North Yorkshire County Council

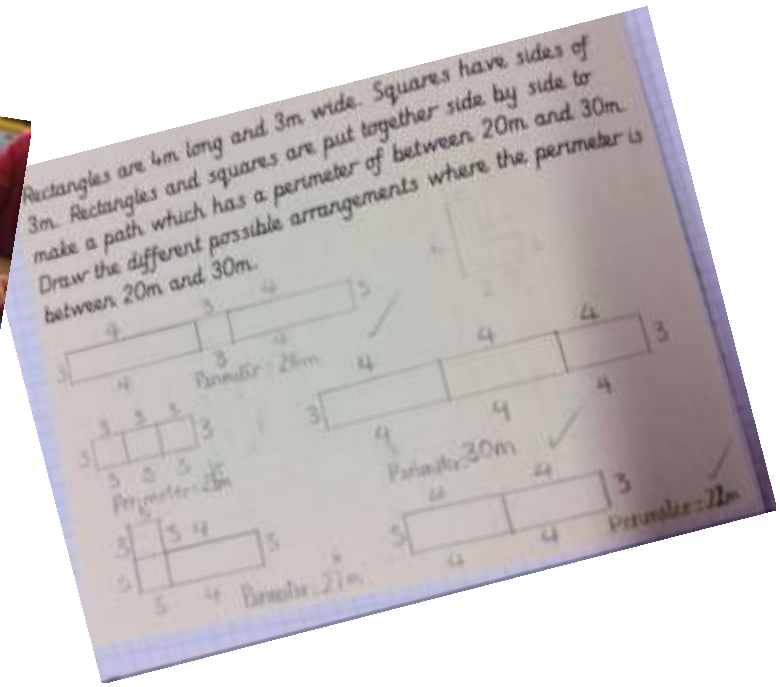
Continuing Professional Development Standard

National Centre for Excellence in the Teaching of Mathematics

Mixed Age Planning Project

Developing Depth and Breadth for Mastery in Key Stage 2

Summary of Findings and Case Studies from the Small School Action Research Project



North Yorkshire County Council

MathsHUBS Archimedes NE

Background

North Yorkshire is England's largest county. The county includes many small rural primaries with mixed age classes, including those with an entire key stage (or more) in one class, many of whom are grappling with how to apply the approaches which are most likely to lead to mastery of mathematics in a mixed age environment. This action research project was undertaken to continue the work completed during phase 1 of this project, which resulted in the production of some mixed age plans to support the teaching of mathematics in mixed age classes. These plans are freely available to download via the Archimedes Maths Hub website (click here to be taken to these).

This action research project focussed on teaching for mastery approaches within key stage 2 (KS2). This project was jointly funded by North Yorkshire's Primary School Improvement Partnership and Archimedes Maths Hub (Carmel School, Darlington).

The purpose of this report is to provide an overview of the processes we went through and a summary of our findings from the project for the benefit of other schools trying to develop depth and breadth for mastery in mixed age classrooms, predominately through exploring individual case studies.

Aim of the Project

The aim of the project was to explore how to develop depth and breadth of learning to support children in achieving mastery of mathematics in a mixed age KS2 classroom.

Overview of the Project

Six small North Yorkshire primary schools completed the project, predominately spread across the Howardian Hills/Ryedale area of North Yorkshire. All but one of the schools involved taught across the entire KS2 age range. The group met on three occasions and some pairs within the project met for an additional 2 days to observe each other teach and to continue their joint planning. The project took place during the spring and summer terms of 2017. The outlines for these meetings are outlined below;

Day 1 – Introduction, action research into mastery in mixed age classrooms, decisions about focus for individuals, joint planning time.

Day 2 – Mid-project review, evaluation of impact of actions since day 1, mastery input session from Laura Wild (Archimedes Maths Hub Mastery Specialist Project Lead), joint planning time.

Days 3 and 4 – some individual pairs met to watch each other teach and then spend the remainder of the day joint planning for the teacher in the 'host' school.

Day 5 (½ day) Final evaluation of the project.

