



Department
for Education

Longitudinal evaluation of the Mathematics Teacher Exchange: China-England Third interim report

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Glossary

Cohort 1, Cohort 2 - unless specified refers to Cohorts of the Mathematics Teacher Exchange programme.

CPD - Continuing Professional Development.

Inspire Maths - primary maths programme using translations of Singapore textbooks as core texts.

Lead primary school - A school designated by the hub that hosted a Shanghai teacher and in nearly all cases had one or more members of staff visit Shanghai.

Lead primary teacher - A term used by the NCETM to denote school staff who had been directly involved in the exchange programme and/or leading wider dissemination within their school and, in some cases, their local and wider hub network.

Mathematics Mastery - primary mathematics programme, developed initially by the Ark Multi Academy Trust informed by Singapore mathematics curriculum and pedagogy

Mathematics Teacher Exchange - Exchange programme involving in 2014/15 48 English primary schools and schools and teachers in Shanghai and in 2016/17 70 English primary schools.

Maths Hubs - A network of hubs across England each led or jointly led by a school or college. Maths Hubs work in partnership with neighbouring schools, colleges, universities, CPD providers, maths experts and employers. There were 32 Maths Hubs in England at the start of the exchange and there are, as of November 2015, 35.

Maths No Problem primary maths programme using translations of Singapore textbooks as core texts.

NCETM - The National Centre for Excellence in the Teaching of Mathematics.

NCTL - National College for Teaching and Leadership.

NLE - National Leader of Education.

Ofsted - Office for Standards in Education.

Primary Mathematics Teaching for Mastery Specialists Programme - Intensive professional development programme for primary mathematics teachers led by the NCETM with 140 (with 133 completing) teachers participating in 2015/16, and 140 per year for 4 years from 2016/17.

SEND - Special Educational Need or Disability

SLE - Specialist Leaders of Education.

Teaching School Alliance - Alliances led by a Teaching School, including schools benefitting from support and strategic partners. A Teaching School is an outstanding school that plays a leading role in the training and professional development of teachers, support staff and headteachers, as well as contributing to the raising of standards through school-to-school support.

Executive Summary

The Mathematics Teacher Exchange

The Mathematics Teacher Exchange (MTE) aims to foster a radical shift in primary mathematics teaching in England by learning from Shanghai mathematics education. The first year of the exchange took place in 2014/15 with 48 English primary schools involved, with teachers and leaders visiting Shanghai or hosting mathematics teachers from China. Subsequently, English schools made changes in practices, they were designated as lead primary schools, and in most cases they shared learning with other schools¹.

Since the initial exchange, partly in response to the reported potential of the exchange and of mastery to foster change in schools' practices, the Department for Education made a further investment in July 2016 of £41 million in supporting what is now referred to as 'teaching for mastery of mathematics'. In October 2017, the Department announced additional investment of £6 million to put Maths Hubs into areas where they will make the biggest difference. And in the 2017 Autumn Budget, the government announced a further £27 million to expand the Teaching for Mastery programme to reach 11,000 primary and secondary schools in total by 2023, including establishing a pre-mastery programme and accelerating rollout of the Mastery for Secondary programme.

The MTE is being evaluated through a longitudinal mixed methods evaluation, to determine the potential of learning from Shanghai mathematics education to impact on teaching in England, and on pupils' mathematics attainment in both the short and long term. The scope of the evaluation is on the impact of the exchange and supporting activities rather than the mastery initiative as whole. This third interim report presents findings from inductive and deductive analysis of follow-up interviews with 43 lead primary teachers from the original Cohort 1 schools, which were undertaken during the second year of implementation. The report addresses evaluation objectives related to implementation and fidelity, change in teaching methods and practices, perceptions of pupil outcomes, professional development outcomes, enablers and barriers to implementation, the relative success of different types of activities and, where applicable, work of lead primary schools with other schools and lessons learned.

¹ Differences between Shanghai and English practices were discussed in the first interim report (<https://www.gov.uk/government/publications/evaluation-of-the-maths-teacher-exchange-china-and-england>), and a summary is provided in Annexe A.

Conceptual understanding and procedural fluency

Interviewees reported a variety of strategies intended to promote conceptual understanding. The three most frequent named were: using representations and models, teacher questioning, and classroom dialogue.

The three most frequently discussed strategies to promote procedural fluency were: careful choice of practice questions, memorising, and recalling and testing of factual knowledge.

Mathematically meaningful and coherent activities

In seeking to develop understanding and fluency, schools sought to engage pupils with mathematically meaningful and coherent activities. Meaning has been enhanced by adopting a slower curriculum pace, a much increased and more sophisticated use of mathematical models, and the use of resources that are designed to communicate mathematics coherently to pupils, and by implication to teachers. Three different types of use of both visual representations and of concrete representations were identified and described: limited, embedding, and embedded. Those schools with embedded use would typically plan for use of multiple forms of representation in every lesson to enable understanding of mathematical structure and processes. Overall some 30 schools are embedding or have embedded either the use of visual or concrete representations, or both, in their mastery orientated lessons.

Mathematically coherent resources

Prior to the exchange, most schools used a variety of eclectic resources to either inform planning, or to be used by children. The majority of schools now use mastery aligned textbooks or programmes as the basis for either planning or use with children, or both. However, only a minority of those using textbooks do so consistently with children within classes in which Shanghai informed approaches are being implemented.

Varied interactive teaching

The development of mathematical understanding was supported in schools by varied interactive teaching. 'Varied' here refers to a range of different types of learning activity and frequent changes between these. The amount of time spent on whole class interaction in a typical mathematics lesson for classes following a mastery approach was on average reported as just over half the lesson (54%). Nearly all schools (38) reported that lessons follow a pattern of multiple short periods of questioning and dialogue between teacher and pupils interspersed with short periods of pupils working on one or two problems or tasks. Schools reported an increased emphasis on classroom talk focused on process and understanding. More frequent interaction meant that an

increased tempo of interaction was reported in all 41 schools responding to questions about this issue.

Engaging and challenging the whole class

Schools have adopted different strategies in order to address the goal of the whole-class moving through the curriculum together, a feature of Shanghai teaching and recommended in the current English mathematics National curriculum. Strategies reported were:

- slowing the pace through the curriculum to support accessibility
- adopting differentiation strategies focused on deepening and support, rather than through tasks pre-allocated to particular groups of pupils
- increases from approximately one-third (2015) to two-thirds of schools (2016) teaching pupils in heterogeneous groups instead of attainment ('ability') grouping.

Previously, as an immediate response to the exchange experience, a majority of schools implemented daily intervention. The numbers of lead primary schools continuing this remained relatively stable at around two thirds. The implementation of daily intervention, however, was varied across schools as interviews revealed that this differed between classes and year groups. Moreover, the timing of the intervention was also variable.

Supportive changes

Schools have made a number of changes to school level practices in order to facilitate implementation of Shanghai informed pedagogies. These included:

A third of lead primary schools changed their timetabling to support the Shanghai model of teaching, with 11 schools moving to a 'split' lesson. Most schools, however, had not changed the length nor the timing of the lesson.

Emergent data suggest more collaboration in lesson preparation, and interviewees described planning of questions particularly related to misconceptions as well as planning for conceptual understanding in lessons.

Homework practices were not asked about directly, however for those interviewees who discussed homework, practices appeared to remain relatively unchanged. Where changes were made, these tended to be to the content rather than the frequency.

Professional development activity has been sustained in all schools since the exchange. Professional development activities perceived to be effective in gaining 'buy-in' and developing teachers' subject knowledge, confidence, and practice included:

- Formal activities such as external courses and conferences, very regular in-school CPD, Teacher Research Groups, and in class modelling and support.
- Embedded activities where learning arose from engagement in teaching practices such as collaborative lesson planning and text-book use.
- Informal talk about teaching and learning in mathematics, sharing of ideas, and giving non-performance related feedback.

Variation in Implementation

Substantial implementation was happening in most schools in Year groups 1-4, with between 26 and 27 lead primary schools having substantial implementation in these year groups. Reception and Years 5 and 6 had less substantial implementation, with reasons for the latter being most often cited as concentration on SATs and wide differences in pupil knowledge having emerged.

Extent of school level change

School level changes were more likely to have been made to classroom practices such as pace and tempo in lessons, rather than school wide practices such as timetabling and grouping. The vast majority of schools were able to attribute the changes to the exchange as opposed to other influencing factors.

Factors influencing implementation

Here, an overview of factors influencing implementation are reported. In the final report these will be related to levels of implementation as reported by interviewees. The vast majority of schools (37) were 'very committed' to mastery. Schools found it easiest to make changes to lesson structure and approaches to classroom interaction and talk. Replacing differentiation by pre-allocated task with mastery approaches that keep the whole class together and deepen understanding was often found to be challenging, as was planning for conceptual sequencing and practice that included procedural variation.

Professional development, including the longer term impact of the MTE, was the most frequently mentioned enabler supporting the implementation of Shanghai informed pedagogy. Other enabling factors were staff responsiveness, resources, senior leadership commitment, and implementation leadership by the lead primary teachers.

The most frequently mentioned barriers to implementation were teachers' beliefs, weakness in subject knowledge, and/or low confidence levels. Challenges were also encountered in higher year groups where the attainment gap was wider and teachers' priority was to ensure high SATs results. Other significant barriers were the lack, or

inappropriateness of, available resources, lack of staff time, staff turnover, and staffing organisation.

Professional development outcomes

The most frequently mentioned professional development outcome for teachers was enhanced subject and pedagogical content knowledge (34 schools). Changes in affect, beliefs, and confidence were also reported as significant outcomes. The most notable belief change was in relation to recognising the potential of all pupils to achieve.

Pupil outcomes

The majority of teachers reported that pupils had progressed 'more than expected' on a number of indicators including mathematical talk (n=37), pupils' knowledge and understanding of key mathematics (n= 29), and pupils engagement in class (n=33). Teachers found it more difficult to comment on attainment, due partly to changes in assessment.

Sharing learning with other schools

Most schools have engaged in some activity to share their learning more widely. This includes modelling mastery in their own school, leading Teacher Research Groups, presenting at workshops and conferences, and providing customised support packages. This is beginning to influence practices in other schools, but has not yet led to mastery practices being fully embedded in those schools. This work was successfully enabled through the support of maths hubs, NCETM, and senior leaders in the lead primary schools. However, potential was restricted due to resistance by some senior leaders in other schools, and by staffing capacity in lead primary schools.

Implications and prospects for impact

Implications of the findings are:

- Cohort 1 MTE schools could be further encouraged to engage with the Primary Mathematics Teaching for Mastery Specialists Programme (PMTMSP). In addition, those schools in the original 48 who have found it harder to implement mastery, may be more appropriately engaged as recipients of PMTMSP support, if they are not already being so supported.
- Consideration should also be given to whether the textbook scheme should be extended to Cohort 1 lead primary schools, and potentially to the schools they work with.
- The detailed findings on implementation have the potential to inform the design of professional learning activities led by: the NCETM, Maths Hubs, mastery specialist

teachers, as well as other providers of mastery focused CPD such as textbook suppliers and leaders of commercial programmes.

- The value of the appropriate balance between flexibility of implementation and consistency is an important issue to be considered by all promoting mastery and one to address in the final report.
- More directly, evidence on the existence of different patterns of mastery implementation offers opportunities for teachers and schools to self-audit and reflect on their current levels of implementation, and potentially be a focus for further professional learning.

Conclusion

The Mathematics Teacher Exchange Cohort 1 schools have extended and deepened practices informed by the exchange and influenced by other mastery initiatives. In those schools where such practices are now embedded, pedagogy is markedly different from practices that have been the norm in English primary mathematics classrooms. English primary schools with a range of characteristics have successfully applied lessons from the Shanghai exchange. Schools have learnt lessons from the exchange and drawn on other support to change practice. Practices implemented, or similar, have, individually, good evidence from previous research including meta-analysis of quasi-experimental trials, that they can potentially improve mathematical attainment². In the final year of the evaluation the extent to which changes are more fully embedded will be established, and this will inform analysis of whether the potential for impact on pupil outcomes is realised. In addition, the third year interviews will offer the possibility to ask interviewees to consider the value of the policy innovation as a whole and of the exchange in particular.

²For example, reviews published by the Sutton Trust; the type of classroom talk promoted and sequencing of activities are resonant of effective practices reported in Coe et al. (2014), see Higgins et al., (2013) for other practices such as one to one or small group tuition.

1. Introduction

1.1 The Mathematics Teacher Exchange

The Mathematics Teacher Exchange aims to foster a radical shift in primary mathematics teaching in England by learning from Shanghai mathematics education. The Mathematics Teacher Exchange is one of a number of initiatives, by the Department for Education and others, to learn from practice in East Asia and promote mastery approaches in mathematics education.

Shanghai whole class interactive teaching aims to develop conceptual understanding and procedural fluency. This is achieved through lessons designed to be accessible to all, through teacher questioning and incremental progression. It is supported by well-crafted mathematical models and exemplar problems, as well as practice materials that focus on critical aspects of mathematical learning. To ensure pupils progress together, tasks are designed to allow for extension by deepening understanding and daily intervention is used to support those needing extra tuition. Curricula progression, lesson timing, and teacher roles and responsibilities are organised at a school level to support these approaches to mathematics teaching and learning. Differences between Shanghai and England in classroom and school practices most salient to the exchange were summarised in the first interim report and an extract is provided in Annexe A ³.

The exchange is funded and managed by the Department for Education. The National Centre for Excellence in the Teaching of Mathematics (NCETM) led the implementation of the exchange through the national network of Maths Hubs. They are engaged in developing, refining, and deepening school and teachers' understanding of not only Shanghai mastery practices, but they also draw on East Asian mathematics teaching more generally, synthesised as 'teaching for mastery'. In September 2014, 60 teachers and leaders from 45 English primary schools visited Shanghai schools. Between November 2014 and March 2015, 59 mathematics teachers from China visited 48 English primary schools and modelled mastery teaching. Subsequently, the English schools made changes in practices, they were designated as lead primary schools, and in most cases they shared learning with other schools.

Since the initial exchange, partly in response to the reported potential of the exchange and of mastery to lead to change in schools' practices, the Department for Education has

³ Boylan, M. Wolstenholme, C., Maxwell, B., Jay, T., Stevens, A., and Demack, S. (2016). Longitudinal Evaluation of the Mathematics Teacher Exchange: China-England. Interim research report. (DfE). <https://www.gov.uk/government/publications/evaluation-of-the-maths-teacher-exchange-china-and-england>

made a further investment of £41 million in supporting what is now referred to as 'teaching mathematics for mastery'⁴. This investment includes:

- funding for the NCETM led Primary Mathematics Teaching for Mastery Specialists Programme (PMTMSP) with 140 participants per year
- support, through Maths Hubs, for PMTMSP participants and alumni to work with other primary schools with an intended reach of over 8000 schools by 2020
- further cohorts of schools engaged in the Mathematics Teacher Exchange programme, with 70 teachers from Cohort 1 of the PMTMSP involved in exchange with Shanghai teachers in 2016/17
- funding to support the adoption of textbooks in primary schools.

Annexe B provides a fuller description of various initiatives and programmes that are informed by East Asian mathematics education. These various mastery initiatives influenced many of the schools and teachers involved in the Mathematics Teacher Exchange alongside the actual exchange programme, and so are referred to in the reported findings. However, it is important to note that the scope of the evaluation reported here is on how the exchange activities have influenced and prompted changes in practice and their impact, rather than an evaluation of the teaching for mastery initiative as a whole.

1.2 The evaluation and this report

The Department for Education (DfE) commissioned Sheffield Hallam University (SHU) to conduct a longitudinal mixed methods evaluation, to determine the potential of learning from Shanghai mathematics education to impact on teaching in England, and on pupils' mathematics attainment in both the short and long term. It is important to note that the scope of the evaluation is limited to the Mathematics Teacher Exchange and support for it and does not extend to the whole of the mastery initiative. The evaluation has a mixed methods design using interviews, surveys, and a comparative analysis of national assessment data to measure impact on pupil attainment⁵.

