areas of

number teaching. Many of the teachers used a number of different representations, including practical artefacts, but some used few or none.

The final evaluation questionnaire revealed a number of interesting developments in practice that will be examined in more detail in the full evaluation. Over 70% of the responding teachers reported that they had begun to use a wider variety of models, representations and images in teaching arithmetic (e.g. Cuisenaire rods, Dienes apparatus and place value counters were cited as 'new' models being used) and over 55% reported that they had developed their understanding of children's progression in arithmetic. Over 70% reported that other colleagues in their schools were using a wider variety of models, representations and images and over 60% reported that their colleagues' understanding of progression in arithmetic was improved. In elaborating on this one teacher commented:

'It has opened their eyes to the need for the use of practical apparatus and how there is an over-reliance on the 100 square and that it also has limitations. The 15% increase in correct response rate (in undertaking arithmetic tasks) with the use of practical apparatus has given us the evidence we need to drive this forward.'

The nature of activities undertaken in relation to the project varied both in classroom activities and in approaches to CPD, but more than 85% reported sharing ideas and activities. This was followed by more than 70% engaging in discussion about activities, resources and research, and more than 60% discussing or sharing teaching approaches.



- Aspects of this model of professional development

The value of working collaboratively with colleagues was appreciated by many of the participants:

'There is more of a confidence in teaching the skills required due to the collaborative approach we have adopted in Y3/4.'

The value of working in network groups and having time to focus on a specific area was also appreciated:

'I feel it has widened my own understanding and made me more open to the subtleties of children's questioning and more ready to explore them. To be able to discuss in detail one area with other teachers was a fantastic opportunity; many heads are better than one!'

These comments illustrate the success of the project in supporting the development of collaborative working across the network groups and also the way in which teachers were able to support one another's professional development through the dialogue and activities they engaged in as a network. The following comment illustrates this:

'Interesting experience and has kick-started our network which has reinvigorated us and promises to be useful as we are all in small schools and lack colleagues to plan and collaborate with. Thanks'

Working in network groups also has its difficulties and the responsibilities of taking the lead can be demanding as one Host School said in their response:

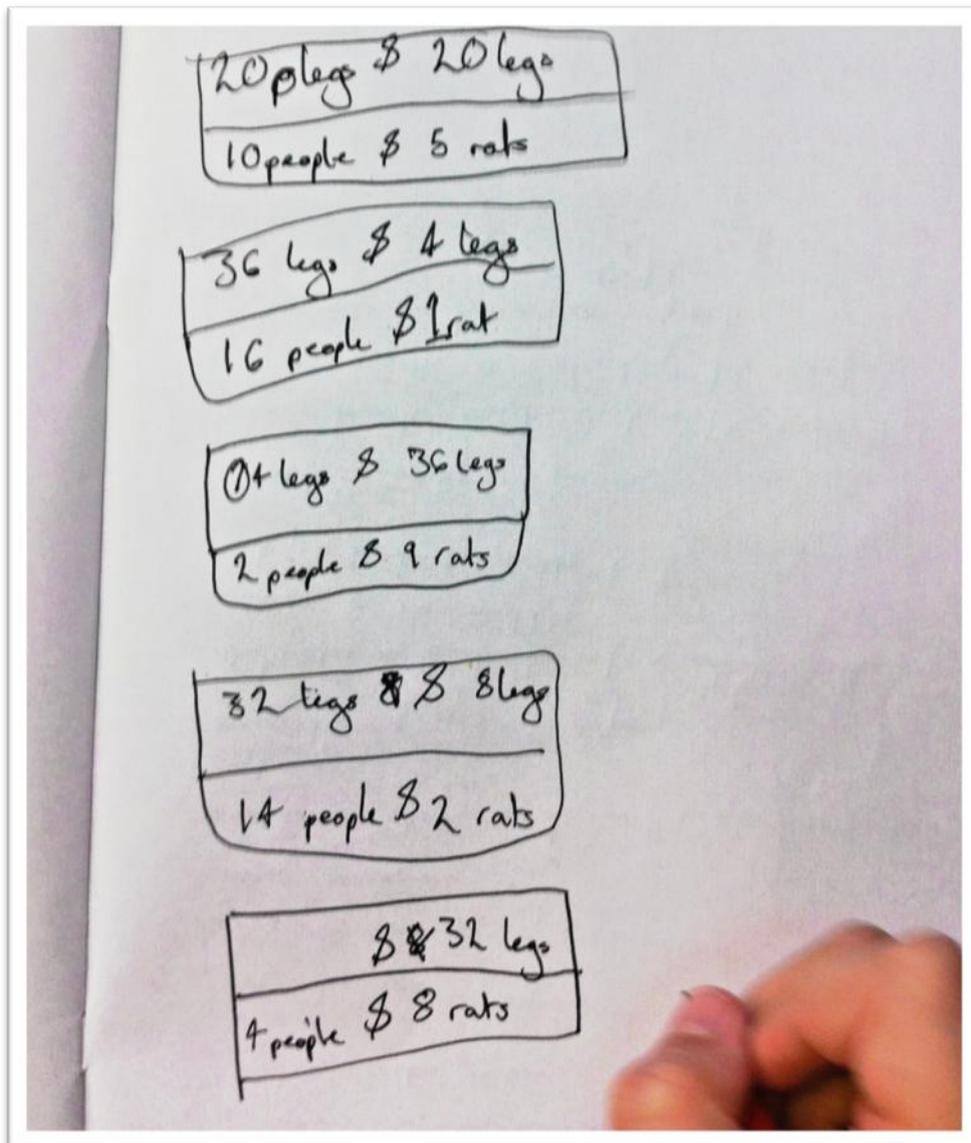
'I know we've had a big cluster, but I have found the amount of time and energy involved in leading the network has been MASSIVE. I've enjoyed every minute of it, and I mention this only as I know part of this project has been to explore alternative models of CPD. I've been quite amazed by the amount of time taken in following things up, planning sessions, just stuff like arranging catering etc. It's a big consideration in our changing CPD landscape as teachers generally have so many class based commitments too. I definitely am so glad I did it but it does make me wonder if some of the expectations about school to school support are a little naive!'

The reservations expressed in this response draw attention to the limited time available for classroom teachers in primary schools who are in face-to-face contact with their classes for 90% of their time and then have heavy administrative, preparation and assessment commitments, as well as pursuing their own professional development and that of their colleagues in a range of subjects. Some of the Visiting Schools clearly appreciated the commitment and leadership that their Host Schools offered, as this comment illustrates:

'The host school was very effective and led the lesson study very effectively. I personally learnt a huge amount and enjoyed the opportunity to work in collaboration with practitioners from other schools.'

Some negative comments were made throughout the project about the short time frame of the enterprise and the following is a typical example:

'Project a little short to really have much impact and discussions only just starting to take place. Project would benefit from extended involvement time-wise.'



- The contribution of the Project Lead and Project Administrator

The input from the Project Lead was also valued highly (over 85% valuable or very valuable) although her contributions to each group were different. Some comments about aspects of the inputs that were the most valuable illustrate the range of opportunities that were offered:

'The Project Lead stepped in and explained a concept that is difficult to explain. She was also on hand to help the group leaders.'

'It added academic rigour to our project, her contributions to our online discussions were excellent - she gave us ideas and references.'

'The training on division given to the group was excellent.'

'Being able to observe the class while being taught/challenged.'

'Having the Project Lead come to the school and offer INSET to both TA's and Class teachers was invaluable. She also made some excellent points in our final lesson study and made teachers aware of the importance of conservation of number and how to improve this across the school.'

'Her role as facilitator in developing discussion'

The support offered by the Project Administrator was also highly valued by the primary schools who frequently have limited administrative support and difficulties in engaging with complex administrative requirements.

'Amazing admin support from Project Administrator who literally deserves a medal for trying to keep up with all of us teachers who are always busy teaching and never sitting at a desk picking up emails! She has been AMAZING.'

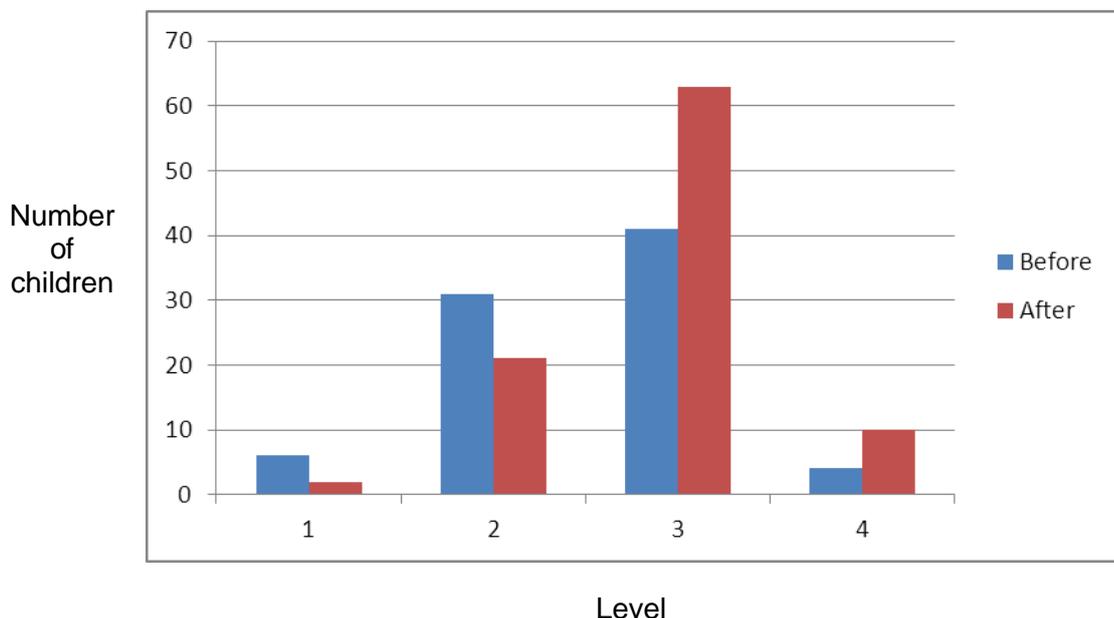
Any consideration of running similar projects in the future will need to take account of the need to employ staff who have the skills and commitment required to ensure comparable levels of success.

- Pupil attainment data

In view of the short time frame of the project, any data that have so far been gathered must be considered as provisional and not many groups have managed to collect pre/post data. However, initial submissions from a few of the groups are encouraging.

Mathematics assessment results submitted from two of the schools involved show pleasing increases in attainment across the whole attainment range in their Year 3 and Year 4 pupils. However, these figures are taken from a very small sample and extrapolating for the whole project would not be appropriate. These are the only schools from whom both sets of figures have been received but it is anticipated that the evaluation team will have access to a more comprehensive data set. The data gathered so far are shown here in table and bar chart form:

Level	No. of children before	No. of children after
1	6	2
2	31	21
3	41	63
4	4	10



Telling stories

In addition to the data that were collected from the initial and final questionnaires, some of the teachers offered to write narrative accounts of their involvement. These accounts are presented in Appendix 11.5 and illustrate a level of the enthusiasm and commitment to the project that was characteristic of their interactions with the initiative as a whole. The accounts are very varied in style, from the academic to the whimsical, but convey the variety of approaches to the project that were used and the thoughtful reflection about the teaching and learning of arithmetic that it provoked.

10 Funding and resourcing

Host Schools were paid a bursary of £500 for each Visiting School they worked with. Of this bursary, a minimum of £200 was passed on to the Visiting School. The funding was an acknowledgement of the reporting requirements the schools had to meet as part of a national project. The funding model proved very successful and enabled the project to be set up as a viable network within a very tight time frame. Just over 60% of schools said that the bursary was important to them but there were varied responses explaining why this was so and some reservations about how much money had been passed on to them. In some cases the Host Schools made significant proportions of the funding available to their Visiting Schools to cover staff release time; in others higher proportions were used to cover events or administration. The decision to leave this to the local Host Schools to determine was adopted partly for pragmatic reasons and might be worth reconsidering for any future projects.

At the national event in March, delegates were asked to outline how they saw the work of their network group continuing. The majority were optimistic about being able to sustain their work collaboratively and the following comments about their plans were received:

Hopping Hill

We plan to develop some activities that will allow children to see that division can be fun (art, colouring, and outdoor learning).

We hope to change teachers' perceptions of teaching division (it can be fun, it's NOT difficult).

We will talk to teachers about their perception of how their children would attempt to solve problems re division and what the questionnaires that we gave to children actually showed.

Heversham Primary School

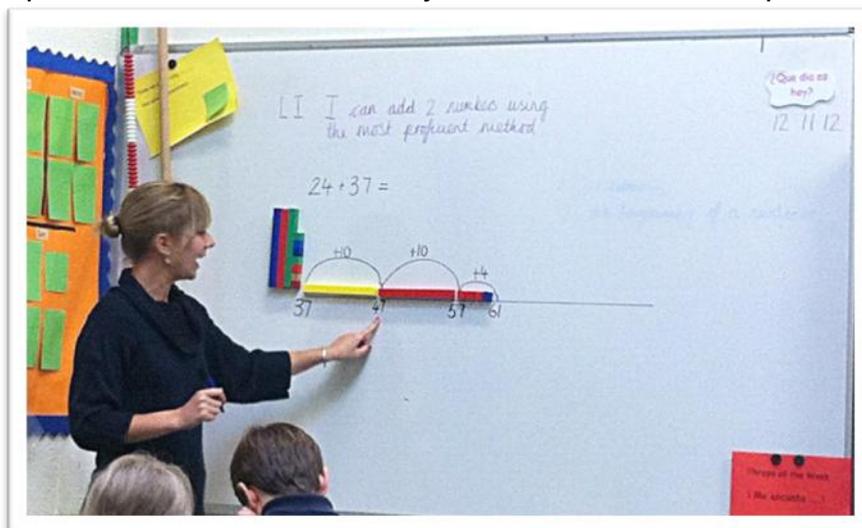
We plan to take the best of today (final evaluation event) and ideas back to schools working with us.