Project Participants

K Dixon	Year 5/6 teacher	Fylingdales Primary School, YO22 4TH	Case study 1
P Jachs	KS2 teacher	Terrington Primary School, YO60 6NS	Case study 2
D Jeffries	KS2 teacher	Carlton and Faceby Primary School, TS9 7BB	Case study 3
Miss Martindale	KS2 teacher	Hovingham Primary School, YO62 4LF	Case study 4
C Pipes	KS2 teacher	Stillington Primary School, YO61 1LA	Case study 5
M Popplewell	KS2 teacher	Foston Primary School, YO60 7QB	Case study 2
Julie Pattison	Project Lead	0-19 Mathematics Adviser, North Yorkshire County Council	
Laura Wild	Mastery Lead	Archimedes Maths Hub, Carmel School, Darlington	

Summary of Findings

Very early in the project it was acknowledged that in order to achieve mastery of mathematics in mixed age classrooms, it would likely have to look different to how it might look in a single age classroom. The group discussed and agreed that since mastery of mathematics is an outcome and *not* a process it can be achieved in more than one way i.e. there is more than one way to peel the proverbial orange!

This means that certain aspects of the mastery movement that are gaining popularity in single age classes will need to be adapted in order to work in mixed age classes and some of the classroom structures and strategies used may not always be sustainable in a mixed age classroom or with limited numbers of staff within the school. Whilst it was agreed by the group that this is the realistic way to achieve mastery of mathematics in mixed age classes this will not sit comfortably with those who have a 'purest' approach to the mastery movement.

The group believes it is important for teachers and Headteachers to recognise this rather than the frustration that can come from trying to conform to a structure that can be difficult to implement in a mixed age class.

That said there are many approaches that develop depth and breadth of understanding that can be used effectively in mixed age classes which will help children achieve mastery of mathematics.

Participants in the project in general focussed on one or two of these approaches and worked in pairs to analyse and refine their practice throughout the project. Specific approaches are outlined below, but common themes were the development of reasoning, the use of manipulatives, using low ceiling, high threshold tasks to differentiate for different year groups and the re-timetabling of mathematics lessons in order to maximise teacher-child interaction time.

At the end of the project participants were asked to evaluate the impact of their approach and this is captured in five separate case studies. Participants were encouraged to tell their story 'warts and all' in order to allow others to see the full learning process that they had engaged with. At the end of the project a*ll* participants felt the development of their approach had had a positive impact in their classroom, had helped children to achieve mastery of mathematics and all would recommend the approach to another teacher. In essence, this reinforced that there are many ways to achieve mastery of mathematics as participants focussed on a variety of approaches.

Whilst individual teachers may find trying some of the approaches within the case studies helpful, the value of the opportunity to collaborate, observe lessons and discuss mathematics with other teachers of mixed age classes should not be underestimated, particularly in small schools where planning is often done in isolation and (as one participant described it) without the 'staffroom chatter' that colleagues in larger schools might find beneficial.

Teaching for Mastery Approaches Explored Through the Project

Foci for participants were;

- *Developing mathematical reasoning effectively (from verbalising to recording)*
- *Refining the use of low ceiling, high threshold tasks*
- *Restructuring and re-timetabling of the class into manageable cohorts*
- *Redesigning medium-term planning approach in order to plan more efficiently and effectively*
- *Developing children's reasoning skills and identifying when mastery had been achieved*
- *Restructuring and re-timetabling of the class so that direct response time (DIRT), pre-teaching time and over-teaching time can be included*
- *Using elicitation tasks to identify accurate starting points and underlying misconceptions*
- *Developing the use of manipulatives to support reasoning and problem solving skills.*

External References Explored During the Group Sessions

The group began by sharing their context, current practice and classroom logistics with the rest of the group so participants could look for commonalities across schools. The groups then discussed and reviewed case studies and reports from a variety of freely available sources. The sources used for discussion on day 1 were;

1. NCETM case study Teaching for Mastery: "Isn't it just good teaching?"
2. NCETM case study Mindset: why is it so important in teaching for mastery?
3. NCETM case study Meeting the needs of all without ability setting
4. NCETM case study England-China Teacher Exchange
5. NCETM case study How can teaching for mastery work in a mixed age class?
6. Devon County council and Babcock LPD report Teaching for Mastery in Mixed-age Classes
7. NCETM community discussion forum Mixed Aged Classes & Mastery

Following this process, participants chose an approach from the case studies that they wanted to explore further and the remainder of day 1 was spent with participants engaged in joint planning with their project partners.

On day 2 participants reviewed their progress so far and following an input on the '5 Big Ideas of Mastery' from Laura Wild at Archimedes Maths hub (please contact Archimedes Maths Hub for more information about the 5 big ideas of mastery), either continued with their initial focus or redirected their work given their experiences since day 1 and the input from Laura.

Case Study 1, Katrina Dixon, Fylingdales C of E VC School

Fylingdales Primary School is a small rural primary school on the east coast between Whitby and Scarborough situated in the village of Fylingthorpe. There are around eighty children on roll and the school has four classes. Katrina is the Year 5/6 teacher. There are 19 children in her class and she has a full-time higher level teaching assistant (HLTA) to support learning.