Initially, the evaluation focused on the first cohort of schools involved in the exchange, identifying ways in which the 48 participating schools - the lead primary schools - implemented learning from the exchange in 2014/15. NCTEM designated the Lead primary schools, and within each of these, the lead primary teachers. Lead primary teachers were identified as such as a result of having been directly involved in the exchange programme and/or were leading wider dissemination within their school and, in

⁴ <https://www.gov.uk/government/news/south-asian-method-of-teaching-maths-to-be-rolled-out-in-schools>

⁵ A full description of the evaluation methodology is provided in the first report, and further explanation of the impact analysis design is described in the second report.

some cases, their local and wider hub network. This is reported in the first interim report (Boylan et al., 2016). From 2016/17, the evaluation is being extended to include Cohort 2 of the Mathematics Teacher Exchange.

Alongside the qualitative analysis, impact on pupil outcomes will be evaluated by considering changes between 2015 and 2017 in key stage 1 and key stage 2 outcomes in lead primary schools, in comparison with a matched sample of similar schools. The second interim report presents analysis of the pupil baseline data.

This third report focuses on findings from the follow up interviews with 43 lead primary teachers from the original Cohort 1 schools, which were undertaken during the second year of implementation.⁶ The interim findings reported address the objectives in bold in Table 1.

⁶ Not all interviewees were known as lead primary teachers within the schools, however, for simplicity 'lead primary teachers' will be used for referring to all interviewees in the report, see Annexe C for a discussion of this issue.

Table 1 Evaluation objectives and third interim report

Objectives
1. Evaluate the implementation and fidelity of the intervention against programme objectives.
2. Identify the types of activity undertaken by teachers from England in Shanghai host schools.
3. Identify the types of activities undertaken by Chinese teachers in host schools in England.
4. Identify the professional development outcomes for teachers.
5. Determine whether teaching methods and practices have changed in host schools in England.
6. Determine what activities have been most successful in meeting the aims of the programme.
7. Identify lessons learned and the extent to which changes resulting from the exchange have been embedded in schools in England.
8. Report on perceptions of pupil performance and depth of understanding of key concepts.
9. Determine whether lessons have been shared amongst schools in the wider hub network, and whether this has resulted in a change in teaching methods.
10. Review, assess and synthesise the findings from the lead primary school reports prepared for NCETM.
11. Determine whether the teacher exchange and its associated activities have had an impact on mathematics skills and ability in the short and long term.
12. Identify initial patterns of effective change and early evidence of pupil impact.

The final report in 2018 will report analysis of interviews undertaken with Cohort 1 teachers in the third year of implementation, interviews with a sample of Cohort 2 teachers, a survey of schools with various degrees of involvement with NCETM led mastery programmes⁷, and the final longitudinal analysis including the impact analysis.

1.3 The report structure

The first interim report presented findings on schools' implementation of Shanghai informed pedagogy as a result of the exchange experiences, focusing particularly on classroom and school level practices. The current report organises material in a more developed form to reflect the ways interviewees discussed further implementation,

⁷ This will only reflect recorded engagement, for example being part of a Teacher Research Group, or being a mastery specialist.

namely - mathematically meaningful and coherent activity, diverse interactive teaching, and a whole class focus. In addition, we report changes that support this teaching approach, variation in implementation, and factors that have influenced implementation. Thus, sections 3 to 6 address evaluation objectives related to implementation and change in practice in lead primary schools. Perceptions of teacher and pupil outcomes are then reported, followed by a description of the ways in which some schools have continued to share learning with other schools. Research findings are then considered in relation to the evaluation objectives and implications are discussed.

2. Data collection and analysis

Findings reported here are based on analysis of telephone interviews with 43 lead primary teachers from Cohort 1 lead primary schools⁸. Interviews were conducted between March and June 2016. Consent was obtained and ethical procedures followed. In 42 cases, interviews were audio recorded and professionally transcribed, with the length of recordings ranging from 33 minutes to 75 minutes, with a mean of 49 minutes. In the remaining case, detailed interview notes were written immediately after the interview. In addition, data from a survey of lead primary teachers undertaken by the NCETM between December 2015 and February 2016 was used to triangulate or supplement analysis.

Interview questions comprised a mixture of open and closed questions, informed by previous evaluation findings and knowledge of East Asian and other effective mathematics teaching. The report is also informed by data on developments in mastery initiatives provided by the NCETM and the DfE, as well as by desk research.

Analysis was supported by NVivo 11 software and was both deductive and inductive. Deductive analysis drew on prior research, whilst inductive analysis used open coding strategies to identify new themes and categorise differences in the level of implementation in schools (Ryan and Bernard, 2003). This combination accords with an adaptive theory method (Layder, 1998). Rigorous and systematic approaches to analysis were used to enhance validity and reliability of findings and are described in Annexe C.

It is important to note that the analysis is limited by how extensive responses to questions were. This means that there may be some under reporting by interviewees of implementation of specific practices, for example lesson design processes or some of the strategies used to promote mathematical talk. In such cases, the fact that a school has not explicitly claimed to be taking a particular approach does not necessarily mean that they are not taking that approach. Looking ahead to the third round of interviews, and to the final report, interpretive judgements will, where possible, be confirmed (or not) by a measure of respondent checking, through the use of closed questions. This will allow interviewees to provide their level of agreement with interpretations made. Similarly, a

⁸ In this section, data collection and analysis are summarised. Further detail is provided in Annexe B including how interviewees were identified and how far they met the NCETM criteria of a lead primary teacher. Of the original 48 schools 4 withdrew from interviews for reasons such as staff changes, and 1 was not currently implementing Shanghai informed practices. These 5 schools will be invited to take part in the third year interviews. With regard to attrition, in the first interim report patterns of implementation at Hub level were reported including that in sixteen hubs the decision was made to have two schools involved in the exchange rather than the one intended in the project design. In some cases this was due to issues such as the large geographical area the hub lead schools served. However, in other cases a second school was selected within a multi-academy trust apparently as school improvement measure and there may have been issues about these schools' (and school leaders') capacity to undertake the innovation.

survey of both exchange schools and other schools, in summer 2017, will provide further data appropriate for quantification.

3. Shanghai informed pedagogy

As noted, mathematics teaching in Shanghai focuses on developing pupils' conceptual understanding and procedural fluency. In this section, an overview is provided of ways that lead primary schools focused on these key learning outcomes. Important aspects of Shanghai informed pedagogy are then discussed in more detail, considered as three components: mathematically meaningful and coherent activity, varied interactive teaching, and a whole class focus. These three components are mutually supporting and interrelated. The description of practice relates to those classes that interviewees identified as having partial or full implementation of the mastery approach, as enacted in their school (see Section 5). However, even in those schools where mastery teaching was not applied to all classes, interviewees indicated that some practices, or many, were being implemented more generally.

3.1 Key Findings

- A number of strategies were described to promote conceptual understanding, and procedural fluency, those most often used were: using representations and models, careful choice of practice questions and teacher questioning and classroom dialogue.
- The pace of movement through the curriculum was reportedly slower, and more step by step, due in part to an increase in the use of models and representations.
- The numbers of schools using either a textbook or scheme with at least some year groups has increased (n=39), the majority of textbooks used being closely aligned to the Mastery approach (n=30). The frequency and ways of use varied between schools.
- Teacher-pupil interaction was said by most (n=25) to make up more than half of an average mathematics lesson.
- Nearly all schools (n=38) reported that lessons follow a pattern of multiple short activities rather than a three part lesson.
- All schools now used strategies to develop mathematical talk in pupils such as asking for explanations of how an answer was arrived at, this approach was used 'always' by 34 lead primary teachers.
- All schools reported an increased tempo of lessons, particularly frequent change in activity during the lesson.
- In order to keep the whole class moving through the curriculum broadly together, the pace was slowed to support accessibility, differentiation was more likely to be focussed on depth rather than acceleration and pupils were taught much more

often in heterogeneous groups (67%) instead of by ability groups (33%).

- Daily intervention (n= 29) along with daily identification of pupils needing intervention (n=31) was happening across most schools, however ways in which this was implemented varied across year groups and schools.

3.2 Conceptual understanding and procedural fluency

Lead primary teachers were asked to describe strategies to promote conceptual understanding and procedural fluency. Generally, strategies to promote conceptual understanding were discussed at more length than those to promote procedural fluency; there were on average, per interviewee, approximately 3 discrete references to strategies related to understanding, and 2 to procedural fluency.

The extent of responses ranged considerably in the number of practices discussed and the extent to which different practices were linked and connections made between understanding and fluency. In schools in which mastery was becoming embedded, often those leading in their local areas, responses of lead primary teachers demonstrated detailed and in depth understanding of the principles of mastery and more generally of mathematical learning theories. For example, one interviewee spoke confidently about links between understanding and fluency using the notion of a 'procept' - an amalgam of a mathematical process, concept, and symbol (Gray and Tall, 1991). Some 23 interviewees made some reference to 'variation' in relation to conceptual understanding, procedural fluency or strategies to develop these. Variation theory is important to the design purposes of Shanghai lessons (Gu, Huang, and Martin, 2004) and is promoted by the NCETM as a core part of teaching for mastery (NCETM, 2016). Of these 23, a majority were using the term in a way that showed an understanding of its purpose beyond 'variety' or simply varying activities.

3.2.1 Developing conceptual understanding

Interviewees were asked an open question about strategies and practices used to promote conceptual understanding. Responses were analysed and categories and frequency of responses in rank order are shown in Table 2.

Table 2 Ways of promoting conceptual understanding (n=42)

Ways of promoting conceptual understanding	Frequency
Using representations and models	30
Teacher questioning and classroom dialogue	28
Understanding as an explicit focus in lesson preparation	25
Starting from a problem or carefully selected task	12
Connecting different mathematical concepts and procedures	12
Precise use of language	8
Planning for and addressing misconceptions	7
Using a textbook, scheme or designed resource	5
Using in class formative assessment of conceptual understanding	4

3.2.2 Developing procedural fluency

Interviewees were also asked an open question about strategies used to promote procedural fluency; analysis is reported in Table 3. The category 'careful choice of practice questions' included those who made reference to procedural variation but also those who whilst not using the term, implied a similar approach.

Table 3 Ways of promoting procedural fluency (n=42)

Ways of promoting procedural fluency	Frequency
Careful choice of practice questions	29
Memorising, recalling and testing of factual knowledge	18
Using representations and models	15
Using in class formative assessment of procedural fluency	8
Using a textbook, scheme or designed resource	6
Addressing this in the calculations policy	6
Connecting different mathematical concepts and procedures	4

The ways schools were promoting conceptual and procedural fluency are discussed in the sections that follow.

3.3 Mathematically meaningful and coherent activities

In seeking to develop understanding and fluency, schools sought to engage pupils with mathematically meaningful and coherent activities. Meaning has been enhanced by adopting a slower curriculum pace, a much increased and more sophisticated use of mathematical models, and the use of resources that are designed to communicate mathematics coherently to pupils, and by implication to teachers.

3.3.1 Curriculum pace

Schools adopting a Shanghai informed pedagogy have slowed the pace of coverage of curriculum content. Lead primary teachers report adopting more of a 'step by step' approach, and a greater focus on mathematical understanding:

[We] slowed down how quickly we covered the curriculum content, but we also realised it was very necessary because it threw up a lot of gaps in our children's understanding. So we have tried to do that and continue with that ... we haven't had that depth of understanding in the past. (School 10A, lead primary teacher⁹)

The focus on conceptual understanding meant that teachers reported no longer following a plan to cover particular curriculum content over a set time period:

Now it is very much, we're doing addition and we're going to do it until we deeply understand it, then we can move on to something different. (School 16A, lead primary teacher)

A general theme was a greater focus on number, though it is not clear in all cases how far this was a result of adopting mastery and the exchange, and how far a response to changes in the National Curriculum. However, some teachers reported that, following the exchange, more attention was paid to what were identified as key and foundational curriculum areas:

So we might teach a whole term on place value... sometimes things take longer to explain and teachers now have the capacity to spend longer if they need to, to make sure children get it right. (School 19B, lead primary teacher)

We spend half a year on number...because we feel that they need to have a good grounding. (School 4A, lead primary teacher)

Whilst a few teachers expressed concern that a slower pace might risk coverage of the full curriculum from year to year, one teacher (School 21A) noted that as teachers' confidence increased, the pace had begun to increase and be more variable.

3.3.2 Representations

One reason for curriculum pace slowing was due to an increased use of mathematical models and representations, which, as indicated in Tables 2 and 3 above, was by many explicitly linked to developing conceptual understanding and procedural fluency. With

⁹ In each of the original 32 maths hubs, either one or two schools participated in the exchange, hence each school is referred to as 1A, 1B etc. These references preserve participants' anonymity.

regard to representations, schools adopted Shanghai practices and also drew on formulations of the Concrete-Pictorial-Abstract principle found in Singapore (Hoong, Kin, and Pien, 2015).

Those schools already engaged with Singaporean informed resources had already developed their practice in this area. Notwithstanding this, the use of representations was one of the largest areas of change in schools. Use of models and representations can be divided into use of visual representations and concrete models and materials. Visual representations referred to by participants included: arrays, bar models, 10 frames, whole-part diagrams, number lines as well as various forms of representations of objects¹⁰. Concrete models and materials referred to by participants included: Dienes/Base 10 equipment, Numicon, Cuisenaire rods, generic counters as well as two sided and place value counters, multilink, unifix, physical 10 frames, place value cards, small world objects (bears, toys and so on), and number beads¹¹. A common change reported was for the use of concrete materials to be extended from use with younger children to the full primary age range. Similarly, use had been extended, in some schools, by attainment: concrete materials were no longer viewed as being more appropriate for low attaining and/or SEND pupils, but were viewed as important for the full attainment range.

Schools' uses of concrete and visual representations were separately categorised in three groups: evidence of little use or unclear use, evidence of embedding use, or evidence of embedded use. Table 4 provides descriptions of the categories. Table 5 provides the frequency of these categories, including interrelationships between use of concrete and visual representations.

¹⁰ Barmby et al. (2013) provides an overview of the use and types of visual representations in primary mathematics.

¹¹ Moyer (2001) provides an introduction to teachers' use of concrete materials in mathematics teaching.

Table 4 Categories of use of visual and concrete representations

	Visual representations	Concrete representations
Limited	Using more visual aids such as photographs or clip art, but not linked to mathematical models or mathematical learning; or having intentions to introduce greater use in the future; more mathematically meaningful practices only appeared to be happening in the lead primary teachers' classes.	Used with younger learners or low attaining pupils and either did not refer to specific materials of such references are limited. Typically materials such as dienes blocks or counters are used for modelling addition or subtraction and simple arithmetic only. In some cases interviewees referred to intentions, or increased awareness rather than to changed practice.
Embedding	Increasing use of visual representation as mathematical models; aiming for consistency in every lesson; some reference made to challenge for some teachers; the Concrete-pictorial-abstract approach was mentioned by some as something that was being adopted. The bar model was frequently referred to as one specific example.	Increasing use including more use in KS2 and across the attainment range, but use inconsistent; more equipment purchased to give access to all classes or 'getting it out of the back of the cupboard'; references made to the concrete-pictorial- abstract with examples of concrete representation as the start of a topic; reporting that teachers are developing knowledge of how to use these with all years and a wider variety of mathematical content.
Embedded use	Multiple and varied visual models used and linked mathematically; different forms of representation were linked, for example referring to concrete-pictorial-abstract as a triangle or to be used alongside each other rather than a sequence; use of models linked to other practices such as questioning, or variation theory; some schools had formulated the approach in policy, for example, to always use two representations in every lesson; patterns of use are consistent across the school.	Used in every lesson and/or across whole school and/or full attainment range; a wide variety of materials are discussed with reference to appropriateness for different mathematical content; routinely, concrete materials are on desk for students to use during explanation; the importance of moving between different representations was discussed, and referring to concrete-pictorial-abstract as a triangle or to be used alongside each other; some discussed creating their own specialised concrete materials for particular topics.