We will support teachers that want support.

We will share ideas and hopefully join up for CPD with all staff on inset days, not just mathematics subject leaders.

We will encourage schools to make more active use of the NCETM site and the partnership

We will try the 4 sums assessment from Norfolk with years 3-6 in the Host School and support other schools in the group to do the same and to identify difficulties and misconceptions.



Ripley and Saltergate

We are all going to continue to meet as a cluster and will continue to share lesson observations and good practice.

We will try to develop lesson study within our own schools and continue to use problem solving.

Adrienne and I (Donna) will look into starting a Collaborative Teacher Project with secondary school teachers to encourage them to go into primary school. They too can use the lesson study approach.

We'd look at university support for this too.

St Lukes Primary School

Our group will now extend our work across the whole of Key Stage 2 and into year 7/8.

We have applied for and received an NCETM Collaborative Teaching Project grant for summer 2013 and autumn 2013. We will carry out a calculation audit in our schools.

Lakenham Primary School

We would really like to enlarge the group to include clusters and secondary schools and follow up on transition and continuity issues taking advantage of funding opportunities through the NCETM and the cluster itself. We would also like to begin talking about sharing calculation policies across the cluster and looking at division and fractions.



Oakthorpe Primary School

- *Meet for another ½ day to look at further use of rich tasks*
- *Further use of forum to discuss the use of rich tasks and impact on making sense and constructing meaning*
- *New Collaborative Teacher Project will run in the autumn term*

Ashley Down Primary School

We still have 2 meetings planned to look at fractions planning for next year.

When asked whether their network group work might support their implementation of the new national curriculum, the groups responded as follows:

Thorne Brooke

To emphasise the need to maintain practical work as a core activity in mathematics. It has become apparent that in many schools the use of manipulatives disappears in Key Stage 2 except perhaps for intervention groups. This seems to stigmatise the use of practical equipment (it is seen as only used by 'less able' children). Even problem solving activities are done as pencil and paper activities. These need to be more actual practical work to support conceptualisation.

Hopping Hill

We will ensure that the understanding to underpin the requirements of the new national curriculum is developed using a wide range of skills including representations, generalising, thinking/problem solving etc.

Heversham Primary School

The initial feeling in the group at the last meeting regarding the new national curriculum revealed worries about moving expectations in different areas of mathematics to younger age ranges. Therefore we feel it is imperative that all staff in schools get mathematics CPD and become comfortable and confident with the teaching of mathematics. We will continue to support schools in this endeavour.

Ripley and Saltergate

We plan to encourage our cluster to respond to the new curriculum draft. We will support each other in developing new changes and managing what we are being told to do.

St Lukes Primary School

As a group we will support each other in making this change.

Lakenham Primary School

We have concerns about 'the efficient method' being pushed inappropriately on a child who lacks understanding. In that case, it will not be efficient as they will get it wrong! However, we take on the point of using visual methods to aid fluency/speed when understanding is there.

Oakthorpe Primary School

- *Go forward into the new national curriculum with a firm belief in the power of rich tasks*
- *To understand a need for progression of understanding across the school*
- *Empowerment in understanding mathematics learning and children's reasoning.*

Ashley Down Primary School

We hope that the group will have the confidence to follow its own path, drawing on the new curriculum but choosing on where to deviate. The group supports the aims of the new NC and will prioritise these.

11 Appendices

11.1 Identification and recruitment

The Project Lead was responsible for developing and agreeing the criteria for the selection of Host Schools. The criteria drew on data from Ofsted's 'Understanding the score' report, as well as the prior experience of the Project Lead and the primary specialists at the NCETM. In addition, the DfE gave the project team access to figures that identified schools that had made significant and sustained improvements in progress over the last 5 years and this database was used to inform the selection process. The NCETM's Primary Mathematics Executive Group (PMEG) proved invaluable in offering advice and insight about potential schools and the model for the project in its initial stages. In addition to these sources of Host Schools, a number of Teaching Schools were also approached and a call for applications was placed on the NCETM portal and disseminated through newsletters and other contacts.

In all over fifty schools were approached with a personal invitation and follow-up phone call before the final group of 29 Host Schools emerged. Approaches were made personally in order secure a geographic spread of locations but some schools also put themselves forward in response to publicity on the NCETM portal. The majority of the network groups were securely established by the first week in November with a few more consolidating their applications by the first week in December. In one or two cases the Project Lead sought to find Host Schools in specific areas in response to a perceived gap in coverage or type of school. The aim was to ensure that the Host Schools comprised a sample that included rural, urban and suburban schools of varying sizes and had pupils with a diverse range of socio-economic and ethnic backgrounds.

After discussion with the primary mathematics advisory group, the NCETM team reached the conclusion that the best approach to building network groups with these schools as their leaders would be to allow the Host Schools to identify and recruit their own Visiting Schools. A further development was the decision to pay some of the money available to the Host School as a bursary for each Visiting School recruited. This proved a very successful model and enabled us to set the project up as a viable network within a very tight time frame. The Visiting Schools also identified a 'mathematics champion' who led their involvement in the project.

One development that had not been anticipated was that of two or more schools in the same area wishing to be Host Schools and this was overcome by allowing these groups to be joint Host Schools and work with a larger number of Visiting Schools. Some of these larger networks have proved to be amongst the strongest on the national network and have had significant impact on local practice. Of the 29 Host Schools Network Groups, there are 4 jointly hosted groups. One of these has 3 joint hosts.

11.2 Personnel and staffing

The programme has been led by Dr Jenni Back (1.0 f.t.e.), with administrative support from Rachel Ball (0.6 f.t.e.). Jenni is an experienced mathematics teacher and teacher educator, and has worked with a number of projects focusing on the development of primary mathematics teaching over the last fifteen years, including the NRICH Project, the Centre for Innovation in Mathematics at Plymouth University and the Royal Institution. She has trained primary teachers of mathematics at Middlesex University and has a national profile as the current Chair of the Association of Mathematics Education Teachers (AMET) and one of the editorial team of Primary Mathematics, the Mathematical

Association's journal for primary teachers. She is also an experienced researcher with an interest in continuing professional development, comparative education and the place of talk in primary mathematics classrooms. At the commencement of the project Jenni was coming to the end of a short term contract with NRICH and so was able to undertake the role full time from September 1st 2012.

Rachel moved over to the Host Schools project having worked for Tribal since September 2009. She has worked on a number of Skills Funding Agency Projects, including large employer Apprenticeships, Offender Learning and Skills Service (OLASS), National Offender Management Service (NOMS) and National Careers Service NCS.

The project was very fortunate to secure the involvement of a team with such expertise and knowledge of the field at such short notice. This contributed significantly to the project's success.

11.3 Details of national events

Launch Event, 20th November 2012: Mary Ward House, 5/7 Tavistock Place, London, Greater London, WC1H 9SN

Programme

- **Welcome:** Dr Jenni Back, Host Schools Project Lead, NCETM
- **Building Relationships in Networks:** Alison Peacock, Head Teacher, The Wroxham Primary School
- **Host Schools Network, an introduction:** Professor Celia Hoyles OBE, Director, NCETM
- **A Mathematical Task:** Exploring the key mathematical issues in years 3 & 4. Dr Jenni Back
- **Exploring Key Educational Ideas in Teaching Arithmetic in Years 3 & 4:** Workshop activity for groups of participants
- **Sharing Experiences from Across the Network:** Various groups will recount their experiences so far
- **Using the Portal:** Opportunities to share resources and discuss ideas
- **Next Steps:** Debbie Morgan, Director for Primary, NCETM, Questions and Answers

Alison Peacock, Headteacher of The Wroxham Primary School in Potters Bar talked about building relationships that support professional development. In addition, Jenni ran a workshop identifying some of the key areas in the teaching of arithmetic in Years 3 & 4. The teachers engaged with a rich task from the NRICH website called 'Strike It Out' that was based on using and recalling the number bonds to 20 and so supported addition and subtraction. Jenni also related a recent piece of research undertaken by a team from Durham University that emphasised the importance of images of arrays to support the development of notions of multiplication. An attitude questionnaire for children was made available to the teachers at this stage and they were asked to collect data about the attitudes to arithmetic of children in their Year 3 and Year 4 classes.

By the event in November, several groups were beginning to be established and three of them shared a brief outline of their plans with others in the network. In most cases the two places allocated to each network meant that one teacher from the Host Schools came to the event along with one teacher from one of their Visiting Schools.

Evaluation Event, 20th March 2013: Thistle Birmingham City, St Chads Way, Queensway, Birmingham, B4 6HY

Programme

- **Charlie Stripp, Director, NCETM** – Vision for NCETM's role in the current context with some reference to the draft National Curriculum that should soon be out for consultation
- **Building on the Relationships in Networks:** Jenni Back will outline some of the findings from the Norfolk longitudinal arithmetic study. The study was undertaken by Alison Borthwick (Norfolk Integrated Education Advisory Services Adviser) and Micky Hardcourt-Heath (NIEAS Adviser) from 2006-2012. Tim Bannister, (Norfolk, Lakenham Primary School) and Vicky Gateshill, (Norfolk, Harleston CE VA Primary School), will talk about how they have used this research in their work.
- **Exploring Division:** Workshop activity led by Clare Christie (Bristol, Ashley Down Primary School) and Alex Parry (Bristol, Westbury Park Primary) on division and the use of resources and images.
- **Raising the bar in arithmetic proficiency:** Patrick Barmby, Durham University and Sally Green, Thornhill Primary School, Shildon will lead a workshop on their approach to raising standards in mental and written calculation skills. This links with the Nuffield project's experiences of developing and interpreting diagnostic tests to analyse children's understanding and misconceptions.
- **Building on Experiences from Across the Network:** Various groups will recount their experiences so far:
 - Matt Chappell and Louise Ryder:** (London, Islington: Thornhill Primary School): Using lesson study to develop approaches to teaching arithmetic.
 - Adrienne King and Donna Langley** (Yorkshire: Ripley Network Group): Developing problem solving approaches to teaching arithmetic.
 - Danny Annaly and Natalie Langtree** (Sussex: Brighton: St Lukes Primary School): Developing common approaches across feeder schools to the local secondary school and considering the 'Big Ideas' in teaching arithmetic.
- **Next Steps:** Sustaining the work of your group and the network as a whole

The focus of the second event was on taking stock of what the groups had achieved and also on considering ways forward in sustaining the work of the groups. One of the larger network groups contributed a workshop on tackling division and Patrick Barmby and Sally Green who had both been involved in the Nuffield funded 'Visual Representations' project talked about some of their approaches to supporting and developing the teaching of arithmetic. Three groups described some of their different approaches including the use of lesson study, a focus on problem solving and working with secondary schools, to consider how they might build on the arithmetic that children engage with in primary school. In total 9 out of the 29 groups contributed to the two events.

11.4 Visits to Host Schools network groups

Host School	Input	Number of participants
Eleanor Palmer (Camden School Network Community on Portal)	21 st March 2013 Afternoon CPD session	23
Boasley Cross CP School	5 th February 2013 Demo lesson, meeting on calculation policy	8
Thornhill Primary School	26 th & 27 th February 2013 Observation of study lesson and contribution to lesson study feedback	8
The Wroxham School	14 th March 2013 Joint CPD day with NRICH linking Host Schools project with use of NRICH resources	20 in am 5 in pm
Lakenham Primary School	12 th February 2013 Demo lesson at 2 Visiting Schools, discussion re ways forward with local lead, twilight session for teachers	12
Harleston CofE VA Primary School	13 th February 2013 Diagnostic arithmetic assessment for two groups of children re key thresholds, demo lesson, observation of study lesson and feedback	12
Latchmere Primary School	7 th March 2013 CPD day with teachers from all schools on curriculum proposals, issues in primary arithmetic and resources for teaching primary arithmetic. IRIS connect	16
Northleigh CE Primary School	30 th January 2013 Discussion with HS and VS teachers re issues in teaching arithmetic particularly multiplication and division and demo lesson using MEP resources	6
St Lukes Primary School	17 th January 2013 CPD morning on division and meeting with St Lukes and St Martins in pm re developing a Big Ideas curriculum in arithmetic and developments for the project – resulted in successful CTP application	am 12, pm 2
Shipston on Stour	29 th January 2013 Three VS visits, time with HS lead and then twilight CPD session on learning key facts and other issues in multiplication	15 twilight
Abbey Gates Primary School	12 th February 2013 bservations in morning and CPD in afternoon for all schools involved on exploring approaches to multiplication and division	10
Chantry Primary Academy	7 th February 2013 Lesson observations in pm and twilight session on using lesson study approaches to developing problem solving approaches to teaching arithmetic	6

