Department for Education

Longitudinal Evaluation of the Mathematics Teacher Exchange: China-England

Interim research report

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Mark Boylan, Claire Wolstenholme, Bronwen Maxwell, Tim Jay, Anna Stevens, Sean Demack

Sheffield Hallam University

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Glossary

Contrast school - 940 schools with similar characteristics to lead primary schools. These were matched to the 48 lead primary schools in a 20:1 ratio[1].

CPD - Continuing Professional Development.

Exchange headteacher - A headteacher from a lead primary school who visited Shanghai.

Exchange teacher - A teacher from a lead primary school who visited Shanghai.

Hub lead - Teacher coordinating a Maths Hub (see Maths Hub below).

Hub school - Schools located in the geographical region of a hub and involved in the hub.

ITT - Initial Teacher Training.

Lead primary school headteacher - A headteacher from a lead primary school.

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 teacher - A term used by the NCETM to denote school staff who have been directly involved in the exchange programme and who are now involved in wider dissemination within their school and their local and wider hub network.

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.

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.

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[1] Please note: Two lead primary schools are a pair of co-located infant and junior schools, but with separate leadership and governance. They were matched together as a pair to 20 primary schools for the quantitative aspect of the evaluation. For the qualitative aspect they are considered as two distinct schools.

Mathematics Teacher Exchange - Exchange programme involving 48 English primary schools and schools and teachers in Shanghai.

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.

UCET - Universities Council for the Education of Teachers, working with the NCETM on the implications of teaching for mastery for ITT.

Wave 1, Wave 2 - Refers to when schools hosted Shanghai exchange teachers. Twenty two Wave 1 schools hosted Shanghai teachers from the 3rd to 28th November 2014 and 26 Wave 2 schools hosted between 23rd February and 20th March 2015.

Executive summary

The Mathematics Teacher Exchange: China-England

The Mathematics Teacher Exchange is a highly innovative programme that aims to foster a radical shift in primary mathematics teaching in England by learning from Shanghai mathematics education – a mastery approach to teaching and learning. The exchange is funded and managed by the Department for Education. The National Centre for Excellence in the Teaching of Mathematics (NCETM) lead the implementation of the exchange through the national network of Maths Hubs and are actively engaged in developing, refining and deepening school and teachers' understanding of Shanghai teaching for mastery.

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.

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 have made changes in practices and shared learning with other schools.

The evaluation

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 so on pupils' mathematics attainment. The first year of the evaluation has focused on the implementation of the exchange and the ways in which the 48 participating schools - lead primary schools - have implemented learning from the exchange. Data for this report was collected between February and July 2015 and included:

- interviews with 12 hub leads, four key NCETM and DfE stakeholders and six Shanghai teachers
- visits to 31 exchange schools and telephone interviews with exchange teachers in the remaining 17 schools

- follow up telephone interviews with exchange teachers in five lead primary schools where there were indications of a relatively high level of change
- a survey of mathematics coordinators in 48 lead primary schools
- a review of 28 school reports prepared for NCETM in August 2015 and NCETM's analytical summary

During 2016 and 2017, data will be collected on further changes in lead primary schools and other schools they work with in their areas. Impact on pupil outcomes will be evaluated by considering changes in key stage 1 and key stage 2 outcomes in lead primary schools. Outcomes in the 2015 assessment will, in most cases, form a baseline with the impact of change measured using 2016 and 2017 assessments.

Key Findings

The exchange visits

The visits of English teachers to Shanghai had a strong impact on teachers' beliefs and motivations towards teaching mathematics, although a minority (just over a fifth) of teachers stated that they would have preferred to spend more time in school than in university. The visits of Chinese teachers to England were identified as particularly good opportunities for learning by English teachers, who valued the chance to observe teaching and participate in post-lesson discussions in the English context.

Implementation by Maths Hubs

Maths Hubs differed in their approach to implementing the exchange in two aspects.

- Their orientation towards mastery. Existing mastery enthusiasts used the exchange to add impetus to existing approaches within the hub. More recent converts became more convinced through participation in the exchange, but voiced concern that other teachers and schools may be harder to convince.

- The steer and support provided. Some hubs acted as project managers providing logistical support to lead primary schools, who then led on which aspects of the Shanghai approach were adopted, and organised professional development. Other hubs took a more active stance, encouraging schools to adopt or experiment with particular aspects of mastery.

In all hubs there were opportunities for teachers from other schools to observe the Shanghai teachers. In two of 12 hubs in which hub leads were interviewed, more than 100 teachers visited lead primary schools.

Schools' orientation to mastery

The schools varied in their attitudes and commitment towards Shanghai mastery approaches. Of the 48 lead primary schools, seven were considered to be already committed to Shanghai mastery, whilst 36 were newly committed as a result of participating in the exchange. Five schools were more cautious in their outlook.

Patterns of implementation in schools

In 39 schools, Shanghai teachers worked with two or more year groups. Year groups they worked with are shown below.

Table 1 Year groups Shanghai teachers worked with

Year group	EYFS	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
No. of schools	2	10	16	22	18	20	9

Level of change in 2014/15

Teachers continued with aspects of Shanghai teaching practice with classes after the Shanghai teachers' visits. Patterns of implementation across other year groups were complex. In some cases, schools adopted particular practices such as same day intervention or changes in lesson structure on a whole school basis. Other schools adopted a strategy of gradual implementation of change in multiple practices in specific year groups.

Overall, of the 48 schools, 38 were making medium to high levels of change. A medium level of change was found in 32 schools, comprising more extensive change in specific year groups or adoption of some Shanghai informed practices across multiple year groups. In six schools, a high level of change occurred with significant changes of multiple practices on a whole or nearly whole school basis. Ten were making relatively smaller changes across the school in 2014/15, with changes restricted to continuing some Shanghai practices after the visit. Of these, four expressed a commitment to mastery and were planning changes for 2015/16, and in one, the level of change was smaller because their existing practices were already aligned with mastery approaches.

During 2014/15 schools reported implementation of some aspects of practice across the year groups, as shown in the tables below.

Table 2 Year groups that schools are implementing one or more aspects of a Shanghai approach with [2]

Year groups implementing a Shanghai approach	EYFS	1	2	3	4	5	6	Whole school
No. of schools	1	19	20	17	13	19	11	5

Table 3 Number of year groups implementing one or more aspects of a Shanghai approach in each school[3]

No. of year groups	1	2	3	4	5	6	Whole school
No. of schools	8	13	5	6	4	1	5

Changes in practice in lead primary schools

Changes in both classroom practice and the organisation of maths in schools were found. Most change took place in classroom practices, with an overall increase in the amount of whole class interactive teaching. Specific aspects of this were:

- increasing teacher-pupil interaction, including increased questioning throughout lessons
- reducing differentiation by task and adopting more inclusive approaches using activities that are accessible to the whole class
- increasing the quality and amount of mathematical talk, with pupils being encouraged to explain their ideas and answers more thoroughly using correct mathematical language
- increasing lesson tempo, through increased questioning, whilst slowing the pace at which the curriculum is covered to ensure all understand and to deepen understanding of the highest attaining pupils
- developing conceptual understanding and procedural fluency by variation in tasks, and careful choice of problems and practice exercises

[2] In both these tables 'Shanghai approach' refers to schools that reported adopting Shanghai teaching methods and those that reported changing school practices such as daily intervention to support these. Reliable data was obtained for 42 schools. In the case of another six, data is missing or unreliable due to timing of interviews, role of the interviewee and/or lack of triangulating data from school reports.

[3] Note that not all schools covered the full range of primary year groups.

- other changes to develop conceptual understanding or support whole class interactive teaching, such as: changing the content of lessons so that they followed a series of small steps rather than an overarching objective/s across the lesson as a whole; more mini-plenaries and multiple part lessons; a stronger focus on addressing misconceptions; increased use of visual representations; and changes in seating arrangements from ability grouped tables to sitting in pairs or rows facing the front of the class

Changes in the organisation of mathematics teaching during 2014/15 were less widespread than changes in classroom practice:

- approximately one third of schools introduced daily intervention[4], with some schools reorganising timetabling to facilitate this
- six schools made changes in lesson timing and structure mid-year to facilitate interactive teaching and/or intervention
- no in-year changes were made to setting of pupils, though ten schools specifically reported changing approaches to differentiation including in-class grouping
- in a small number of schools, more frequent homework was introduced
- the use of specialist mathematics teachers was piloted in two schools

Planned future changes

Schools intended to deepen and embed changes in classroom practice, often through extending implementation to further year groups. Schools were considering the use of textbooks or other resources to support teaching for mastery.

Early evidence of pupil impact

Across all 48 schools, most teachers reported that the changes implemented since the Shanghai teachers' visit had led to positive outcomes for pupils. These outcomes included increased enthusiasm for mathematics, deeper engagement, increased confidence, and higher levels of attainment. These findings are perceived outcomes and any impacts on pupil attainment will be reported in future evaluation reports.

Three schools reported examples of comparative measures that suggest possible improvement in attainment. In one school, year 3 pupils who followed a mastery approach achieved higher scores than year 4 pupils who had been taught in the usual manner on the same assessment task. In a second, in year 6, more pupils achieved level

[4] Intervention refers to providing additional teaching to groups or individual pupils to ensure they progress.

5 on fractions, the focus for mastery teaching, than on other topics. In the third, the highest attaining pupils in year 3 were assessed as achieving more highly than previous cohorts.

Enablers and barriers to implementing a mastery approach

Enablers identified were:

- support from the NCETM and the Maths Hub
- senior leaders and mathematics coordinators' commitment to change
- teachers' openness to change
- headteachers' willingness to lead or support implementation

Perceived barriers identified were:

- teacher beliefs, attitudes and subject knowledge
- resources to support teaching for mastery
- challenges for implementation in Early Years Foundation Stage (EYFS) and year 1
- cultural and structural differences between England and Shanghai

Given the English context, lead primary schools are implementing the new Shanghai informed pedagogy and curriculum generally with an adaptive rather than adoptive approach. The risk in an adaptive approach is that the scope of change is not well defined and may lead to continuation of existing practices under new descriptions or changes that are not well aligned with the intended mastery approach. However, some schools are demonstrating the potential for major change.

Conclusion

There are early indications that the exchange has the potential to meet its core aim of fostering a radical shift in mathematics teaching in primary schools and to impact on pupil attainment. Policy support and coordination of activity across a wider layer of stakeholders will be important to the success of the exchange. Important too will be those schools and teachers that have a positive orientation to mastery and the exchange and are developing practices that can be examples to other schools involved, as well as more widely.

1. Introduction

The Mathematics Teacher Exchange: China-England brings together two important approaches to improving mathematical teaching and attainment in England: benchmarking against, and learning from, high performing countries; and the move towards school-led system improvement, in this case through the Maths Hub initiative co-ordinated by the National Centre for Excellence in the Teaching of Mathematics (NCETM). The exchange is an innovative approach to both learning from Shanghai mastery mathematics education and developing an effective adoption of mastery in England.

This is the first of two 2015/16 reports involving 48 lead primary schools. It draws predominantly on qualitative data collection and aims to assess the initial impact of the exchange on school and teacher practices of those schools directly involved.

In addition, the report:

- outlines the background to the initiative and describes the purposes and organisation of the exchange
- provides an overview of the longitudinal evaluation methodology
- evaluates the efficacy of exchange activities
- describes and analyses the implementation of the programme during 2014/15 at national, hub and school levels
- reports on initial perceptions of impact on pupil engagement, learning and attainment outcomes
- identifies issues to consider for the success of the initiative in the future

In the second 2015/16 report (to be published in autumn 2016) further details on the evaluation methodology will be provided, including detail of the methodology for evaluating impact using a contrast group of schools. The autumn report will provide analysis of key stage 1 and key stage 2 attainment outcomes that, in most cases, will provide a baseline for the longitudinal evaluation, and in a smaller number of cases will give an indication of initial impact on attainment, where schools' focused immediately on year 2 and/or year 6 cohorts. Data will also be reported from a survey of other primary schools in hubs and contrast schools, as well as a pupil attitude survey in lead primary schools.

The final report, in spring 2018, will report on the longitudinal impact of the exchange.

2. Background

2.1 The origins of The Mathematics Teacher Exchange: China-England

There are long standing concerns about the English primary mathematics curriculum and pedagogy, as well as the mathematical subject knowledge of many primary school teachers in England (Williams, 2008; Ofsted, 2008). This has led to interest in what can be learnt from education systems in high scoring education systems, including Shanghai, which had an 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 Leadership[5] (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.

2.2 The context

The Mathematics Teacher Exchange is 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).