Teaching Timetable:

Monday-Friday 11:00-12:00	Year 5 and 6 children all learn mathematics together

What was new?

Katrina wanted to develop mathematical reasoning so that children could make the transition from verbalising their reasoning to recording it with increasing sophistication.

Why did she want to do this?

Katrina knew that the children in her class needed more practice rehearsing their verbal and written reasoning. In part, this was because she has noticed that children were struggling to respond appropriately to the reasoning questions on practice SATs papers (which was limiting their overall attainment in the SATs) but also because she could see the link that strengthening reasoning would have on developing a deeper understanding for children that would lead to mastery.

What was the process she went through?

Katrina used the NCETM reasoning questions as a key source (these are incorporated into the mixed age plans produced as phase 1 of the project) and used them throughout lessons.

What were the positive changes for children?

By introducing these, children's opportunities to verbalise and then record their reasoning increased. This in turn exposed children to a wider range of mathematical vocabulary than they had previously used and experienced.

The quality of mathematical dialogue improved, and children became more confident at explaining verbally (and then recording) their understanding.

Children discussing equivalent fractions to improve their use of vocabulary and using multi-link to support their verbal reasoning

What were the stumbling points and how were they overcome?

Katrina found that it took a lot of teaching input to help children develop these skills. Initially it felt like the lesson pace was slowed down in order to give children the time to clarify their thinking to enable them to articulate their reasoning effectively. This was time well invested because as children became more confident the pace returned to the same pace as it had been prior to starting the project, but now there was more evidence of children having a deeper understanding of the work they had completed.

If someone wanted to develop mastery of mathematics in their classroom, would she recommend this approach and why/why not?

Yes, explicitly focussing on improving children's reasoning and allowing time for that thought process to happen deepened the children's understanding and ultimately improved the quality of their written reasoning. Children have also become better at using mathematical vocabulary.

How do you know if this approach is effective?

Outcomes have improved significantly at KS2. In 2017 88% of children achieved the expected standard. Children have become more confident and can apply their knowledge to different problems.

'This approach has impacted hugely on our outcomes at KS2! We had an average scaled score of 106 in 2017'

What are the next steps?

As the school's subject leader for mathematics and with the data now to back up the approach, Katrina wants to use this approach with other classes across school. She plans to use the ideas she has explored through the project to develop continuing professional development (CPD) for other teachers in the school.

Case Study 2, Philip Jachs and Martin Popplewell, Foston and Terrington Primary Schools

Foston and Terrington Primary Schools are two federated rural primary schools near the town of Malton. Martin and Philip are the KS 2 teachers in the two schools and meet regularly to collaboratively plan the broad outline of their mathematics lessons. Both teachers have a teaching assistant to support their mathematics lessons.

Teaching Timetable:

Terrington	Monday, Tuesday, Thursday	Wednesday	Friday
09:15-10:15	All KS2 children study mathematics together		The whole school study mathematics together (with a problem solving focus)
13:00-14:00		All KS2 children study mathematics together	

Foston	All days except Friday	Friday
09:30-10:30	All KS2 children study mathematics together	The whole school study mathematics together (with a problem solving focus)

What was new?

Martin and Philip wanted to develop their use of low threshold, high ceiling tasks.

Why did they want to do this?

Martin and Philip had been exploring low ceiling, high threshold tasks as a way to provide a common task that would meet the learning needs of all age groups within their class, during their lessons on Fridays when the whole school learns together. During the project they wanted to evaluate the impact of these tasks on teaching and learning across the federation to ensure it was meeting the needs of the children and wanted to use a lesson study approach to help them do this.

What was the process they went through?

Martin and Philip met to explore suitable low threshold, high ceiling activities that would be suitable for all children in school during their Friday morning maths lesson. They predominately used NRICH resources (these are incorporated into the mixed age plans produced as phase 1 of the project), but also generated their own questions. They evaluated the effectiveness by observing each other teach using a lesson study format during these Friday morning lessons.

What were the positive changes for the children?

There were many positive changes for the children, some of which had been observed prior to the start of the project, but during the project Martin and Philip noticed an improvement in the use of mathematical vocabulary and the quality of children's reasoning skills, specifically with younger children picking up new mathematical vocabulary from older children. Children also began to recognise that there are often many answers and approaches to a mathematical problem. The low threshold, high ceiling tasks ensured that all children could attempt the same (or similar) tasks which allowed for greater collaboration across year groups. In addition, the children really enjoyed the activities and this led to better group co-operation, more resilience and sustained concentration.