Host School	Input	Number of participants
Oakthorpe	22 nd February 2013 CPD session on using rich tasks to support fluency and understanding in arithmetic, supported observations of children engaged in rich tasks and identification of progression and evidence of learning. Development of CTP bid on basis of this work after session.	12
Ripley Endowed Primary School	22 nd January 2013 Two demo lessons on problem solving approaches to teaching arithmetic one in each of the joint lead schools, discussion with both school leads on calculation policy and using artefacts to develop arithmetic proficiency, twilight session on key issues in primary arithmetic and problem solving approaches to teaching arithmetic	25 twilight 2x 3 in schools
Fairlawn Primary	28 th February 2013 Two diagnostic assessment sessions with groups of children, discussion with members of group about calculation policies, and input on issues in teaching primary arithmetic	3
South Green Junior School	14 th February 2013 Day on developing calculation policy and issues in teaching primary arithmetic	5
Lady Joanna Thornhill Primary School	28 th January 2013 Two demo lessons with audience of teachers, TAs and LA advisors, day on issues in teaching multiplication and division in years 3 & 4	25
Great Bowden Academy	12 th November 2012 Discussion with subject leaders at Host School, observation of study lesson and feedback, work on calculation policy, twilight CPD for all schools on Number sense	18
Eardisley CE Primary School	1 st February 2013 CPD comprising 2 lesson observations and feedback, videoed demo lesson with children from all schools, meeting with subject leaders re calculation policy, twilight CPD session on issues raised during the day for parents, teachers and TAs	15, 4, 25
Fleetville Junior School	4 th February 2013 CPD day for all teachers on issues in teaching arithmetic focusing particularly on subtraction with demo lesson on subtraction	15
Ashley Down Primary School	7 th December 2012 Support and contribution to day on addition and subtraction with presentation on models, images and using rich tasks to develop arithmetic proficiency.	40

Host School	Input	Number of participants
Thorne Brooke Primary School	24 th January 2013 Input to full day on division, observation and feedback on lesson and discussion about calculation policies	5
Heversham St Peter's CE Primary	23 rd November 2012 Input on sharing resources and Hungarian approaches to teaching arithmetic. Participation in workshop exploring use of Big Mats in arithmetic, developing plans for the rest of the work of the group.	7
Carleton Endowed CE Primary	30 th November 2012 Input on teaching arithmetic in Y 3 & 4 and discussion about calculation policy.	5
Benedict Biscop CE Academy	23 rd November 2012 Input on teaching arithmetic in Y 3 & 4 and discussion about calculation policy – comparing approaches across the network and sharing resources	20
Highlands Primary School	23 rd January 2013 Host school visit and lesson observations, discussion about calculation policy, contribution to afternoon network meeting looking at identifying progression in teaching arithmetic in Y3 & 4	6
Widey Court	6 th December 2012 Two lesson observations and feedback, focus on division, twilight discussion about calculation policy across schools and the secondary school which they feed into	7
Hey With Zion	20 th March 2013 Two lesson observations and afternoon session on calculation policies	4
Hopping Hill Primary	21 st February 2013 Led day on issues in primary arithmetic and developing calculation policy for all schools in network group	6
Totals	29 visits	371

N.B. The relationship between this figure of 371 participants with whom the Project Lead had face-to-face contact on her visits and the 802 participants identified in the questionnaire is of two overlapping sets. Some people who were not directly involved attended face-to-face meetings, as they were for instance teaching another year group in one of the schools, and some of those who were involved in a network group were unable to attend the face-to-face meeting with the Project Lead.

11.5 Telling stories

11.5.1 Story 1

Fiona Mackay, New Park Primary School; Ripley and Saltergate Network Group

As a Newly Qualified Teacher (NQT) the prospect of my first year whilst exciting was also very daunting with the 'progress' cloud that overshadows every practitioner ever looming. Having only ever taught for six weeks on teaching practice before, the first half term of eight weeks seemed a marathon in itself, never mind the following two and a half terms that followed! Mathematics teaching in the school was one of the biggest areas for development and whilst you should always enjoy all the subjects you teach, mathematics is definitely a favourite of mine. Being an NQT means you are subject to half-termly observations from your mentor - mine is the Head Teacher. My first observation in mathematics received outstanding praise and comments particularly in regards to the children's attitude towards their learning. Despite this I still felt there was an unhealthy balance between the children that enjoyed the limelight--answering questions without prompts--and those that preferred to sit back, and whom you had to tease feedback from. A term commonly coined as 'Hogs and Logs.' 'Hogs' take over classroom conversation and group work and 'Logs' sit back and do not involve themselves. In addition whilst the children had arithmetic competence, their ability to transfer it to problem solving was poor. If I could conquer this 'Hog/Log' divide and increase their competence to make them confident in problem solving, I felt the ever-daunting push for rapid and sustained progress would be manageable. In the second half term leading up to Christmas the Head Teacher received an email asking for our participation in an arithmetic study linked to children in years three and four. Having discussed my enthusiasm for mathematics and talked to the year three and four teacher, the Head asked me if I would like to be involved. Although I am an NQT and one should not have extra responsibility and pressure, I felt the experience would be invaluable to my continuing professional development and would help with some of the issues I had found in mathematics. My school is in North Yorkshire in the Spa Town Harrogate and as a result, the school serves a predominantly white/British community. The school is much smaller than the average-sized primary school but since September 2012 pupil numbers have begun to increase. Almost all of the new arrivals have significant additional needs including two EAL (Hungarian) pupils who joined with no English, one pupil with a statement of special educational needs with global delay, four children from families working in the armed services and a pupil with a diagnosis of ADHD (Attention Deficit and Hyperactivity Disorder). The school has also improved its systems for early identification and intervention for vulnerable pupils and those in receipt of pupil premium funding, with the result that in the school census January 2013, 53 pupils out of a total of 121 were identified as being at school action or school action plus. This is a significant increase on previous years. Attainment on entry to Reception is substantially below Age Related Expectation (ARE) particularly in mathematics.

The school has come through an extended period of unstable leadership and turbulence in staffing but is rapidly establishing a stable and secure leadership team and staffing structure. The school this year has focused on evaluating, revising and implementing some key policies, particularly its aims and values and behaviour management strategies; this has supported a drive to change the culture of the school towards high aspirations on behalf of parents, pupils and staff to improve attainment and progress and enhance other pupil outcomes, especially around their personal, social and emotional attributes. The outcomes of this have been significantly increased parental engagement, improvements in pupil attitudes to learning and their behaviour and a growing awareness of the school in the community and the good work it does.

The Head accepted on my behalf, passing on my email, correspondences were exchanged over a couple of weeks and the first meeting between the schools involved was scheduled at one of the Host schools in November 2012. With mixed feelings of what is going to happen? Is this going to make a difference to my teaching and my children's learning? Can I make valuable contributions being such a new teacher? I went to the meeting armed with data about my children. At the first meeting of the Network Group, when both village and town schools met, it was agreed, to my relief, that problem solving was a significant area where improvements could be made and that my children had similar ability to the other classes. In addition Ofsted and North Yorkshire consultants had also identified the weakness in problem solving. Although I had worries that my class's weakness was a result of my lack of experience in teaching problem solving, it was reassuring that more experienced teachers had individually implemented different problem solving strategies and techniques in their mathematical teaching and had similar findings to myself. A collective approach to Lesson Study encompassing challenging and engaging activities was decided as a suitable method to begin to address problem solving more effectively. With the problem solving vision in mind, we embarked on collecting evidence to share at the next meeting.

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To provide the most realistic and comparable study it was decided after the initial meeting that town and village schools would meet and study separately. This meant that my school would be one of five town schools. This was one of the first benefits of taking part in the study, as two of the schools are my school's neighbours, thus providing a platform to make my own cross-school links. Whilst I knew it was important to network for yourself and your school, as an NQT I had apprehensions on how to communicate with other schools without presenting myself as being quite forward and without tenuous links. However the project eradicated both of these concerns. The first town meeting took place at the end of the Christmas term with eight teachers from five different schools and allowed for in depth discussion of the processes of Lesson Study. The fact I was a NQT did not present a problem, I was listened to and accepted as a fellow primary colleague with an enthusiasm for mathematics. Two practitioners shared their experiences of Lesson Study gained through their participation in the MaST course at Sheffield Hallam University. This highlighted two factors: time, particularly after the Study Lesson and the importance of developing and re-teaching the lesson. As an NQT, although observed regularly I had little in depth knowledge of Lesson Study. Adrienne gave us an insightful article by Maddern (2012), which provided a strong platform with foci and rules for our Lesson Study. The key points made were: include the children in the Lesson Study process so they understand its purpose, their roles and the roles of the observers. We did this by explaining to them prior to the lesson why the adults were coming in and that they wouldn't be able to help them. Four children were also selected to talk to the observers after the lesson to share their experience.

- *Follow the agreed lesson plan which was developed in collaboration by all in the study and followed by the teacher.*
- *All participants in the group should observe the lesson, taking notes of key points or incidents. To do this we split into teams with each team having a focus, either on arithmetic competence; language of reasoning; collaborative learning; or the ability to problem solve.*
- *Observers should not obstruct the flow of the lesson*
- *Observers should not review or evaluate the lesson until the scheduled session afterwards so 90 minutes was put aside where all could congregate, discuss what was witnessed, possible*

reasons why and an action plan to take the study forward.

Teachers also shared recent experiences of problem solving. Websites and resources (please see end list with relevant links) were compared and contrasted. This was definitely a huge strength of the project, the opportunity to discuss and question in depth with teachers who are in similar class situations. As a NQT learning through collaboration and using stories to teach mathematics were two areas of which I had little knowledge, and as a whole, were weaknesses that the group had also found in their lessons. As a result, these two strands would also be woven into the lesson study. My toolbox for teaching and learning was growing and my confidence in being a practitioner was growing. The agreed emphasis of the Lesson Study was problem-solving activities with calculations as the main focus. It was hoped this would also assist in developing the children's oral and reasoning skills.

Time was always the most difficult element to manage effectively especially for those teachers that had so many more responsibilities than just class teacher. Although the Christmas meeting allowed for initial plans to be made for the Lesson Study it was decided, to ensure thorough planning, to meet again before we broke up for Christmas and so we left with the hope of finding a suitable problem-solving task. As Hayes (1997) suggests 'planning is the process of thinking, consultation and developing ideas that leads to the production of plans, which act as a guide for your lesson' (p. 54). As he discusses in a later publication, a good teacher plans their session thoroughly (Hayes 2006). So although not all the practitioners were present, it was hoped that the six of us who could be there would be able to prepare a lesson that would allow a detailed insight into collaborative problem solving. Although we all agreed like Hayes (2006) that learning is a continuous process and it is important to take into consideration the lesson before the Study Lesson, because of the nature of the study and with the second Study Lesson in mind, we were more concerned with where we wanted the lesson to lead. Unlike some lesson studies in which the teacher teaching does not know the children, both lesson studies, although in separate schools, had the class teacher, teaching. This as English and Newton (2005) valuably suggest, ensured that both sessions would address the preferred learning styles of the children in the class. Together we planned a lesson based on the same pro forma as the village school and because I was teaching the lesson, chose to adapt it to a more detailed individual session plan. We chose to use the problem Potter Potions:



Potter Potions

The Witch needs a 24-leg potion to turn The Dragon into a frog.

He's got Spiders (8 legs) **Lizards** (4 legs) and **Bats** (2 legs)



Try to find all the possible spells to turn The Dragon into a frog! e.g. 2 spiders, 1 lizard and 2 bats would do the trick.

Be systematic and draw up an ordered list. Make a table of your results. Look for a pattern.

We felt it important that the main teaching supported the activity but did not lead or tell the children exactly what to do, thus encouraging them to work together, adopt a strategy and find a solution. The planning process deepens, as to respond further to each child's individual need, learning style and ability, every session requires differentiation. Pollard (2006), Jacques and Hyland (2003) extensively discuss the difficulty in defining differentiation, but as Pollard (2006) suggests, it relates to the appropriateness of the task for the child. It is not suggested that every aspect of a lesson can be differentiated. As English and Newton (2005) propose, there are many ways to differentiate. As all the teachers in the study agreed, planning with differentiation provides pupils with the best environment to make progress and learn effectively. We carefully planned the groups to support the lower ability with the middle and higher ability, but also extend the more able through reasoning and explanation. This supports Hayes' (2006) argument that it is important not just to differentiate according to ability but to take into consideration the personality of individual learners. As a result the groups of four were carefully selected taking into consideration academic ability, learning need and personality.

It is impossible to measure the total success of the project as some findings were very personal to the classes, teachers and children involved. However a range of assessment strategies were used to gain an understanding of the impact of the lesson on the children's ability to problem solve. We found that there were added holistic benefits for the children and not just cognitive advantages. Ofsted (2009) stress the importance of good assessment, the Study Lesson put the team at an advantage as there were eight adults in the classroom with four different assessment foci. Assessment throughout and after the lesson allowed an insight into the children's thinking and indicated how to adjust the teaching for the second study and future lessons. In writing this article, I found it interesting to note how much reading supports many of our findings.

To summarise the main findings of Lesson Study One please refer to the table below:

Area of focus	Positive Findings	Points for Development
Arithmetic Competence	Number bonds were strong. Independent use of concrete apparatus when a child/group required it. Secure in low numbers adding/multiplying. Some tables very secure.	In main task, many struggled to keep three numbers in their heads, more could have used jottings to help.
Language of Reasoning	Identified number patterns quickly and accurately. Some knowledge of commutative law evident- 'if it's repeated addition, it's the same as multiplying!' For triples activity good at explaining a simple strategy.	More reflection in plenary about strategies used, didn't seem to relate strategies from starter activity to main. Some couldn't explain the task.
Collaborative Learning	Worked well as teams on carpet for Triples activity- evidence of higher attaining children explaining to other group members.	Groups mainly split into pairs for main activity. One child who 'got it' carried on regardless of others. Lots of evidence of 'Hogs and Logs.'

<p>Ability to Problem Solve</p>	<p><i>Different strategies throughout class - random number selections leading on to developing a systematic way of choosing numbers. Some useful jottings made by some groups.</i></p>	<p><i>No group referred to problem solving prompt provided. Some lack of understanding of main task as the link from Triples to Potions they did not utilize. Table set up didn't assist problem solving.</i></p>
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Mathematical teaching followed a similar pattern in both lessons: beginning with an oral and mental starter, followed by a main teaching point- which was heavily interactive between teacher and pupils either on the carpet or at tables. An activity in groups then followed, culminating with a plenary.