Each Maths Hub is led by one or more schools or trusts 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. In addition, in 2014/15 there were three national collaborative projects: the exchange

[5] Now the National College for Teaching and Leadership (NCTL).

programme with Shanghai schools involving both primary and secondary schools; teacher-research into the use of Singaporean mathematics (including the use of high quality textbooks in primary schools); and a third focused on post-16 participation.

2.3 Shanghai and English primary mathematics education

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 below[6].

[6] 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 1 including on cultural and structural differences at system level that are outside the scope of potential change through the exchange.

Classroom practices

Table 4 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[7] with younger pupils, usually one model or visual representation used per topic/concept.

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

School practices

Table 5 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.

3. The Mathematics Teacher Exchange: China-England

The aim of the exchange is to foster a radical shift in primary mathematics teaching in England by learning from Shanghai approaches, with the measure of success being the extent to which the exchange impacts on pupil attainment in mathematics. The immediate aim focuses on a small number of schools involved directly in the teacher exchange - lead primary schools - who hosted Shanghai teachers and, apart from a few exceptions, had representatives visit Shanghai. More widely, the intention is for new practices to be shared with other schools. The evaluation is focused on the primary phase of the exchange which took place in 2014/2015. In addition, in 2015/16 Maths Hubs will also lead an exchange of secondary school teachers, which is out of scope for this evaluation.

In summer 2014, Maths Hubs identified a total of 48 schools to be involved in the exchange to visit Shanghai (45 schools visited Shanghai) and to host Shanghai teachers (the 45 that visited Shanghai plus a further three schools). Each hub nominated two teachers, either from the same school or from two different schools, to take part in the exchange visits to Shanghai. Further detail is given in Section 5.3.

Details are given in Section 5.1 of activities undertaken during exchange visits. Lead primary schools, supported by the hub network and hub lead schools, also hosted teachers from other schools to observe lessons given by Shanghai teachers and participate in other collaborative professional development activities.

The exchange is funded and managed by the DfE. The NCETM lead the implementation of the exchange through the Maths Hubs and their role is considered below.

4. Evaluation methodology and methods

4.1 Aims and objectives

The overarching aim of the evaluation is to determine the potential of learning from Shanghai mathematics education to impact on teaching in England and so on pupils' mathematics achievement in both the short and long term. This first report assesses the approach taken by schools, and informs delivery for 2015/16 - see Table 6 for relationship of report and evaluation objectives.

Table 6 Objectives and 2015/16 interim report

Objectives	Section of report addressed
1. Evaluate the implementation and fidelity of the intervention against programme objectives.	Sections 5.1 and 5.3
2. Identify the types of activity undertaken by teachers from England in Shanghai host schools.	Section 5.2
3. Identify the types of activities undertaken by Chinese teachers in host schools in England.	Section 5.2
4. Identify the professional development outcomes for teachers.	Section 6.1
5. Determine whether teaching methods and practices have changed in host schools in England.	Section 6
6. Determine what activities have been most successful in meeting the aims of the programme.	Sections 5.1, 5.2 and 5.3
7. Identify lessons learned and the extent to which changes resulting from the exchange have been embedded in schools in England.	Sections 6 and 7
8. Report on perceptions of pupil performance and depth of understanding of key concepts.	Section 7
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.	Addressed in future reports.
10. Review, assess and synthesise the findings from the lead primary school reports prepared for NCETM.	Section 6
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.	Initial findings Section 7. Future reports will address this more fully.
12. Identify initial patterns of effective change and early evidence of pupil impact.	Sections 5.4, 6, and 7

Longitudinally, the evaluation will identify whether there has been a sustained change in teaching practice in lead primary schools, and whether the learning has been shared and practice changed across Maths Hub networks.

4.2 Methodology and methods

A comprehensive account of the methodology and methods relating to the findings in this report is included in Annex 2. This section contains a summary of the main data collection methods used.

Strand One

To address objectives 1-10, a longitudinal multiple-case study design focused on lead primary schools, encompassing both exploratory and evaluative dimensions (Yin, 2013). This was supplemented by a set of interviews with hub leads and key NCETM and DfE stakeholders, a survey of lead primary schools and others within the Maths Hubs, and interviews with a small sample of Shanghai teachers.

The first round of data collection to inform the lead primary school case study analysis took place between February and July 2015. In total, 31 lead primary schools were visited. There are 16 hubs where both exchange teachers from England work in the same school; all but one of these schools were visited. In the 16 hubs where the exchange teachers from England worked in two different schools, only one school was visited, while telephone interviews were conducted with the exchange teacher in the second school. In total, 107 teachers or headteachers were interviewed: the 60 who visited Shanghai and an additional 47 who worked in the participating schools. Further detail is given in Annex 2.

Planning materials were also collected during case study visits. These included schedules for exchange visits and documents relating to schools' mathematics teaching (such as lesson planning pro-forma and calculation policies). Through these interviews, an understanding of each school's individual context and ways of working was developed.

During four of the case study visits it was possible to interview the Shanghai teachers visiting the school, and a further two interviews were conducted by telephone in Chinese. In total, this enabled data to be gathered from six Shanghai teachers.

In February and March 2015, telephone interviews were conducted with 12 hub leads and four key stakeholders at NCETM and DfE, to understand the implementation of the exchange in its initial phase.

In July 2015, lead primary schools were surveyed with a response rate of 46 out of 48 possible completions[8].

In addition to the above, 28 school reports were received either direct from schools or from NCETM in August 2015. The NCETM also provided an analysis and summary of all end of year reports received by them as well as of schools' interim reports.

Strand Two

The main activity of this strand will involve longitudinal analysis of key stage 1 and key stage 2 attainment data, in comparison with a sample of 940[9] contrast schools. These contrast schools were surveyed about classroom practices using the same survey as in strand one. In addition, pupil attitudes to mathematics and to mathematics learning in the lead primary schools will be analysed for the next report. Initial data from strand two will be reported in the autumn 2016 report. Please see Annex 2 for further details of the methodology.

Strand Three

The aim of strand three was to identify initial patterns of effective change and early evidence of pupil impact. This involved follow-up telephone interviews with exchange teachers in five lead primary schools. Criteria for selection of the schools for strand three were:

- the initial case study visit indicated that notable changes in practices were occurring as a result of the exchange
- there were indications that the school might have monitoring or other data to allow for an assessment of impact to be made using measures with external validity

School attainment levels were also considered for sample balance. A thematic case analysis was conducted for each of the five lead primary schools drawing on data collected during the case study visit together with data from the follow-up telephone interview. In three of these cases, interviewees reported indications of evidence of early impact on attainment (detailed in Section7.2). However, data was not supplied by schools.

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[8] The same survey was also distributed to other schools in hub networks (see A2.2). Outcomes will be reported in the autumn 2016 report.

[9] Please note: Two lead primary schools are a pair of co-located infant and junior schools, but with separate leadership and governance. They were matched together as a pair to 20 primary schools for the quantitative aspect of the evaluation. For the qualitative aspect they are considered as two distinct schools.

Ethics and data protection

The study has been approved by Sheffield Hallam University's (SHU) ethical process and is conducted in line with SHU's ethics procedures, which are consistent with guidelines from the British Educational Research Association (BERA, 2011) and the British Sociological Association. Information on which schools are involved in the exchange is publicly available; however schools are anonymised in reporting the evaluation. Contrast school details are not shared with DfE and school names are not reported. All data is stored securely on password protected computers. All data, including pupil's data such as test results, is held confidentially and in compliance with the Data Protection Act 1998.

5. Implementation

5.1 National and Hub implementation

The role of the NCETM

The Maths Hub programme and the implementation of the Mathematics Teacher Exchange are led nationally by NCETM. The NCETM is actively engaged in developing, refining and deepening schools' and teachers' understanding of Shanghai teaching and mastery. They have undertaken extensive activity to support implementation, including visits to lead primary schools, organising events focused on mastery and contributing to other organisations' events. The NCETM has created and recruited teachers to a new two year professional development programme, to develop 140 new primary mathematics mastery specialists. It is also beginning to work with the Universities Council for the Education of Teachers (UCET) in relation to mastery and initial teacher training (ITT). In October 2014, NCETM published a guidance document *Mastery approaches to mathematics and the new national curriculum.*

The NCETM have produced reports that summarise: school's mid-year experiences (NCETM, 2015a); and the end of year reports submitted to the NCETM by schools (NCETM, 2015b). Notably, the template for the end of year reports asked schools to consider five key aspects of practice:

- teaching for mastery
- calculation practice and developing greater number fluency
- lesson design
- effective use of high quality Shanghai textbooks
- assessment and feedback of classwork and homework

Maths Hubs

Maths Hubs are central to dissemination of Shanghai-informed approaches beyond the exchange schools. There were initially 32 hubs, which as of October 2015, increased to 35. There are potentially 400-700 primary schools associated with each hub.

From analysis of interviews with 12 hub leads and teachers in lead primary schools, three types of orientation to mastery were identified. These are described below. Given the sample size of 12 interviewees, it is not possible to determine the relative proportion of these categories across all 32 hubs originally involved in the exchange. It is also important to note that most of these interviews took place relatively early in the exchange, and in some cases, before or at the time that Shanghai teachers were hosted in their hubs.

Existing mastery enthusiasts

> Four hub leads were already mastery enthusiasts; they were already using similar approaches in their own schools and/or promoting them in the hub. In all cases they had gone on previous visits to Shanghai with the then NCSL. These hub leads engaged in detailed discussion about Shanghai pedagogy and its relationship to the Singapore textbook project and other initiatives.

Recent mastery enthusiasts

> A second group of four hub leads can be described as 'converts' to mastery. This group declared initial scepticism or caution about the approach, but through engagement in the exchange programme and seeing Shanghai teaching practice, they have become more convinced. However, they also sought to act as a voice for other teachers/schools who they think will be harder to convince – particularly mentioning secondary schools as being potentially more sceptical than primaries.

Exchange enthusiasts but cautious about mastery

> The remaining four leads appeared to value the exchange but with less enthusiasm. In two cases they expressed doubts that Shanghai mastery teaching can be imported, though aspects of it may be relevant. This group appeared to emphasise ways in which the exchange fits with their wider agendas in developing the hub in their particular area or what they see as priorities, for example, where the exchange is seen as an opportunity for creating discussion about pedagogy in general, or for linking the primary and secondary arms of the exchange to focus on year 6 to year 7 transition.

Hub leads reported that the exchange start-up was very short, with hubs having only one to two weeks to identify schools in some cases. The tight schedule impacted on selection of schools and the initial intention to focus on year 4 pupils across all schools.

A key hub level implementation decision was about how many schools to involve directly in the exchange. In 16 hubs, one school was identified (with two people nominated to go to Shanghai). In the other 16 hubs, two schools were identified, with, in most cases, one member of staff visiting Shanghai from each school (see Section 5.3). Decisions about involving one or two schools were, firstly, influenced by geographical issues, or, secondly, a desire to include both a high attaining school and a lower attaining school, or thirdly, the influence of multi-academy trust relationships.

In hubs where only one school was involved, the criteria for identifying staff meant that there was direct involvement by both a senior leader (potentially providing power to ensure whole school change) as well as a class teacher (who could implement new

approaches and work closely with colleagues). Where hubs had two schools involved, schools chose either a senior leader or a classroom teacher/mathematics coordinator to participate[10]. This meant that in some schools the person who visited Shanghai was not then involved in the direct teaching of pupils.

Some hubs acted as project managers and provided logistical support to lead primary schools, who then led on which aspects of Shanghai mathematics education were adopted and arranging CPD opportunities. In others, the hub seemed to have taken a more active stance, encouraging schools to adopt or experiment with particular aspects of the approach.

Similarly, hubs have taken different approaches to involving schools beyond the lead primary schools. In one area, the hub provided resource for a group of ten schools to work closely with the lead primary school, focussing on a particular year group. Other hubs reported organising visits of more than 100 teachers (ten or more per lesson) to observe Shanghai teachers and to take part in follow-on conversations modelled on Teacher Research Groups. Hubs also organised a variety of supporting events to extend reach, for example a meeting hosted by a local university in one hub attracted 90 people.

5.2 The teacher exchange

Mathematics teachers from England's visits to Shanghai

Exchange teachers and headteachers valued the visits to Shanghai and these impacted on their beliefs about mathematics teaching and helped them to develop a commitment to mastery in most cases. A minority (just over a fifth) of interviewees expressed some dissatisfaction with aspects of the experience, in particular the balance between time spent in Shanghai schools and in sessions at the University and the content of those sessions. Some teachers reported that more time could have been spent seeing 'ordinary' lessons rather than demonstration lessons. However, teachers visiting other schools reported being able to choose freely which lessons to observe. In a number of schools the visit to Shanghai catalysed immediate changes in practice without waiting for the visit of the Shanghai teacher to England.