Table 5 Frequency of types of use

		Visual			
		Limited	Embedding	Embedded	Total
Concrete	Limited	2	8	1	11
	Embedding	2	14	4	20
	Embedded	0	3	9	12
	Total	4	25	14	

Some 30 schools - shaded boxes above - are embedding or have embedded either use of visual or concrete representations, or both.

3.3.3 Mathematically coherent resources

Prior to and during the first year of the exchange, in 2014/15, resources used were eclectic with individual schools selecting different materials to fit with schools' schemes of work. Thus, they were similar to most English primary schools.

In the first interim report, survey findings were reported about use of commercial resources specifically, including textbooks with Y2 and Y6 in 2014/15. Only eight schools reported using a commercial scheme for teaching in year 2, and four in year 6. Of these eight schools, only half were using it as a basis for instruction, and a number of these were involved in the National Textbook project (see Annexe B), and others were engaged in the Mathematics Mastery programme. Moreover, in some cases, these characteristics guided the selection of schools to take part. A similar number of schools in 2014/15 were doing initial trials of textbooks and others reported considering using textbooks.

However, the exchange has raised for many schools the need to refresh resources used in planning and for pupils to use. Changing resources has been important to implementing mastery teaching. Thirty nine schools now used an external source of mathematical activities as a main resource in at least some classes or year groups that are following a mastery approach, as shown in Table 6.

Table 6 Use of textbooks and schemes

Main source for activities	No: of schools
Mastery aligned textbooks	24
Mathematics Mastery	6
Other sources (including other schemes and textbooks)	9

Table 7 Textbooks used

	MNP	Inspire	Collins	Other
Number of schools	21	7	3	4

Note that 5 schools were using more than one textbook, in most cases to support planning. Disregarding such instances, 24 schools were using, in some way; a textbook based on either translations of Singaporean text, or of a translation of a Shanghai informed text. In addition, 6 schools were using Mathematics Mastery, a Singapore-informed mastery programme. Thus, 30 schools were using resources closely aligned to the Mastery approach.

However, the way textbooks, in particular, were being used varied. Table 8 displays differences in use. Where textbooks were used with children in some year groups/classes, there was generally intent to increase use, representing a progressive implementation.

Table 8 Ways textbooks are used

Ways textbook are used	No: of schools
Use with children	8
Used for planning only	9
Used for planning for some year groups/classes and with children in others	8

Interviewees from schools in which textbooks or schemes were used were also asked about the frequency of use with children.

Table 9 Frequency of use

Frequency of use of textbook or scheme	No: of schools
Usually	12
Sometimes	15
Never	6

Reasons given for use of East Asian informed textbooks or the Mathematics Mastery programme focused on:

- alignment to mastery
- progression of material - linked to slowing the curriculum
- the representations and models used
- the support for addressing gaps in teacher knowledge

The use of textbooks in planning and the value of this as a form of professional development are discussed in Section 4.

3.4 Varied interactive teaching

The development of mathematical understanding was supported in schools by varied interactive teaching. 'Varied' here refers to a range of different types of learning activity and frequent changes between these. This contrasts with adopting a more compartmentalised lesson structure such as the National Numeracy Strategy three part lesson.

3.4.1 Lesson activities and structure

Lesson activities here refer to the balance between interaction, teacher explanation, individual or group work and so on during the lesson.

Percentage of whole class interaction

Lead primary teachers were asked to quantify the amount of time spent on whole class interaction in a typical mathematics lesson experienced by classes following a mastery approach in their school. The average response was just over half the lesson (54%) being dedicated to whole class interaction.

Mean = 54%; Median = 50%; Mode = 50%; Range = 75%.

The minimum time reported was 25%, and the maximum was 100%.

Balance of lesson activity

Of the time spent on whole class interaction, lead primary teachers were asked to distinguish between time spent giving instruction and explanation as opposed to questioning, dialogue, and discussion. Table 10 details responses, with one interviewee not able to answer on behalf of their school.

Table 10 Balance of lesson activity

Questioning, dialogue and discussion	No: of schools
More than half of time spent on teacher pupil interaction	25
About half of time spent on teacher pupil interaction	16
Less than half of time spent on teacher pupil interaction	1

Lesson structure

Lead primary teachers were also asked to choose between two statements which they felt best described mathematics lessons of those classes in which mastery was being implemented. Statement one is based on a traditional English approach of a three part lesson. Statement two reflects a lesson which is typically based around shorter activity periods, change between them, and with more whole class interaction, which is more similar to Shanghai practices.

Statement one: 'Lessons follow a pattern of: a starter, an introduction, a main activity involving a teacher led explanation or interaction, followed by practice or consolidation, and a final plenary.'

Statement two: 'Lessons follow a pattern of multiple short periods of questioning and dialogue between teacher and pupils interspersed with short periods of pupils working on one or two problems or tasks.'

Nearly all lead primary teachers (n=38) chose statement two, and 2 chose statement one, while 3 participants stated that they were unable to choose between the two statements.

This form of lesson structure was described variously as 'to-ing and fro-ing' 'back and forth', 'short bursts of teacher led activity' and 'I do, you do, I do you do'. One lead primary teacher described their own practice after noting that this was now used throughout the school including years not yet fully following a mastery approach:

I introduce a topic. There is a lot of paired discussion about what we already know, what we can use, and what we don't. From that I model a question. The children

self-assess. They then complete a short amount of tasks for 5-6 minutes. We then mark those together, assess once more, and then move on to the next level of difficulty, where we repeat that structure. (School 8A, lead primary teacher)

3.4.2 Classroom talk

A set of statements were read out to lead primary teachers relating to the extent pupils are engaging in mathematical talk. They were asked to answer either 'always', 'sometimes' or 'never' to each, again in relation to those in which mastery teaching was being implemented. The results in Table 11 show that all lead primary teachers are using techniques to engage pupils in mathematical talk either always or sometimes. Most notably, 34 out of 43 lead primary teachers answered that teachers always ask pupils for explanations of how answers were obtained and for details of the methods they used. Seven interviewees also reported building on existing or other structures to support pupil discussion and mathematical communication.

In some cases teachers went beyond encouragement of precise language to insisting on it:

The teacher will say the mathematical sentence and the child will say it, and if the child misses just one word, they will say 'can you say that again please'. It's that expectation. (School 9A, lead primary teacher)

As well as recitation by the whole class, one teacher described the way the same question might be asked of more than one individual to encourage all to engage. Mathematical communication was also encouraged by avoiding initiation-response-evaluation sequences that result from correcting or affirming a response immediately (Lemke, 1990), and instead collecting multiple responses. One teacher described how they used a strategy learnt from their visiting Chinese teacher.

Our teachers are getting much better at listening to what a child has said and then saying 'Do you agree?' and encouraging other children to think it through. (School 31B, lead primary teacher)

Such approaches accord with other successful interactive teaching approaches previously implemented in English schools such as dialogic teaching (Alexander, 2008). Generally, an increased emphasis on classroom talk focused on process and understanding was reported. A further strategy to support this was planning key questions in advance, for example in relation to identifying misconceptions and deepening understanding.

Table 11 Engaging pupils in mathematical talk

Pupils' mathematical talk statements	Always	Sometimes	Never
Pupils are asked to discuss with a partner before answering.	20	23	0
Teachers use precise mathematical language in full sentences when explaining or responding to pupils.	30	13	0
Pupils are encouraged to use precise mathematical language in full sentences when responding to questions.	31	12	0
Key ideas or concepts are recited - either individually or by the whole class	18	24	1
Teachers ask for explanations of how answers were obtained and for details of methods used.	34	9	0
Pupils are encouraged to communicate mathematically to the whole class e.g. by coming out to the board.	25	18	0

3.4.3 Tempo

In the first interim report a distinction was made, based on interview responses, between lesson pace and lesson tempo. Pace is the amount of content covered in a lesson (discussed above in section 3.2).

Interviewees were asked about the changes in lesson tempo, in response to the interviewer noting that a feature of Shanghai lessons is a brisk tempo and by that we mean the frequency of interaction or change in types of pupil activity. In all 41 cases where there was a clear response about tempo, an increase in tempo was reported. Of these, 16 referred to practices that focused on the tempo of interaction between teacher and pupils in interactive episodes, 31 focused on lesson tempo, related to more frequent changes in forms of activity as reported above. Thus, 7 lead primary teachers talked about both forms of increase in tempo.

3.5 Engaging and challenging the whole class

In Shanghai primary schools the whole class is taught together, a practice that is supported by evidence from meta-analyses that attainment grouping has an overall negative effect (Higgins et al., 2013). Schools adopting Shanghai informed pedagogy adopt, to varying degrees, strategies to engage and challenge the whole class. An important motivation for change in practice has also been the new National Curriculum expectation "that the majority of pupils will move through the programmes of study at

broadly the same pace" (DfE, 2013) with the intention of increase in challenge in content rather than acceleration where appropriate. Schools have adopted different strategies in order to address this. In this sub-section, approaches to curriculum pace, differentiation, attainment grouping, and intervention are reported.

3.5.1 An accessible pace

As discussed above, generally pace of content coverage has changed to promote conceptual understanding, but this has also supported keeping the class together:

We're trying to go at the speed that the children understand, rather than that just one or two of them understand and move on. (School 10A, lead primary teacher)

3.5.2 Differentiation

In the first interim report, two approaches to differentiation were described that had been used previously. In most schools 3 to 5 different activities were planned per lesson, often linked to attainment grouping (see below). Only three schools reported an alternative approach in which children generally had a choice about which activities they did rather than these being prescribed by the teacher. Thus, in the main, forms of differentiation prior to the exchange were those commonly found in English Primary schools (see Boylan et al., 2016 pp.35-36).

In Year 2, lead primary teachers answered yes or no to a number of statements about differentiation. As Table 12 below sets out, 41 of the 43 teachers interviewed said that planning does not involve setting differentiated learning objectives. Overall, responses show that schools are adopting alternative approaches to allocating different tasks to students in advance.

Table 12 Differentiation practices

Differentiation Statement	Yes	No
Planning involves setting differentiated learning objectives	2	41
Differentiated tasks are set for pupils, for example different main activities or different practice questions	9	34
The main activities would be the same and differentiation would happen by outcome, for example how far a pupil progresses with an exercise	34	9
Pupils who learn the main content before others are set tasks or questions to deepen understanding rather than moving on to new content	42	1

These findings are supported by NCETM survey data with 36 of 38 respondents reporting that differentiation by acceleration is no longer school policy. Based on interview responses and further analysis of elaboration of approaches to differentiation, schools can be categorised into three approaches, for those classes where mastery is being implemented. These approaches are listed in Table 13 below.

Table 13 Approaches to differentiation

Differentiation	No: of schools
Differentiation by deepening and support	31
Differentiation in transition	5
Differentiation by allocated task	7

However, it is important to note that in some schools in the first category, different approaches were used in classes that were *not* following a mastery approach.

Differentiation by deepening and support

There are a variety of different practices that are included within this broad category. In some schools the focus was on the whole class: everyone gets the same work, everyone is ‘kept together’ in the lesson, and the aim is for everyone to achieve and understand - so everyone accesses the same activities. Teacher questioning and additional resources (such as concrete materials and alternative models, see section 3.2) are used to support or deepen understanding:

It's more about providing the materials they might need to achieve. (School 6A, lead primary teacher)

A variation on this is to expect differences in the tasks that learners might undertake and in outcomes, but to step away from a fixed view of what learners could do or might need:

We make no assumptions; we don't assume that in one particular activity somebody who might have struggled in a previous one will necessarily struggle in that one.... We differentiate by questions and task, but we don't pre-label which children are necessarily given which activities or questions. It's very much what the children can show us they can do. It's more responsive actually. That's the word we use. We only plan for three lessons [per week] deeply, because we know it could go in any direction. (School 3B, lead primary teacher)

A third form is that all questions or types of tasks that might have previously been allocated to different groups of children are now provided for everyone to work through:

There will be three activities in the lesson and they start at 1 and then if they're super confident they can move on to 2, and then move on to 3. And 3 is where the deepening happens. (School 13A, lead primary teacher)

Different ways in which differentiation by deepening and support is achieved will be probed in the third year of the evaluation.

Differentiation by allocated task

Although practices in these schools were more similar to previous differentiation practices, in that different tasks were allocated to different pupils, there were still changes. Sometimes these appear to not fundamentally change the approach:

The learning objectives wouldn't perhaps be differentiated but the tasks would be. (School 18A, lead primary teacher)

Other schools had reduced the number of tasks allocated to 2 or 3, rather than 3-5. These tasks were also more connected:

In the past there would have been a lot more focus on accelerating more able pupils, whereas now the focus is very much on everything is about depth of understanding, so they won't be doing something completely different from the rest of the class. They'll be doing something very similar, but again the focus in working at a deeper level. (School 32B, lead primary teacher)

Differentiation in transition

As the name implies, this category refers to schools where a mix of practices was described and teachers discussing changes in the direction of differentiation by support and deepening.

3.5.3 Attainment grouping

In the first year of the exchange, 66% of schools used some form of attainment ('ability') grouping in Y2 and 70% in Y6. In Y2, 10% were grouped in sets, and 56% experienced within class attainment grouping. In Y6, however, 40% experienced setting and 30% within class attainment grouping. This was in line with recent studies on attainment grouping in Primary schools (Hallam and Parsons, 2013). Table 14 highlights that for pupils in mastery classes there have been significant changes, with the majority of pupils experiencing all attainment ('mixed ability') grouping¹². The number of schools that have changed their approach is shown in section 8.

Table 14 Grouping arrangements for pupils in mastery classes

Form of grouping	Percentage of schools
Heterogeneous grouping (pupils not set or grouped by attainment within class)	67%
Pupils set by class (pupils allocated to classes based on prior attainment and/or perceptions of 'ability')	14%
Pupils grouped by prior attainment within class (pupils of similar attainment sat together)	19%

These findings are confirmed by NCETM survey data with 34 schools reporting a reduction to a greater or lesser extent in attainment grouping. In schools in which pupils were not grouped by attainment, just under half of teachers talked about allocating pupils to, what they described as, 'mixed ability' pairs or groups (pupils with higher prior attainment sat next to pupils with lower prior attainment than them). This was said to facilitate pupils learning from each other, which some teachers referred to as 'the little teacher'. In other schools, pupils were randomly allocated seating or were moved around on a weekly or monthly basis to sit with a different peer.

As Table 15 below shows, pupils were most likely to be sat in groups rather than in rows. Where interviewees discussed the rationale for rows, reference was made to teaching the whole class.

¹² Comparative percentages are not given, due to different sources and meaning of data.

Table 15 Seating arrangements

Seating	No: of schools
Small groups	22
Rows	12
Other/mixed	9

In addition to changes in forms of grouping, teachers also discussed how engagement with mastery had changed their thinking about ability. This was reflected in encouraging colleagues to avoid terms such as 'high ability', and to use instead 'high attaining' pupils. Changes in grouping were linked in two cases to the promotion of growth mind-sets (Dweck, 2008).

Teachers perceived that the lack of setting had, in some cases, led to increased confidence for pupils who had historically been put into low ability groups:

Previously it was pretty depressing, if you were in the red group you were going to be in the red group forever, they certainly know about it. (School 1B, lead primary teacher)

I'm not making artificial gaps between the children and therefore we are managing to master things and stay broadly together. It means that children feel quite empowered that they're doing the same activity, perhaps, as someone they perceive as being really good at maths. (School 28A, lead primary teacher)

In some schools, the interviewee stated that they felt the need to retain grouping by ability in older year groups (Y5 and Y6) due to pre-existing attainment gaps and a focus on SATs:

In Years 5 and 6, the gaps in children's understanding and knowledge are so huge from the top to the bottom that at times it's difficult to keep everyone on the same learning, because some children really, really understand it deeply already and there isn't much more deepening that can be done, whereas there is a selection of children in there that have got such huge gaps in their basic understanding that they can't access it. (School 1B, lead primary teacher)

For some of the schools that were continuing to set pupils either by class or within class, there was discussion of working towards all attainment teaching in mathematics in the near future. Reasons for continuing to group by perceived ability were varied. Some lead primary teachers said that it depended on teachers' preferences or confidence levels, as it appears that less confident teachers preferred to keep pupils in ability groups. One school experimented with heterogeneous grouping before reverting back. Another teacher suggested that they believed pupils in Shanghai were taught in sets, and that

pupils were still progressing through the curriculum at the same pace, though one set would experience deepening activities before the other.