Both classrooms provided a supportive learning environment, but at the same time presented opportunity for all to go off and work collaboratively, thus encouraging independent and collaborative working skills, an aim of the National Curriculum (DfEE 1999). The main teaching Triples activity in the first Lesson Study was delivered on the carpet. This was deliberately organised in the children's mixed ability groups allowing an abundance of opportunities for children to share ideas and develop mathematical thinking.

In addition, The National Curriculum encourages teachers to create an 'effective learning environment' (pg 31 DfEE 1999) to provide inclusive learning opportunities for all pupils. To accomplish this we provided time for children to discuss mathematical ideas out loud throughout the lesson. The peer support and nurturing encouraged the children, who were not afraid to make mistakes, supporting Ofsted's (2009) and the National Curriculum's (DfEE 1999) suggestions that thinking aloud whilst in groups promotes mathematical development and ensures the learning needs are met.

The first lesson study showed that the majority of children were competent in arithmetic skills. However their capacity to share this learning and to work together to scaffold their peers' learning so that they could move forward together in completing their challenge was limited and they usually preferred to complete the task independently. This meant that they did not utilise the many opportunities provided to develop their arithmetic competence. As Cockburn (2007) suggests 'people's understandings can be vastly improved if they have ample opportunities to demonstrate and discuss their thinking' (p1) and they missed this chance. Cockburn (2007) and Haylock (2007) both agree that when children are given the opportunity to manipulate numbers through a range of processes, to make errors in this process but have time to discuss them, they are able to build a stronger foundation in 'authentic mathematical understanding' (Cockburn 2007 p15). Thus our challenge was to provide opportunities that supported children in being able to discuss with each other, with minimal adult prompts, as opposed to our presumption that they would naturally work in larger groups than their pair.

Many of the observers had already carried out the planned lesson, which supported many of the findings from the Lesson Study. Other teachers also found that the children did not work collaboratively, creating a 'Hogs' and 'Logs' divide, the children did not apply strategies or did not manage to devise a strategy. These observations made us question if the differentiation in the groups was suitable for all the children. As the learning objectives included collaboration, and there were such obvious gaps in the children's ability to work in groups larger than a pair, we decided to focus on group work for the last couple of months of the study.

One of the practitioners had received training in the Kagan methodology (http://www.kaganonline.com/free_articles/dr_spencer_kagan/ASK38.php) and volunteered to provide a training session to help us adopt some of these ideas to aid our children in their ability to work collaboratively. To summarise: Kagan believes that by using step by step simple timed instructions there is an increase in student engagement and cooperation. With the training and resources we received it was clear that we were only scratching the surface but it was fantastic and gave everybody the enthusiasm and inspiration to break through the collaboration block we were all facing in our classrooms.

We also spent time in the training discussing the second and final Lesson Study, which would also sadly be our final meet linked with the study. Using the fresh Kagan ideas, children were still placed in mixed ability groups of four but with specific structures to aid children of all abilities to join in and contribute to discussion and learn at a level appropriate to them. We had found that when the children were sat at tables in their groups of four for the main activity, this did not aid their collaborative learning. After speaking to the children about the Lesson Study, we decided to still use the same groups at their tables. The children had all spoken about their preference for working on tables as opposed to the floor or the carpet. As had previously been identified, the children struggled to keep three numbers in their head linked with the three different animals being put into the potion so it was decided to just use two characters, the Pied Piper (2 legs) and rats (4 legs) and the Pied Piper problem from the NRICHS website <http://nrich.mathematics.org/1996>.

Having taught the previous lesson, I now had the role of the observer. It was a huge learning curve being in an experienced teacher's classroom and watching her interactions with her children - another added benefit to the study. As my class had a collaborative learning weakness I opted to focus on this area during the Lesson Study. Using the Kagan ideas the children used their own initiative to move out of their chairs and huddle. Although not every group fulfilled the task in its entirety, in relation to collaborative learning, many more did than in the first lesson study. Although Hogs were still apparent they were more willing to share and try to include the Logs but there were fewer Logs. With all children trying to contribute, the difficulty lay in their ability to apply logic, with the Hog leading this decision. In the discussion that followed the lesson study we all agreed to continue to implement the Kagan methodology, learning as much for ourselves as for the children. The short timescale was not enough to have fully embedded the Kagan ideas.

In the Christmas holidays my colleague and I were inspired by the work of our Host School group and made the brave decision, with support from our head teacher, to teach purely from where the children were at and needed to go as opposed to teaching through the Primary Numeracy Strategy blocks. We wanted to revolutionise the way we taught and how the children learnt numeracy in years three, four and five. The NCETM study had given me insight into how other teachers taught the basic number skills and embedded all the different areas through each topic e.g. data handling. We wanted to take this one step further and have a theme for the week to give our children more real life and practical connections to their numeracy work because, as Haylock (2007) recommends, through practical activities, children make connections that provide them with a stronger platform in other areas of mathematics.

It is important to note at this point that we use a traffic light system as an Assessment for Learning (AfL) tool. Work is not banded to particular groups; all the children have access to all the learning/challenges/activities based on a red, yellow and green system. The children understand that red is something they all must complete and where the most adult support is offered. This is where the main teaching point begins. The children move at their own pace and as a result, groups are always changing and learning is much more personalised.

The idea

There are four activities per week, two in each classroom.
In each classroom there is:

1. An activity with a teacher providing the teaching input who has 2 groups with her- this is split across two tables. One table with the teacher for a 20 minute focused teaching session, the other table has the group pre or post teaching input. Either, a group is waiting for their teaching input, they will be doing a challenge linked to the Learning Objective (LO) with the teacher at a borderline level that they can access but, slightly challenges them so, when the teacher is with them she can close the gaps that are beginning to show and move them to the next level of their learning. Alternatively the children will be doing a challenge set by the teacher after their teaching input that will be a step above the level they started at but they still have the security of having the teacher close by.
2. A collaborative challenge that is independent of a teacher but linked to the LO in that classroom. For each challenge there is a red, yellow and green level. This is to develop the children's ability to work collaboratively within a strand they have some understanding of because collaborative skills were weak when discussed in the initial meetings of the study.

On a Monday we keep our usual numeracy class y3/4 or y4/5. This begins with an extended oral and mental starter to get rid of the weekend cobwebs, followed by all the children (lower ability supported by the Teaching Assistant) attempting a mini version of the challenges of the week- this not only gives the class teacher a secure starting point for the week to aid in accurate assessment and show progress, but allows the child to self-assess so they understand fully where they are starting and where they need to go to develop their ability to talk about their learning confidently. This is something of a weak area.

The children are able to access all the learning objectives of the week with support from the class teacher or teaching assistant. This time is valuable so the children are secure of the expectations for Tuesday, Wednesday and Thursday when an adult isn't as readily available for all of the activities. This also means that any gaps that put children at a significant disadvantage for the independent challenges away from the teacher, are identified and can be understood before the activity takes place.

On a Tuesday, Wednesday and Thursday the hour follows a similar structure. Our two classes are split into four groups, Circles, Triangles, Quadrilaterals and Pentagons (lower attaining through to higher attaining). As there are two classes there are two of each group. Each day I see one of my groups and one of my colleague's. The same applies to her, but in her classroom. The lower ability children are with the teaching assistant and one group is independent.

Friday provides the chance for children to show off what they can do and how they have progressed in the week. For the majority of children this is an independent challenge where they choose the colour most suitable to their progression in the week and answer a mixture of levelled questions from the week. This also provides time for both teacher and teacher assistant to support or intervene with individuals or small groups who have not met a learning objective as well through the week.

With the first Lesson Study in mind on Potter Potions we decided to use the book 'Room on the Broom' by Julia Donaldson to give the children's numeracy learning a theme. They enjoyed it so much we extended it for two weeks! The children took part in a Young Voices singing extravaganza and we based two weeks teaching on this. Having been provided with a theme, the children have become much more involved in their learning. Many of our children are now asking for extra mathematics homework or if they can take their books out to play, particularly a group of high ability year 3 boys. They have a real buzz about mathematics and are enthusiastically inspired by their learning and motivated to push through boundaries that arise.

When we sit on the carpet together on a Monday the children are all eager to see what their mathematics challenges will be for the week. This emphasis on practical work and discussion is much more inclusive; the lower ability children, many of whom have Individual Education Plans (IEPs) for various Special Education Needs (SEN), have soared, enjoying a much more hands-on approach with a relatable objective. As Cockburn (2007) found, SEN children have great success when given the opportunity to communicate and demonstrate their mathematical thinking.

Although we placed the children in mixed ability groups for the Lesson Study, for our day-to-day mathematics, children are set in ability groups because the lower ability children in mathematics were, at a minimum, more than one National Curriculum level below the middle ability. This put them at a significant disadvantage as they could not access all the learning, particularly because of the vocabulary used. The Training and Development Agency for Schools (TDA 2009) and Ofsted (2009) would support this action, believing that for lessons and activities to be fully inclusive and successful, barriers affecting children with SEN need to be overcome. The lower ability children also struggle with communication because some do not receive high quality interaction at home and also two of the children's first language is Polish. Consequently, all the children are appropriately supported and able to contribute in whole class discussions and decision-making. Meanings and symbols are highlighted and, when possible, represented pictorially. As the DfES (2003) found, more pupils understand problems when presented in this way. It also encourages discussion of activities to help the lower ability children understand further and they can answer questions that are accessible to them, avoiding the issue we had found in the Autumn/Christmas term, which is supported by Van der Aalsvoort, Harinck, and Gosse (2006), that low achievers, when stuck, did not utilise adult support.

My colleague who teaches a mixed class of year four and five, is an experienced teacher of 16 years and has also seen many positives as a result of the initiatives taken from the NCETM study.

'Experimenting with some new ideas for the way in which we teach mathematics in Key Stage 2 has had a positive impact both on the teachers and the pupils. Planning is now much more collaborative and with a much stronger emphasis on AFL techniques planned for throughout the lesson. Key AFL questions are written on the plans and highlighted which enables teachers to have a clearer focus on individual, group and whole class questioning which will probe and challenge the children's thinking. Once initial ideas and learning objectives have been discussed, weekly plans have become much more purposeful and less time consuming. Planning for a rotation of activities over the week allows all children to have both focused work with a teacher or TA, as well as opportunities to work independently.'

Problem solving, which is a key feature of each unit, has resulted in children becoming much more able to show resilience and perseverance when tackling activities which require creative and hypothetical thinking. Pupils' engagement in their mathematical learning has improved and they show increased enjoyment especially with the opportunities to work collaboratively with peers from their own year group as well as mixing with other year groups. They enjoy working with different adults during their focus group too.

Offering pupils a choice of challenges each day has improved their ability to self-assess and most are able to select the appropriate task for their ability. They are also keen to move on to the next challenge when they feel one has been achieved. There is a healthy competitive eagerness amongst the children as well as supportive and cooperative learning occurring on a daily basis.'

Having the Head as my mentor has allowed him to see many of the positive impacts of the project first hand. He comments:

'When I arrived in the school it quickly became apparent that the teaching of mathematics was a weakness - standards and progress were barely satisfactory and contrasted sharply with standards and progress in reading and writing.'

Having discussed the turbulent journey of leadership in the school it is important to note that the Head Teacher has only been in post since January 2012. I have summarised what he has observed and commented on over the past six months in the table below in regards to teaching and learning characteristics in mathematics. As can be seen he has noticed the same positive findings as my colleague and me as a result of the involvement of the school in the study.

January 2012 - July 2012	September 2012 - Date
<i>Slavish adherence to the block and unit structure and timings to the point that pupils were being moved on regardless of whether or not they were secure in the aspect being taught or with the underpinning knowledge required to make progress to the next levels. This was particularly so in number.</i>	<i>Most importantly, rapid improvements in progress, more or less across the school- data shows that almost all will make expected progress and a significant minority will make good progress.</i> <i>Improved practice leading to more sharply focused lessons and a far deeper teacher understanding</i>
<i>Inadequate differentiation of work exacerbated by an 'if you don't get it, bad luck' attitude, especially in upper KS2</i> <i>Pupils insufficiently aware of how well they were doing and what they needed to do next to improve- AfL and pupil focused target setting identified by OFSTED as an ongoing priority for improvement.</i>	<i>More pupils achieving ARE as a consequence of better progress.</i> <i>Levels of confidence of less able pupils have increased significantly and they are observably less anxious about mathematics activities.</i> <i>Classroom environments which visibly and actively support mathematical learning and understanding</i>
<i>Pupil disengagement- lessons were predictable,</i>	<i>Significantly improved attitudes to learning in</i>

<p><i>uninspiring and marred by low level disruption and very poor learning behaviour</i></p>	<p><i>mathematics- pupils are consistently motivated, engaged and enjoying lessons.</i></p> <p><i>Higher levels of collaborative work and for many a subsequent improvement in their group working skills- informal observations would indicate that the higher ability pupils have gained a lot from supporting others both mathematically and in their social learning behaviour.</i></p>
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I am lucky enough to have a High Level Learning and Teaching Assistant (HLTA) in my classroom and therefore the bursary money has not been needed to cover staffing costs so we have been able to invest in some high quality resources and training to continue to improve mathematics, particularly number. A TA has been trained as a Number Counts leader and supports children working significantly below ARE. However, from speaking to other practitioners involved in the project I know they would not have been able to be a participant without the financial support offered by the project. To conclude, in the morning my class and I enjoy thinking together about wise words from others as it helps us come together and begin our day with clarity and vision. Recently I used these words.