Representatives from 32 of the English schools spent time in one school while in Shanghai, while the rest visited two or more schools. The main activities undertaken were observing ordinary lessons, and, in just over half of exchange teacher visits, observing demonstration lessons. Most exchange teachers also reported taking part in post-lesson discussions and Teacher Research Groups. Activities outside the schools included

[10] In this report schools identified by a number are schools where there was one school in the hub, schools identified by a number and A or B are where there are two schools per hub.

having lectures at the Shanghai Normal University for around four days, and meeting with other visiting teachers from England for reflection.

A large majority of exchange teachers reported that observing ordinary lessons was the most useful aspect rather than observing 'perfect' or demonstration lessons. Some teachers pointed to the value of conversations that took place after the observations, to discuss why the teaching happened in the way it did and to gain a deeper understanding of the teaching methods. Interim reports and feedback from teachers influenced the conduct of the 2015/16 secondary exchange visits, by identifying issues that they felt could improve the experience for others.

Shanghai mathematics teacher visits to England

On balance, it appears that the visit of the Shanghai teachers to England had more impact on teacher beliefs and motivation to change practice than the visits to Shanghai, due to seeing the application of Shanghai teaching in an English context. However, clearly the visit to Shanghai was an important foundation for the second part of the exchange, and the differences in school culture were remarked on by many interviewees.

During their visits to English schools, Shanghai teachers spent most of their time teaching lessons, with some time spent observing at the start of their visits. Most worked closely with one or two classes and teachers, with a larger number of teachers from the lead primary school observing. English exchange teachers reported that the most useful activity for them while hosting was observing the Shanghai teachers teaching, in order to see how the Shanghai teaching for mastery works in practice in an English school context. Engaging in post-lesson discussion groups was also valued. Some Shanghai teachers brought copies of textbooks from Shanghai and used these as the basis for teaching; generally they adapted PowerPoint materials. In one school, the mathematics coordinator worked closely with the Shanghai teacher to support their planning, so they could adapt their approach to teach in ways that were more familiar to those the pupils were used to.

There were concerns in some schools about whether low attaining (including Special Educational Needs (SEN) pupils) and high attaining pupils were challenged at the right level, with eight teachers interviewed mentioning that high attaining pupils were bored.

Shanghai teacher perspectives

The Shanghai teachers were very positive about the teaching skills of English exchange teachers and found it difficult to comprehend how they could teach across all subjects and for so many hours. They also observed that the English national curriculum introduced some concepts, in their view, at too early a stage, before more basic concepts had been securely understood by pupils. For example, one teacher pointed to how fractions were introduced (in year 1 and year 2) through everyday meanings and language before a solid and deep conceptual understanding of multiplication and division

were developed. This led to misconceptions about fractions based on use of language terms rather than introducing fractions as mathematical concepts.

5.3 School implementation

Teacher and headteacher participation

In total, 60 teachers, senior leaders or headteachers from 45 primary schools, accompanied by other representatives from hubs and NCETM delegates, visited Shanghai from 19th September to 4th October 2014. In exchange, 59 mathematics teachers from China came to England for a month long visit. Exchange schools were identified as either Wave 1 or Wave 2. The 22 Wave 1 schools hosted Shanghai teachers from the 3rd to 28th November 2014 and 26 Wave 2 schools hosted between 23rd February and 20th March 2015.

In 15 schools, two teachers went to Shanghai, in 30 schools one teacher went and there were three schools where subsequently a Shanghai teacher was placed where no English teachers went to Shanghai. The table below gives details of the number of teachers from each school who visited Shanghai. In the three lead primary schools where no teachers visited Shanghai, this was due to either secondary school teachers or two teachers from a different school in the hub making the visit. Further details of teacher and headteacher participation in the exchange are provided in Annex 3.2.

Table 7 Delegates from each school who visited Shanghai who were employed at the school at the time of the interviews.

Number of delegates who went to Shanghai from each school	2 teachers	1 teacher	0 teachers	Total number of schools
1 school per hub	13	2	1	16
2 schools per hub	2	28	2	32
No. of lead primary schools	15	30	3	48

Pupil participation

Shanghai teachers were deployed in different year groups, covering the range of year groups across all the lead primary schools, including the EYFS in two schools. Most Shanghai teachers were asked to teach more than one year group in each school. In 12 cases Shanghai teachers were deployed to teach the classes of teachers who had visited Shanghai; however, this did not happen in most schools because those who visited Shanghai did not have direct teaching responsibilities or there were more suitable classes for the Shanghai teacher to work with. In all but two cases, schools continued to use Shanghai informed approaches with classes the visiting teachers had taught after the visit. Further details are given in Annex 3.3.

Table 8 Year groups that schools are implementing one or more aspects of a Shanghai approach with [11]

Year groups implementing a Shanghai approach	EYFS	1	2	3	4	5	6	Whole school	Classes not specified or missing data
No. of schools	1	19	20	17	13	19	11	5	6

Table 9 Number of year groups implementing one or more aspects of a Shanghai approach in each school

No. of year groups	1	2	3	4	5	6	Whole school	Changes not reported or missing data
No. of schools	8	13	5	6	4	1	5	6

When the cohort of schools is considered as a whole, Shanghai informed practices were implemented across the full age range of key stage1 and key stage 2, and in one case was influencing reception practice (Table 8).

5.4 Orientation to mastery, levels and patterns of change

Orientation towards mastery mathematics education

As with the hub orientations, lead primary schools can be grouped by three orientations to mastery, with similar designations:

- already committed
- newly committed
- cautious and/or less engaged

Seven schools had previously engaged with mastery approaches either through the NCSL study visits or through the ARK mathematics mastery curriculum[12]. These schools

[11] 'Shanghai approach' refers to schools that reported adopting Shanghai teaching methods and those that reported deploying Shanghai influenced approaches such as daily intervention. Reliable data was obtained for 42 schools. In the case of another six, data is missing or unreliable due to timing of interviews, role of the interviewee and/or lack of triangulating data from schools' reports.

[12] Mathematics mastery (referred to by participants as 'Ark Mastery') is a mathematics scheme with associated professional development informed by Singaporean mathematics education. See http://www.mathematicsmastery.org/

were already committed to mastery. In one case the school had an existing well developed pedagogy and curriculum which had similarities with a mastery approach, for example a strong expectation that all could learn, but differences in pedagogical approaches.

Most schools developed a clear commitment to mastery approaches as a result of visiting Shanghai and attending NCETM-led professional development and/or due to hosting a Shanghai teacher.

A small number of schools expressed caution about the Shanghai approach. A typical comment of such schools was:

> *[We are] not adopting the whole system completely and mimicking it, but taking it apart and asking what can we use from it.* (School 3B, mathematics coordinator)

Levels of change

For simplicity, schools can be grouped into three levels of change (frequencies are provided in Table11 below):

- low: often change did not extend beyond one or two teachers whose classes had been taught by the Shanghai visitor
- medium: some change in practices across many years groups or significant changes in one year group as part of a strategy for progressive roll out through the school
- high: changes across multiple practices on a whole school or nearly whole school basis

It is important to distinguish between levels of implementation of mastery approaches and levels of change. It is possible for a school to demonstrate a medium or high level of implementation of mastery, but have a relatively lower level of change. For most schools, mastery is new or relatively new. However, as stated above, a small number of schools were already engaged in Asian-inspired mastery approaches, or locally developed practices that, similar to Shanghai, are based on the underlying mastery principle that everyone can achieve highly in mathematics, and the teacher and schools' role is to find ways of ensuring that can happen.

Given the innovation is at an early stage, changes made in 2014/15 may not be predictive of the degree of change in 2015/16. Section 6 identifies how schools have responded to the exchange in terms of specific practices.

Patterns of change

Tables 10 and 11 describe different relationships between orientations to mastery and levels of change, and provide an analysis of the number of schools identified with the

different patterns of change. This initial model will be both used and tested in future data collection and analysis.

Table 10 Patterns of change[13]

	Orientation to mastery		
Level of change	**Cautious**	**Newly committed**	**Already committed**
Low	Low level of breadth and/or depth of change or adaptation leading to low levels of fidelity. Relatively low level of planned changes.	Limited changes made in 2014/15, more extensive changes planned for 2015/16.	Existing mastery or similar practices. High level of school confidence in current practices.
Medium	Not applicable	Some changes across whole school or in depth changes, but limited in scope, plans for further changes.	Refinement and extension of existing mastery approaches.
High	Not applicable	Significant changes already undertaken and further planned extensive changes across the whole school.	Refinement and extension of existing mastery approaches and further significant changes.

Those schools which had pre-existing practices aligned with mastery may not provide the best examples of how to introduce changes. However, they may provide models of how schools can learn from the exchange to implement teaching for mastery in England.

As the table below shows, most lead primary schools are newly committed to mastery and engaged in some or a high level of change in 2014/15. These may be the most important leaders for extending the lessons learnt and changed practice to other schools.

[13] Note that not all of the possible cells of the matrix are found in practice.

Table 11 Frequency of patterns of change

	Orientation to mastery			Totals
Level of change	**Cautious**	**Newly committed**	**Already committed**	
Low	5	4	1	10
Some		27	5	32
High		5	1	6
Totals	5	36	7	48

The above table should be considered against the original aim of the exchange to engage an initial 32 schools in the exchange. The table indicates that 38 schools implemented some or a high degree of change in 2014/15, and a further five are committed to mastery approaches. Two of the five schools characterised as cautious are in hubs in which there is another lead primary school. However, three are in hubs where they were the sole lead primary school and so this may have implications for the implementation of Shanghai approaches in those hubs.

This last finding supports the NCETM's approach of widening the leadership base for mastery through the Primary Mathematics Mastery Specialist CPD course to involve other schools in hubs. Given the different patterns of orientation and change, the analysis suggests the need to take account of the willingness and capacity for a small number of lead primary schools to undertake local leadership to support the aims of the exchange. Thus, some hubs may need additional support to lead change if the designated lead primary schools are not yet exemplifying new practices.

There is some initial evidence that a school’s commitment to mastery and the degree of change is influenced by the enthusiasm of both the headteacher and mathematics coordinator.

6. Influence on school and classroom practices

In this section, findings are reported on actual and planned changes in classroom and school practices[14]. School practices are issues that broadly require whole school policies or change, whereas classroom practices are more amenable to change by individual teachers. In Section 2.3, Shanghai and English practices were compared, indicating the potential for change towards teaching for mastery in England.

6.1 Classroom practices

This section reports changes at the classroom level. Whilst the findings are separated in relation to different classroom practices, it is important to note that in Shanghai mathematics education the different aspects of the approach, such as the development of conceptual understanding and procedural fluency and use of models, are highly inter-related.

To recap on the description in Section 2, Shanghai teachers employ whole class interactive teaching focused on conceptual understanding and procedural fluency through incremental progression to ensure the whole class moves together.

Lesson activities and teaching approach

Practices before the exchange

One interviewee summarised the teaching approach that is commonly found in primary English classrooms:

> *Pre-Shanghai - typical lesson - mental oral starter for ten minutes, then introduce what children were going to learn. Very differentiated [differentiated learning objectives]. Then set off higher ability, they'd start on their own and then we would teach the two other groups. Then we would go over it and see how the higher ability group were getting on as the others were completing something. Then at the end we'd do a plenary to assess how the children were in their learning and that would be written down.* (School 31B, Mathematics coordinator/exchange teacher)

Another described the balance as 20:80, meaning 20% of teacher 'input' and 80% pupil 'independent' work.

Survey[15] participants completed a scale comparing the percentage of time they spent on different activities in a typical week of mathematics lessons, shown in Table 12.

[14] See details of the analysis methods employed for this section and limitations in A2.5.

[15] Representatives from 46 out of 48 lead primary schools completed the survey.

Table 12 Differences in time spent on different types of activity

	Percentage of time spent	Respondents (n)
Whole class versus other activity		
Whole class activity	44	40
Individual and small group work	56	40
Activities during whole class time		
Instruction and explanations	30	39
Questioning and interaction, dialogue and discussion	70	39
Individual versus small group		
Working individually	49	39
Small groups (including pairs)	51	40

Respondents reported slightly more time was spent on average on individual or small group work than whole class activity in the lead primary schools. Much more time, it was reported, was spent on questioning and interaction, dialogue and discussion than on instruction and explanation (70% to 30%). There was a similar amount of time spent with pupils working individually (51%) compared to working in small groups or pairs (49%).

With regard to the amount of questioning and interaction, the survey data does not accord with other studies (for example, Miao & Reynolds, 2015; Sammons, et al. 2005; Smith et al, 2004) which indicate less interaction in English primary classrooms. Therefore, the survey may represent: a distorted reflection of actual practices; a reflection of the mathematics coordinators beliefs about what ought to be happening; a reflection of change that has resulted through participation in the exchange; a sampling bias meaning that the schools in the exchange are not representative; or a combination of these factors.