3.5.4 Intervention

A notable feature of Shanghai primary teaching is intervention based on daily assessment of learning and immediate response by teachers. This is different from usual English practice where specific and relatively stable groups of children are identified for additional support. Many lead primary schools have adopted practices closer to Shanghai, indeed, as previously reported, this was often a change made during the exchange year.

By the summer term 2015, survey data indicated that intervention happened on a daily basis in 64% of year 2 classes and in 60% of year 6 classes. Tables 16, 17, and 18 below, report how intervention now happens in lead primary schools. Although data is not directly comparable, Table 16 indicates that schools have maintained arrangements that had been made by the end of the exchange year. That is those adopting a daily intervention strategy have continued with this, but the numbers of schools doing this has not increased to any great extent. This may reflect practical issues of staffing and timetabling.

Table 16 Frequency of intervention and frequency of pupil identification for intervention

Frequency of intervention	No: of schools	Frequency of pupil identification	No: of schools
Daily	29	Daily	31
Less than daily	15	Less than daily	12

*Totals are greater than 43 due to some respondents saying there was variation between classes or years.

It is important to note, approaches to intervention are implemented in a variable way in many schools (see Section 5). These variations in implementation include for example, different approaches in different classes and year groups, including variability in the timing of the intervention during the day:

It's not daily for every year group. It's definitely daily for Year 2 and Year 3. Year 4 it's a little bit intermittent and 5, just simply because of staff, but the intention is there that we do the same-day intervention. (School 11A, lead primary teacher)

In Shanghai, daily intervention is undertaken by the class teacher. Table 17 below shows who works with pupils during an intervention in the lead primary schools.

Table 17 Staff working with pupils during intervention

Staff	No: of schools
TA	6
Teacher	16
Teacher and/or TA	20

*numbers are below 43 due to some respondents not saying who worked with pupils

In summary, the exchange has led to a review and change of intervention practices in most schools, with many introducing some form of daily intervention. However, this was not necessarily a full replication of the Shanghai approach. For example, some lead primary teachers reported intervention taking place during the lesson (possibly similar to previous practices in which a TA worked with a small group). Some schools appear to have adapted the Shanghai principle of daily intervention by offering individual or small group support (to keep classes progressing together) in the morning, during break, after school, and during assembly, which was generally combined with having a split lesson (see section 4).

Table 18 Timing of intervention

Timing of intervention	No: of schools
After lessons	26
Before lessons	1
During lessons	9
Mixed	7

*Mixed= before and after lessons or during and after for different classes or years.

The amount of daily intervention was said to be dependent on a number of factors, including for example setting arrangements in the school. Where pupils are set within classes, those pupils set in a lower attainment group may be more likely to receive intervention on a regular basis in a similar way to before the exchange. Other factors include timetabling arrangements, staffing and other logistical issues, and even parental permission where intervention takes place after school. Some schools reported having a number of interventions in mathematics running concurrently, including, for some, pre-learning¹³.

¹³ Teaching individuals or small groups lesson content prior to teaching the whole class.

For those adopting a Shanghai style daily intervention, most said that those pupils requiring intervention would vary daily (as shown in Table 16 above):

It's highlighted the children who have got gaps or the children who have got misconceptions and actually they're not the same children. Sometimes they are, but most of the time they're not the same children from every lesson. It's become far more bespoke and far more individualised to the children's needs. (School 22A, lead primary teacher)

I think that has been one of the most successful changes that we've brought in and it's successful from the children's point of view of themselves, because they know that they'll get help if they need it and they know that if they've understood it that day then they'll be left to work on something which will deepen their understanding... it's much more targeted support. (School 10A, lead primary teacher)

4. Supportive changes

Schools have made changes to various practices to support the pedagogical changes. These are different to how this pedagogy is enabled and/or supported in Shanghai, taking into account the English context. This section reports on these supportive practices.

4.1 Key findings

- Around a third of schools adapted their timetable, including 11 schools that split lessons into two parts to align with Shanghai lesson structures.
- Although lesson preparation was not asked about directly, some schools reported more detailed planning of questions and planning for misconceptions.
- Homework practices remained unchanged for the majority of schools, where schools had made a change (n=12) this was more likely to be to the content (n=9) rather than the frequency (n=3)
- All schools used formal professional development activities, particularly external events, in-school CPD, teacher research groups, in-class support and modelling to support the implementation of teaching for mastery. Learning through informal CPD opportunities was also important. The most frequently reported outcome was enhanced subject and pedagogical content knowledge (n=34).

4.2 Timetabling

In Shanghai, mathematics lessons are shorter than is customary in England - usually 35 to 40 minutes rather than an hour. Arguably, highly interactive lessons require teachers and pupils to work more intensely but for shorter periods of time. Approximately, a third of schools have made timetabling changes to adapt the Shanghai model in their schools (see Table 19). Most schools have kept lessons the same length which was reportedly an average of about 1 hour, although a number of teachers said that the length of the lessons were different for different year groups.

Table 19 Changes to timetabling

Changes to Timetabling	No: of schools
Additional lessons	1
No Change	27
Shorter lessons	4 ¹⁴
Split lesson	11

A notable innovation is the introduction of split lessons usually with an assembly in the middle. The first part (normally around 30-40 minutes in length) would entail pupil teacher interaction and questioning, and then pupil practice. During assembly, teachers would use the time to assess the progress of pupils work. The second part (around 20-30 minutes) would then be used to deepen knowledge or for daily intervention for those pupils needing it.

Some teachers talked about 'splitting' the lesson, however not in relation to a timetable/organisational change, but in terms of the lesson activities, as discussed in relation to classroom practices, having half or more on teacher and pupil interaction, and then having the second part of the lesson with pupils practicing. In these examples there was no actual split or break in the lesson:

The actual structure of the lesson and the lesson timing, it's more to do with the children interacting with the teacher for a far longer period and then doing some independent practice afterwards, rather than a short period with the teacher and then a long period of working independently. (School 22A, lead primary teacher)

A much smaller number of teachers reported changing to a shorter mathematics lesson (n= 4), and one of these teachers reported how shortening the lesson fit naturally with adopting Shanghai practices:

We realised, looking at the Shanghai lessons which were much shorter, it's not about how long they are, it's about what you put in it. We recognised that children spent ages doing independent work and in fact we didn't need to do that anymore because they were only doing three or four examples, rather than 25 examples. There was no need to keep that lesson longer. It also gave us an opportunity to do some other catch-up intervention, other things after lunch and at different times of the day. (School 19B, lead primary teacher)

¹⁴ In the NCETM survey of lead primary schools, respondents were asked if lessons were either the same length as previously or shorter, with 8 responding that they were shorter. The difference in data may be explained by some interviewees where lessons are shorter referring to this through the category 'split lesson'.

4.3 Lesson preparation

The NCETM is promoting the term 'lesson design' (NCETM, 2016) as an alternative to 'lesson planning' which is the usual term in English primary schools. The concept of design points to the Shanghai practice of giving a carefully sequenced journey through mathematical content and the focus on key concepts and procedures, and consequently tasks, activities and questions focused on these. The term 'design' was used by a number of interviewees. However, more often reference was to planning. In this section we use the term lesson preparation to encompass both design and planning.

Lesson preparation was not a theme for the interview. However, prompts about preparation were included in questions relating to strategies to develop teacher questioning, and also when interviewees were asked about other practices that had changed. Thus, data on lesson preparation is indicative and only related to 26 out of 43 schools. Emergent themes will be addressed in more depth in the third set of interviews in 2017.

Interviewees referred to a greater focus in preparation on conceptual understanding and also more detailed planning of questions, particularly in relation to anticipated misconceptions. A number of schools reported innovative tools to support planning, such as frameworks to ensure different representations were included, or principles to work through that would support depth of understanding. Lessons were prepared either individually, with a common approach (for example modelled by the lead primary teacher), or through collaborative processes which in two cases were linked explicitly to Teacher Research Group's adopted from Shanghai practice. Although data is limited, there is some evidence of a link between collaborative approaches and more embedded implementation of mastery.

4.4 Homework

Whereas in England practice exercises are generally completed during the hour lesson, in Shanghai homework is set daily. Lead primary teachers were not asked detailed questions about homework as this had not been identified by interviewees in 2014/15 as an area likely to be as subject to change as other practices. During the 2015 interviews, lead primary teachers were asked in general about school practices, such as homework, and 12 interviewees reported changes to homework, with the type of change each reported below.

Table 20 Changes to homework practices since the exchange

Changes to Homework	No of schools
Change in content	9
Change in frequency	3

During the 2016 interviews, 19 interviewees mentioned their homework practice. When discussed, homework procedures were often said to be unchanged (n=9), or where there had been a change, this was a change in content (n= 9) rather than frequency (n=3) such as being more topic specific, focussing more on number or times tables. Some teachers voiced concerns in relation to moving to more frequent setting of homework, in relation to parental reaction.

Some schools have changed to include more variation in the homework set, with questions for depth of understanding. One teacher talked about using homework to enforce the methods used and to show parents examples of methods:

Things like the homework we make sure that it's really topic specific, so what we try and do is send home examples of worked examples, so if in class we're using a particular strategy, we'll try to put that as a topic for homework so parents can be informed. (School 18A, lead primary teacher)

Conversely another teacher explained that they had concerns over confusing parents with methods and therefore avoided setting topic specific homework:

We've tended to shy away a little bit from sending maths [homework], just because we're worried that parents wouldn't have the knowledge of how children have been solving things in school, and it could send mixed messages, so the only maths we have sent home has been that sort of rote learning and recall kind of thing, like number bonds and times tables. (School 16A, lead primary teacher)

4.5 Professional development activity

As noted in the first interim report, teachers visiting Shanghai were impressed by the sustained and embedded professional development they observed and in particular by Teacher Research Groups. Hosting Shanghai teachers gave an opportunity to innovate forms of professional learning and this has been sustained in many schools in the second year of the exchange. Further, adopting or adapting East Asian practices has created a need and opportunity for significant professional learning.

All the lead primary schools deployed a range of sustained professional development activities to support the implementation of mastery practices. Three different stimuli for professional development were described by lead primary teachers: formal activities such as in-school CPD and Teacher Research Groups; embedded activities where learning arose from engagement in teaching practices such as collaborative lesson planning; and informal discussion.

Formal professional development activities spanned: attendance at external courses; conferences and workshops; in-house CPD and staff meetings; Teacher Research Groups; in-class support and modelling; and observation. External courses

predominately were those provided by NCETM, including the PMTMSP, and by the local maths hub. Generally, they were attended by the lead primary teacher and sometimes a small number of other teachers with responsibilities for leading mathematics.

Interviewees reported that course attendance was important in supporting the development of subject knowledge in their school and providing demonstration lessons or CPD activity that could be replicated in school. External conferences, particularly national conferences, were valued as an opportunity to find out what others were doing, talk and reflect on their own practices.

Since the exchange, there has been a sustained focus on teaching for mathematics mastery within in-school CPD events and staff meetings:

The amount of time we've spent thinking about mathematics has changed significantly. It's been a real focus in staff meetings and much more regularly.
(School 31A, lead primary teacher)

This form of CPD was perceived to 'get people on board', 'ensure they got the same message', and build subject knowledge as well as providing the opportunity to plan changes to practice and review implementation. More broadly, in-school CPD created a 'buzz about maths as a subject' and fostered increased talk about teaching mathematics. Teacher Research Groups, in-class support, modelling and observation were perceived to enable in depth learning on how to implement or further refine specific practices. The nature of Teacher Research Groups varied - in some cases lead primary teachers described a lesson study approach involving joint planning, observing the lesson (in person or watching a video of the lesson) and post-lesson discussion. In other cases joint planning was omitted, focusing instead on the teacher (often the lead primary teacher) delivering the lesson, and on the post-lesson discussion. Post-lesson discussions in these cases included the rationale for planning, as well as the group unpicking what had happened during the lesson. Modelling mastery teaching - either to a group of teachers or as part of a normal lesson was regarded as important:

I've just had an open classroom...I'll plan a lesson and I know obviously all the elements that need to be there, so I try and make sure everything that I'd expect to see in a lesson was there.. They saw the expected standard or quality of a lesson of teaching for mastery really. (School 21A, lead primary teacher)

Lead primary teachers reported that teachers' engagement in collaborative lesson planning and the use of a text-book or other resources, and activities embedded within practice, also supported professional development. The detailed focus on developing conceptual and procedural fluency in lesson planning was perceived to enhance subject knowledge and support teachers in developing questions. Text-books were perceived to improve confidence, for example in how to use resources effectively, and subject knowledge:

There are several high quality published resources around things like [textbook name] practice books have been really useful, because they've got some of that variation in the practice activities for the children, so they've been really useful for staff who are really struggling.....If you don't understand a concept yourself, you're not going to be able to explain it to somebody else. (School 22A, lead primary teacher)

A frequently mentioned outcome of formal and embedded professional development activities was increased informal talk about teaching and learning in mathematics, including more willingness to share ideas and to give non-performance related feedback. This, in turn, created an opportunity for informal professional development. Lead primary teachers perceived that these opportunities led to further enhancement of subject knowledge as well as a positive attitude towards developing practice.

There is a really nice atmosphere in school where people just go and ask for advice, talk about things, discuss things, get their books out, look through things together... It has had a big impact on our subject knowledge. (School 16A, lead primary teacher)

5. Variation in implementation across year groups

5.1 Key findings

- Substantial implementation was most frequent in schools in year groups 1-4, Reception and Years 5 and 6 had less substantial implementation.

5.2 Patterns of implementation by year groups

In order to assess the level of implementation across classes and year groups in the schools, schools were asked to complete a grid prior to the interview which asked how many classes and years were implementing 'some', 'substantial', or 'no' Shanghai informed mastery teaching in 2015/16. This data had been recorded previously for 2014/15 through the first interviews and triangulation with the schools end of year reports for the NCETM.

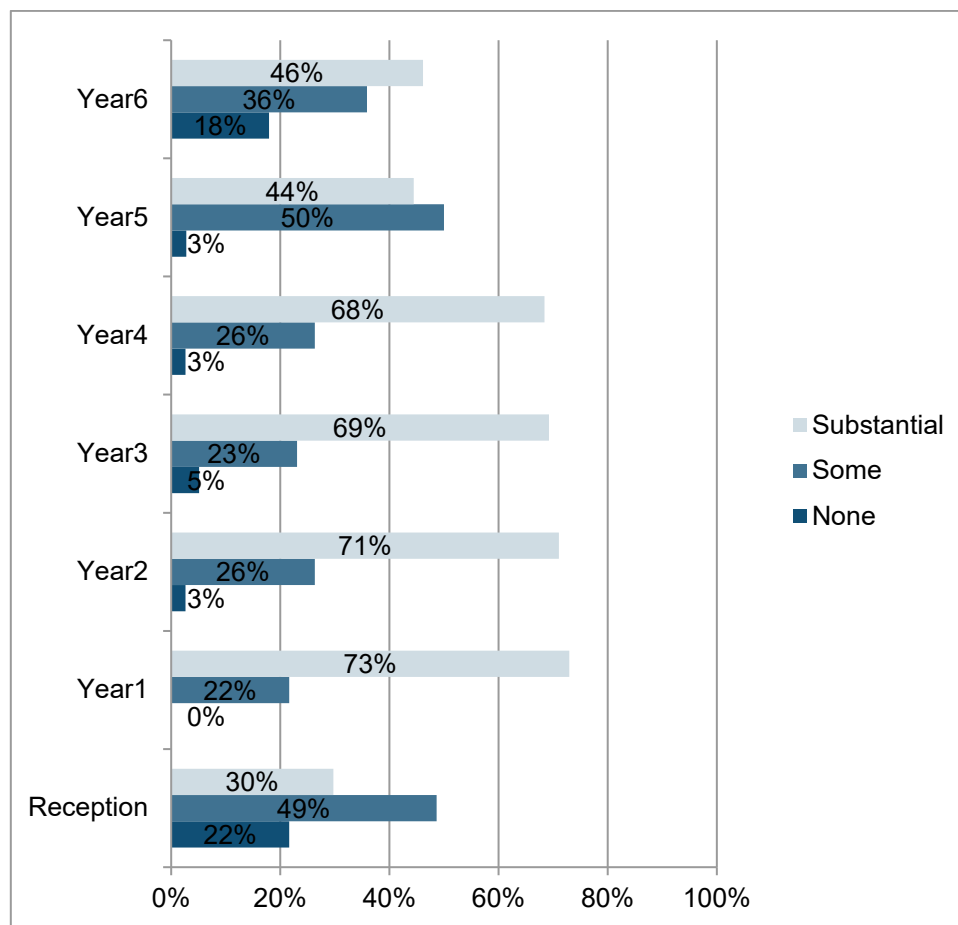
During interviews, lead primary teachers were read a statement summarising Shanghai informed pedagogy, and asked to confirm or amend data recorded on 2014/15 implementation by year group, and to provide detail of 2015/16 implementation by year group. The tables below report descriptive summary statistics for the 43 schools. However, in Table 22 there is some missing data and in addition one school was an infant and another separate junior school, so the maximum number of schools for each year would be 42. In larger schools, where the lead primary teacher was attempting to answer on behalf of the whole school, there was sometimes a lack of knowledge of exactly what was happening in each class in each year group.