*Don't be upset by the results you **didn't** get, by the work you **didn't** do.*

This helps raise the question, are we putting in the work to get the best results from our teaching and learning? If we are not continually seeking out to better our professional development, are we not limiting the children we want to inspire and motivate? By taking part in this study I have developed a key network of like-minded practitioners who endeavour to push boundaries and provide the very best for those in our care. Although the time frame might be closing on the project, we already have a diary date to continue with our mathematical journey, looking more closely now at assessment in numeracy. The network has also been utilised to further support Gifted and Talented children across all subjects.

As an NQT I was never made to feel inadequate and my contributions felt highly valued. I was lucky enough to have the added benefit of being both the teacher of the first Lesson Study and observing an experienced practitioner for the second Lesson Study. I was supported by my school and network friends throughout the project and always felt I could ask anything. By having clear foci that had both depth and development we could measure accurately to show progress. What I hope to have shown, if you are inspired by any aspect of what you have read- don't wait for the opportunity to come along, be the one to create it and just do it!

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11.5.2 Story 2

Susan Meadland, Eardisley Primary School; Eardisley Network Group

Eardisley CE Primary School is a small country school located near the Welsh border and in the western part of Herefordshire. It has a wide catchment area from a rural background. The area is dominated by agriculture and pupils travel in from a wide area. There are 76 pupils currently and they are across 3 classes – Years R/1, Years 2/3, Years 4/5/6. The school follows the national curriculum in mathematics.

Other schools in the network in this project are Kington Primary School which is based in the local market town and adjacent to the secondary school. This is a larger school with a nursery and pupils in single year groups. Pembridge C of E primary school is also in the cluster which feeds into Lady Hawkins School at Kington and it has around 90 pupils arranged in mixed age groups. Almeley C of E Primary School is again part of the cluster and is similar in size to Eardisley. Its classes are also mixed age and it too is a rural school.

First a local network was established and this has now met on several occasions. At the core of the network are the mathematics coordinators from each school. The network has agreed its objectives and agreed a programme of pupil and professional development. At the initial meeting it was agreed that, as the focus of this project was years 3/4, we would support these teachers through a Lesson Study, whereby they could observe each other teaching the same lesson. The focus was to be subtraction – looking at mental calculation strategies. The Year 3 and 4 teachers met and agreed a lesson format and within the short timescale observed each other and then met again one afternoon to feedback on what they felt they had learnt.

The project was then supported by NCETM giving a day of Dr Jenni Back's time. This opportunity was quickly seized on and a full programme established. Initially Jenni observed a Year R/1 class and then a Year 2/3 class working on problem solving. Later in the morning we were joined by pupils in Year 3/4 from the network schools and staff – both teachers and teaching assistants were able to observe Jenni giving a demonstration lesson. All commented how useful it was to watch their own pupils learning and to listen to the pupils' conversations. It was insightful to see how they approached problem solving and to think about what was included in the lesson and what was not – offering ideas on where to take the children in their learning next. The lesson was videoed and will be available for the network to use and for anyone else interested. After lunch the mathematics coordinators were able to meet and discuss their calculation policies and the day finished with a twilight session for all the teachers from the network as well as teaching assistants, governors and volunteers. This session looked at progression and aimed to address how to move on children who get stuck.

As part of the work of the group, the Year 3/4 teachers observed each other completing a problem solving lesson using RUCSAC (Read, Understand, Choose, Solve, Answer, Check) which gives pupils a structure to their problem solving, a method to follow in order to find solutions to word problems. These resources are freely accessible from the TES website

(www.tes.co.uk/.../RUCSAC-mathematics-problem-solving-method-3)

The bursaries have allowed teachers time to reflect on their practice and given them time to stand back from their day to day work. The group offered teachers the chance to have discussions where ideas can be exchanged and developed through face-to-face contact. This has been most useful

as the primary schools are all rural and relatively small. The opportunity to talk to a colleague in a similar situation, that is someone else who teaches the same age group/mixed age, is limited or non-existent in our rural setting and therefore the reward from this project will be long-lasting. We now have a mathematics network and the coordinators have experienced the opportunity to discuss ideas/issues, exchange resources and teaching methods and put together a programme that aims to give pupils opportunities and experiences for all teachers (and teaching assistants) from the different age groups.

Our experience of working in the network group has shown us that it is worth the effort of putting it together, allaying concerns, and promoting the benefits of a respectful, non-judgemental, professional working relationship that is wider than your own school community. It boosts confidence as you see you are working in a similar way to others and share the same views or experience and face the same difficulties. It may take time with all the commitments teachers have, issues around part time, different timetables, support in different schools to the network, people's time commitments but as it starts and gathers momentum teachers will see the value.

11.5.3 Story 3

Deborah Hodgkin, Holy Trinity C E Primary School, Dobross; Hey with Zion Network Group

A nursery rhyme

Once upon a time in a land far, far away there stood, nestled in the loving arms of the surrounding desolate hills, a little school. A little school: stood alone, battling against the rages of the local savage, inclement climate, battling against the rages of time and modernisation.

A little school where pupils from different year groups happily sat together in classrooms and learnt from their wise teachers. A little school where money was scarce and scant resources highly valued.

The evil ones at the controlling LA did not value the little school and so did not give it enough money to survive- preferring instead to spread the money between the few schools down in the dark heart of the town, surrounded by crumbling satanic mills.

The children at the little school (168 in all) were much loved and cherished by the staff and they happily toiled away each day on their sums in their mathematics lessons- battling their way through the confusing hazy maze of formal algorithms or as they were commonly known in school – stand up sums.

Far too polite and unquestioning, the children accepted the methods of addition and subtraction laid before them- the way that many children (and their parents) had been taught for many, many years. The way that promoted knowledge but never, ever asked for understanding.

Then came the news that the school had been invited to join in with another local school to work together on improving their mathematics practice

'Why change?' was the teachers' cry. 'Our results are good!' And they were!

'Why change?' was the children's cry. 'You don't have to understand it to get the sums right!'

'Why change?' was the parents' cry. 'It worked for us and we have done ok!'

It was a chance, a golden opportunity to take a tentative step into modern teaching practice, to gain insight into new thinking, new ideas, gain new understanding.

Bravely, the little school took a deep, deep breath, threw back its shoulders and tentatively agreed to join in.

Within weeks the school was signed up to websites that held untold wonders of opportunity for the teachers: modern research revealed, lesson ideas that promoted children using equipment and teachers scaffolding learning.

Their journey had begun.

Teachers began to take note, children began to question, things were slowly beginning to change in the little school.

Next the teachers were invited to travel outside of the village across to the outskirts of the dark town to visit one of the other schools on the project.

With a slight feeling of trepidation and unease about what was to come, the staff of the little school accepted the invitation and all proceeded to the outskirts of town one winter's evening.

The first meeting focused on the optimum use of empty number lines as contributing towards the performance of efficient, fluent and accurate calculations, and the instructor drew extensively on research by Rousham and Beishuizen (<http://www.tes.co.uk/article.aspx?storycode=358461>) and Anghileri (2000). The second session was used to draw almost exclusively on the use of algorithms with manipulatives, a key feature of the new national curriculum changes, and subsequent sessions were to be arranged for further work on areas of interest to the staff and the schools involved.

The teachers sat down nervously and waited with anticipation for the training to begin. Into the training room came other colleagues from surrounding schools, also entering with trepidation, which was a good opportunity to talk and work alongside others. Then the training began. The trainer was wise (for he had been trained on a Professional Development Lead Programme by NCETM). Oh what wonders passed before them! Empty number lines, different techniques for number lines – forwards, backwards, F10, B10 - clear and insightful understanding. The teachers were invited to model activities, use a range of practical equipment. Logical, practical ideas and scaffolding ideas to take right back into the classroom, straight back into the heart of the little school.

Emboldened by their new knowledge the wise teachers returned back to the village, to their homes to ponder and think through the new learning they had just been exposed to. How would it be received in school? Would the parents understand? Would the children respond?

Imagined screams of protest sounded silently in their heads.

Morning broke, the teachers entered the little school filled with hopeful enthusiasm and a renewed vigour about their mathematics teaching practice. Would they be able to get the children to take these new methods on board? Would they be able to convey the simplicity and clarity of the new teaching methods to parents?

Work in the classrooms began- children given whiteboards, empty number lines, and practical equipment, dusted off and placed in front of the children. Teachers modelled new ideas and techniques placed in front of the children and the slow process of change began. Children began to understand and use the new techniques. Some fought against the changes and clung tightly to the old methods- most embraced them and quickly demanded more challenges from their teachers. Teachers noted an improvement in mental mathematics ability – children using their partitioning, number bonds knowledge (as had been modelled on the number lines) to mentally add and subtract numbers.

The teachers were able to move the children's learning on by introducing number lines to work that involved decimals- always a fearful subject to the children – they noted success and a growing confidence within the children and an eagerness to be challenged.

Reception children were introduced to the concept of number lines and the teacher modelled this in the class successfully with the children. The children in year 2 began to use number lines – evidence in their books began to show a much greater understanding and a confidence growing in them. Parents began to notice the changes in the children's thinking and practice.

When questioned, the children reported that:

I like a busy classroom- with lots of things going on- I like something to do I don't like sitting still listening. (Y1 – Boy)

I like mathematics where you have to move around a lot using practical equipment. (Y2 Boy)

I find subtraction on a number line easy because you just have to count it up at the end. (Y2 Girl)

But I find 'stand up' subtraction sums difficult (using the formal algorithm) – use a number line sometimes. (Y3 Boy)

I like to be able to talk to others about problems in mathematics. I like practical mathematics best with lots of tricky problems and challenge. (Y5 Boy)

This more than anything signalled the changes in practice that had began to take place.

The teachers began to actively enquire about the next training sessions and with that the chance to move their practice on.

This is where the little school is now – taking its first tentative steps towards a new acceptance and understanding of the new curriculum changes- eagerly anticipating further input and chances to collaborate with its new partners.

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11.5.4 Story 4

Provided by Tim Mills, Latchmere School; Latchmere Network Group

A 'diary' written by Tim Mills after discussing their involvement in the Host Schools project with the network group.

SEPTEMBER

I'm going to get that evil Deputy Head. He pipes up in a staff meeting that there's a really "interesting project" and they want a volunteer. I normally look away and slurp my coffee and avoid eye contact when "interesting projects" get offered out at staff meetings. I'm not sure whether I wasn't concentrating or my mind was elsewhere but I suddenly found myself nodding and, would you believe it, I have agreed to be involved in some arithmetic project for the NCETM. I've never heard of the NCETM and let's face it arithmetic is pretty dull and anyway I teach it well enough so I'm not the happiest bunny in the warren. Even more dischuffed to discover I have to go to some school that are hosting the project and meet a load of other teachers also caught unawares by their Dep Head. NOTE TO SELF – concentrate more in staff meetings – don't get lumbered with another "interesting project"!!!

OCTOBER

Well, turned up at Latchmere School on a grim autumnal evening. Traffic was dreadful, so was late and everyone stared – I glared back. Tea was good tho'. Nice choice of biscuits including Jammy Dodgers – classy! Latchmere lot seemed pretty nice and actually I sat next to someone I knew (yes, also press-ganged into the "interesting project" by evil Deputy Head). Good mix of teachers – some new and some not so new but all really switched on and I had to raise my game. Actually I know quite a lot about arithmetic so felt pretty comfortable and people seemed to like my input. We had to decide on a focus for our arithmetic project. My great bugbear is times tables. Why oh why are we not more creative when encouraging children to learn them? Arithmetic can be creative too you know. Anyway, I clearly fought my corner hard. Yep, you guessed it. Focus for the project is times tables!

Just found out what NCETM stands for – National Centre for Excellence in the Teaching of Mathematics – just rolls off the tongue doesn't it? Great website tho'. I mean it. Go on it. It is fantastic. Did the self-evaluation exercise – ha – no mathematics flies on me – although I must have another look at my mathematics vocab – couldn't remember what 'commutative' meant. Had to register on the site to join our 'network'. All the teachers involved in the "interesting project" have to register. We can now share resources and leave notes for each other. Really quite cool. I uploaded a PowerPoint - little games to help with times tables division facts. Also downloaded our baseline assessment. Doing it with my class tomorrow. Oh yes – looked up commutative – means can be done in any order – like addition and multiplication but not division and subtraction.

NOVEMBER

Ugh! Just marked the baseline assessment. Not good. Quite surprised really – thought my class were pretty good but clearly some conceptual problems. Really need to do some work on times tables – not just the class. I need some new teaching strategies. I’ll see if anyone in our network has had a shock as well and if they have any advice.

NOVEMBER

What a relief! Everyone seems to be in the same boat. Baseline assessments all a nightmare. Used a link to the NRICH website (recommended on the network) – really great stuff and have ordered a book (Derek Haylock) just to reinforce my teaching strategies. Went back on the NCETM site and found a load of great resources. Also checked out their stuff on the new draft curriculum. Feel so much happier – I actually know what the changes to mathematics actually are. Piped up with some stuff at the staff meeting. Everyone dead impressed – even my evil Dep Head looked surprised. Thought I was meant to be keeping a low profile; I’ll be on another “interesting project” before I know it.