In discussing differences between school practices and Shanghai, many teachers interviewed commented on the differences in lesson design and teaching approach, implying lessons in England in comparison with Shanghai lessons have:

- less teacher interaction with pupils throughout the lesson
- less teacher questioning of pupils
- lessons in two or three parts rather than multiple small parts as in Shanghai
- shorter lessons in Shanghai with practice done outside the lesson

Changes in practices

Interviewees from 17 schools reported changes in the teaching approach during 2014/15. Many interviewees discussed increasing the amount of whole class interactive teaching described as aiming for a more 'back and forth' approach with teacher and pupil talk, where the teacher explains and asks questions throughout as the lesson progresses. Seven interviewees specifically described changing the content of lessons so that they

were structured to address a series of small steps rather than an overarching objective or objectives across the lesson as a whole; in particular, moving towards more mini-plenaries and multiple part lessons (Lopez-Real et al., 2004; Miao & Reynolds, 2015). This was an attempt to adopt a Shanghai-style lesson observed during the exchange:

> *We're having very much a whole class lesson whereby the teachers teach it and then the children do short bursts of activity, then come back to whole class teaching, then back to short bursts of activity, so that everybody in the class grasps the concept from the start. As the lesson progresses, the tasks that they are asked to do become more challenging.* (School 28B, Exchange teacher)

Four teachers highlighted addressing misconceptions in lessons:

> *We are pulling those misconceptions out to begin the lesson and saying, what do you think about this?* (School 10A, Exchange teacher)

This had come directly from the Shanghai experience. Some 17 exchange teachers noted the emphasis on addressing potential misconceptions in advance of misunderstandings arising. It is noteworthy that addressing misconceptions was an important element of the National Numeracy Strategy approach and one also identified in Ofsted reports as good practice (Ofsted, 2011), yet was experienced by some teachers as novel.

Future plans

As described in Section 5.3, most schools experimented with new teaching approaches in some year groups rather than all. Future plans in relation to teaching approach were reported as spreading a more interactive approach to teaching to other year groups.

Differentiation

Practices before the exchange

Interviewees were not explicitly asked about differentiation practices prior to the exchange. However, from discussion of changes, in most cases, as in English primary schools more generally (see Annex 1), teachers used differentiated learning objectives with different tasks set for pupils, depending on assessment of prior attainment.

Changes in practice

Ten teachers talked about reducing differentiation by task, sometimes referring to this as keeping everyone together. In addition, 27 teachers also discussed changes in approaches that made teaching more inclusive and aiming to carefully design activities to be accessible to the whole class, thus adopting the Shanghai practice. This was said to enable those pupils who had historically been classified as 'less able' to access the same work as those deemed 'more able':

> *The main shift is teachers' expectations, an expectation that all can achieve. Some may take longer but they will all get there, and this can change pupils' attitudes.* (School 12A, Exchange teacher)

Some teachers also talked about alternative ways of differentiating learning, which they considered aligned more closely with the Shanghai approach, such as extending higher attaining pupils through deepening their understanding, rather than providing them with tasks that provided greater or quicker curriculum coverage.

However, not all schools appeared to understand or adopt the Shanghai philosophy. For example, one school continued to prepare three different sets of activities, but allowed pupil choice about which activity to engage with.

Future plans

Four schools were also planning changes to in-class grouping by having less differentiated tasks. For example:

> *I am going to look carefully at the activities that I give to children to make sure they are accessible to all and that in the course of a lesson they get progressively more difficult, whereas I would previously have differentiated and not given the lower ability children the opportunity to try the harder activities. [I am] no longer sitting them in ability groups, now sit mixed ability rows facing the front and trying carefully to select the quality of activity that I ask them to do.* (School 28A, Exchange teacher)

Developing conceptual and procedural fluency

Practices before the exchange

The Shanghai exchange drew teachers' attention to habitual aspects of English practice and the following were highlighted when asked about differences with Shanghai:

- moving on quickly (with the risk that this was before understanding was secure for all)
- addressing a concept in only one way
- practice based on sets of similar questions
- emphasis on coverage in lessons (contrasted with Shanghai teaching where a small number or even one problem would be considered in depth)
- focus on writing things down, doing and coverage rather than a focus on learning, as in Shanghai
- waiting for misconceptions to arise and then addressing them in contrast with anticipating them

Changes in practice

The Shanghai method of developing conceptual understanding and procedural fluency has been described in terms of variation; it is through engaging with or experiencing

different situations, models or problems that conceptual understanding and fluency develops.

Forms of variation discussed by teachers included variation in fluency, concepts, and careful choice of examples. However, the way teachers from England talked about variation differed between interviewees and between schools. Four teachers simply stated they would be 'having more variation' but without specifying what that would mean. Some demonstrated sophisticated understanding of issues such as the relationship between conceptual and procedural variation.

Variation in Shanghai teaching is multi-faceted with many subtly different practices (Gu, Huang & Marton, 2004). For the purposes of analysis three broad categories were considered: conceptual variation (using different models or examples to develop conceptual understanding); procedural variation (for example, the careful choice of practice examples that bring attention to important issues in relation to concepts or algorithms); and conceptual-procedural variation (varying activities between those primarily aimed at developing conceptual understanding and those primarily aimed at developing fluency).

Given that most interviewees did not use these terms, analysis has required an interpretive approach to mapping implemented or planned changes to variation as found in Shanghai. Considering those mathematics coordinators or other exchange teachers interviewed who visited Shanghai:

- 18 referred to changing or introducing practices that would allow for conceptual variation
- ten referred to changing or introducing practices that would allow for procedural variation
- 11 discussed the importance of combining activities that promote conceptual understanding and fluency

Interviewees from 27 different lead primary schools discussed changes that could be linked to one or more issues related to variation.

Future plans

Two further teachers specifically identified engaging with the approaches to variation as a priority for the future.

Models and visual stimuli

Practices before the exchange

Ten exchange teachers commented on the use of visual models as a notable feature of Shanghai education that was different from England. This was linked to careful crafting of examples and lessons and the development of conceptual understanding.

Changes in practices

Teachers from four schools specifically described attempting to adopt Shanghai practices, placing greater emphasis on the use of visual representations. Others spoke of using a wider variety of examples or linking mathematics to situations.

Future plans

No interviewee discussed the use of models or visual stimuli as part of their future plans, although four commented on the time intensive nature of Shanghai lesson design, which was difficult to adopt given teachers' workload. Two suggested the need for national support.

Engaging pupils in mathematical talk

Practices before the exchange

Eight teachers contrasted Shanghai practices with English practice in terms of the frequency and type of questioning by teachers and/or the precise use of mathematical language. Some interviewees commented on the way Shanghai teachers would continue to ask questions of an individual pupil until they were satisfied the pupil understood. This was culturally different from England where teachers would move on to another pupil or provide clues to help a pupil to the right answer, perhaps to save embarrassment. Four teachers commented on seeing peer to peer talk in lessons and this being similar to English classrooms; however three specifically commented on lessons being teacher dominated and there being fewer opportunities for pupils' active engagement.

Changes in practices

Interviewees from 14 schools identified increasing the quality and amount of mathematical talk. For example, pupils were being encouraged to explain their ideas and answers more thoroughly using correct mathematical language, either standing up to do so at their table, or coming to the front of the class.

> *Peer modelling "the little teacher" - to get children to show their activities and to talk it through - developing their confidence in speaking and listening skills.* (School 2A, Exchange teacher)

Questioning was seen as central to engaging pupils mathematically, for example, asking pupils why an answer was given, and the use of true and false questioning. One interviewee spoke of introducing lessons with a 'hook' or story to get pupils to engage in the area of learning, as a way of learning from Shanghai.

Future plans

As with the move to adopt a whole class interactive teaching approach in general, interviewees emphasised increasing the number of year groups in which new questioning approaches would be implemented.

Pace and tempo in lessons

Pace is an issue that teachers commonly remarked on. Nine teachers identified this as an important difference between Shanghai and England. Others identified this as an aspect of their practice that had changed as a result of the exchange.

However, the notion of pace in lessons is problematic as it has multiple meanings. This was reflected in the teacher interviews with some teachers asserting that Shanghai teaching was fast paced and others noting that the pace was slower, in particular at the start of lessons and in terms of overall lesson content covered. This may be due to observation of differing practices in Shanghai. However, given the relative consistency in Shanghai teaching, this is unlikely. It appears that what was being commented on were different aspects or types of pace:

> *Pace can mean lots of different things and you could be hinting at pacing through all the different objectives, or pace as in the feel of the lesson, the tasks the children are doing, how engaged they are.* (School 3B, Mathematics coordinator/exchange teacher)

It may be helpful to consider the difference between tempo and pace. The tempo of the lesson that arises from the frequency of interactions between teacher and pupils in Shanghai teaching may be experienced by teachers from England, as reported, as having a fast tempo because it involves more interaction than is common in teacher directed portions of English lessons. However, pace in Shanghai lessons is not uniform, with exchange teachers noting how teachers will slow the pace to ensure that key concepts are understood by everyone.

The lesson tempo is different from the pace at which mathematical content is covered from the start of the lesson to the end. Here, Shanghai teaching may appear to have a slower pace. However, this may not account for the amount of content in the lesson. Because Shanghai teaching involves breaking down content and considering concepts in depth, there is potentially more curriculum content covered and more ‘movement’ due to multiple steps, than might appear from a perspective informed by the usual English approach. A mathematical analogy is the difference between travelling the shortest distance between two points on a network and alternatively, taking a longer route but visiting more nodes, and so having a more in depth knowledge of the network or - analogously - of mathematics.

Practices before the exchange

From responses to questions about differences with Shanghai teaching practices in English classrooms, one can surmise that in most cases the existing practice in schools focused on curriculum pace, with coverage from lesson to lesson being a key measure of good teaching.

Changes in practice

Fourteen teachers described slowing down the curriculum pace.

> *[We are] trying to slim down the amount taught in a lesson, and to have a sharper focus.* (School 32B, Exchange teacher)

Teachers talked about spending more time on an area of learning instead of feeling they had to rush through it to move onto the next topic as they may previously have done. Using a step by step approach and 'chunking' work within a lesson was discussed in interviews. The aim of this was to ensure that every pupil had understood the area of work before moving on. Teachers talked about aiming to build a deeper understanding and fill the gaps in knowledge, indicating an aim to increase the learning pace, with 14 respondents mentioning changes that related to this. Ways they sought to do this included, approaching problems from a number of different points of view, and spending more time on questioning. Conversely, eight teachers also described increasing the tempo of the lesson, particularly through increased questioning.

It was often teachers with relatively high levels of subject and mathematical pedagogical knowledge, for example gained through the Mathematics Specialist Teacher (MaST) programme, who recognised different meanings of pace. This suggests that the capacity to accurately distinguish between and assess pace and tempo in mastery lessons requires mathematical expertise.

Future plans

In considering future plans, participants at five schools expressed a concern that a Shanghai teaching approach would be seen unfavourably in Ofsted inspections. This was linked in part to a concern as there might be a perception of a slower pace in terms of apparent progression from the start to end of the lesson.

Seating

Practices before the exchange

Most year groups throughout the lead primary schools are seated in small groups; however there is an increase in sitting pupils in rows from year 3 onwards with 36% of schools choosing to seat pupils in rows in year 6 (see Figure A12 in Annex 4).

Changes in practices

Teachers from ten schools described changing seating practices in response to the Shanghai exchange, from sitting in ability grouped tables to sitting pupils in pairs or rows and facing the front of the class. The change was made in order to facilitate the new style of whole class teaching. In at least one school this happened immediately following the teachers' visit to Shanghai, whilst in others, seating arrangements were changed at the time of, or following, the visit of Shanghai teachers and then continued after.

Future plans

Further changes to seating was not named as a future plan, as presumably those schools who considered this an important change to make would have already enacted it.

6.2 School practices

In this section, findings are presented about changes in aspects of school practices that were undertaken to support changes in classroom practice. It is important to note that changes in school practices are, in general, less amenable to implementing mid-year than those in classroom practices. In addition, the timing of interviews for some schools is particularly pertinent here with regard to future plans, with interviewees spoken to in February or March 2015 having not yet identified intentions for 2015 in many cases. Nevertheless, the interview data gives indications of how the exchange has influenced thinking.

Intervention for pupils needing additional support

Practices before the exchange

In the survey, mathematics coordinators were asked how often additional support is given to pupils in year 2 and year 6 whose progress in mathematics is not at the expected rate; additional support means one-to-one tuition or teaching small groups outside of normal mathematics lessons. Figure A7 (in Annex 4) shows that this happened on a daily basis in 64% of year 2 classes (n=39 responses) and 60% of year 6 classes (n=42 responses).