Table 21 and Figure 1 below show that either 'some' or 'substantial' implementation is happening across the year groups in the schools. Substantial implementation is happening the most in Years 1- 4 (between 68% and 73% have substantial implementation in these year groups). There is less substantial implementation at Reception (30%), Year 5 (44%), and Year 6 (46%). Reception (22%) and Year 6 (18%) are the year groups where no implementation was occurring in 2015/16.

Table 21 Implementation in 2015/16 by year group

	none		Some		Substantial		Mixed implementation with year groups		Total n*
	n	%	n	%	n	%	n	%	
Reception	8	22%	18	49%	11	30%	0	0%	37
Year 1	0	0%	8	22%	27	73%	2	5%	37
Year 2	1	3%	10	26%	27	71%	0	0%	38
Year 3	2	5%	9	23%	27	69%	1	3%	39
Year 4	1	3%	10	26%	26	68%	1	3%	38
Year 5	1	3%	18	50%	16	44%	1	3%	36
Year 6	7	18%	14	36%	18	46%	0	0%	39

Figure 1 Implementation per year group, considering only year groups where there was consistency



As shown in Figure 1, there are lower levels of implementation in reception and Y6. With regards to reception classes, children in Shanghai start primary school later than in England and so would not routinely experience the pedagogical approaches being implemented. Therefore, schools do not have models of practice or curriculum to follow. Further, formal whole class teaching is not particularly encouraged in the EYFS framework. With regard to Y6, interviews gave two reasons for lower implementation. Firstly, a concern that pupils in this year group had 4 years' experience from Y1 to Y5 of other methods and often large gaps between pupils were already present. Secondly, some respondents cited the pressure of SATS and avoidance of risk as a reason for continuing with their customary approaches to prepare children for national tests.

Data presented in Figure 1 is relevant to the comparative study of impact on attainment that will be reported in the final report. This study focused on Y2 and Y6 outcomes, thus implementation in 2014/15 with the Y1 and Y5 pupils and then the same cohorts in Y2 and Y6 will be important to interpreting the impact analysis.

Table 22 shows the number of year groups in which schools are implementing substantial mastery practices: 6 schools indicated that they were doing substantial

implementation across all year groups; a further 9 across 6 year groups; and 10 schools were not implementing substantial mastery teaching across any whole year group, however may still be doing some within year groups. Interview data on implementation is supported by similar patterns across year groups reported in the NCETM survey of lead primary schools (see Annexe C).

Table 22 Number of year groups experiencing substantial implementation

	n	%
No substantial implementation	10	24
2 year groups experiencing substantial implementation	5	12
3 year groups experiencing substantial implementation	5	12
4 year groups experiencing substantial implementation	4	10
5 year groups experiencing substantial implementation	3	7
6 year groups experiencing substantial implementation	9	21
7 year groups experiencing substantial implementation	6	14
Total	42	100

Interviewees were asked about any key difference between classes and years in terms of implementation of aspects of Shanghai informed pedagogy. Smaller schools tended to have a more consistent approach across classes and year groups. In those schools who talked about differences in school practices depending on classes and year groups, this was most often in relation to interventions.

Table 23 Variation of implementation and timing of intervention

Level of intervention	No: of schools
Varied by class or year	25
Whole school approach	18

However some lead primary teachers also mentioned variation by class or year group in relation to attainment grouping (shown in Table 24). Smaller levels of variation were also reported for homework, textbook use/schemes of work, and lesson timing/organisation.

Table 24 Consistency of grouping arrangements

Consistency of form of grouping	No: of schools
Consistent across the school	28
Variation by teacher	2
Variation by class or year group	13

Some teachers reported lower implementation in years 5 and 6 due to large attainment gaps that had emerged in these year groups, and a focus on SATs in year 6, meaning

that changes to practice were limited. Lastly, some teachers talked about variation due to teachers' experience. For example, where there were mathematics specialist teachers or teachers who had been on the exchange, mastery was more likely to be strongly implemented in their classes. In addition, where less experienced/less confident teachers or supply teachers were teaching a class, there may be less of a mastery focus.

6. Extent of school level change arising from the exchange

6.1 Key findings

- Changes made to practices were more likely to be classroom practices such as pace and tempo in lessons, rather than school wide practices such as timetabling and grouping. The vast majority of schools were able to attribute the changes to the exchange as opposed to other influencing factors.

6.2 Changes to practice

Below, detail of implementation of Shanghai informed pedagogy is reported. In this section there is an overview of the extent to which practices have changed as a result of participating in the exchange. Interviewees were asked whether they (and their colleagues in the school) had made changes to a range of classroom and school practices since the beginning of the exchange in 2014. Responses were categorised using four codes - yes, partially¹⁵, no, and unclear. The code 'unclear' indicates that when asked about that issue, the respondent discussed another issue or their response was unclear. Interviewees were then asked whether the change was due to the exchange. Responses were categorised; yes, partially¹⁶, no, unclear or NA where they had not made a change to the particular area. Figures 2 and 3 below show the responses for the categories yes, partially, and no.

Figure 2 highlights that the greatest changes to practice were to classroom practices such as conceptual and procedural fluency and the pace and tempo of lessons, rather than school wide practices such as timetabling and grouping. This is to be expected due to the relative ease of making these types of changes. Homework was the practice least likely to have changed across the schools.

¹⁵ Here partially may refer to both a partial change to practice, or to a change in some classes/year groups and not others.

¹⁶ Here partially may refer to the school already having adopted a mastery related practice prior to the exchange, or that their change to the practice came about for a reason other than the exchange.

Figure 2 Extent of Changes made to practice since 2014

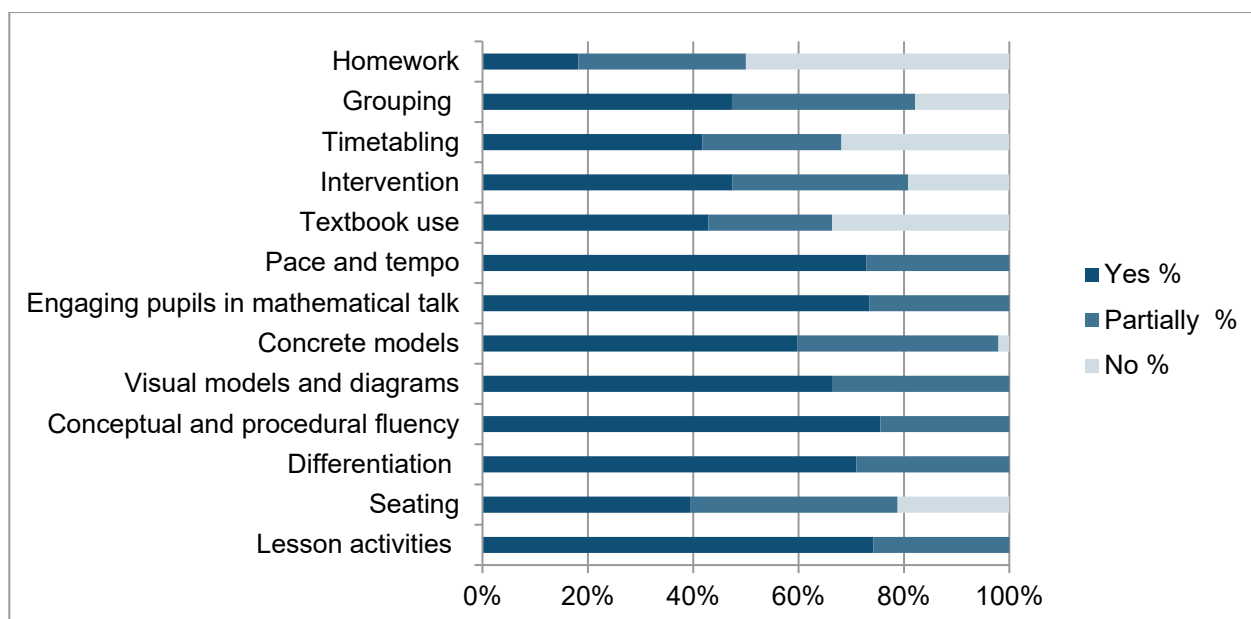
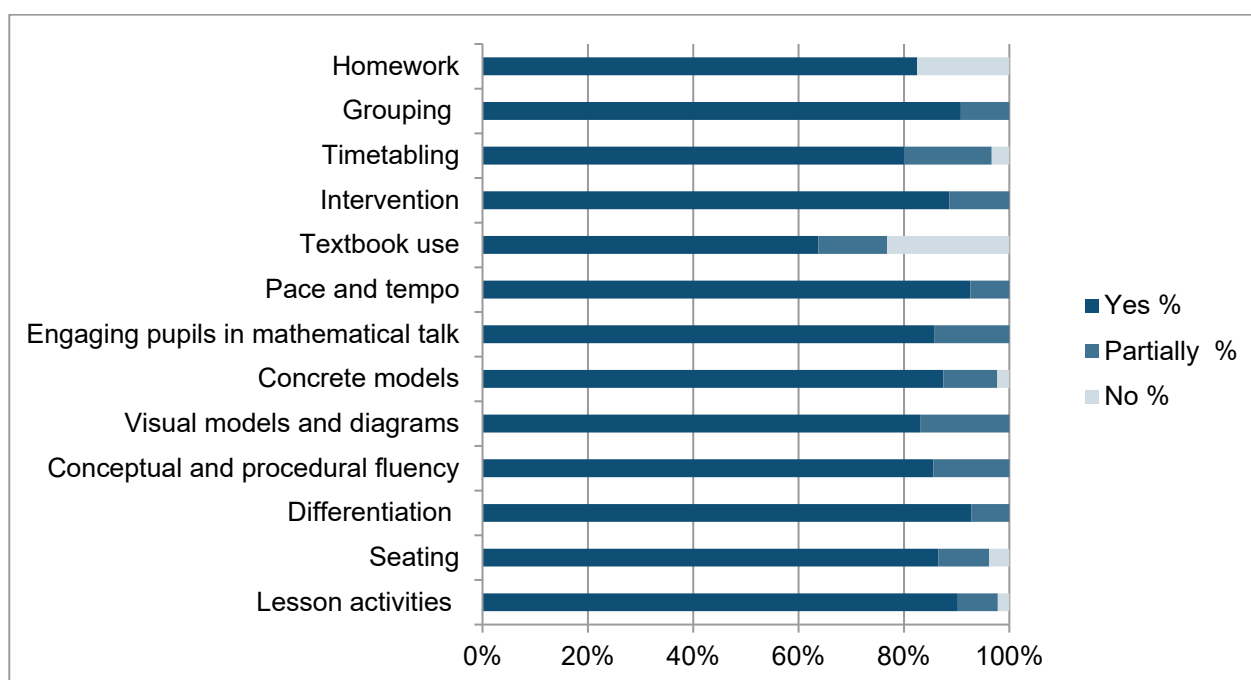


Figure 3 shows that changes made were, in the large majority of schools, a result of taking part in the exchange.

Figure 3 Extent of change as a result of the exchange



7. Factors influencing implementation

7.1 Key findings

- Most lead primary teachers (n=37) stated that they were now 'very committed' to mastery.
- Classroom practices were said to have been on the whole easier to implement than school wide practice.
- The most frequently mentioned enabler to implementation of a mastery approach was professional development (n = 30).
- Teacher beliefs, knowledge and confidence was the most reported barrier (n=17).

7.2 Orientation to mastery

An important overarching factor influencing implementation is the schools' orientation to mastery¹⁷. Lead primary teachers were asked about how committed to mastery their school was since they have been involved in the project for roughly a year. As Table 25 below displays, the large majority of lead primary teachers (n=37) stated that they were 'very committed' to mastery. For the lead primary teacher who answered 'somewhat cautious', this was said to be due to the number of new staff having started at the school, meaning that mastery teaching was not fully embraced at the school at the time of interview.

Table 25 Commitment to mastery

	Very committed	Somewhat committed	Somewhat cautious	Very Cautious
Orientation to mastery 2016	37	5	1	0

7.3 Ease or difficulty of implementation

There was variation in which aspects of Shanghai informed practices different schools found easier or more difficult to implement, with some schools finding one component easy to implement, while others found the same component difficult to implement. Nonetheless, analysis indicates that generally schools found it easiest to change the

¹⁷ Detail of relationships at the start of the exchange are provided in Annexe C

structure of lessons and approaches to classroom interaction and talk, including the use of precise mathematical language - all aspects of diverse and interactive teaching. Lead primary teachers linked ease of implementation of these aspects of mathematics mastery to a range of factors, including the in-depth professional development they and/or teachers in school had received, planning resources, and approaches to talk and discussion that mirrored approaches in English teaching. More generally, interviewees reported that it was easier to implement changes with the classroom than to orchestrate whole school practices.

Replacing differentiation by pre-allocated task with mastery approaches that keep the whole class together and deepen understanding was often found to be challenging, as was planning for conceptual sequencing and practice that included procedural variation. Lead primary teachers attributed the difficulties to a range of factors. These included teachers' concerns that they would be unable to address the needs of both high achievers and pupils with SEND or to meet Ofsted retirements, and their lack or understanding of how to deepen understanding.

What's been difficult I think is for some people to get their heads around no differentiation and worrying that they're not stretching the more able. That's what they've found really hard, to know how to deepen for those children. We've had to work a lot on supporting them in doing that, knowing how to do that. (School 11A, lead primary teacher)

The above quote suggests a possible misinterpretation of the mastery approach as meaning no differentiation rather than a change in differentiation (ATM/MA primary working group, 2016). In addition, keeping the whole class together was found to be difficult in classes with a wide attainment range and where senior leaders were not convinced of the need to replace differentiation by pre-allocated task with more responsive practices.

7.4 Enablers

As Table 26 illustrates, professional development was the most frequently mentioned factor that supported the implementation of Shanghai informed pedagogy. In 14 of the 30 schools who identified the enabling role of professional development, the influence of the exchange and subsequent follow-up meetings were highlighted. It is also notable that schools in which there are teachers who have engaged with the PMTMSP have relatively higher levels of implementation of mastery practices.

Lead primary teachers highlighted the impact of visiting Shanghai on their enthusiasm for implementation, the importance of the visit by the Chinese teachers in generating staff 'buy-in', and the value of on-going networking with others who had been to Shanghai in supporting implementation.