FEBRUARY

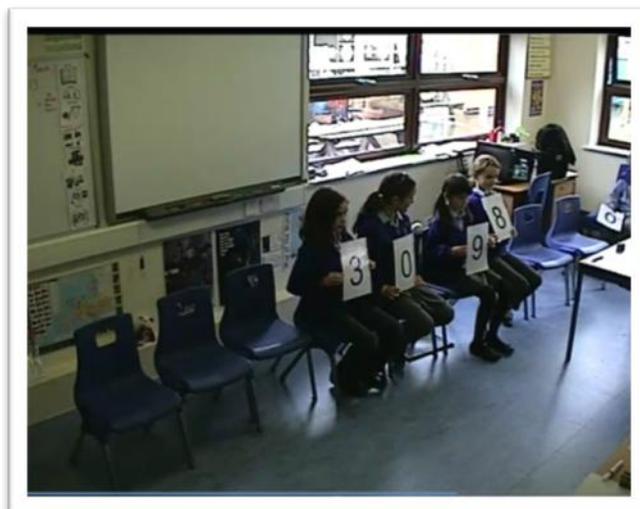
Mid-year assessments. Really pleased with the mathematics – quite an improvement. Just checked the multiplication questions and definite evidence of greater understanding. Had an e-mail through from the project host school – Latchmere – they’re running a special day for all on the project in March with supply cover. My Head is keen for me to go. I’m actually looking forward to it. It’ll be good to get out of school and meet up with the network. Evil Dep Head wanted to know where he’d get the cover – said cover was covered – by the project – ha!

MARCH

You know those courses you go on and they seem to last forever? You look at your watch, stare out of the window and wish the fire alarm would go off so you could waste some time and get some fresh air? Well, today wasn’t one of them. I feel energised and empowered – yeah I know – me?

Spent the day at Latchmere – great lunch btw – sun even shining. The whole network was there and Dr Jenni Back from the NCETM was with us for the entire day. Wow! - she was fantastic. So clear and thorough and inspiring. She gave us a detailed outline of what to expect in the new curriculum and the logic behind many of the changes and expectations. Not nearly as scary as it seemed. I’ll have to feedback at school.

Some teachers are so brave!! Latchmere are a Teaching School and they have a teacher observation video system called IRIS. It’s a high definition video recorder and microphone that sits in the classroom and records. It links to the network so we were able to sit in a classroom upstairs in the school and watch teachers in another classroom teaching mathematics. We watched four teachers delivering number and arithmetic activities. The link was live so we could discuss what we saw with Jenni and each other. The children weren’t distracted by us being in the classroom. The camera can be controlled by us and was so HD we could actually see the children’s work – in close-up. The teachers were amazing – really inspiring and their activities and games will be easy to repeat.



I took so many notes. It was great to be able to discuss what we were seeing as it actually happened, rather than just remembering what we saw. Big thank you to the teachers who were prepared to be filmed! RESPECT! Actually made me think – we should be braver about sharing practice. I know I do stuff that works and will work in other classes and schools.



*Lasagne for lunch – a school lunch but good. Stank of garlic all afternoon but hey – sacrifice!
Got a bit nervous in the afternoon. We all had to bring an activity to share with the network – live. We had to pretend that we were delivering to a class. I'm fine in front of children but adults...hmm. Quite a few jumped up and volunteered and it was quite a laugh so when I went didn't feel such a*

prat. Did a tables recitation activity with a pendulum – worked really well and most found it quite challenging – my class rock with it. Again made a load of notes and Jenni helped us focus on the arithmetic. We're going to put the activities on the NCETM web portal.

Was starting to flag a bit. Might have been the lasagne. But then Jenni told us about the Hungarian mathematics curriculum. (Just a thought – would have been better if we'd had goulash for lunch – Hungarian goulash – no? – oh, please yourself) Apparently, Hungarians are real beasts at mathematics – mathematicians in most major mathematics departments in universities across the world. A very different approach from ours – only number bonds to 20 in KS1 but boy do they know them. Even some algebra in year 1 (!!) but using pictures rather than letters and they use stories to teach numeracy – seems really obvious now. Jenni showed us a website (<http://www.cimt.plymouth.ac.uk/projects/mep/default.htm>) where we could find all the planning and resources. Now, my Hungarian is a little dodgy and unlikely to stretch to quadratic equations but hey, it's all translated into English! Had a whistle-stop tour through it. It's amazing. Would really love to introduce it in its entirety to our school but probably a step too far – we're still struggling with fruit instead of biscuits in the staff room – but boy am I gonna use some of it in class. Brilliant idea – why don't I do it as a research project – action research and all that? Ben Goldacre, evidence based teaching – eat your heart out. Maybe could do it as a Master's project – always wanted to do a Master's, never had the energy.

Head still buzzing – must write it all down. Latchmere are keen to keep the network going beyond the project if we want it. It's a yes from me!!

APRIL

Mathematics assessment in. Progress outstanding in my class!!! Head wants me to do some INSET on mathematics – especially times tables. I think I might have a few ideas!! Hungarian mathematics here we come!

FOOTNOTE:

Dep Head caught me after INSET – went well btw, thanks for asking – said what a good idea of his it was to involve me in the interesting mathematics project. Thought about involving him in a fat lip. Thought better of it and smiled sweetly. Anyway it's Friday and I'm making goulash for supper – I'll get him later!!

11.5.5 Story 5

Keith Ellis, Oakthorpe Primary School; Oakthorpe Network Group

Oakthorpe Primary School is a small village school in North-West Leicestershire. It gained a Good Ofsted report in March 2012 - the first time in its history after being the fourth worst school nationally based on value added results. The school is smaller than the average-sized primary school. Almost all pupils are White British with very few from other heritage and very few who speak English as an additional language. The proportion of pupils who have disabilities and those with special educational needs, including those with a statement of special educational needs, is similar to the national average. The proportion of pupils known to be eligible for free school meals is below the national average.

The group of schools were selected based on having worked together in other lesson-based research projects funded by the local authority. We first met as a group of year 3 and 4 teachers to look at the common misconceptions and issues with teaching the age group. We used the (then) current National Strategies expectations for Year 3 and 4 to pick out a key issue that children found difficult to learn. This included areas such as multiplication, division and fractions. We explored these issues using 5 whys. For each of the issues we asked ourselves 'why' the children found this difficult, to help us really pick out the underlying issues relating to children's learning. We didn't just stop at one 'why'. We kept to asking it and in the end all the groups came up with similar issues for the group to explore further. As well as a need for effective models and images and the need for these to be the same as those used in Key Stage 1, we also came to the conclusion that children are not given enough time to apply their arithmetic to help them make sense of it and improve fluency.

After watching a video from Mike Askew, we looked how we could further use rich mathematical tasks in our teaching and what effect this could have on children's understanding. Towards the end of the first meeting we looked at how we are able to use the NRICH website to begin our investigative work into rich mathematical tasks. Teachers were asked to explore one of these tasks with a group of children back at school and video the learning that was taking place to be able to share at the next meeting. Between the two meetings, the NCETM forum was used to discuss how rich tasks had been used in school and begin to look at how this impacted on the children's learning.

At the beginning of the second meeting, we shared some videos of tasks, with a close look at what the children were saying to show arithmetic fluency and understanding. The purpose of the meeting was to further develop the use of rich tasks with children and understand the impact they can have on learning. We used the evaluative tool 'Think, feel, say, do' to help focus our thinking on children's learning throughout the meeting. We used our experience of working with children in these situations to think, in an ideal world, what would we want children to think, feel, say and do to show they are interacting, engaging and learning from the rich mathematical task? As soon as a group of teachers start to look at videos and explore children's learning, they automatically start to look for improvements in their own teaching and start to hypothesise about how different approaches would have a further impact on leaning.

As we were approaching the main event of the second meeting, where we would be working with children to explore an open ended task, we looked at the list to define an effective rich mathematical task taken from the NRICH website.

Rich mathematical tasks:

- *are accessible to a wide range of learners,*
- *might be set in contexts which draw the learner into the mathematics either because the starting point is intriguing or the mathematics that emerges is intriguing,*
- *are accessible and offer opportunities for initial success, challenging the learners to think for themselves,*
- *offer different levels of challenge, but at whatever the learner's level there is a real challenge involved and thus there is also the potential to extend those who need and demand more (low threshold - high ceiling tasks),*
- *allow for learners to pose their own problems,*
- *allow for different methods and different responses (different starting points, different middles and different ends),*
- *offer opportunities to identify elegant or efficient solutions,*
- *have the potential to broaden children's skills and/or deepen and broaden mathematical content knowledge,*
- *encourage creativity and imaginative application of knowledge.*
- *have the potential for revealing patterns or lead to generalisations or unexpected results,*
- *have the potential to reveal underlying principles or make connections between areas of mathematics,*
- *encourage collaboration and discussion,*
- *encourage learners to develop confidence and independence as well as to become critical thinkers.*

Piggott, J, <http://nrich.mathematics.org/5662>

We came to the conclusion that some parts of this definition were easier to teach than others, but it did help us to understand how we plan for these tasks.

Colleagues worked in groups of 3 to plan, teach and evaluate a rich task with a group of 6 mixed ability year 3 and 4 children from Oakthorpe. We used the Pied Piper of Hamelin problem from the NRICH website (<http://nrich.mathematics.org/8315>). It was important before we started the planning process that we looked at the arithmetical understanding involved in the problem and how this might be progressive amongst the mixed ability group. Interestingly before starting to plan how the problem could be introduced to the children, none of the groups actually completed the problem themselves at their own level of understanding. This will have helped see different approaches and helped to understand how different children may 'break into' the problem.

From this part of our second meeting, my advice to other teachers that are using rich mathematical tasks with their learners, is to carry out the task at your 'adult' level first to help you to see how children would approach the problem too. Also ask others that you work with how they would approach the task as different learners will approach the task in many different ways. Once the teachers had worked with the groups of children and adapted it for their learners, we reflected on our approach and found how similar it was that we took the children down the same approach that ourselves as individual learners did. Questions were raised as to how much an open ended task is truly presented as an open ended approach for all the learners. How much do we as teachers steer the direction of the learning to make it easier for us to 'teach'? How much do we facilitate different approaches and help the children to understand a range of different approaches? Should we refer to

ourselves as facilitators more rather than teachers? Will this change of role help us to change our mind set towards the use of rich mathematical tasks in the classroom?

The task that we chose to use with the groups of children had high expectations for higher order thinking and there were many ways in which it could be adapted for different learners. It was important for us to supply children with a choice of resources for them to represent their thinking and help to apply their understanding of arithmetic. One of the groups of teachers introduced the problem and instantly made the numbers more manageable by decreasing the size of them (i.e. changed the number from 600 to 60). The other groups started with 600 and allowed the children to show how they could manage the problem at this level. As the teachers did not fully know the children's ability, it was important to start with high expectations and then scaffold children who didn't have the arithmetical fluency to work with these numbers. Throughout the sessions with the children, all groups of teachers scaffolded the children's understanding by decreasing the size of the numbers involved but not with all children. Some of the children, when they were given the chance, were able to work with numbers up to 600. During the group's reflections on this, teachers could see how important it is to allow children to work at the high expectations that you set them. If given the chance many of the children were able to rise to the challenge. As discussed earlier a clear understanding in progression of children's arithmetical understanding within the chosen problem is so important to know how to start the problem with the children and what to look for in order to know which children need further support than others and how to support them.

The sessions with the children were deliberately planned as two 30-minute sessions with the same groups of children. This allowed teachers to start off with the group allowing them to show their thinking on large sheets of paper before they had time to look back at the impact of their approach on the learning of the group. The same emphasis on 'Think, Feel, Say, Do' helped to focus the reflection on the learning that had taken place. Teachers decided on the next steps for their group and their plan for how they would progress children's fluency and understanding of arithmetic (multiplication and addition strategies in this open task). There was also much discussion on the development of problem solving techniques in terms of how to use initial ideas to find other answers, how to make conjectures using what we know, and looking for patterns in answers. On reflection, the teachers found this split session incredibly useful on a number of different levels. It gave time to look over the responses from the children and reflect on the answers they had given. It gave an opportunity to look back at the progression in arithmetic for this particular task and how this looked in practice. This then helped the teachers to hypothesise how a change in approach could help to further explore and develop fluency in arithmetical understanding. For the learners, the break in what they were doing re-motivated them and gave time for children to share their thinking before further progressing their understanding. It was thought that often we spend a full hour in one go, exploring a problem and, without sufficient use of mini plenaries, many children find it difficult to retain the motivation for the full session. As with all effective rich mathematical tasks, this problem could have been extended a lot further than just an hour. All participants agreed that there was much more that could be explored by the children and it could be used effectively to develop understanding and fluency more.

The set-up at the second meeting was intentionally designed to push the teachers out of their comfort zone when tackling rich mathematical tasks. All participants had the opportunity to use rich tasks with children in their own class who they know well, but the use of a task in this meeting was to allow teachers to test out new ways to approach rich mathematical tasks with learners they did not know. Participants were only given a limited time to plan for the problem so had to rely on where the children took the problem and have a clear understanding of what they had to look out for as they had no pre-conceived ideas of what the children in their group would be able to achieve. All the

participants found this very rewarding and were able to take the understanding of this new problem back to children they knew in their own classes. Teaching a new rich task 'blind' to a group of children also helps to build confidence in using tasks. If you are able to facilitate a task with a group of children you don't know, then teaching it back in class would be a lot more straightforward.

- *What has been learned, including evidence where possible – this can be from the children or from colleagues or a bit of reflection about your own practice*
- *The impact on teachers' practice – how has your teaching changed? What changes have colleagues reported or what have you seen in their classrooms? Has this had any effect on the children? If so what?*
- *Impact on others – has your involvement had any impact on the wider schools involved?*

All teachers involved in the group have used rich mathematical tasks within their teaching as a result of being part of this group. The evidence of this is shown through the use of videos and the discussions on the NCETM forum. Teachers have a better understanding of what to look for in terms of an effective rich task to know that it has had an impact on children's learning and how they know it has developed arithmetical understanding. One member of our group has reported that she has used a rich task at least once a week and has been able to assess how children within the class have been able to apply their arithmetical understanding. This has informed her future planning by picking out misconceptions and errors through discussions with the children.