However, interview data suggests that usually at the time of interviews this was additional support provided to a relatively fixed group of pupils rather than the daily intervention that happens following daily assessment in Shanghai. There are a number of possible explanations for this discrepancy. Firstly, some survey respondents may be referring to intervention in class, for example by the regular support of a teaching assistant. Alternatively, it may be that in some schools some pupils are withdrawn from normal lessons to work in small groups regularly. However, given that intervention is an aspect of practice that can be changed mid-year, the end of year survey data may not present practices before the exchange in the case of some schools, but rather changes that were been made after the interviews took place.

Another important issue is who undertakes the intervention activity (Blatchford et al, 2007). In year 2, teaching assistants worked more frequently (45%) with pupils during the daily/weekly intervention time, than the classroom teacher (39%). However, the opposite was the case in year 6 where the classroom teacher was more likely to undertake the intervention (59%), compared with teaching assistants (32%) (Figure A8, Annex 4).

Changes in practice

From interview data, 16 interviewees from different schools identified intervention as an area of change during the year, with an increase in interventions undertaken by qualified teachers and an increase in the frequency of intervention. An additional approach adopted in one school was pre-teaching groups at the end of the school day, outside of school hours. 'Pre-teaching' means covering essential material prior to teaching the whole class; this is an alternative to additional teaching after material has been taught. Some teachers had chosen to use teaching assistants to work with the pupils needing support, whilst others had opted to deploy teaching assistants with pupils who had understood the area of learning, in order to free up the class teacher to do the intervention work.

Future plans

A further seven schools reported plans to introduce same day intervention from September 2015.

Lesson timing and structure

Practices before the exchange

The survey shows that the majority (88%) of lead primary schools had five maths lessons per week for both year 2 and year 6 classes (Annex 4, Figure A3), with lessons lasting for one hour in both year 2 and year 6 in most lead primary schools (68% for year 2 and 67% for year 6), as shown in Table A8 in Annex 4. This shows the continued influence of the National Numeracy Strategy daily mathematics lesson.

Changes in practices

Six schools described altering lesson structure or timing. This was informed by the lesson length and structure of the school day observed in Shanghai, and the adjustments needed by visiting teachers and schools during the Shanghai teacher visits. One school reorganised lesson structure mid-year to split the lesson into two parts to facilitate daily intervention (see Section 7.2). Three other schools worked within existing timetabling but changed practice to more clearly split lessons into two sections. In the first half (30, 35 or 40 minutes) teachers would teach a 'Shanghai approach' to the whole class, and the second half (30, 25 or 20 minutes) would be used for practice, or in one school reserved for intervention work. Two other schools had introduced ten minutes of daily mental mathematics separate from the main lesson.

Future plans

In total, another six schools discussed changing lesson timing or structure in the future, with two of these reporting definite plans to change the timing of lessons.

Curriculum content and organisation

Practices before the exchange

Exchange teachers and headteachers contrasted the Shanghai curriculum with that in England, with the former being described as having less in it, attending to key concepts and emphasising number in the primary years.

Changes in practice

Interviewees from 16 schools described changing the curriculum in response to involvement in the exchange. Changes described were:

- less coverage
- moving through the curriculum more slowly
- focusing more on number and less on shape and space and data handling

Future plans

Five teachers discussed reviewing the curriculum as a priority for future plans, considering moving away from a spiral curriculum and ensuring that all pupils gained a full understanding of topics before moving on to new areas. Some teachers pointed to differences between the English primary curriculum and the Shanghai curriculum, particularly in the early years and key stage 1 in terms of the amount of material covered.

Resources and materials

Practices before the exchange

The large majority of lead primary schools did not use a commercial scheme for teaching mathematics in year 2 (76%) or in year 6 (90%) (Figure A12, Annex 4). Eight schools used a commercial scheme for teaching in year 2, and four in year 6. Of these 12, half said they used it as a basis for instruction, and half as a supplementary resource. Thus, practice in schools was typical of that in English primary classrooms where a wide variety of materials are used, in contrast with Shanghai where a standard textbook with supporting presentation material is used universally.

Changes in practices

Five schools reported introducing textbook use, usually those based on Singapore textbooks. In addition, one school had worked with their visiting Shanghai teacher to develop materials that parallel the Shanghai textbook for a single year group, and in another the visual representations found in the Shanghai textbooks were being adapted.

Future plans

Teachers from six schools spoke about introducing or increasing the use of textbooks as a planned change, with a representative from one school talking about having the Shanghai textbooks translated, and others specifically mentioning Singapore textbooks.

One headteacher interviewee (School 25B) cited the recent adoption of a commercial scheme as a reason for only being selective about adopting or adapting Shanghai approaches, thus indicating a potential barrier to uptake of mastery informed textbooks. Five interviewees, when asked about what was needed to support adoption of Shanghai approaches, specifically named the need for national resources, either textbooks or other teaching materials.

Grouping

Practices before the exchange

Grouping, either between classes or within classes, was generally established in two thirds of lead primary schools by year 2 (Figure A9, Annex 4). The survey data broadly reflects other recent research on grouping practices in primary schools (Hallam & Parsons, 2013; Marks, 2014).

Broadly, the use of setting or ability groups between classes was found to be more prevalent as pupils progressed through year groups, with a mirroring reduction in the grouping within classes.

Changes in practice

In Shanghai, pupils are taught in all attainment classes. Given the barriers to changes in organisation of lessons and grouping during the year, it is unsurprising that setting practices largely continued unchanged during the year. The interview data did not indicate any in-year changes to setting arrangements, although there are a few examples of schools which had already made changes to grouping in particular year groups due to prior engagement with mastery approaches.

Future plans

Two exchange teachers talked about reducing ability grouping in the future, while a number of others discussed this as a possibility. However, as noted in relation to differentiation, above, in more than half the schools teachers discussed strategies for ensuring all pupils mastered the curriculum.

Homework

Practices before the exchange

The survey of mathematics coordinators asked about homework practices (reported in Figure A10 in Annex 4). Pupils were most frequently asked to complete homework on a weekly basis in both year 2 (76%) and year 6 (81%). The most frequent length of time of the homework set was 15 minutes for year 2 (41%) and 30 minutes for year 6 (34%).

Changes in practice

Interviewees in eight schools described changes in practice from setting weekly homework to daily, as in Shanghai, or that homework was to be set little and often.

A number of interviewees in other schools mentioned concerns about parental responses in relation to increasing homework, and in one school staff ambivalence. It may be these comments represent more widespread cautions about changing homework practices. As an alternative to Shanghai daily homework, changes in lesson structure in some schools was linked to providing an equivalent time for practice.

Future plans

In discussing future plans, only one interviewee specifically mentioned homework as an area for change, in the context of implementing multiple Shanghai practices in 2015/16, initially with year 1 and year 3 classes.

Specialist Mathematics teachers

Practices before the exchange

The deployment of specialist mathematics teachers is not common in English primary schools. The term 'specialist' can be used with various meanings, including: having a specialism in mathematics as part of a general primary ITT; CPD as part of the MaST programme; teaching one to one mathematics recovery programmes; or teaching multiple whole classes mathematics.

Due to this potential confusion, in the survey of lead primary schools mathematics coordinators were specifically asked if they had teachers who only teach mathematics. Most lead primary schools (77%) did not have specialist mathematics teachers (Figure A4 in Annex 4). Of the 23% of schools reporting that they had a specialist mathematics teacher, data on intervention practices indicates that half of those specialist teachers were undertaking one to one work. This suggests that specialist class teaching was occurring in six of the lead primary schools.

Mathematics was reported to be taught by the usual classroom teacher in 67% of the lead primary schools (see Figure A5 in Annex 4) and is more likely to be taught by a class's usual classroom teacher in the younger year groups.

Changes in practices

Given that deployment of teachers and timetabling is undertaken as part of a school's annual planning cycle, unsurprisingly only two reported changes in practice in terms of specialist mathematics teaching during 2014/15. One school reported trialling specialist mathematics/English teachers in years 4 and 5, with teachers now teaching a single subject to both year groups. In the second school, a teacher described doing a small amount of specialist teaching as a pilot.

Future plans

Visitors to Shanghai invariably commented on specialist mathematics teaching as being an important feature of Shanghai mathematics education and potentially important to its comparative success in mathematics. However, when asked about the possibility of

having specialist mathematics teachers, headteachers, in particular, identified a number of obstacles:

- lack of available teachers
- without additional resource for mathematics specialists above the normal workforce, mathematics specialists would need to be balanced by, for example, literacy specialists and the two subjects had different marking demands leading to an unequal workload
- staff concern about potential career implications if not teaching mathematics
- organisational challenges, particularly in small schools

It is notable that these are not seen as 'in conflict' in Shanghai, but mutually supportive.

Four interviewees discussed concrete plans or steps to increase specialist teaching, with others discussing it as something being considered for the future.

Professional development

Practices before the exchange

Teachers and school leaders contrasted professional development in Shanghai with that in England. Opportunities for collaborative professional development prior to engagement in the exchange were limited, although a small number of schools reported previous use of approaches such as Lesson Study.

Changes in practices

Five schools used the experience of hosting Shanghai teachers to implement Teacher Research Groups and to undertake associated lesson observations and lesson discussions, similar to those witnessed in Shanghai. In four of these five schools, Teacher Research Groups or similar approaches have continued since hosting the Shanghai teachers during 2014/15. One school led a Teacher Research Group that involved teachers from ten other schools, supported by Maths Hub funding. Another school has engaged with Lesson Study and linked this to participation in the exchange.

Future plans

Teachers and school leaders report that these approaches are time consuming and difficult to implement due to a limited amount of time available for planning or professional development. This suggests a risk that the level of professional development opportunities the exchange afforded may not continue, although one school was planning timetabling changes to facilitate ongoing collaborative professional development. A small number of interviewees expressed a desire to increase planning time for teachers, including collaboratively.

7. Early evidence of pupil impact

In this section, early evidence of impact on pupils is presented, drawing on evidence from both the interview and survey data, and reports submitted to NCETM by schools.

7.1 Evidence of impact on pupil attitudes and engagement

In considering impact on pupil attitudes and engagement, evidence from all 48 schools is supplemented by a particular focus in this section on the five case studies where strand three follow-up interviews were conducted.

Most, but not all, teachers across the 48 schools were positive about pupils' responses to changes put in place in schools since the Shanghai teachers' visit. Teachers perceived greater confidence and engagement with mathematics, and higher levels of attainment. Evidence for these assertions is either anecdotal, or its reliability is limited by other changes to curriculum and assessment procedures in schools. A small number of teachers mentioned strategies for ongoing, within-school evaluation of the intervention.

Engagement

Across the schools teachers talked about pupils being more engaged, in terms of enjoying maths more, having a more positive attitude to maths and being more enthused.

A further pupil outcome was a deeper engagement in mathematics. In one school this was attributed to teachers' demands for pupils to respond to questions in mathematics and to explain their answers. The resulting deeper engagement was evidenced by pupils' willingness to volunteer responses, and by their confidence in those responses. In one school this was linked to a focus on teaching the whole class together:

> *The children are very sort of mixed up. There's no feeling of, 'I'm in the lower group*'. (School 2B, Mathematics coordinator)

This, coupled with the use of the same-day intervention group, may convey a message to pupils that their current achievement matters, regardless of their prior attainment. According to the mathematics coordinator, some of the higher attaining pupils were surprised when they found themselves in the same-day intervention group; it had made them more careful about their work.

> *It might be because there's just a small inaccuracy in the way they've set something out, or it might be just something quite little. And they clearly have the concept, but they are being, for want of a better term, pulled up on it. So, you know, there's no expectation that certain people will have the same-day intervention. It could be anybody in the group.* (School 2B, Mathematics coordinator)

Deeper engagement was also attributed to the amount of content, pace of the lessons and the opportunity to revisit learning.

Confidence

Ten of the exchange teachers either explicitly stated or indicated that pupils were more confident or, as one observed:

> *Their attitudes are a lot [more] positive. They feel that they can achieve a bit more.* (School 5, Exchange teacher)

Similarly, a year 3 class teacher reported that pupils were more confident and less reliant on their teacher. In the end of year report to NCETM, a third school reported that pupils were becoming more confident in approaching calculation problems, and in an interview the headteacher noted that the increase in confidence of lower achieving pupils was particularly marked:

> *A big difference in the children's confidence, particularly for children who were lower attaining at maths. It's not a massive leap forward in their attainment. Just to see them, in the classroom, stand up and speak about maths confidently, and use the correct mathematical vocabulary – it was quite a change in the children's attitude.* (School 2B, Headteacher)

The impact of Shanghai-informed approaches on lower achieving pupils was also noted by the mathematics coordinator in another school, who reported that pupils were more engaged and enjoying mathematics more. Shanghai-informed approaches were also perceived to be helpful in developing the confidence of pupils with English as an Additional Language (EAL), and in reducing anxiety for pupils on the autistic spectrum. For example, a year 3 class teacher described how using visual images to introduce concepts had made the mathematics more accessible to pupils with EAL.