The impact on teaching has been an increase in rich and creative maths teaching which both teachers have enjoyed delivering and more collaborative teaching. This has led to an increase in children's exposure to problem solving activities overall.

The Alice in Wonderland problem devised by the schools – 'How much will Alice need to shrink by to go down the rabbit hole?'

What were the stumbling points and how were they overcome?

Some of the problems took children more than one session to complete, which meant these lessons looked different in structure to a 'normal' lesson. Researching and adapting the right activities to meet the learning needs of all the children in the school and planning these sessions collaboratively took a great deal of planning time.

If someone wanted to develop mastery of mathematics in their classroom, would they recommend this approach and why/why not?

Yes. In addition to the problem solving opportunities planned into daily mathematics lessons; this approach ensures that children are given opportunities to explore 'bigger' problems that use all of their mathematics skills (rather than problems linked to the current unit of learning).

How do you know if this approach is effective?

Both schools know that this approach is effective as it has been evaluated through lesson study, pupil voice, lesson observations and work scrutiny.

What are the next steps?

This is an ongoing project which will continue to be evaluated and refined in both schools over the next academic year.

Case Study 3, Diane Jeffries, Carlton and Faceby Primary School

Carlton and Faceby Primary school is a small school in the village of Carlton-in-Cleveland, about 10 miles south-west of the town of Stokesley. There are two classes within the school. The school is federated with Bilsdale Midcable Chop Gate and the two schools regularly meet to evaluate their mathematics lessons. Diane is the KS2 teacher and mathematics subject leader across the two schools. She has the support of a full-time teaching assistant within her class who predominately provides 1:1 support for one child.

Teaching Timetable:

Monday – Thursday	Year 3 and 4	Year 5 and 6
09:30-10:00	Y3/4 teaching time with **teacher** or vice versa	Y5/6 independent mathematics time - continuation of teacher led learning (from previous day) with support from **teaching assistant (TA)** or vice versa
10:00-10:30	Y3/4 independent mathematics time - continuation of teacher led learning with support from **TA** or vice versa	Y5/6 teaching time with **teacher** or vice versa

Friday 09:30-10:30	All pupils from Bilsdale Midcable Chop Gate School travel to Carlton and Faceby School to solve mathematical problems. During this time KS2 is split into two teaching groups and Diane teaches Years 5 and 6.

What was new?

Focus 1: Restructuring and re-timetabling of the class into two cohorts (see above) and redesigning planning format in order to plan more efficiently and effectively
Focus 2: Developing children's reasoning skills and identifying when mastery had been achieved

Why did she want to do this?

Diane was new to the school and new to teaching four year groups as one class. She had been exploring different ways to manage the class so that she could provide teacher input to all children at an appropriate pitch and how to plan for all four year groups in an efficient time-frame. She had been struggling to find a sustainable model.

In addition, she recognised that the children in her class needed to develop their reasoning skills as she had noticed that many children in the class could 'do the maths' but not explain their thinking.

What was the process she went through?

Diane began by re-designing her planning approach for her Monday-Thursday lessons. She started by splitting the class into upper and lower KS2 and devised a staggered teaching model so that each half of the class could have input from her for half the lesson and independent learning time during the other half of the lesson (supported by the TA when possible).

She used the mixed age plans (created during phase 1 of this project) to help her develop a 'layering' approach to planning that allowed her to create an medium-term plan for the upcoming unit of work (typically a three week plan). This process also helped her to clarify the smalls steps in learning needed for progression and identify the aspects of teaching and learning that would be most helpful for children to achieve mastery.

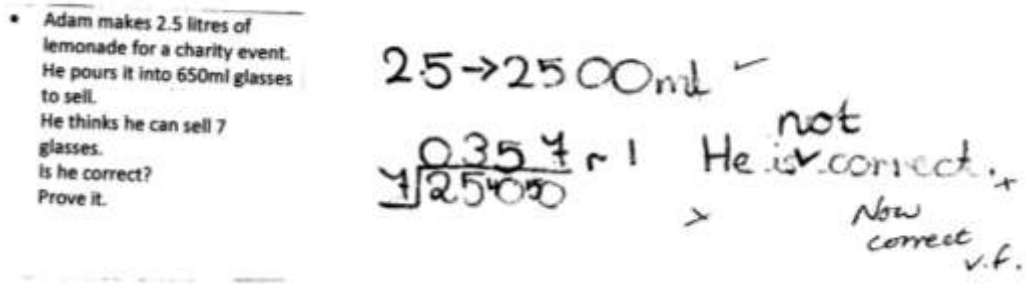
During the first 'layer' of planning Diane assigned learning objectives to each cohort of learners. This enabled her to see when teacher input for each cohort would be needed and plan how to cater for the rest of the class whilst doing this. When planning the second 'layer' Diane then considered suitable differentiation to cater for the two different year groups in each cohort. She then planned her third 'layer' by adding the resources, activities and manipulatives that she would use during these phases. It was during the third phase of 'layering' that Diane would identify how to develop reasoning during lessons.