All schools involved in the group want to further explore the use of rich mathematical tasks across the whole school. As discussed earlier, it is important to have an understanding of progression within a task before carrying out the task with a group of children. Part of the planning process needs to look at what level the children are working and how you might be able to measure the arithmetical fluency of the children. All schools are planning to pick a rich mathematical task to carry out across the school from Reception to Year 6. The results from this task will be shared with all staff in the school to develop an understanding of an aspect of arithmetic. This will then link to monitoring of the school's calculation policy and an understanding of how children might approach the same task in many different ways. There is a huge amount that can be gleaned from this and would be a truly worthwhile approach to develop subject knowledge of teachers.

As a group we discussed when rich mathematical tasks were used during the teaching process. More often than not, rich tasks are used during the application of arithmetical understanding once procedures have been taught to carry out the arithmetic involved in the problem. Personally, through my involvement in the project, I have thought more carefully about when I use rich tasks with my class. For example when teaching multiplication and division, I used a rich task to explore the children's understanding and fluency before I planned to teach the procedures involved. The rich task gave me an insight into the children's fluency of how much they understand the concept of multiplication and its inverse in practical, real life context. When teaching the procedures of multiplication and division, the same context of the problem could then be used so children had a real purpose for learning rather than a list of procedural calculations to complete. The impact on the children was they were able to talk more practically about how multiplication and division are related to solve inverse problems and there was an increased understanding of how to represent multiplication using repeated addition, number lines and arrays.

The bursary from NCETM was used to bring the group together for two meetings. This paid mainly for supply costs. Some schools that were designated as visiting schools sent more than one teacher

to the group. One large school that has an Ofsted grading of Requires Improvement, sent four teachers to the second meeting at their own costs to explore ideas surrounding rich mathematical tasks.

References and resources:

<http://nrich.mathematics.org/5662> - J.Piggott – Rich Mathematical tasks

Mike Askew video – http://www.educationscotland.gov.uk/video/m/video_tcm4571623.asp

Charlie's Delightful Machine – NRICH - <http://nrich.mathematics.org/7024>

Pied Piper of Hamelin problem – NRICH - <http://nrich.mathematics.org/8315>

11.5.6 Story 6

Tim Bannister, Lakenham Primary School; Lakenham Network Group

Lakenham Primary School serves an area of extreme urban deprivation in Norwich; 82% of the population live in the 30% most deprived areas nationally. 40% of the population have no qualifications. The school currently has 326 pupils on roll, 43% of our pupils are eligible for FSM, and 37% are on the SEN register. In this context we are very proud of the progress that our children make. Children come into the school well below the expected age-related expectations but progress of those children is good throughout the school. Last year in numeracy 87% of our year 6 children made 2 levels progress while 33% made 3 levels progress. We have outstanding teachers and a school ethos that encourages everyone to be the best they possibly can.

Since 2009 I have worked at the school as Numeracy Champion. This role, which has changed and developed over the years, has, at its heart, the core aim to improve and develop the standard of learning and teaching of mathematics across the school. There have been many different aspects to this role:

- *working in classrooms with teachers*
- *leading CPD to introduce and embed new school wide initiatives and strengthen existing policies working with teachers to develop planning*
- *using lesson study*
- *team teaching*
- *modelling teaching practices*
- *working with individual and groups of children to support gaps in their conceptual understanding*

During each year there has been a different focus and this organic and flexible role has meant the job has always been demanding and rarely dull! I have learnt an incredible amount professionally during the last 3 years and enjoyed the opportunity immensely.

One of the interesting opportunities afforded by my role has been the way I have been able to play a part in a variety of different types of networks. There have been small networks as in the one which involves 2 local schools with very similar catchment areas. In this network I have extended the work begun during my MaST course where I initially began supporting teachers within my own school. This role has now grown to support teachers with mathematics from these other schools. I have also been actively involved within our own Secondary cluster (6 primaries and 1 secondary) as part of the mathematics group which is currently working together to create a mathematics calculations policy which we hope will run seamlessly between primary and secondary school. As well as this I have been involved with the County mathematics leaders' network which has been very useful in terms of getting information, support, sharing experiences and expertise. And last but not least my role within the Host school network through the NCETM working with the Project Lead and 5 primary schools; Larkman Primary School, Tuckswood Primary School, Cavell Primary School, Dussindale Primary School and Lakenham Primary School. All these schools serve areas of similar deprivation to our own and the mathematical issues within each school are similar. We have been able to work together selecting a focus to develop our professional understanding to improve our practice and our effectiveness as teachers. In all of these networks the fundamentally crucial thing which has made them worthwhile and important for me personally has been the professional dialogue they encourage and provide a structure for. As well as this, at their best they are able to elevate and accelerate

understanding amongst those who take part. As part of the evaluation feedback for this network I would like to illustrate this point by referring to our experience.

The main focus of the story I want to tell is based around on-going research done by Alison Borthwick and Micky Harcourt Heath into calculations strategies used by children in Norfolk. Their research into calculation strategies with approximately 1000 year 5 children has been carried out at two-yearly intervals since 2006. The data was analysed to see what methods these children were actually using to solve addition, subtraction, multiplication and division problems. The data has been collected in the same form, from the same schools, every two years since 2006, so giving some very interesting information about what is effective, how effective strategies are developing in supporting children to calculate accurately. As far as I am aware the research is unusual in that it provides the only current longitudinal study of calculations strategies in the U.K. This research has fed directly into the focus for the work at our school and of our network. It has also fed into the work and professional dialogue I have had in other networks I am involved in.

Both Alison and Micky have worked as advisers for Norfolk County Council and during my 18 years working in schools in Norfolk their individual and collective influence upon schools and teachers has been and is important to this story. Their regular visits to schools, the on-going dialogue with teachers and contributions to inset sessions and staff meetings across the county have always had a strong focus upon developing children's conceptual understanding by using simple, clear visual methods for calculations.

At Lakenham primary school our Calculations Policy uses as its basis the core understandings from their work, namely (as Alison Borthwick and Micky Harcourt Heath say in their introduction):

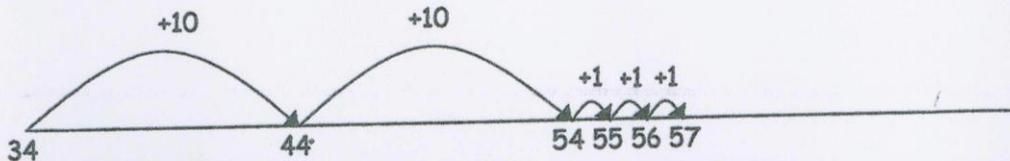
“Calculation strategies in the UK have been well-documented by researchers such as Ginsburg (1977), Hughes (1986), Thompson (1997, 1999) and Anghileri (2000, 2007). Our study focuses on a comparison between different strategies for each of the four calculations, for example, number lines and decomposition for subtraction. The thrust of this research is related to the relative merits of a range of strategies. Some, as will be demonstrated through the outcomes of this research, are more effective for children because they demonstrate transparency, build on mental calculations strategies and are efficient as they result in a correct answer. What seems to be lacking is research relating to the effectiveness of these suggested strategies, built on empirical studies. Our work is a contribution to this field.”

The methods that calculation strategies at Lakenham centre around are the power of the partitioning and number line for addition and subtraction, and using the grid method and factors for multiplication and division. Some illustrations of how this might look which are taken from our calculations policy below:

The use of empty number lines is strongly encouraged in Year 2. When calculating using larger 2 digit numbers, children are encouraged to count on in multiples of 10 then add the ones.

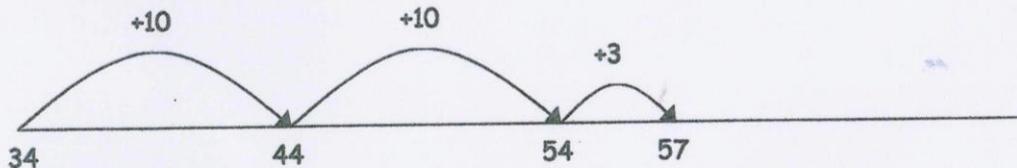
First counting on in tens and ones.

$$34 + 23 = 57$$



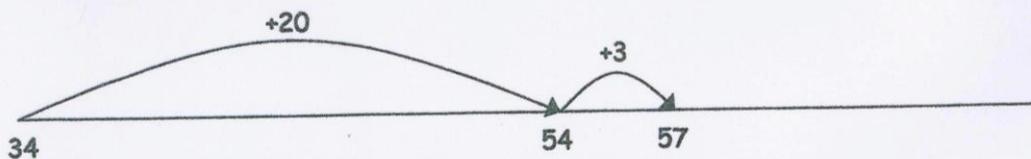
Then helping children to become more efficient by adding the units in one jump (by using the known fact $4 + 3 = 7$).

$$34 + 23 = 57$$



Followed by adding the tens in one jump and the units in one jump.

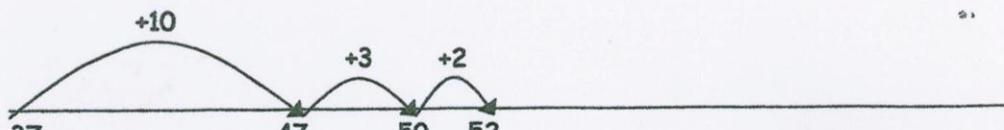
$$34 + 23 = 57$$



Bridging through ten can help children become more efficient.

Bridging through ten can help children become more efficient.

$$37 + 15 = 52$$



As children become more confident with the method and with multiplying higher numbers they will go on to a more efficient way of using the method by partitioning into tens and units.

There are 3 buses each transporting 15 children. How many children are there altogether? 15×3

$$\begin{array}{r|l} \times & 10 \quad 5 \\ \hline 3 & 30 \quad 15 \\ \hline & 45 \end{array}$$

$$10 \times 3 = 30$$

$$5 \times 3 = 15 \quad 30 + 15 = 45. \text{ So the answer is 45 children.}$$

There are 71 trays each containing 69 eggs. How many eggs are there altogether.

$$\begin{array}{r|ll} \times & 70 & 1 \\ \hline 60 & 4200 & 60 \\ 9 & 630 & 9 \\ \hline & 4890 & 9 \end{array}$$

$$70 \times 60 = 4200$$

$$70 \times 9 = 630$$

$$60 \times 1 = 60$$

$$9 \times 1 = 9$$

$$4200 + 630 + 60 + 9 = 4899. \text{ So the answer is 4899 eggs.}$$

In Year 5 and 6 these methods will be extended to use larger numbers and numbers involving decimals.

If there are 24 hours in a day and 365 days in a year, how many hours are in a year?

X	300	60	5	$6000 + 1200 + 1200 = 8400$
20	6000	1200	100	$240 + 100 = 340$
4	1200	240	20	$+ 20 = 360$
				$8400 + 360 = 8760$

I have got 156 sweets; I share them between 17 people. How many sweets will each person get? How many will be left over?

17×2	17×2	17×2	17×2	17×1	$r3$	$1 \times 17 = 17$	
0	34	68	102	136	153	156	$2 \times 17 = 34$
							$3 \times 17 = 51$
							$4 \times 17 = 68$
							$5 \times 17 = 85$
							$85 + 68 = 153$
							$156 \div 17 = 9 r3$

When the children really understand these expanded methods they can be shown how they are developed into a compact method.

Children need to feel confident with numbers and to enjoy playing with them and using them, that's really what it's all about. It then means that using them for everyday purposes becomes straightforward rather than a threat.

Over the last three years part of my role has been to ensure that not only are these methods embedded, but also that they are taught in a clear and concise way which supports children's conceptual understanding and underpins the mental methods children most commonly use. Working in all classes across the school on a weekly basis has enabled me to build up a clear picture, not only of how calculations are taught in this school but also how children are using these methods to actively scaffold, support and articulate their own understanding. The importance of this has become more evident as teachers have moved towards encouraging children to justify and conjecture when talking about their own personal understandings.

The calculations strategies we use have been publicised and shared with parents through regular mathematics mornings across the school and there are also videos which support the parents in understanding the thinking behind the methods which are available to download from the school's website. Before going on to talk about how this research has been useful for us, I need to briefly

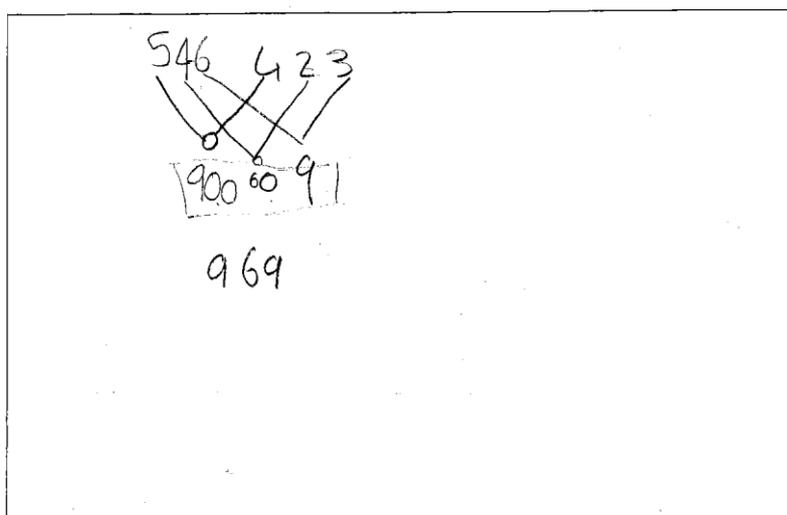
outline what the research actually shows us.

Looking at the research in more detail, it is very interesting to see how children's methods support or confuse their understanding. Looking at the current set of data from 2012 we can see that for addition, 430 children used the standard algorithm with 98% success. This was the most successful strategy used, however expanded addition, use of a number line and partitioning were also used by a significant number of children (379 children) and with 95% achieving a correct answer. To me this demonstrates how children will use a range of methods to visualise and support their understanding.