And also [the visit to Shanghai] being followed so quickly by a visit from the Chinese teachers, was invaluable. Without a doubt, it wouldn't have had the impact without their visit and without their resources to build upon. (School 20A, lead primary teacher)

Participation in external conferences and courses, predominately provided by NCETM or the local mathematics hub, provided lead primary teachers and others in their school with subject knowledge, and the opportunity to share ideas on how to implement aspects of mastery teaching, as well as confidence which helped to maintain momentum. In section 3.1, the sophisticated discussion of mathematical learning and mastery of some lead primary teachers was noted. It is notable that such teachers were generally ones who were participating in the PMTMSP.

As reported in section 4, implementation was supported by sustained in-school professional development. The enabling impact of modelling and coaching were emphasised in three schools, as exemplified below:

There is a teacher who was struggling with the approach. I taught a lesson and one of her perceived most able children couldn't grasp a really simple concept when asked to show it as a representation. [...] the ability to unpick that with the class teacher, there and then, helped to show that if we had been teaching in the traditional way, you'd have been giving this child something to move them on and never exposed any deeper understanding of misconception. Being able to model the examples and model the language used and show that the less able children can keep up. Yes, I think that's really helped. (School 4A, lead primary teacher)

Table 26 Enabling factors each reported by 10 or more schools

Enabling factor	No: of schools
Professional development	30
Staff responsiveness	19
Resources	16
Senior leadership support and engagement	16
Lead primary teacher and others leading the implementation	10

As might be expected in all educational innovations, the willingness of staff to 'have a go' (mentioned in 19 schools) and the support and active engagement of senior leaders (mentioned in 16 schools) in driving implementation were important enablers. The availability of supporting resources, mentioned as an enabler in 16 schools, was particularly apposite in implementing lessons from the exchange. NCETM guidance on mastery, reasoning, assessment and progression, materials from maths hubs, a named textbook, a translated Year 2 Shanghai textbook, Kangaroo maths and NRich materials were all identified as enablers. These resources supported implementation in two ways.

Firstly, they provided structures for planning, and activities and images that could be used in lessons to support mastery approaches:

[We are] using a lot of the NCETM materials as well, because they're specifically for the mastery. So the assessment guidance and the mastery guidance... and the reasoning questions and the activities, we've been using a lot of those. So [in Years 1 and 2 and Reception] there's been a complete shift in how they're approaching their maths and how they're organising activities. (School 18A, lead primary teacher)

Secondly, lead primary teachers resources supported the development of teachers' subject knowledge and confidence, and created a positive attitude towards mastery:

Without that Singapore textbook ... I would have more of a battle than I'm having now, because [teachers'] subject knowledge is so weak. They're not going to ask a child why if they don't know the answer themselves. (School 14B, lead primary teacher)

Lead primary teachers were not asked to reflect directly on the impact of their leadership of change. However, it was evident across the interviews that they played a crucial role in driving implementation forward. This included planning and sequencing implementation, delivering CPD, providing in-class support, as well as enthusing teachers, and where necessary, convincing senior leaders of the value of mastery approaches. Lead teachers identified three factors that enabled them to implement mastery within their school: participation in the exchange and other professional development opportunities; time to hone their own practices and provide in-class support to other teachers; and one or a small group of other teachers in the school being given additional training and then promoting and supporting mastery teaching in the school. In addition, where lead primary teachers also had a role in their maths hub, they were able to include teachers in their school in a wider range of supporting activities, such as cross-school Teacher Research Groups, and had greater access to observing effective practice in other schools.

7.5 Barriers

The most frequently mentioned barriers to implementation (Table 27), reported by lead primary teachers in 17 schools, were teachers' beliefs, weakness in subject knowledge and/or low confidence levels. Resistance to change was most often encountered in relation to changing approaches to differentiation since this represented a fundamental shift in teachers' beliefs about pupils' ability to achieve:

It's very difficult because it's taking a very bold and brave move, because we were very preconditioned into thinking that was the way it needed to be. (School 28A, lead primary teacher)

Challenges were also encountered in higher year groups where the attainment gap was wider and teachers' priority was to ensure high SATs results. Some teachers who had a track record of high pupil attainment were reluctant to change their approaches as they feared that attainment could dip. Schools had made progress in changing teachers' beliefs as well as improving their subject knowledge and confidence since the exchange, but stressed that the change was complex and extensive so there was 'no quick fix':

It's naive to suggest that you can absolutely get this straight away, because the whole principle is about deep thinking and refinement over time. We're generalists, we're not specialists. (School 22A, lead primary teacher)

Table 27 Barriers reported by 10 or more schools

Barriers	No: of schools
Teacher beliefs, knowledge and confidence	17
Resources	14
Staff time/ competing priorities	12
Staffing levels and organisation	12

Lack of resources and/or the inappropriateness of available resources were identified as a barrier in 14 schools. The most pressing issue reported was the lack of textbooks, which lead primary teachers attributed to school budget constraints and/or their perception that available resources were not sufficiently well matched to the demands of the new mathematics curriculum. Budgetary constraints also meant that some schools were unable to purchase sufficient manipulatives.

As might be expected, lack of staff time was also identified as a barrier to implementation (mentioned in 12 schools). Interviewees explained that this limited teachers' engagement in professional development activities and in-depth discussion of lessons. Likewise, some schools were unable to release lead primary teachers from their own classes to support others. Constraints on time were compounded by competing demands and changes in other areas of the primary curriculum:

There has been a lot of change in school...In another year everything else would be ticking along quite nicely and we'd have a real focus on maths, but every bit of planning has changed, every bit of assessment has changed, so teachers' capacity to think and be creative...has been hampered. (School 31B, lead primary teacher)

The level and organisation of staffing impeded implementation (mentioned in 12 schools) in a number of ways. The most frequently mentioned issue was turnover of staff which necessitated continual training and slowed the progress of implementation, an issue that

was also evident in schools with a high number of NQTs. In instances where a lead primary teacher or other in-school implementation leader left the school, the loss of momentum was marked¹⁸. Organising staff to enable daily intervention proved problematic in some schools. Class size was not mentioned as a relevant concern. Issues of leadership and staffing will be explored further in the final report.

¹⁸ It is also noteworthy that issues of leadership change appeared to be important in relation to some schools that declined to take part in the second round of interviews. Although given that participation was withdrawn reliable data is not available.

8. Teacher and pupil outcomes

In this section we consider outcomes for teachers and pupils as a result of the exchange.

8.1 Key findings

- The professional development outcome mentioned most frequently was knowledge (n=34). This was discussed in relation to both subject and pedagogy.
- Teachers reported that pupil achievement was more than expected in a number of areas such as mathematical talk (n =37) however there was less certainty for pupil attainment where 18 teachers answered it was higher than expected.

8.2 Professional development outcomes

This section focuses on the lead primary teachers' perceptions of the professional development outcomes that occurred for teachers in their schools. Table 28, which summarises qualitative responses, indicates that the most widespread teacher outcome was enhanced knowledge (reported in 34 of the 41 schools who discussed positive teacher outcomes). Increased teacher affect (mentioned in 20 schools), changes in beliefs (19 schools), and increased teacher confidence (12 schools) were also reported as significant outcomes.

Table 28 Professional development outcomes

Professional development outcome	No: of schools
Knowledge	34
Affect	20
Beliefs	19
Confidence	12
Any PD outcome	41

Changes in knowledge, beliefs, affect and confidence were inevitably highly inter-related. In many instances interviewees pointed to a general improvement in teachers' subject and pedagogic subject knowledge, beliefs, affect, and confidence. Where they made specific links between knowledge development and the critical components of mastery teaching, they most frequently (15 schools) referred to developing mathematically meaningful and coherent activity - spanning conceptual and procedural fluency, visual and concrete representations and how to use resources. Changes in beliefs related most

frequently to engaging and challenging the whole class (mentioned in 9 schools) than either varied interactive teaching or practices grouped as mathematically meaningful and coherent activity. Recognising that all children have the potential to achieve was perceived to be a particularly important outcome. This belief change was further supported by the realisation that replacing differentiation by prior allocated task and attainment grouping with whole class strategies designed to engage and challenge all enabled mixed attainment teaching. Lead primary teachers also mentioned the importance of changes in teachers' beliefs about their subject knowledge and ability to teach mathematics, which they related to increased affect and confidence.

8.3 Pupil outcomes

This section gives a summary of lead primary teachers' perceptions of pupil outcomes on a number of measures for those pupils in classes in which Shanghai informed practices were implemented to at least some extent.

Table 29 below shows that on all indicators, with the exception of pupil attainment, 37 lead primary teachers stated that pupils had progressed more than expected; this was particularly the case for pupils' mathematical talk (the same number) and pupils' attitude towards, and confidence in mathematics had also increased. Lead primary teachers were less confident about improvements in pupils' attainment, however, 18 lead primary teachers answered that attainment outcomes in mathematics were more than expected.

Table 29 Perceptions of pupil outcomes

Perception of pupil outcome statements	More than expected	About as expected	Below expected	Not able to answer
Pupils' knowledge and understanding of key mathematics	29	11	0	3
Pupils' mathematical talk	37	5	0	1
Pupils' engagement in class	33	7	0	3
Pupils' attitude towards and confidence in mathematics	37	4	0	2
Pupils' attainment	18	14	1	10

For those who felt that there had been an increase in attainment, evidence for this was limited and often said to be anecdotal. When asked about evidence, some teachers were able to say there had been improvements in internal assessments, and most teachers talked about looking in pupils' books at their understanding of key concepts and methods or observing classes where pupils were engaged and using mathematical language:

You'll often hear, even quite young children engaging in mathematical conversations and explaining their reasoning, and questioning other people's findings and conclusions. (School 32B, lead primary teacher)

[The] Year 2 teacher came in showing me this middle attaining child's work and all the different representations of fractions that she had used and shown. She was absolutely amazed. (School 3B, lead primary teacher)

Teachers talked about narrowing the gap, and how that they were noticing improvements, particularly for the lower attaining pupils in their confidence and ability:

Anecdotally, teachers all say that their children are a lot more homogeneous as a group than they have ever been before. And children who we would have thought previously wouldn't have been able to progress, have, but it's with the removal of levels, it's just so difficult to measure. (School 20A, lead primary teacher)

This was often discussed in relation to teaching the whole class together, removing setting within classes, and the additional support given through daily intervention.

For those answering about as expected (n=14) or not able to answer (n=10), the reasons were a combination of the following; being a high attaining school to begin with, changes to the curriculum meaning higher expectations, changes to assessment procedures making data comparisons difficult, and the focus on deepening knowledge which some felt meant less coverage of curriculum content. Some teachers explained that although higher levels were not being reached, more pupils were attaining age expected levels.

As outlined in Annex C, the NCETM school survey data about pupil outcomes was analysed thematically, in order to triangulate findings and add to the data about impact on pupils. Schools in the NCETM survey were asked specifically about a small number of pupils for whom they felt that 'teaching for mastery' had been particularly significant. When discussing impact on some of the lower attaining pupils, schools reported similarly to above, that there had been an increase in their confidence in mathematics and their language ability. These impacts had come from a combination of: slowing the pace of the curriculum, moving away from differentiated groups, and removing the additional adult support, such as TAs who would have previously worked with these groups of pupils regularly. The approach to whole class teaching had helped these pupils to realise they could access the same work as other pupils, and feel more able to contribute to lessons. For the higher attaining pupils, teaching for depth and working on conceptual knowledge had helped to improve their understanding of mathematics and to apply their knowledge.

There were few examples given about evidence of this impact, such as results in tests, percentage of pupils reaching age related expectations or schools own pupil voice surveys. Most reported that the evidence came from contribution in class, such as verbal and written communication skills. This is in part because of issues of comparability given

recent changes to national assessment. The comparative study of attainment that will be reported in the final evaluation report will address in more depth the impact on pupil learning.

9. Sharing learning with other schools

This section reports progress in the sharing of learning from the exchange with other schools, early indications of the impact of this activity, and the enablers and barriers experienced (Evaluation Objective 9). As noted earlier, schools participating in the Mathematics Teacher Exchange were designated as lead primary schools. However, the very short period of time in which the programme had to be set-up meant no requirement was placed on lead primary teachers to share their learning when they were recruited. It is therefore important to note that although lead primary teachers have subsequently been encouraged by NCETM to share their learning with other schools, they are not accountable for doing so as part of the exchange. As supplementary data to that derived from interviewees, data from the NCETM survey of lead primary schools (see Annexe C) is also reported here about the level of interest in their local area.

9.1 Key findings

- The majority of schools (n=39) had undertaken some work with other schools in relation to sharing learning from the exchange. Types of activities varied, modelling mastery approaches within their own school was the most common approach.
- Other schools were reportedly making some changes to practice but it was too early to report on embedding teaching for mastery practices.

9.2 Interest

The NCETM survey asked respondents to consider how many schools in their area were already very committed to mastery, interested in, or were considering introducing it. This data supplemented interview data, which did not include a direct question on the level of interest of other schools. A total of 27 respondents reported that locally 8 or more schools had introduced or will be introducing aspects of Shanghai style teaching for mastery. Further, 30 lead primary schools reported that there is at least one school in their area, other than themselves, very committed to the approach.

9.3 Activity

Interview data indicated that thirty-nine lead primary schools had led or contributed to activities that shared learning from the exchange with other schools. The four schools that had not done so lacked capacity within their own school due to the mathematics leader leaving, or a more general lack of leadership capacity. The main approaches to sharing learning are summarised in Table 30.

Table 30 Types of work lead primary schools engaged in with other schools

Activity	No: of lead primary schools
Presenting and leading workshops at external events	21
Modelling mastery teaching in their own school	25
Customised support focused on supporting schools to implement mastery in their own context	19

Similar data was reported in the NCETM survey with regard to work with other schools. Focusing on the interview data, presenting and leading workshops at external events had wide reach, typically engaging 50 to 100 schools but, as a 'one-off' events were limited in duration. Modelling mastery teaching within the lead primary school usually mirrored the approaches taken when schools observed the Chinese teachers during the exchange visit. Observation was usually followed by a Teacher Research Group (sometimes referred to as a workshop) where the observed lesson was discussed in depth. In some schools teachers were also involved in discussion of intentions before the observation and/or were provided with an audio commentary while the lesson was in progress. Most lead primary teachers estimated that between 50 and 100 schools had visited their school to observe and take part in Teacher Research Groups or workshops in the period between the exchange and the second year interview. Duration over time varied, in some cases they were 'one-off' events, and in others the same teachers attended on several occasions.

Customised support differed from modelling mastery teaching, in that it focused on the specific needs of participant schools and included opportunities for schools to trial and review the implementation in their own school. Duration was longer, typically spanning a term or more, but reach was more limited, usually engaging between one and ten schools. Some lead primary teachers led this activity as part of their PMTMSP. Most often support took the form of a series of Teacher Research Groups, sometimes supplemented by visits from the lead primary school to observe teaching and directly support implementation. Some lead primary schools adopted a more formal diagnostic school to school support model. The basis for selecting schools varied. In some instances it was determined by system structures, for example schools within the same Federation, in other cases lead primary schools supported any interested schools. Two lead primary schools took a more strategic approach, one to ensure spread across the large and diverse area covered by the maths hub, and the other to target 'educational cold spots'.

While most schools found a strong demand for modelling of mastery teaching and more customised support, a few struggled to recruit participants and/or experienced a drop-off in attendance. However, both the overall level of activity of work with other schools, together with the data from the NCETM survey, indicate that there is potential for lead primary schools to work with clusters of schools to develop wider engagement in mathematics mastery.

9.4 Outcomes

There was no requirement to capture outcomes of work with other schools and, as would be expected, lead primary teachers were only able to comment on outcomes in schools they had worked with more intensely. Their over-riding perception (held by 32 lead primary teachers) was that schools were beginning to implement aspects of mastery and/or were trialling mastery in a limited number of year groups. Of the remaining lead primary teachers who had worked with other schools, one reported an instance of a school fully implementing mastery, and the remaining five were unable to identify outcomes at this stage.

9.5 Influencing factors

The most frequently mentioned enablers and barriers to working with other schools are summarised in Table 31. Maths hubs supported connectivity and networking, provided marketing support, and helped raise the profile of lead primary schools. Some took on an organising role and in one instance provided cover to enable the lead primary school to prepare and deliver training. NCETM resources were identified as an enabler in working with other schools. NCETM also supported profile raising and supported lead primary teachers engaged in the PMTMSP in their work with other schools. Senior leaders in the lead primary school were perceived as drivers of work with other schools as well being crucial to enabling the activity to happen.