Diane would then return to this medium term plan at the end of each day, evaluate where the children had got to and consider the key questions and vocabulary that she wanted to use to support children's learning in the next day's learning.

What were the positive changes for the children?

Reorganising the structure of the day has ensured Diane maximises the children's learning time. It has given her more time to listen to individual children's responses and identify and address any misconceptions more easily.

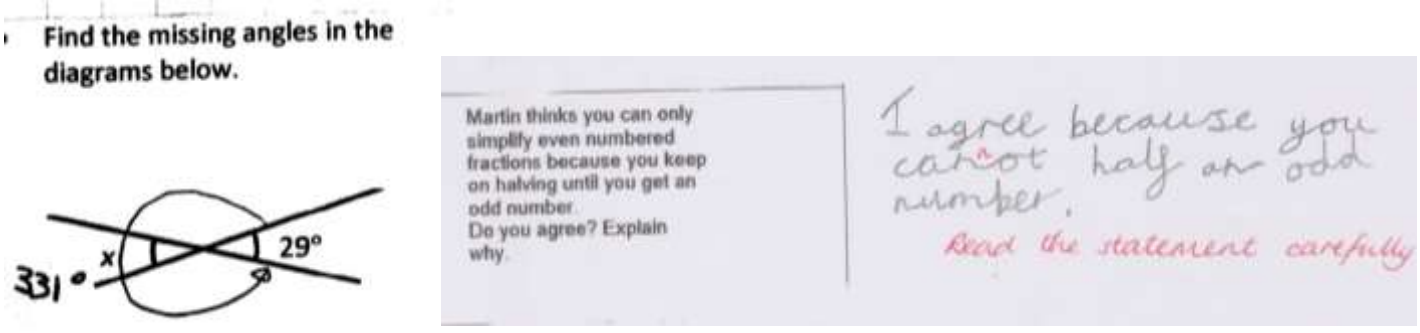
Introducing 'layers' to her planning has ensured children are given more opportunities to develop their reasoning. Some of the children's responses have revealed misconceptions that may not have been revealed unless Diane had focussed in on their reasoning.



Misconceptions revealed

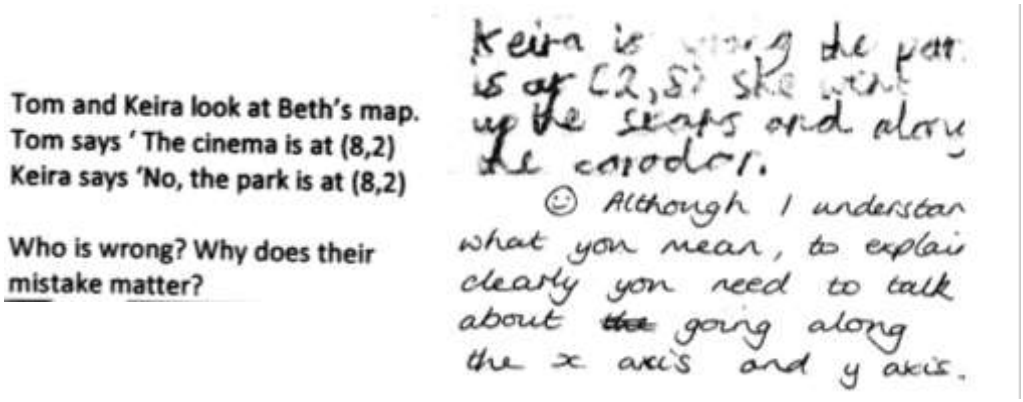
What were the stumbling points and how were they overcome?