546 + 423	Number Correct	Number Incorrect	Percentage Correct	Percentage Incorrect
Not attempted				
Standard algorithm	430	10	98%	2%
Number Line	32	7	95%	5%
Partitioning	179	9	95%	5%
Expanded vertical	168	6	97%	3%
Answer only	114	22	84%	16%
Other	14	8	64%	36%
Totals	937	62	94%	6%

A typical response to the addition problem using partitioning is shown below

$$546 + 423 = 969 \quad \checkmark$$



For subtraction the data shows a different picture

317 – 180	Number Correct	Number Incorrect	Percentage Correct	Percentage Incorrect
Not attempted		11		
Standard Algorithm – decomposition	106	71	60%	40%
Standard Algorithm – equal addition	0	2	0%	100%
Number Line	484	70	87%	13%
Negative Number	13	5	72%	28%
Counting Up	20	65	24%	76%
Counting Back	16	1	94%	6%
Answer only	28	9	76%	24%
Other	24	74	24%	76%
Totals	691	308	69%	31%

For subtraction the number line was used much more consistently by children with evident success. The number of children who actually used the standard algorithm was now significantly lower (106) and showed that the strategy was used much less consistently (40% gaining an incorrect answer). The preferred method used by the majority of the children was the number line (484 children). Below are two examples which demonstrate a classic confusion by a child who is using a method which does not support their understanding. Compare this to the child who has successfully been able to use a number line to find the correct answer.

Calculate **317 – 180**

$$300 - 100 = 200$$

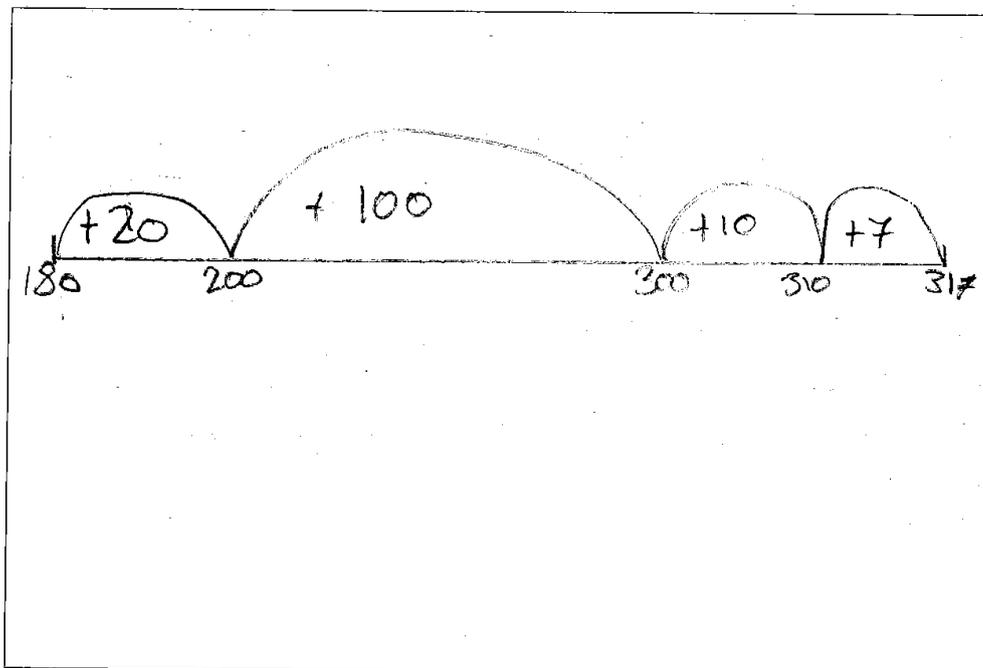
$$80 - 10 = 70$$

$$7 - 0 = 7$$



277

$$317 - 180 = 137$$



The results for multiplication allowed us to pose some interesting questions about which strategies are used most effectively.

56 x 24	Number Correct	Number Incorrect	Percentage Correct	Percentage Incorrect
Not attempted		109		
Standard Algorithm	5	19	21%	79%
Grid Method	397	283	58%	42%
Expanded Vertical	7	7	50%	50%
Two partial products only	0	70		100%
Answer Only	0	14	0%	100%
Other	11	77	13%	87%
Totals	420	579	42%	58%

Approaching 700 children chose the grid method but only 58% gained a correct answer. However, where correct, the strategy selected most often was the grid method. Why is it that children in Year 5 have found it so difficult to gain the correct answer? If we had been using a standard algorithm as our

only taught method in school what would have been the implication for children's success rate on this question?

$222 \div 3$	Number Correct	Number Incorrect	Percentage Correct	Percentage Incorrect
Not attempted		151		
Standard Algorithm	48	38	56%	44%
Chunking Down	58	19	75%	25%
Chunking Up	83	47	64%	36%
Number Line	152	142	52%	48%
Answer Only	19	96	17%	83%
Other	23	123	16%	84%
Totals	383	616	38%	62%

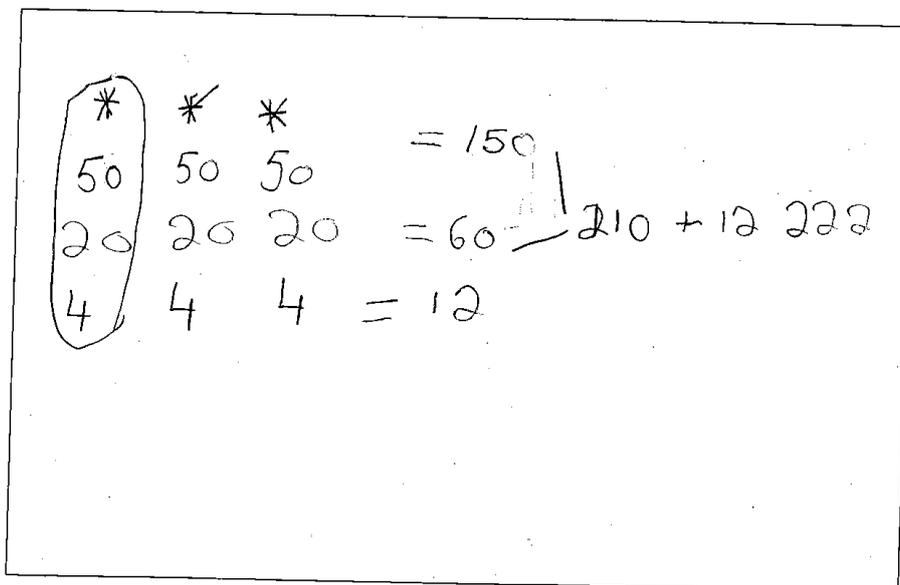
Children who took part in the research struggled with the division problem. Not only were the results inconclusive but there were a variety of methods used, with most of them being used inefficiently to create an incorrect response. The number line was the most successful however this was only used by 152 children (with 52% success), with chunking up and down also with limited success (64% and 75%). Interestingly only 4 out of 10 children managed to answer this problem correctly. The illustrations below demonstrate some of the confusion.

16 Calculate $222 \div 3$

Handwritten student work for the problem $222 \div 3$. The work shows various methods and confusion:

- Some students use boxes for unknowns: $200 - 3 = \square$, $20 - 3 = \square$, $2 - 3 = \square$.
- Others use subtraction: $200 - 4 = 50$, $20 - 4 = 5$, $2 - 4 = 0.5$.
- Some use division: $20 \div 4 = 5$, $2 \div 4 = 0.5$.
- There are also some scribbles and a small diagram of a circle with "1 mark" written below it.

222 divided by 3 = 74 ✓



If we look at the long term trend of the results from the results below, you can see that there has been a gradual but definite improvement, most notably for subtraction, multiplication and division. However there is obviously still a way to go.

Operation	2006 995 children		2008 1068 children		2010 973 children		2012 999 children		Change (06-12)
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect	
Addition	894 (90%)	101 (10%)	955 (89%)	113 (11%)	875 (90%)	98 (10%)	937 (94%)	62 (6%)	+4%
Subtraction	422 (42%)	573 (58%)	575 (54%)	493 (46%)	569 (58%)	404 (42%)	691 (69%)	308 (31%)	+27%
Multiplication	223 (22%)	772 (78%)	313 (29%)	755 (71%)	351 (36%)	622 (64%)	420 (42%)	579 (58%)	+20%
Division	206 (21%)	789 (79%)	298 (28%)	770 (72%)	318 (33%)	655 (67%)	383 (38%)	616 (62%)	+17%

When you look at the results from all of the research since 2006 you can identify a positive trend. During the 6 years all the results have improved suggesting that teaching and learning at the key schools have improved. The biggest gains have been for subtraction, multiplication and division. The main findings of this research suggest that where visual methods are used consistently across a

school to reinforce and scaffold children's understanding then over time results of these methods have a lasting benefit. One interesting feature of the research has been that Alison and Micky's roles in the authority have given them an insight into the schools used for the research (their identities have remained confidential), allowing a knowledge about the circumstances in specific schools to be examined a little more closely. For example, in a school where there was a clear focus upon the introduction of number lines for subtraction and division and grid method for multiplication compared to all schools where a variety of methods, these results were found:

Operation	School	Overall
+	97%	94%
-	91%	69%
x	67%	42%
÷	61%	38%

The results of the research heavily influenced our decision to use visual methods throughout our school. This decision, taken 4 years ago, has had a very positive effect on mathematics teaching and learning across the school and specifically demonstrated in Years 2 and 6 where our results rose by approximately 20% and have stayed at that level over the last 3 years.

The focus for our network primarily centred on strengthening mental methods and children's understanding of place value in years 3 and 4. It inevitably included both email and face-to-face discussions around the issues of how to improve children's visual understanding in a way that is both useful to them and simple enough for them to be able to remember and use independently and fluently. So as part of our on-going discussions the calculations strategies taught at each school played a large part in our shared understanding and professional dialogue.

The time when Jenni Back was able to give us support was an invaluable part of the network's success, both in terms of the support she was able to provide through email discussion contributions, prompts and resources, as well as the visit that she made to deliver exemplar, observed lessons in two schools, and a very informative and thought provoking twilight CPD attended by 4 of the 5 schools (CPD shared later by video). This was invaluable in the way it focused our professional dialogue onto the key areas of importance with the area we were struggling with.

One simple and effective way to begin this discussion is by using a calculations audit. This work came from Vicky Gateshill who ran another network from Harleston Primary School; she took the idea of the 4 different calculations and used some questions adapted by Alison and Micky making them appropriate for children from year R to year 6. She asked all the teachers to do this simple task with their respective classes and the results were collated across the school.

Dec 2010	Addition	Subtraction	Multiplication	Division
Reception	84%	66%	36%	61%
Year 1	88%	68%	27%	19%
Year 2	82%	77%	61%	55%
Year	76%	76%	83%	37%

3				
Year 4	85%	75%	76%	69%
Year 5	100%	86%	59%	82%
Year 6	98%	78%	34%	27%

These results show the great variation in methods the children were using.

In simplistic terms

88% of our school could add.....300/341 children

78% of our school could subtract... 266/341 children

54% of our school could multiply....184/341 children

50% of our school could divide.....170/341 children

Following INSET and lots of work with teachers and TAs on the new Calculations Policy, Vicky and her colleagues then achieved these results (5 months later).

May 2011	Addition	Subtraction	Multiplication	Division
Reception	84% 88%	66% 88%	36% 47%	61% 94%
Year 1	88% 84%	68% 72%	27% 53%	19% 35%
Year 2	82% 95%	77% 63%	61% 68%	55% 61%
Year 3	76% 80%	76% 69%	83% 91%	37% 49%
Year 4	85% 97%	75% 90%	76% 94%	69% 71%
Year 5	100% 89%	86% 82%	59% 82%	82% 82%
Year 6	98% 98%	78% 83%	34% 68%	27% 35%

Now

90% of our school could add.....307/341 children 2% increase

78% of our school could subtract... 266/341 children (exactly the same number but different children!)

71% of our school could multiply....184/341 children 17% increase

61% of our school could divide.....170/341 children 11% increase

She has continued with these tests and the last round was in November 2012.

96% of our school can add 6% increase

80% of our school can subtract 2% increase

78% of our school can multiply 5% increase

70% of our school can divide 9% increase

We now have a far more coherent set of algorithms with most children choosing to use:

Addition:

Number line up to year 3/4 and then column addition

Subtraction:

All children using number line

Multiplication:

Number line and arrays up to year 3/4 and then grid method

Division:

Number lines

The results of this data are very clear and positive about the use of consistent teaching of visual methods across a school. During feedback at the final evaluation meeting in Birmingham discussion centred around the need to monitor calculations strategies in our own schools as a matter of course. During the discussion that followed Mrs Sally Green from Thornhill Primary School in County Durham shared a similar format which she uses with each year group, half termly. This allows her school to keep abreast of the methods and misconceptions evident in her school so that her staff can diagnose and work to counter those misunderstandings early on.

In conclusion it is clear to see that the model we followed was very useful for us. In essence it is not dissimilar to the Lesson Study approach, but focuses more on whole school/many school initiatives for greater impact. The idea of sharing information and research amongst colleagues which then leads to some input to focus thinking and develop dialogue further is also not new. Following this with

some action agreed as a school or a network which will enhance the effectiveness of the teaching and learning has also been done many times. Carrying out rigorous monitoring of impact and using this to think about next steps is part of every school's action planning. However a discussion and conclusion about the relative benefits of the work carried out and any future tweaks or additions which would make it more effective builds on what has gone before and puts power in the hands of professionals to move forward in their context, based on what works. The power of networks is that focused professional dialogue can empower, galvanise and encourage schools to become masters of their own destiny working together to implement initiatives and developments that will have obvious benefits for both teachers and children in these schools and more widely in education.