Table 31 Enabler and barriers to working with other schools

Enablers	No: of schools reporting enabler	Barriers	No: of schools reporting barrier
Maths hub support	9	Resistance of senior leaders in participating schools	9
NCETM support	6	Staffing capacity in lead primary schools	7
Support of senior leadership in lead primary school	6	Contextualising mastery	4
		Lack of local and/or marketing support	4

The most frequently mentioned barriers to working with other schools were resistance from senior leaders in those schools, particularly where attainment was high, and the lack of staffing capacity in lead primary schools which meant they were unable to release staff to work with other schools. A few lead primary teachers felt unable to provide advice on how schools in different circumstances or with structures such as mixed age teaching should implement mastery:

I think we've come unstuck when teachers have asked us questions about how this would look in their school. (School 2A, lead primary teacher)

A lack of support for marketing and promotion from three local authorities and one maths hub were also identified as limiting work with other schools.

10. Conclusion

In this section, key findings are summarised in relation to evaluation objectives and the prospects for impact on attainment are considered. Following this, implications of findings are discussed.

10.1 Key findings and prospects for impact

10.1.2 Implementation and level of change in lead primary schools (objectives 1 and 5)

Lead primary teachers in many schools report substantial implementation of key aspects of Shanghai pedagogy and significant levels of change in practice, particularly in those schools that were newly engaged with East Asian informed practices. Teaching was focused on conceptual understanding and procedural fluency through increased use of representations, a slower more step by step pace through the curriculum, and varied interactive teaching. A notable change has been the adoption of textbooks by many, as well as the exploration of alternatives to pre-allocating tasks to pupils. Linked to this is a move by many to embrace whole class teaching approaches.

At this stage of the evaluation, a reliable and accurate characterisation of the overall degree of implementation is not possible. However, patterns across individual practices indicate that approximately 30 schools already show evidence that they have high levels of implementation, or they will have high levels by 2017/18, three years after the exchange ('high' levels is understood in relation to what can reasonably be expected to be undertaken in current English contexts). It is important to note that change has not been limited to learning from Shanghai, particularly in relation to the embrace of the importance of concrete experiences in conceptual development, emphasised in Singapore. The remaining 13 schools considered in this report, are broadly evenly split between those which have made significant steps towards high levels of implementation and those where change is more limited. Taken together these indicate that pupils in many of these schools now experience a markedly different way of learning mathematics than previously. Changes were directly linked by teachers to engagement in the exchange.

10.1.3 Professional development outcomes (objective 4)

Lead primary teachers describe professional development outcomes in relation to teacher knowledge but also affective dimensions, including increased confidence and changed beliefs in relation to all children being able to achieve highly.

10.1.4 Activities that have been successful in meeting the aims of the programme (objective 6)

Key activities have been the exchange itself, and activities and support led by the NCETM and Maths Hubs. However, embedded professional development, for example through engagement in collaborative planning, has also been important. The impact of these activities has been enhanced or constrained by school-related factors such as the orientation of senior leaders and staffing stability.

10.1.5 Pupil performance and depth of understanding of key concepts (objective 7)

Lead primary teachers are positive about the impact on pupil performance and understanding. This is perhaps not surprising given that the individual components of implementation, such as interactive teaching, the use of multiple representations, and all attainment teaching, have all been shown to have positive effects on pupil attainment (Higgins et al., 2013).

10.1.6 Sharing of learning and embedding in other schools (objective 9)

Most lead primary schools have engaged in activities to share their learning more widely. This is beginning to influence practices in other schools, but has not yet led to fully embedding mastery practices in those schools.

10.2. Implications

In this section, implications of the interim findings for various stakeholders and actors, as well as for future evaluation activity are considered. The findings reported here show that in 2015/16, the majority of lead primary schools were actively engaged in learning the lessons from the Shanghai exchange. In 2016 the government extended funding to support mastery innovations, the analysis presented here, and in the first interim report, suggests there should be a specific focus on:

- addressing teacher subject knowledge: the need for investment in professional development
- the value of the exchange experience itself and so the extension of the Mathematics Teacher Exchange to further cohorts
- recognising the value of Singaporean informed practices as well as Shanghai, and their synergies
- the value of mastery informed textbooks and the issue of the cost of textbooks.

It will be important in the final year of the evaluation, extended to include Cohort 2 of the Mathematics Teacher Exchange, to consider how these initiatives support further implementation in schools. There are, however, a number of issues to consider.

(i) Only 8 teachers from Cohort 1 of Mathematics Teacher Exchange schools have yet engaged with the PMTMSP. Engagement with the PMTMSP could support more schools to deepen implementation in their own schools, as well as provide a greater return on the investment in funding the first exchange. Many lead primary schools have begun to support other schools to implement mastery teaching, but require further support if they are to meaningfully impact on more schools.

Thus, Cohort 1 lead primary schools could be further encouraged to engage with the PMTMSP. In addition, those schools in the original 48 who have found it harder to implement mastery, may be more appropriately engaged as recipients of PMTMSP support, if they are not already being so supported.

(ii) Consideration should also be given to whether the textbook scheme should be extended to Cohort 1 lead primary schools and potentially to the schools they work with.

(iii) The detailed findings on implementation have the potential to inform the design of professional learning activities led by: the NCETM, Maths Hubs, mastery specialist teachers, as well as other providers of mastery focused CPD such as textbook supplier and leaders of commercial programmes.

(iv) The value of the appropriate balance between flexibility of implementation and consistency is an important issue to be considered by all promoting mastery and one to address in the final report.

(v) More directly, the evidence reported of patterns of mastery implementation offers opportunities for self-audit or reflection by teachers and schools on their current levels of implementation, and potentially be a focus for further professional learning.

10.3 Looking forward

The Mathematics Teacher Exchange Cohort 1 schools have extended and deepened practices informed by the exchange and influenced by other mastery initiatives. In those schools where such practices are now embedded, pedagogy is markedly different from practices that have been the norm in English primary mathematics classrooms¹⁹. English primary schools with a range of characteristics have successfully applied lessons from the Shanghai exchange. Schools have learnt lessons from the exchange and drawn on other support to change practice. It is important to note that this is in keeping with the original intervention design which did not specify in advance what practices schools should adopt.

¹⁹ See Boylan, et al. 2016, pages 57-61

However, practices implemented have, individually, good evidence that they can potentially improve mathematical attainment (Higgins et al., 2013). In the final year of the evaluation, the extent to which changes are more fully embedded will be established and this will inform analysis of whether the potential for impact on pupil outcomes is realised. In addition, the third year interviews will offer the possibility to ask interviewees to consider the value of the policy innovation as a whole and of the exchange in particular.

Annexe A. Shanghai and English primary mathematics education

This Annexe is reproduced from the first interim report where it appeared as Section 2.3, pages 16-18, see also first interim report pages 57-61 for more detailed review with sources.

Shanghai mathematics education is a mastery approach and so is premised on the belief that all pupils can succeed as mathematical learners. Classroom practices and organisation of mathematics teaching follow from this belief.

Shanghai whole class interactive teaching aims to develop conceptual understanding and procedural fluency. This is achieved through lessons designed to be accessible to all through teacher questioning and incremental progression. This is supported by well-crafted mathematical models, exemplar problems, and practice materials that focus on critical aspects of mathematical learning. To ensure pupils progress together, tasks are designed to allow for extension by deepening understanding and, in primary schools, daily intervention is used to support those needing extra tuition.

Curricula progression, lesson timing, and teacher roles and responsibilities are organised at a school level to support these approaches to mathematics teaching and learning.

Differences between Shanghai and England in classroom and school practices most salient to the exchange are summarised in the tables below²⁰.

²⁰ It is important to note that whilst there is considerable uniformity in Shanghai mathematics education, there is more variation in English primary schools and so the table describes 'typical' English practices. Further detail is given in Annex A including on cultural and structural differences at system level that are outside the scope of potential change through the exchange.

Classroom practices

Table 32 Differences in classroom practices

	Shanghai	England
Teaching approach and purposes	Whole-class interactive teaching, brisk tempo to cover multiple small steps, focus on questioning, mini-plenaries, teaching for variation, mathematical talk an instructional priority, emphasis on correct mathematical language.	Explanation through teacher transmission (quick pace) plus individual group practice (slower pace), start from objectives, plenary at end of lesson if at all.
Lesson content and purposes	Focus on specific content in a lesson including all small steps, mastery before moving on, start from mathematical content or problem, teaching for conceptual understanding and procedural fluency. Differentiation through extension/deepening rather than acceleration, the whole class progresses together.	Maximise content covered in a lesson, differentiated learning objectives, spiral curriculum, meeting objectives to progress through levels. Differentiated learning objectives and activities, low attaining pupils progress more slowly, higher attaining pupils accelerated.
Materials, models and resources	Textbooks that are aligned with curriculum support teaching with variation, variety of mathematical models and visual images used to support teaching through variation by careful choice of examples and practice questions.	Variety of resources and materials, often worksheets, use of manipulables ²¹ with younger pupils, usually one model or visual representation used per topic/concept.

²¹ 'Manipulables' refers to physical materials such as blocks and cubes to develop understanding of mathematical concepts and procedures.

School practices

Table 33 Differences in school level practices

	Shanghai	England
Organisation of mathematics teaching	Daily 35 minute lessons with practice as homework. Teach 2 x 35 minute mathematics lessons a day, undertake daily intervention teaching, more time preparing than teaching, lesson design rather than lesson planning.	Daily one hour lesson with most practice in the lesson. Prepare and teach almost a full timetable of different subjects, small amount of planning time during the school day.
Curricula progression	Coherent progression encapsulated in textbooks that are system wide.	National curriculum interpreted as school schemes of work.
Pupil access to the curriculum	Pupils taught in all-attainment classes of 40-50 pupils. Daily intervention by class teacher, pupils identified by daily assessment. Daily homework.	Mixture of setting, in-class grouping and all-attainment teaching in classes of 30 pupils. Intervention often by teaching assistant to pupils identified for blocks of time - term or year. Weekly homework.
Teacher roles and professional development	Primary mathematics specialist, undergraduate study of mathematics, teach only mathematics. Teach the same class for a number of years. Teacher Research Groups embedded, 340-560 hours of collaborative professional development in first five years of teaching.	Generalist primary teachers with some specialist teaching at the end of primary school in some schools. Usually teach the same year group for a number of years. Limited opportunities for specific mathematics professional development.

Annexe B. The mastery innovation in England

This section presents an overview of different East Asian informed initiatives and programmes that have come to be collectively referred to by the term mastery or 'teaching for mastery' (NCETM, 2014; 2016). This contrasts with previous uses of the term mastery in education, such as 'learning for mastery' associated with Bloom (Ellis, 2014). Together these initiatives can be referred to as the mastery innovation in England. Different strands of this innovation have influenced each other, and have been developed with the intention of being mutually supportive.

Antecedents

There is a long history of innovation in mathematics education in England being informed by practices found elsewhere, specifically in East Asia. The National Numeracy Strategy (DfEE, 1998) introduced in 1998, promoted whole class interactive teaching, and was informed by comparative studies of international practices (e.g. Reynolds and Farrell, 1996) and educational research (see Brown et al. 2003). The recommendation of a daily oral or mental starter activity was informed by practices in Taiwan, and East Asian emphasis on whole class plenaries was also influential. However, the extent to which such practices were fully implemented is contentious (Smith et al., 2004).

In addition, Japanese Lesson Study has also gathered much interest. This is a collaborative approach to teacher professional learning that is particularly suited to supporting teaching for conceptual understanding (Goldsmith, Doerr, and Lewis, 2014). A comparative study of Chinese and US teachers' knowledge for teaching identified the importance of a 'profound understanding of fundamental mathematics' to Chinese teachers' successful practice (Ma, 1999). This concept influenced the design of subject knowledge enhancement courses for those needing to undertake further study of mathematics before training as secondary teachers (Stevenson, 2008). The importance of deep understanding of subject knowledge also informed the Mathematics Specialist Teacher (MaST) programme, a government supported Masters accredited, 2 year professional development programme for primary teachers (Walker et al., 2013).

More broadly, aspects of pedagogy found in East Asia have themselves been influenced by western educational research and practice. For example, Skemp's concepts of instrumental and relational understanding (Skemp, 1976) and Bruner's categorisation of forms of representation (Bruner, 1966) have been important influences on Singaporean mathematics (Hoong, Kin, and Pien, 2015).

Recognising such antecedents is important to distinguish where more recent innovations have the potential to build on, or reprise previous innovations, and where they bring new elements. It is also important when considering forms of implementation and barriers and enablers to it.

Singaporean informed initiatives

Prior to the Mathematics Teacher Exchange, two innovations informed by Singapore mathematics education were introduced in England. *Maths No Problem* started in 2007, and is based around translations of Singapore textbooks supported by a programme of professional development and online activities. In 2009-2010, the Ark Multi Academy Trust began to develop as a 'curriculum for depth'²² influenced by Singaporean mathematics education. In 2010-11 the term mastery was first used in relation to the programme with Mathematics Mastery adopted as the name. The principles underlying the programme were published in a book aimed at school leaders, teachers and others (Drury, 2014). Mathematics Mastery has been subject to a randomised control trial funded by the Education Endowment Foundation that reported in 2015-16 (Jerrim and Vignoles, 2016; Vignoles, Jerrim, and Cowan, 2015). The evaluation found a small positive effect on attainment. The programme continues to develop curriculum materials for more year groups; by 2016-17 curriculum materials have been developed for Y1 to Y5 and Y7 to Y10. Currently there are 264 primary schools and 103 secondary schools engaged in the programme.

More recently, Inspire Mathematics²³, also based on translations of Singapore textbooks, has been developed. This has been subject to a recent evaluation that found potential for positive impact, though the size of the trial means that caution is needed about ascribing causal relationships (Hall, Lindorff, and Sammons, 2016).

The Singaporean informed initiatives are relevant to the Mathematics Teacher Exchange both as mastery innovations but also more directly. A number of schools were already engaged with these programmes or became so following the 2014/15 exchange (see section 3.2). Consequently, the emphasis in Singapore on using concrete, pictorial and abstract representations in mathematics teaching was important in these schools. This heuristic appears to have been taken up more widely. However, it is important to recognise that the importance of using multiple forms of representations in learning mathematics has been encouraged by English mathematics educators for some time (see for example Haylock and Cockburn, 2013), therefore such ideas will be familiar to many teachers from their initial teacher training. One particularly flexible representation - the bar model - has come to be associated with Singapore, although it is used in Shanghai as well as being an important model in the Realistic Mathematics Education tradition developed in the Netherlands (Van Den Heuvel-Panhuizen, 2003). Notably, the Netherlands is a relatively high performer in international comparative tests relative to other European countries. As reported in Section 3.1, the bar model was frequently referred to by interviewees in the second round of interviews.

²² <http://www.mathematicsmastery.org/about-us/>

²³ <https://global.oup.com/education/content/primary/series/inspire-maths/?region=uk>

The origins of The Mathematics Teacher Exchange: China-England

The origins of the Mathematics Teacher Exchange: China-England were described in the first interim report (Boylan et al., 2016). Here, these are briefly recapped and contextualised in relation to other mastery innovations in England.

Shanghai had outstanding performance on the Programme for International Student Assessment (PISA) 2009 and 2012 tests. Interest in Shanghai's success led the DfE to commission the National College for School Leadership²⁴ (NCSL) to develop the *China Maths and Science International Programme* as part of the UK-China Partners in Education bilateral programme. Activities included a week long study visit in January 2013 of National and Specialist Leaders of Education (NLE/SLE), representing 23 Teaching School Alliances (TSAs), to Shanghai and Ningbo. The latter is a middle size city in a province near Shanghai that attained comparably with Shanghai in PISA 2012, the first year of testing in Ningbo (NCSL, 2013). The NCSL followed up this visit with a specific *International Maths Research Programme China 2014* involving 50 SLEs from a further 48 TSAs in January 2014 (NCSL, 2014). In February 2014, a DfE funded research trip led by the former Parliamentary Under Secretary of State for Education and Childcare, Elizabeth Truss, with a representative from Ofsted and other educational experts, took place. This led to the agreement with Shanghai Municipal Education Commission for a teacher exchange.