Another exchange teacher made a link between increased confidence and the removal of differentiation within lessons:

> *And because we're not differentiating as such any more... where the teacher will set the same kind of work for everyone… So, the children feel that they can access it a bit more. They feel that, yes, I can achieve this, I can do it. So, there's more of a can-do attitude…. And they're not really classing themselves as, 'Oh, I'm better than you', or, you know, 'You've got different work than me'. They know that it's, they're all on the same page.* (School 5, Exchange teacher)

Improvements in confidence were not just limited to the mathematics classroom but were evident at home too:

> *They feel that, you know, they can all achieve, and it's not just in the class, in the classroom; it's what happens at home as well.* (School 5, Exchange teacher)

This has led to a different attitude towards learning mathematics:

And they know that it's not about getting to the end of their work or just finishing it off. They know that good mathematicians need to make as many links as possible, as many connections. (School 5, Exchange teacher)

7.2 School case studies and early evidence of impact on attainment

In this section, three case study examples of early evidence of impact on attainment are reported. Follow up interviews with these schools took place in July 2015. There is considerable challenge in evidencing immediate impact on pupil attainment given the current context of a move away from levels, thus not allowing for year to year comparison.

Case study one

Case study one (school 4) is a large school with a six form entry and an outstanding Ofsted judgement. It is a Teaching School and lead primary partner in the local Maths Hub. The school had already undertaken significant implementation of practices aligned with mastery approaches prior to participation in the exchange. Other influences on practice have been previous engagement in the MaST Programme, the NCETM accredited professional development leader programme, NCETM progression and reasoning documents, and other sources such as NRich[16].

The school embraced the challenge of the new curriculum with two INSET days for teachers at the start of the year, in anticipation of the exchange visits, focussing on: using models and images to develop conceptual understanding; the importance of how mathematical language is used and encouraged; making connections between areas of mathematics; and developing fluency. In addition, the school had already moved away from setting in year 3. The mathematics coordinator demonstrated considerable understanding of key concepts in Shanghai pedagogy, such as variation.

During 2014/15, year 3 pupils were the focal point for the exchange, with the visiting Shanghai teacher allocated to the class of the teacher leading mathematics across the whole year group. The Shanghai teacher also worked with year 6 pupils. Given existing mastery approaches, the exchange experience led to refinement rather than new practices, in particular greater planning to identify small steps of progression. The school has developed considerable resources to support this, working with Shanghai teachers to translate the Shanghai textbook.

For year 3, the school restructured mathematics teaching into two 35 minute lessons per day, with one mainly focused on interactive teaching to develop conceptual

[16] NRich (http://nrich.maths.org) offers support for the enrichment of mathematical learning of learners.

understanding, and the other to support consolidation and practice. The new approach has led to a different understanding of pace:

> *Previously we raced through content to the next level, and as you worked through you could see the gaps that the children had and you were constantly trying to plug those gaps. Whereas now we try to make sure those gaps aren't there to start with, and those foundations are so solid that they can build on top of them and have that new learning. It is about the small connections, but you can see that you're constantly bringing in the previous learning all the time… it's built on continually from there - a little step up.* (Case study one, Mathematics coordinator)

The new structure is also supporting a new approach to intervention with assessment of pupils needing additional support happening daily. In addition to further supporting the new all-attainment approach to grouping, the school created a single 'closing the gap' group of 27 pupils across the year 3 cohort who needed the most intensive support. Through using the new approaches and forms of intervention, by January 2015 this had reduced to 17 pupils, with the other ten being integrated into the all-attainment classes. At the same time, high attaining pupils were being stretched by problems that required greater understanding, rather than previously using the same procedures with larger numbers.

Adoption of mastery approaches was linked to an improvement in the development of pupils' self-regulation strategies, such as looking back at previous work. The mathematics coordinator associated the development of these strategies with gains in learning, and reported that the pupils had also begun to use self-regulation strategies in other subjects.

The school trialled an assessment tool and used the same test with both the year 3 and year 4 cohorts. Year 3 followed a more fully developed mastery approach, and year 4 followed the previous pattern of teaching. The year 3 cohort was reported as having higher scores on the same test than the year 4 pupils, even though they were younger. The mathematics coordinator identified that the nature of the assessment task - aligned with the new national curriculum - was more in keeping with a mastery approach and this may have influenced the outcome. Nevertheless, this outcome provides early evidence of positive impact of mastery approaches.

Case study two

Case study two (school 6) is part of a TSA. The school was judged as good at the last Ofsted inspection. The Shanghai teacher worked with one year 3 and one year 6 class. Owing to the exchange teacher teaching year 6 and being the exchange lead and mathematics coordinator, both year 6 classes are having lessons planned and delivered in a Shanghai-style. Other teachers are also making changes to teaching across the school. The biggest changes made in this school were to curriculum planning. Teaching for mastery has been embedded, including the use of mathematical language, and the

use of questioning to encourage pupils to fully explain their answers and make linkages to other areas of learning. Another key change has been to stop ability streaming, informed by a change in beliefs about the potential that all pupils can succeed in mathematics. Teachers have brought in in-depth questions for those who have previously attained highly. The school has reported a positive change in the attitude of previously lower attaining pupils.

Pupil impact can particularly be seen in the class that received the teaching from the Shanghai teacher. The Shanghai teacher was asked to teach fractions to year 6 pupils, and the school followed this up by continuing to embed and deepen understanding of the topic after the Shanghai teacher had left. School analysis of key stage 2 outcomes showed that in year 6 more pupils had achieved level 5 on fractions than on other mathematical topics. The mathematics coordinator in the school was of the view that pupils have better retention of knowledge since the move to the mastery approach.

Case study three

Case study three (school 30) is a one form entry school for pupils aged 4-11, judged to be outstanding by Ofsted with high value added scores.

Following the visit to Shanghai, the school split the mathematics lesson into two parts. This was a change across the whole school. An initial 35 minute lesson is used to develop conceptual understanding. During this lesson, pupils needing additional support are identified. The class teacher then works with these pupils (who do not attend the school assembly) to ensure they understand the lesson content. Following this, a second 35 minute mathematics lesson is used for practice and consolidation. If needed, further small group or individual intervention takes place at lunchtime. Notably, the mathematics coordinator reported that approximately 20 of the pupils in the class received support, rather than the previous approach where support was focused on a smaller group of pupils.

The school reorganised seating, moving away from small groups organised by attainment, to arranging desks in rows. This also led to a change in the deployment of teaching assistants. This was viewed as leading to greater engagement by previously low attaining pupils with core teaching in lessons and higher attaining pupils developing greater resilience due to challenging extension tasks.

In addition, the exchange experience influenced teaching and planning, focussing on progression and smaller steps in curriculum coverage. Future plans include the adoption of a Singapore-style textbook.

The school has worked closely with a group of other schools across the hub, focussing on changing lesson design, approaches to intervention and deployment of teaching assistants. The school is distinguished from most other exchange schools in its embrace of the Teacher Research Group approach, working with ten schools across the hub as

well as seeking to embed the teacher research approach in its own school by creating additional time during the school day for all teachers to engage in this activity.

The school used previous key stage 2 SATS papers with the year 3 pupils and assessed using levels formerly used. The previous expected level for highest attaining pupils in year 3 in this school was level 3c. In the cohort that experienced Shanghai-informed teaching, the highest attaining pupils achieved level 4a.

8. Enablers and barriers to implementing a mastery approach

Interview respondents identified a number of enablers and barriers to implementing Shanghai practices in their schools.

8.1 Enablers

Four enablers appeared to be particularly important in supporting the implementation of a mastery approach.

NCETM and Maths Hubs

National activity, guidance and organisation by the NCETM and activity by Maths Hubs, which in some cases organised substantial local activity involving a large number of teachers from other schools.

Senior leaders’ and mathematics coordinators' commitment to change

The exchange strongly influenced many participants; others already had developed a strong commitment to mastery. Linked to this was an interest to review previous practices and an aspiration for English primary mathematics education to emulate Shanghai's success.

Teachers' openness to change

Many interviewees commented on the willingness of staff in the school to embrace change. This was summed up by one headteacher who observed that implementing the mastery approach had been facilitated by staff 'who are very willing to change and adapt for the best needs of their pupils'.

Headteacher leadership and/or support

In line with literature on school improvement (see for example, Leithwood, Hopkins & Harris, 2008), headteacher support was perceived to be a crucial enabler. Such support was pivotal in getting teachers on board, as well as for releasing resources to facilitate teacher participation. Headteachers who had visited Shanghai noted that they were well placed to implement changes. Several other teachers pointed to the positive impact of a senior leader participating in the exchange, who could then make decisions within the school.

8.2 Barriers

Teacher beliefs, attitudes and subject knowledge

The research has identified five schools categorised as ‘cautious’ or ‘less engaged’. It is clear that the take up of new approaches is not universal across all schools. Other interviewees were not convinced that all aspects of Shanghai mathematics teaching would work in their school or reported that other teachers believed this. Two considered that Shanghai teaching relied on mathematics specialists and this would not work in their school. Two teachers did not consider that the Shanghai approach catered adequately for high and/or low attaining pupils.

Where schools are implementing changes, a small number of headteachers and mathematics coordinators reported some general reluctance by teachers in their schools (n=5). Additionally, others focused specifically on risks of change given that their schools were already successful in terms of attainment and/or Ofsted grade (n=5), with a further two citing greater barriers to implementation in year 2 or year 6 given their importance for national assessment.

A further issue, raised particularly by mathematics coordinators, was the weakness of some teachers' subject knowledge, which made it difficult for them to plan and devise examples or to respond to pupils in a way that developed conceptual understanding. The lack of confidence of some teachers in teaching mathematics was also pointed to as a barrier to implementation.

Teaching resources

Another barrier mentioned by interviewees in five lead primary schools, and reiterated in four interviews with teachers from Shanghai, is a lack of appropriate teaching resources, particularly a mastery textbook and associated visual resources. The lack of textbooks created additional difficulties. Schools found that creating appropriate examples for variation and other materials required a substantial amount of time, and linked to the concern about subject knowledge stated above, some were concerned that teachers did not have sufficient knowledge to create resources themselves. One mathematics coordinator would have welcomed exemplar materials and assessments so that they could understand what a pupil should be doing in a particular age group.

Challenges for EYFS and Year 1

A number of respondents noted that Shanghai pupils start school at seven years old, and there is no Shanghai curriculum for this age group. Reflecting on why the Shanghai approach had not worked in their reception class, one exchange teacher considered that, at least in part, this was due to the absence of guidance for teaching for mastery with younger pupils.

School-level challenges

A key challenge for the headteachers and mathematics coordinators who were interviewed was funding. They pointed to the resource implications for implementation, such as the training needed for teachers and in some cases, teaching assistants, as well as the funding resources needed to sustain Shanghai methods; release time for teachers to plan and engage in Teacher Research Groups; and the cost of textbooks, once they become available, or, in the meantime, the time required to create resources.

Organisational and structural challenges

The organisation of primary schooling in England was perceived by interviewees, including the Shanghai teachers, as a particular challenge. Interviewees emphasised the contrast between Shanghai teachers' professional roles and those in England. Moving to a specialist teacher model was perceived by many schools as difficult within the English system. One reason given is because expertise across subjects is expected, so becoming a specialist in mathematics has the potential to de-skill a teacher and have implications for future employment or career prospects. This was related to both those who become mathematics specialists as well as those who do not then teach mathematics. Early indications are that schools are aiming to develop mathematical expertise of all teachers as an alternative to specialist teachers.

The Shanghai teachers interviewed emphasised the challenge of the English mathematics curriculum, pointing out that it includes topics such as fractions earlier than in Shanghai. They argued that a secure grasp of basic concepts, and particularly tables, is required before moving onto more complex concepts. This view was echoed by other interviewees in a small number of schools.

Concern about meeting the national curriculum demands was expressed in some schools. Four exchange teachers mentioned concerns that Ofsted may be critical of aspects of the approach. Of these four, two referred to pace and/or progress in lesson and two to possible perceptions of lack of differentiation. Although assurances had been given at national meetings that this would not be the case and guidance had been given to inspectors, the concern persisted in some schools.

9. Conclusion

The Mathematics Teacher Exchange: China-England is an innovative approach to supporting schools to adopt and develop mastery approaches informed by Shanghai mathematics education. Although initiated in a short time scale, the early implementation of the exchange programme has led to change in practices in many of the schools involved, as well as catalysing reflection on English primary mathematics education practices in the lead primary schools and more widely.