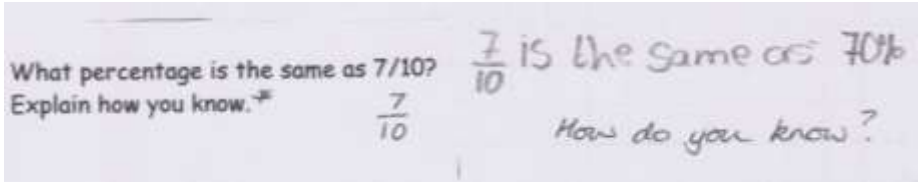
Developing the quality of children's reasoning took children some time. In particular some needed on-going prompting to ensure they read the question or statement correctly and answered what had been specifically asked for.



Misreading the question

At first, their responses were limited. Once Diane noticed this she modelled her own reasoning out loud so that children could hear what a full response sounded like. This has helped children to develop the quality of their responses.





Limited or no reasoning

Occasionally the timetabling didn't quite work out as she'd hoped as children took a longer or a shorter amount of time than she had anticipated. When this happened she returned to her medium-term plan and moved things around so she could accommodate this.

If someone wanted to develop mastery of mathematics in their classroom, would she recommend these approaches and why/why not?

Yes. The new planning approach has reduced the amount of time Diane spent planning significantly and gives her more high quality time with the children during the lesson to assess their depth of understanding. The focus on reasoning has identified misconceptions and improved the overall quality of the children's responses.

How do you know if these approaches were effective?

The new planning format has helped with a smoother running classroom. This in turn has highlighted some further areas to address (such as a slower pace of working by some of the children than Diane had previously noticed) which she was then able to address to improve learning further.

Adopting a focus on reasoning questions has challenged the children and deepened their thinking. Year 5 have been a particular focus group for this as they are all confident mathematicians but are reluctant to explain their thinking.

What are her next steps?

Next year Diane's cohort will change significantly again, bring the added dimension of a larger group of Year 3 children with a wide range of starting points as well as some very high prior attaining Year 6's. Diane will continue to focus on developing their reasoning, but will have to tweak her planning approach to work for this new cohort of children.

Case Study 4, Miss Martindale, Hovingham CE Primary School

Hovingham CE Primary School is a small school in the village of Hovingham. There are 2 classes within the school. The school is federated with St Hilda's Primary, Ampleforth approximately 8 miles away. Miss Martindale is the KS2 teacher and sometimes has the support of a teaching assistant during mathematics.

Teaching Timetable: (variant depending on when the teaching assistant is available)

09:00-09:30	Y3/4 direct response time (DIRT) or pre-teaching activity with **TA**	Y5/6 teaching time with **teacher**
09:30-10:00	Y3/4 teaching time with **teacher**	Y5/6 independent mathematics time - continuation of teacher led learning with support from **TA**
10:00-10:30	Y3/4 independent mathematics time - continuation of teacher led learning with support from **teacher or TA**	Y5/6 DIRT or over-teaching activity with **teacher or TA**

What was new?

Focus 1: Restructuring and re-timetabling of the class so that DIRT, pre-teaching time and over-teaching time can be included
Focus 2: Developing the use of manipulatives to support reasoning and problem solving skills.
Focus 3: Using elicitation tasks to identify starting points and identify misconceptions

Why did she want to do this?

Miss Martindale was both new to the school and new to teaching four year groups at the same time and had been trying to find suitable open-ended whole class activities that would enable her to teach the whole class at the same time. With such a variety of prior knowledge, misconceptions and ages, she had found that whole class teaching was either too fast or too slow for children, or that learning was not going deep enough. Children's reasoning and problem solving strategies across all year groups were weak, so she wanted to find another way to teach effectively and instil a love of maths and problem-solving.

What was the process she went through?

Miss Martindale began by simply getting the equipment out of the cupboard, encouraging children to use it to explain their thinking. She had to train the children to move away from simply finding 'the answer' as quickly as possible. If children found an answer, they were immediately challenged to 'prove it' and then 'find other ways'. Secondly, she split the class and re-designed the timetable to enable DIRT, pre-teaching and over-teaching time.

Y3 pre-teaching work on multiplication before completing Y3 multiplication tasks from White Rose. The child was able to prove her thinking for the fluency tasks using diagrams as a result of firstly answering 'how many different ways can you make 12' 'is 3 x 4 the same as 4 x 3?' and 'if you know 3 x 4 = 12, what else do you know?' with numicon©

Since then, she has also introduced elicitation tasks and progression grids at the start of a teaching unit. She prints out a progression grid to show the objectives for the year below, at and above the child's year group and sticks in the child's book. There is time to read and discuss the objectives and then children complete an elicitation task. Children use this time to show the skills from the list that they can already do. Following the elicitation task, Miss Martindale then marks their work and highlights the grid to show the child's starting point giving her a secure understanding of what she needs to teach and, crucially, any misconceptions that need to be addressed during teaching. This has meant that she can better focus her teaching and also means that children are more aware of what they need to achieve and can see what they are working towards. At the end of the teaching sequence, her and the child review the progression grids again and highlight what has been learnt.