The role and activity of the NCETM in relation mastery

This section provides a short overview of the NCETM's main activities in relation to mastery²⁵. Following the February 2014 research trip, the National Centre for Excellence in the Teaching of Mathematics began to develop resources and activities to support schools in learning from East Asian mathematics. The term 'teaching for mastery' was adopted by the NCETM (2014), and the description of this has been further refined (NCETM, 2016). It is important to note, in relation to NCETM activity, that the promotion of 'teaching for mastery' as a set of principles and practices clearly has a significant overlap with lead primary schools implementation of lessons from the exchange with Shanghai. However, it is also important to recognise that they are distinct and so, for example, participants in the Primary Mathematics Specialist Mastery Teacher programme are tasked with supporting schools they work with in implementing teaching for mastery rather than Shanghai specific practices.

During the exchange year and subsequently, as well as coordinating the 2014/15 Mathematics Teacher Exchange, the NCETM engaged in a range of activities to support

²⁴ Now the National College for Teaching and Leadership (NCTL).

²⁵ For fuller description of NCETM activity see <https://www.ncetm.org.uk/>

implementation. Activities included visits to lead primary schools, organising regional and national events focused on mastery, and contributing to other organisations' events. Since the exchange, the NCETM have developed a variety of on-line professional development activities including video material, some of which focuses on exemplary practice in Mathematics Teacher Exchange cohort 1 lead primary schools. The NCETM have developed exemplar assessment materials for each primary year group (Askew et al., 2015). The NCETM regularly include articles on mastery in their newsletters and often it is the main focus of the 'Bespoke' newsletter focused on Maths Hub activity.

The math hubs recruited 140 teachers to a new two-year professional development programme, the Primary Mathematics Specialist Mastery Teacher Programme (PMTMSP), which ran for the first time in 2015/16. The PMTMSP has been further developed, with 140 teachers taking part each year from 2016/17 for the next 4 years. The programme includes online training/courses, and three residential events. Whereas the original Cohort 1 exchange lead primary schools were *encouraged* to share learning with other schools, this is a feature of the PMTMSP.

The Teaching for Mastery programme is expected to reach 11,000 primary and secondary schools in total by 2023. Schools on the programme are eligible to apply for a textbook subsidy (see below).

The expectation on the specialist is that during their training year, they will run a Teacher Research Group (TRG) in their own school to begin to embed teaching for mastery. In the year immediately after training they are expected (and funded) to run a TRG with 6 other schools to support them in developing teaching for mastery. Mastery Specialists are released for approximately 1 day a week to do this. School leadership are expected to support the specialist teacher in undertaking their work. The programme promotes collaborative forms of development found in Shanghai such as TRGs, and provides a forum through which teachers share learning and experiences.

The programme is centred on five core concepts of mastery:

- coherence in teaching
- representation and structure
- variation
- fluency
- thinking mathematically

A number of teachers from lead primary schools in the first cohort have engaged with the PMTMSP, with 6 joining the first year that PMTMSP was offered and 2 joining the second iteration. From 2015/16 the connection between the PMTMSP and the Mathematics Teacher Exchange will be further strengthened in that all 70 of the teachers that comprise Cohort 2 of the Mathematics Teacher Exchange were participants in the first

PMTMSP. The rationale for this is that participants will participate in the exchange having already developed understanding of mastery and East Asian practices. Similarly, future participants in exchange visits will be recruited from PMTMSP cohorts.

Maths Hub activity

The Mathematics Teacher Exchange and other mastery innovations are being implemented and shaped in the context of the move to a self-improving school system. TSAs were central to the initial visits to Shanghai in 2013 and 2014. In July 2014, the DfE established a network of 32 Maths Hubs (increased to 35 since October 2015) coordinated by the NCETM. The Maths Hubs have a central role in the promotion of mastery including: recruiting schools involved in the 2014/15 primary and secondary Mathematics Teacher Exchange; promoting the PMTMSP, including recruiting mastery specialists, and deploying them once trained and overseeing their work; coordinating a variety of professional development activities focused on Mastery, including events linked to Cohort 2 Shanghai teacher visits.

Each Maths Hub is led by a lead school or college with a record of high quality mathematics teaching and high attainment of pupils, and experience in supporting and coordinating professional learning and improvement in other schools (DfE, 2014a). Hubs are tasked with supporting the supply of specialist mathematics teachers, professional learning, curriculum resource development, and support for mathematics subject leadership. Hubs develop projects and activities related to priorities to meet local needs.

Textbook trial and scheme

The Maths Hub led a national textbook trial 2014-16 in which schools used either Maths No Problem or Inspire textbooks. The purpose of the trial was not to compare the textbooks, but rather to enquire into the potential of East Asian informed textbooks generally. Some of the schools in the textbook trial were also involved in the Mathematics Teacher Exchange. The outcomes of the textbook trial were positively viewed by the NCETM. Following this and on the basis of a variety of criteria, the DfE allocated resources to set up a scheme to support schools engaging in mastery to access textbooks to use with pupils²⁶. A set of criteria have been developed for textbooks²⁷ to be eligible for this scheme, and an expert panel will assess applications by publishers for inclusion.

²⁶ <http://www.mathshubs.org.uk/what-maths-hubs-are-doing/teaching-for-mastery/textbooks/>

²⁷ <http://www.mathshubs.org.uk/media/5559/assessment-criteria-final-09012017.pdf>

Annexe C. Methodology

In section 2 of the report, methods of data collection and analysis were summarised. Further details are provided in this section, including, for ease of reference, detail on the overall evaluation objectives reported in the first interim report, where fuller details of the evaluation methodology can be found.

Research questions that informed the interview and analysis

The following research questions were developed to inform the interview schedule and analysis.

- In what ways have lead primary schools changed their practices (as detailed in interim report one) as a result of taking part in the MTE? (Objectives 1, 5, 7)
- What have been the medium term professional development outcomes for teachers in the lead primary schools from participating in the MTE? (Objective 4)
- What are lead teachers' perceptions of pupils' short and longer term outcomes in mathematics? What evidence do teachers have of these pupil outcomes? (Objectives 8,)
- In what ways have the lead primary schools shared their learning from the MTE in the hubs, and more widely? What are the lead teachers' perceptions of the impact of this activity? (Objective 9)
- What activities have been most successful in meeting the aims of the project? (Objective 6)
- What has helped and what has hindered implementing this phase of the programme in lead primary schools and within hubs? (Objectives, 1, 4, 5, 6, 7, 8, 9, as covered in other research questions above)

In addition, we collected data to address any gaps in the descriptive case records from year 1 of the evaluation, for example in relation to the year groups implementing a Shanghai informed approach.

Moreover, a number of questions were asked to provide some level of respondent check on analysis from the first round of interviews, particularly about classes with which mastery was implemented and on schools' orientation to mastery. This was important because of the timing of the first year interviews, in some cases, in the middle of the school year. Later changes in practice may not have been identified.

Interview themes

Interview questions comprised a mixture of open and closed questions. To support validity, the choice and wording of questions was informed by findings from the first year of the evaluation, and by prior research and scholarship about East Asian and other effective mathematics teaching, and was subject to review by an evaluation steering group with relevant expertise.

The interview questions addressed the following themes with regular questioning of the extent of changes for specific practices and variations in implementation across different year groups:

- Lead teacher characteristics
- Scale of Implementation)
- Nature and depth of changes to classroom practices
- Lesson activities and structure, including time spent on interaction
- Seating
- Differentiation
- Developing conceptual and procedural fluency
- Models visual stimuli and concrete materials
- Engaging pupils in mathematical talk
- Pace and tempo in lessons
- Textbooks
- School practices
- Priorities for changes in school practice this year
- Intervention for pupils needing additional support
- Lesson timing and organisation
- Grouping by attainment
- Other school practices (open question inviting response on any other developments)
- Medium term professional development outcomes for the lead teacher and other teachers in the school
- Perceptions of pupil outcomes
- School orientation towards mastery

- Implementation (including ease/difficulty of practices and enablers and barriers)
- Working beyond the school (reach and activity, perceptions of outcomes of work with schools, enablers and barriers of implementation beyond own school)

Details of data collection

In total, telephone interviews were conducted in 43 of the 48 lead primary schools between March and June 2016. The remaining 5 schools withdrew from the research. Reasons given for withdrawal were: a change of staffing - either key staff leaving the school (in one case this was combined with the school not implementing teaching for mastery), or staff shortages, meaning the school staff felt unable to engage. Each of the five schools had been identified as newly committed to mastery in 2014/15.

The lead primary teacher of the 43 schools was interviewed wherever possible. DfE provided a list compiled by the NCETM of 37 of the lead primary teachers. For the remaining 11 schools the teachers from the first round of interviews were contacted and asked if they were the correct person to interview. Where this was not the case, a request was made to interview a teacher who had been on the exchange, ideally the maths coordinator. On the rare occasions where no teachers remained at the school that fitted these criteria, the interview was conducted with a teacher who would have the best overall knowledge of implementation of the innovation in the school. Although not all interviewees identified as a lead primary teachers, for simplicity this is used for referring to interviewees within this document.

Of the 43 lead primary teachers interviewed, 32 had been on the exchange visit in 2015, and the other 11 had not. Of the 11 who did not go on the visits, 7 were maths coordinators, 1 was a head teacher, 2 were teachers, and 1 was a senior leader.

Table 32 shows that the majority of lead primary teachers were maths coordinators (n=21), followed by senior leaders (n=13).

Table 34 Interviewee job roles

Maths coordinator	Head Teacher	Other senior leader	Other teacher
21	7	13	2

Ethics

Full detail of ethics and ethical approval are set out in the first interim report. Informed consent was sought in all cases, both in emails inviting potential interviewees to participate and with information provided; making it clear that participation was voluntary. As noted above teachers in 5 of the original 48 schools declined to participate. Voluntary consent was also reconfirmed at the start of interviews and audio recorded at the start of each interview.

Analysis

Summary data and answers to closed questions were entered into a database by fieldworkers. This data was subsequently checked by a second researcher to ensure reliability. Transcribed interviews were analysed using NVivo 10 software with a variety of protocols and processes used to ensure reliability of analysis. Checks were made against analysis undertaken of the first year interviews. For example, the degree of orientation to mastery was rechecked.

During the second round of interviews (2016), lead primary teachers were asked to think back to the previous year (after they had been involved in the exchange visits) and say whether or not they agreed with this judgement. The results are presented in Table 33 below.

Table 35 Orientation to mastery 2015 and 2016

Orientation to mastery	Newly committed	Already committed	Somewhat cautious	Cautious
Orientation to mastery 2015 judgements	36	7	4	1
Orientation to mastery 2015 confirmed 2016	33	7	0	3

The 'confirmed 2016' numbers do not include the 5 schools who have withdrawn from the research this year. These 5 schools had been categorised as 'newly committed' the first time round.

All categorisations' judgements were confirmed with the exception of 3 schools.

Analysis was both deductive and inductive. Deductive analysis drew on prior research and scholarship about East Asian and other effective mathematics teaching as well as first year findings. An example of this is coding data on the use of multiple mathematical representations to teach a concept. Inductive analysis was used to identify emergent themes and importantly to categorise differences in the nature and extent of implementation of practices in different schools.

An adaptive theory methodology was used (Layder, 1998), with emergent themes and categories identified (Ryan and Bernard, 2003). Across the different interviews, coding was organised into 6 broad thematic categories, as well as contextualising information and case attributes. These 6 themes comprised 16 sub themes, many of which had further sub categories. A total of 224 distinct codes were identified.

To support reliability, frequency of response is provided for the closed questions. Other data are derived from interviewee elaboration or response to open questions. For this data, interpretations have been subject to checking by more than one researcher.

A four phase approach to analysis of the interviews was implemented.

Phase 1: Following each interview, the fieldworker created an interview record on a spreadsheet database that summarised key data where respondents were asked closed questions or to confirm (or amend) existing data held, for example on year group implementation the previous year.

Phase 2: All interviews (except one)²⁸ were recorded and fully transcribed; transcripts were uploaded onto NVivo 10. An initial 'phase 2' coding frame and protocol was developed which detailed how the analysis team of three researchers would code transcripts to ensure that there was consistency in the approach. An analysis meeting of all fieldworkers discussed outcomes from the initial analysis and supported development of the second version of the coding frame. In order to test the second version of the coding frame, the team chose one transcript at random and each coded this transcript. The inter-rater agreement, provided on NVivo, was reviewed by the analysis team and further adjustments were made to the coding frame and coding protocol. This process was repeated a second time; higher inter-rater agreement was achieved and minor modifications were made to the coding frame and protocol to address remaining discrepancies. The transcripts were then divided between the three team members to undertake the phase 2 coding. The purpose of phase 2 coding was to identify all text in the transcripts related to a particular theme, regardless of the place in the interviews the text occurred.

Phase 3: Sets of data coded in relation to different themes were then analysed by different members of the analysis team. Outcomes were discussed and agreed at an analysis meeting. Where coding required interpretation of data which was potentially subjective, data was independently coded by another member of the team and any differences were highlighted and discussed. This procedure was specifically followed

²⁸ See page 20, for one interview recording failed and so a summary record of the interview was made by the fieldworker immediately after the interview to supplement responses to closed questions taken during the interview as noted in Phase 1.

where evaluative judgements of degree of engagement were made related to potential important components of mastery implementation relevant for the sensitivity analyses of the impact strand of the evaluation (see interim report 2).

Phase 4: Closed question data was re-coded in NVivo and checked against the original phase 1 record and changes made where discrepancies emerged. Coding was checked for accuracy and completeness during the process of preparing the report. Outcomes of other analysis were added to the original case record database for purposes of preparing data for reporting.

Triangulation from NCETM survey

At the end of the first year of the exchange, schools submitted a report to the NCETM summarising implementation of change following the exchange. The NCETM followed this up with a survey which was completed between December 2015 and Feb 2016. Survey data was provided to the evaluators by the NCETM, and it was used to triangulate data generated by the evaluators and reported in relation to the extent of school level change, variation in implementation, and change in particular practices.

There were 39 responses to the survey. Of these, 38 were representatives from MTE cohort 1 schools, 37 of whom also participated in evaluator interviews. One of these 37 survey respondents completed data on an associated infant school in addition to reporting on their own school, thus a total of 38 MTE cohort schools are represented in the data. In addition, 1 survey respondent was a teacher with responsibility for mathematics across 5 schools, of which 2 had participated in the exchange. Moreover, in 2 cases the survey respondent and interviewee were different. In some cases, questions asked in the survey were formulated differently from the interview questions, and so are not directly comparable. For all these reasons and given the different time point of data collection, survey data was not fully merged into the interview data set. Rather, survey findings were usually used to check that overall similar patterns of change and implementation were reported across the survey and interviews.

In addition, survey data was sampled on a school by school basis as a cross-check of interview data reliability. Similar patterns of implementation were found reported in both data sets and individual school responses. However, in some cases where survey questions closely matched interview questions, survey data was used to more directly confirm findings and in those cases this confirmation is included in the relevant sections of the report.

Further, in order to triangulate findings on pupil outcomes, the section of the NCETM survey relating to pupil impact was analysed using open thematic coding. In the NCETM survey, schools were asked:

Please give a brief example of one or two pupils on whom the impact of adopting Shanghai-style teaching for mastery has been very significant. Why has the effect been so strong? How do you know that it has been?

All 39 lead primary schools responded to this question, and these responses were coded thematically by the research team, and the findings are summarised in section 8.2 of the report.

Respondents to the NCETM survey were also asked to consider how many schools in their area were already very committed to mastery, interested in, or were considering introducing it. This data supplemented interview data, as this was not directly asked about during the interviews. Therefore, key findings from the responses to this question are reported in section 9.

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