This report has focused on what has happened so far, on early evidence of influences of practices and indications of positive impact on pupil attitudes and attainment. It has also outlined developing approaches and tools for analysis for evaluating the success of the exchange through longitudinal study.

There are early indications that the exchange has the potential to meet its core aim of fostering a radical shift in mathematics teaching in primary schools and to impact on pupil attainment. The majority of schools have made some or a high level of change. Others indicated a commitment to mastery that would indicate more substantial change in the future. However, whilst the exchange clearly has influenced practice, it remains to be seen whether the potential for change will be fully realised.

Policy support and coordination of activity across a wider layer of stakeholders will also be important to the success of the exchange. The NCETM and Maths Hubs have played a central role in the programme so far. As pointed to above, since the primary exchange visits the NCETM has collaborated with UCET to inform and influence ITT provider practice, developed a CPD programme for mathematics specialist teachers and through the Maths Hubs is coordinating the development and sharing of resources and materials.

Further, coordination and guidance to schools will be important to future success. Important too will be those schools and teachers that have a positive orientation to mastery and the exchange and are developing practices that can be examples to other schools involved in the exchange as well as more widely.

Annex 1 Mastery and Shanghai and English mathematics education

A1.1 Introduction

In this Annex different uses of the term mastery in mathematics teaching are considered. In addition, further details about Shanghai and English mathematics education and differences between the two systems are given.

A1.2 Mastery teaching

The term 'mastery' is used to refer to a range of different pedagogical and curriculum approaches developed in a variety of education systems. In the US and other western countries mastery is associated with a teaching and curriculum approach associated with Bloom, and the regular use of formative assessment (Guskey, 1997). Essential to mastery is a view that everyone can succeed mathematically, except those with specific cognitive disabilities, if appropriate resources, support, time and teaching are provided. Features of Western mastery approaches are (Guskey, 2010):

- diagnostic pre-assessment
- high quality group based instruction
- monitoring of progress through regular formative assessment
- high quality corrective instruction for individuals or groups
- leading to further formative assessment, and enrichment or extension activities

Thus, Western mastery focuses primarily on learning and opportunities to learn -learning for mastery. The adoption of such mastery approaches has been found to improve mathematical attainment in meta-analysis of innovations (Hattie, 2013).

Asian mastery pedagogy shares firstly, an expectation that everyone can achieve mathematically, and secondly, frequent formative assessment to check understanding and guide supplementary instruction where needed. However, it differs in focussing on the use of carefully designed lessons using models, problems and practice materials centred on critical aspects of mathematical learning used in the context of whole class interactive teaching. Thus, the emphasis is on developing teaching methods and lessons that lead to mastery - teaching for mastery

Western mastery learning was developed as an intervention designed as an alternative to usual educational practices. Asian mastery teaching, however, is the product of educational and cultural norms; the expectation is that all will learn and the role of the teacher is to design lessons and use practices that ensure that will happen. Consideration of success in international comparison of countries using Asian mastery approaches has influenced the new Primary Mathematics Curriculum (DfE, 2014b).

The NCETM has identified the following features common to south-east Asian mastery (NCETM, 2014):

- teachers reinforce an expectation that all pupils are capable of achieving high standards in mathematics
- the large majority of pupils progress through the curriculum content at the same pace; differentiation is achieved by emphasising deep knowledge and through individual support and intervention
- teaching is underpinned by methodical curriculum design and supported by carefully crafted lessons and resources to foster deep conceptual and procedural knowledge
- practice and consolidation play a central role; carefully designed variation within this builds fluency and understanding of underlying mathematical concepts in tandem
- teachers use precise questioning in class to test conceptual and procedural knowledge, and assess pupils regularly to identify those requiring intervention so that all pupils keep up

A1.3 Shanghai Mathematics Education

Shanghai mathematics education is an example of a mastery approach to teaching and learning mathematics. It shares features with other mastery teaching approaches, including teaching elsewhere in China. These features are organised into the following interconnected categories.

Culture and beliefs

- Parental, pupil and teacher culture of high expectations and independent study and beliefs that ability is malleable rather than fixed (Li Jin, 2004; OECD, 2011).
- The effect of the one child policy that means most families in China now consist of two parents and one child, leading to high level of involvement of both parents and usually four grandparents focused on supporting a single child's preschool and school learning (Tobin, Hsueh & Karasawa, 2009).
- Very little if any time spent on behavioural management (Miao & Reynolds, 2015).

Organisation of mathematics teaching

- Pupil entry to school at seven years old (OECD, 2011).

- Specialist primary mathematics teaching in all attainment classes with 40-50 pupils per class (OECD, 2011).

- Relatively low levels of pupil contact for teachers. Typically a teacher has 60-80 minutes of contact per day, plus one to one or small group remediation or extension teaching (NSCL, 2013, 2014).

- Allocation of the same mathematics teacher to a class for three or more years (NSCL, 2013, 2014).

Pedagogy

- Teaching that integrates the development of conceptual understanding and problem solving with a proficiency in routine skills (An, Kulm & Wu, 2004; Huang & Leung, 2004) through conceptual and procedural variation (Gu, Huang & Marton, 2004).

- An emphasis on careful choice of examples and precise mathematical language (Gu, Huang, & Marton, 2004).

- Whole class interactive teaching commencing from a problem rather than lesson objectives, and frequent meta-cognitive and reflective discussion (Miao & Reynolds, 2015).

- Pupil talk is an instructional priority (Clarke, Xu & Wan, 2010) usually in the context of teacher directed or orchestrated whole class discussion (NCSL, 2014; Xu & Clarke, 2013). There appear to be differences between primary and high schools related to peer to peer talk with Lim (2007) noting peer talk in primary schools in contrast with others noting that it is largely absent in grade seven classrooms (Clarke, Xu & Wan, 2010; Xu & Clarke, 2013). The difference between primary and secondary phases was noted in the NCSL 2013 visit (NCSL, 2013).

- Daily practice set as homework, immediate intervention to prevent gaps developing to meet the expectation that all pupils will progress through the curriculum together (NCSL, 2013, 2014). Thus differentiation is by depth rather than by acceleration.

Curriculum, resources and assessment

- The use of common textbooks across schools and with all pupils accessing the same resources; with teachers developing in depth knowledge of the textbooks (Li Jianhua, 2004).

- Textbooks support teaching with variation and are aligned with a challenging curriculum; and the use of problems as a starting point for lessons (Lopez-Real, Mok, Leung & Marton, 2004).

- Activities and resources developed in collaboration with university researchers and informed by teacher research (NCSL, 2013, 2014).

Professionalism

- The high status of the teaching profession leading to competitive entry of highly qualified graduates (OECD, 2011) and identity as a specialist teacher.

- In depth mathematical study at undergraduate level for all specialist primary mathematics teachers leading to teachers' 'deep and profound understanding of fundamental mathematics' (Ma, 1999). This enables teachers to plan and teach mathematics incrementally whilst making connections between different areas of mathematics (Gu, Huang & Marton, 2004).

- Intensive on-going school based professional development (Huang, Peng, Wang & Li, 2010) with mathematics teachers undertaking 340-560 hours in the first five years post-qualification (NSCL, 2013, 2014).

- Vertically and horizontally networked Teacher Research Groups (Yang, 2009 Huang, Peng, Wang & Li, 2010) supported by expert teachers (Ding, Jones, Pepin & Siko, 2014) with an expectation of teacher enquiry and research rooted in collaborative peer observation and curriculum development (NSCL, 2013, 2014).

A1.4 Differences from English primary mathematics education

Although those involved in English mathematics education have much tacit knowledge of practices, there is limited in depth research on the prevalence of practices in English primary mathematics education, with few systematic studies. In addition, teachers often over-report practices such as interaction (Smith et al, 2004) and studies that include observation of teaching are rare. The challenge of identifying differences between Shanghai and English primary mathematics education is compounded by greater variation in teaching in England (Ofsted, 2011; Sammons, et al. 2005) than appears to be the case in Shanghai. Nevertheless, there are clear differences between mathematics education in Shanghai and England. These are summarised below.

Primary mathematics lessons in England are marked by low levels of interaction between teacher and pupils, including during whole class episodes. The format that dominates is teacher explanation in a transmissive manner followed by individual practice or group practice (Smith et al., 2004; Miao & Reynolds, 2014, 2015). Practice tends to be based on worksheets or other resources that focus on routine problems and use of textbooks is rare (Askew et al., 2010).

Although recommended since the introduction of the National Numeracy Strategy, end of lesson plenaries are not always used (with one study suggesting that they are only used in half of lessons - see Sammons et al., 2005), even though they can be key to

developing conceptual understanding and metacognitive skills such as problem solving. This contrasts with Chinese mathematics in which there are multiple episodes in every lesson of what could be considered as mini-plenaries in which key concepts and metacognitive processes are discussed (Lopez-Real et al., 2004; Miao & Reynolds, 2015).

In England, lessons usually start with informing pupils of differentiated lesson objectives rather than, as in China, from a mathematical problem or content with objectives being introduced at an appropriate time (Miao & Reynolds, 2015). A priority is placed on demonstrating maximum coverage of content within a lesson and, consequently, often material is retaught in subsequent years. Formative assessment in Shanghai is undertaken through written homework tasks. In-class assessment for learning activities do not appear to be used (NCSL, 2014).

Attainment grouping is increasingly prevalent in English primary schools either, in larger schools, involving setting pupils, or, more frequently, in class grouping where pupils who are perceived to have similar ability sit together (Hallam & Parsons, 2013). This arrangement is linked to a pervasive belief that mathematical ability is fixed (Marks, 2014) and leads to differentiated access to the curriculum with progression being determined by progress through National Curriculum levels. In addition, there is differentiated access to spaces, resources and qualified teachers (Marks, 2014) with often ineffective use of teaching assistants in class, and when undertaking small group interventions (Blatchford et al., 2007).

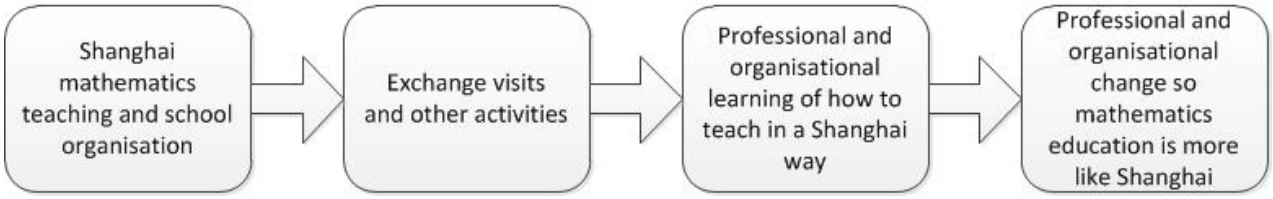
English primary teachers are usually generalists teaching across all subjects. The level of mathematics qualification needed for entry to the profession is low and many primary teachers lack in depth subject knowledge and confidence (Williams, 2008).

Annex 2 - Evaluation methodology

A2.1 Form of innovation and evaluation design

The Mathematics Teacher Exchange can be conceptualised in two different ways in terms of the nature of innovation and both of these inform the evaluation design. Firstly, the exchange has features of the implementation of a relatively well defined innovation. From this perspective, the aim of the exchange is to *adopt* at least aspects of the Shanghai teaching approach. This is described in the figure below.

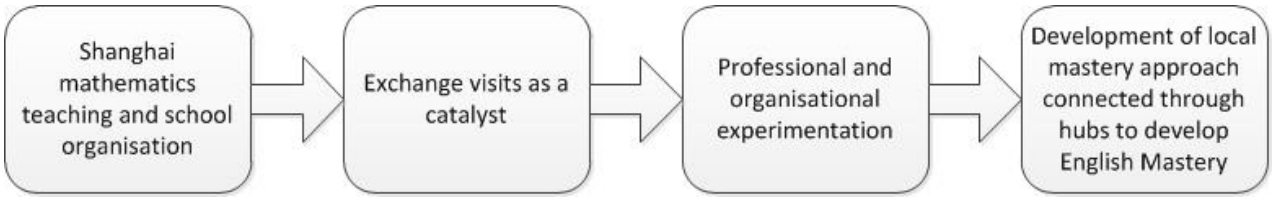
Figure 1 The Mathematics Teacher Exchange as an adoptive innovation



The expectation would be that implementation is similar across schools and hubs and the intermediate success criteria for the exchange would be the extent to which aspects of the Shanghai approach are found in both lead primary schools and other schools. In other words, the success of the exchange would relate in part to the degree of fidelity of implementation of Shanghai approaches. The longer term success criterion is how the degree of adoption of Shanghai approaches relates to pupil impact. An adoptive approach allows for a clear focus on what is to change but in being specific risks change being minor. It requires a relatively tight coupling or relationship between actors and clear agreement over goals. Such change is more likely to be successful in a stable environment.