Elicitation task on statistics - Y3 child was confident to collect her data and then chose to use multilink blocks to build her block diagram. When happy, she transferred this into her book by drawing around the blocks. Very quickly, she was able to see the link between her first block diagram and bar charts. Later on, she was also able to use cubes to represent more than 1.

What were the positive changes for the children?

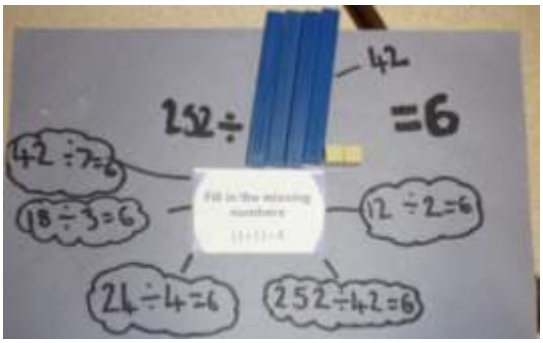
Having split the class into two separate cohorts, Miss Martindale could tailor activities and create smaller group-like sessions. This made it possible for her to see every child for longer without the feeling of 'juggling plates'.

In addition, there were some older children who, although mathematically very confident could only explain verbally and numerically, without exposing their reasoning and in such a way that other children (particularly those who found mathematics challenging) could not understand them. Through encouraging all children to 'prove' their thinking using manipulatives or find other ways to solve problems, it unlocked the reasoning for many others in the class and created 'lightbulb' moments. As a result all children could engage with how others had arrived at their solutions. Younger children who may have previously felt less mathematically able because they 'needed the equipment', became more confident using the maths manipulatives as they could see older children using it too.

'We broke the stigma associated with using equipment and turned it into something more positive'.

What were the stumbling points and how were they overcome?

It quickly became apparent that children needed to be taught how to use the manipulatives and that the school needed to buy more equipment now that everyone in the class was using it at the same time!



'When we first started using manipulatives in class, not all children were sure how to use them to reason or problem solve'.

Some children were resistant to 'proving it' or 'finding other ways', believing that they had found 'the answer' and that was all that mattered. In time they discovered that the challenge deepened their thinking and this helped them when it comes to explaining their reasoning.

Splitting the class into the two groups could only work effectively if there was another adult in the room and this was not always the case. Having a TA available during these sessions was the key to making the structure work.

The re-designing of the timetable was an idea Miss Martindale had picked up from reading one of the case studies on day 1 of the project. In the case study, the teacher had designed her morning timetable in order to allow time for same day intervention, marking after the lesson but before the afternoon session began. As she trialled this, Miss Martindale soon found that there wasn't enough time to build the same day marking process into her day, so she tweaked the timetable to incorporate DIRT and some pre-teaching or over-teaching instead.

If someone wanted to develop mastery of mathematics in their classroom, would she recommend these approaches and why/why not?

Yes to all! By finding a manageable way to timetable mathematics lessons Miss Martindale feels she can concentrate on the quality of teaching and learning more effectively.

Since the class are new to her, starting each unit with an elicitation task and sharing the progression grids with children, de-mystifies the curriculum for them and means teaching can be better tailored to children's needs.

Encouraging all children to use manipulatives to prove their thinking has had an extremely positive effect across the class, those who find maths a struggle are no longer the only children in the class using equipment, and children who need help visualising a problem can then access problem-solving tasks more readily.

How do you know if these approaches were effective?

Children no longer ask if they can get out equipment, they simply go and get it to show their understanding. Children are now annotating and drawing diagrams to help them complete the "tricky questions" rather than leaving them because they believe they can't.

'Children say they enjoy maths and like being challenged. They have developed a "can-do" attitude'.

What are her next steps?

Miss Martindale would like to embed the White Rose hub's assessments. She would also like to develop her teaching approach so she starts teaching with a problem to solve more often rather than skill acquisition.

Case Study 5, Charlotte Pipes, Stillington Primary School

Stillington Primary School is a small school in the village of Stillington about 10 miles north of York. There are two classes within school and approximately 40 children on role. Charlotte is the KS2 teacher. She has the support of a teaching assistant during four of her mathematics lessons per week (Monday to Thursday).

Teaching Timetable

Monday-Friday 09:30-10:30	Year KS2 children all learn mathematics together

What was new?

Charlotte wanted to develop the use of the manipulatives to develop reasoning, in particular encouraging more use in upper key stage two, where children had been resistant to using them. Charlotte taught children ways they could explain their reasoning to others both orally and using manipulatives.

Why did she want to do this?

Charlotte wanted to develop children's reasoning skills and believed that an increased use of manipulatives would support them to do this more effectively. She wanted them to be able to explain why they did something and justify their solution rather than simply being able to find the answer.

What was the process she went through?

Charlotte added a 'reasoning' column to her weekly maths planning sheet and ensured that every week; every child in class had at least one reasoning activity. Charlotte focussed on the reasoning rather than the manipulative as she realised that this was the driver rather than the manipulative.

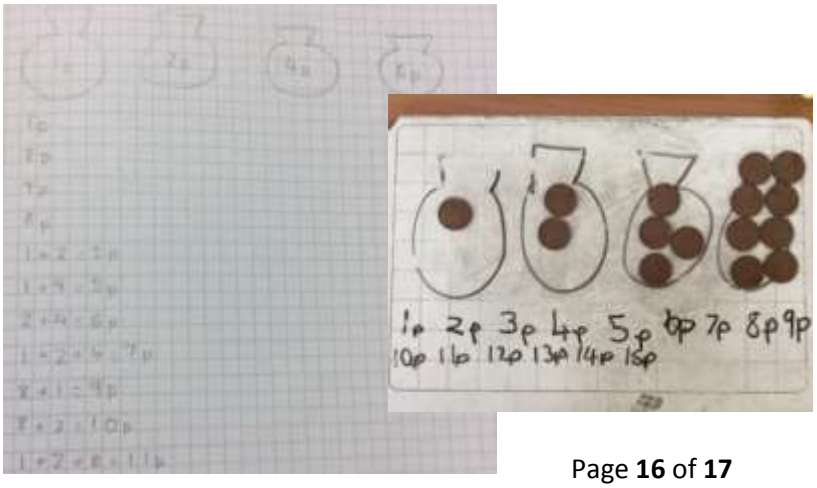
Charlotte also added key reasoning questions to her planning each day for all parts of the lesson to ensure that every opportunity to develop reasoning was taken.

What were the positive changes for children?

Children enjoyed using the manipulatives to 'convince me'. Using resources such as multilink and plastic coins was particularly beneficial for some children. In addition it was noticed that using manipulatives when introducing a topic proved useful in helping to identify misconceptions and to demonstrate patterns and relationships.

Children liked working in pairs and groups with children who were not necessarily at the same point of mathematical understanding as they were. Older children not only passed on their knowledge to younger children but the process also clarified their own thinking and allowed them to model key vocabulary and demonstrate chains of reasoning.

Children also used drawings well to record, beginning to develop the concrete to pictorial to abstract (CPA) process.



Children working on the NRich problem 'Money Bags' using a variety of recording strategies to show their reasoning.

What were the stumbling points and how were they overcome?

In her classroom Charlotte has a selection of resources available for children to use at any time (in a zone called 'The Maths Helpdesk'). Charlotte quickly realised that older, more confident children didn't want to access resources even when encouraged as they didn't want to be seen to 'need help'. During the project Charlotte changed the name to the 'Help Yourself Resource Station'. As the project has progressed more of these children have gradually begun to access resources.

The newly branded 'Help Yourself Resource Station'

During some lessons Charlotte noticed that a number of the upper key stage two children did not always need the manipulatives and occasionally (for more complex mathematical concepts) the manipulatives chosen would sometimes confuse matters or be a distraction. This clarified for Charlotte that it needed to be the right resource, for the right concept at the right time.

If someone wanted to develop mastery of mathematics in their classroom, would she recommend this approach and why/why not?

Yes, each of the approaches trialled was easy to implement, encourage children to become more independent and better at explaining the reasoning behind their mathematics.

How does she know if this approach was effective?

Charlotte noticed an improvement in children's understanding of both basic and more abstract concepts, an improvement in the quality of talk between children and an increased use of accurate mathematical vocabulary. In addition she noticed a shift in attitude of some of the older children who had been reluctant to use manipulatives

'It's ok for us to use cubes! They're not just for the people who can't do it.'

What are her next steps?

Charlotte would like to develop this next by now moving children on to *writing* clear explanations of reasoning, developing a chain of reasoning. She is considering introducing the sentence stem 'First, Next and Then' to help children structure this.