Alternatively, the exchange can be viewed as aiming to *adapt and develop* aspects of Shanghai mathematics education. This is shown in the figure below.

Figure 2 The Mathematics Teacher Exchange as an adaptive innovation



From this perspective, the primary aim of exchange visits and other activities is not to lead to professional learning of how to teach or organise learning in a Shanghai way. Rather, it is to provide a stimulus to catalyse change that leads to professional and organisation learning through adaptation. Through the hubs and NCETM coordination, an English approach to teaching for mastery may develop appropriate to this culture, circumstance and situation, including the context of the development of a school-led system. This is likely to have features of Shanghai mathematics education but also be

different in significant ways. The expectation is that the innovation would be local and diverse. Intermediate success criteria would be the development of local adaptations for different contexts and the evaluation of these would focus on assessing the relationship between this diversity and impact. Adaptive implementation is appropriate to complex and unstable change environments.

Analysis of the exchange design, implementation in the first year and plans for 2015/16 (see below), all indicate that the exchange has features of both adoptive and adaptive innovation and this informs the evaluation methodology.

A2.2 Strand One

During the lead primary school visits, the evaluation team interviewed a selection of (depending on availability):

- exchange teacher(s) from England (approx. 45 minutes-1 hour)
- headteacher (approx. 30 minutes)
- mathematics subject lead (approx. 30 minutes)
- exchange project lead (approx. 30 minutes)
- Shanghai teachers (approx. 45 minutes)

Strand one data collection activity is summarised in Table 13.

Table 13 Strand 1 fieldwork data summary

	Lead primary schools			Hubs	National
	Lead primary school case study visits	Lead primary school telephone interviews	Shanghai teacher interviews	Hub lead telephone interviews	National NCETM/DfE telephone interviews
No.	31	17	6	12	4

The sample of schools visited ensured that there was variation in key characteristics such as school type and pupil profile. In many schools the interviewees had dual roles, for example the exchange teacher was also the mathematics co-ordinator or headteacher, and so individual interviews were adapted to cover multiple roles as necessary. In total, 107 teachers or leaders were interviewed at lead primary schools: 88 face to face and 19 telephone interviews[17]. Of these 107 interviews, 60 were exchange teachers.

For this report, data from all interviews were analysed using a framework derived from the study objectives. Drawing on this initial analysis, further thematic analysis (Ryan &

[17] 17 telephone interviews at schools not visited and a further two follow up interviews to complete data collection with two schools that were visited.

Russell Bernard, 2003) was used to identify themes such as orientation to mastery and patterns of implementation. At the next stage a thematic individual and cross-case analysis will be deployed to provide the basis for comparison over the three years of the study. A thematic analysis of the hub leads and NCETM and DfE stakeholder interviews was undertaken for this report.

In addition, 28 school reports were received from schools directly or from NCETM in August 2015. The NCETM also provided an analysis and summary of all end of year reports as well as schools' interim reports.

Between June and July 2015 an online survey of both lead primary schools and of other schools in hub networks was conducted. The response rate for lead primary schools was 46 out of 48 completions. The same survey was distributed to a wider sample of schools identified by Hub Leads as having had some contact with Maths Hub activity and/or with the exchange schools. A total of 218 schools completed the wider hub schools survey. The findings will be reported in the autumn 2016 report and the survey will be repeated between June and July 2017 in order to identify any changes over time.

Further telephone interviews with all exchange teachers will be carried out between February - April 2016 and January 2017- March 2017 to examine the way in which this project continues to develop. The follow up interviews will help build the longitudinal dimension of the case studies and will focus on the activities engaged in and the implementation of Shanghai-informed approaches, as well as teacher outcomes and changes to pupil learning observed in the classroom.

A2.3 Strand Two

The main activity of this strand involves longitudinal analysis of key stage 1 and key stage 2 attainment data using propensity score matching (Holmes, 2014). Alongside attainment data, some analysis of pupil attitudes to mathematics and to mathematics learning will be carried out.

Details of the strand two methodology will be in the autumn report.

A2.4 Strand Three

The aim of strand three was to identify initial patterns of effective change and early evidence of pupil impact. This involved follow-up telephone interviews with exchange teachers in five lead primary schools. The filtering criteria for selection of the schools to follow up in strand three were:

- the initial case study visit indicated that significant change in practices was occurring as a result of the exchange

- there were indications that the school would have monitoring or other data to allow for an assessment of impact to be made using measures with external validity

Attainment levels were then considered to ensure that the sample included some schools with lower attainment as well as high achieving schools, since there may be ceiling effects in the highest attaining schools. Six schools were invited to participate in strand three, with five responding. A thematic case analysis was conducted for each of the five lead primary schools drawing on data collected during the case study visit together with data from the follow-up telephone interview. In three of these cases, schools' reported that internal evaluation data gives evidence of early indications of impact on attainment (reported in Section 7.2). The five strand three cases also informed the analysis of patterns of implementation.

A2.5 Identifying influences on school practice.

In Section 6 findings on actual and planned changes in school practices were reported, focusing on changes in: the organisation and support of mathematics teaching across the school; approaches to intervention, grouping, differentiation and homework; classroom practice; and the curriculum. Each sub-section is organised into three parts: practices before the exchange; changes in practices (where applicable); and future plans (including issues influencing plans).

There are three principle sources of data: interviews with teachers and others in lead primary schools; a survey of mathematics coordinators in lead primary schools[18]; and the school reports prepared for the NCETM, with the latter being used to triangulate other data or, in some cases, to complete gaps in the data.

To identify practices before the exchange participants were asked to identify differences between their current practice and practices seen or discussed in Shanghai. Analysis of interview data was supplemented, where appropriate, by data from the survey.

Analysis indicates that schools were less likely to have made organisational changes to teaching within the school year of the exchange, particularly with year 2 and year 6 groups. Thus, the survey data on organisational practices is likely to be close to a baseline measure for many of the lead primary schools, particularly those in wave 2.

However, there were some schools which did report having made some significant organisational changes more immediately, as reported in examples in Section 8. Given the timing of the survey, survey data on other practices, particularly where change was

[18] Note that tables on lead primary schools' practices are based on 43 survey responses. Current initial analysis of surveys completed by wider hub schools had led to the finding that three lead primary schools used the wrong survey link. In the autumn report, their data will be included to provide data from 46 schools in comparison with other schools including the contrast schools.

reported during the year may provide a mixed picture of practices before the exchange and the effect of changes.

Further analysis of the survey data will be undertaken for the autumn 2016 report in which comparisons will be made between lead primary schools' practices and those of other schools in the hub and the contrast schools. This will give further insight in to this issue. Annex 2 describes other issues related to the interpretation of this data - in summary for a variety of reasons there may be some under-reporting of change by interviewees. Further, it is notable that many of the changes in practice (described in Section 6) do not involve the introduction of practices that are unknown in English schools. Indeed many of the practices are ones championed at the time of the introduction of the National Numeracy Strategy, such as whole class interactive teaching, an increased emphasis on number and addressing misconceptions (Brown et al. 1998; Brown et al. 2003). Thus some schools may already be implementing practices that accord with mastery that in other schools are described as changes.

Given these issues, whilst the absolute values reported should be treated cautiously, the data provides a useful overview of how the exchange influenced practice in 2014/15.

A2.6 Limitations

The main limitation of strand one, at this stage, is the lack of precision with which it is possible to report on the numbers of schools intending to, or already, implementing aspects of the intervention. The school case studies revealed that lead primary schools were pursuing a much broader range of implementation patterns than had been envisaged in the original evaluation commission, and that different interviewees had different understandings of particular aspects of the interventions.

Interviews were conducted over an extended period of time, in part due to restrictions on conducting field work during the UK election period; therefore it was not possible to collect data on intentions and changes at the same time from different schools. In relation to Section 6 of the report on changes in practices, data on school practices collected in interviews early in the fieldwork period may not reflect changes schools made later in the year. Therefore, there may be some under-reporting of change.

Further, teachers interviewed early in 2015 were understandably cautious about identifying plans for future change. A number of teachers interviewed at this time said it was too early to discuss future changes, some because they had only just had the Shanghai visitor at the time of interview and others wanted to see what the impact of their current changes were before planning for further change.

A second, potentially more complex, set of limitations concerns the definition of the intervention that is being tested in this study. Interpretation is always easiest when a narrow definition can be used to describe the intervention taking place. In the case of the present study, the intervention is multi-faceted and continually developing over time.

Participating schools engaged in many different activities: visited Shanghai schools; hosted Shanghai teachers; have allowed in some cases participating teachers additional non-contact time to prepare to teach a mastery curriculum and to support other teachers in the school; have had support from the NCETM; have participated in a number of events around teaching for mastery; and will increasingly be supporting other schools to develop a mastery curriculum and pedagogy. Schools' understandings of 'mastery' are also developing through the exchange; these are not the same now (around one year into the exchange) as they were at the outset, and are likely to continue to develop as teaching for mastery is further developed. The NCETM, in supporting the exchange, has highlighted key aspects for development and so has focused schools attention on these. Strand two may not be able to differentiate between these various aspects of the intervention to any great extent.

Annex 3 Participation in the Mathematics Teacher Exchange

A3.1 School participation

Tables 14 and 15 set out the key characteristics of the lead primary schools. Most of the 48 lead primary schools were academies (18), community schools (15) or voluntary aided schools (nine). Most schools were rated as outstanding (26) or good (20) by Ofsted at their last inspection; only two were rated as requiring improvement.

Table 14 School type

School Type	N	%
Academy - Converter Mainstream	15	31
Academy Sponsor Led	3	6
Community School	15	31
Foundation School	2	4
Voluntary Aided School	9	19
Voluntary Controlled School	4	8
Total	**48**	**100**

As Table 15 (below) shows, lead primary schools were on average larger than primary schools across England, had a lower proportion of pupils claiming free school meals (FSM), and were also more likely to draw pupils from areas of relative socio-economic advantage. The key stage 1 to key stage 2 contextual value added scores were higher in the lead primary schools, both overall and in mathematics, as were the proportions of pupils gaining levels 4, 5 and 6 at key stage 2 in mathematics.

While this indicates that the lead primary schools are on average higher performing and have more advantaged intakes, it is important to note that there is variation across schools. It appears that in some hubs where two schools were selected for involvement, one of these has lower attainment than the national average. A full analysis of the lead primary school and contrast schools will be presented in the autumn 2016 report.

Table 15 School characteristics

	Primary schools in England		Lead primary schools	
	N=13,498		n=48 (47*)	
	Mean	sd	Mean	sd
Total Number of Pupils (census) *	282	148.1	380	186.9
% girls (census) *	49	3.75	49.5	3.14
% of pupils with SEN statement/ Schl Action +*	8.1	4.92	7.9	4.23
% of pupils with English not as first language*	17.2	22.78	18.5	22.31
% FSM*	18	13.73	14.3	13.99
% FSM at any time during the past 6 years*	26.8	17.94	22.4	17.53
IDACI Score*	0.2	0.165	0.17	0.158
KS1 average points score*	15.2	1.36	15.6*	1.41
KS2 average points score	28.9	1.63	29.7*	1.64
KS1 to KS2 Value Added Measure (overall)	100	1.05	100.4*	1.02
KS1 to KS2 Value Added Measure (maths)	100	1.28	100.5*	1.27
% pupils making at least 2 levels of progress in maths	90.6	9.21	94.1*	6.09
% boys at least 2 levels of progress in maths	91.4	9.79	95.7*	5.37
% girls at least 2 levels of progress in maths	90.3	10.44	92.8*	8.73
KS2 Attainment in Maths (external tests)				
% attaining level 6 in KS2 maths test	8.6	7.89	13.3*	10.65
% attaining level 5 or above in KS2 maths test	42.1	16.23	48.2*	15.55
% attaining level 4B or above in KS2 maths test	77	13.87	82.5*	12.86
% attaining level 4 or above in KS2 maths test	87.4	10.1	91.4*	7.59
% attaining below level 3 in KS2 maths test	12.4	10	8.4*	7.59

*There was one infant school in the study which has no KS2 data but data is included in rows indicated by an asterix.

A3.2 Teacher and Headteacher participation

The table below (16) provide details of the number of teachers, senior teachers or headteachers who visited Shanghai from each of the 48 schools which later hosted a Shanghai teacher.

Table 16 Number of delegates visiting Shanghai

Number of delegates who went to Shanghai from each school	2 teachers	1 teacher	0 teachers	Total number of schools
1 school per hub	13	2	1	16
2 schools per hub	2	28	2	32
No. of schools	15	30	3	48

As Table 17 illustrates, most teachers who went on the exchange were mathematics coordinators, followed by headteachers and other senior leaders or classroom teachers.

Table 17 School roles of exchange teachers

Main role in school of exchange staff	Headteacher	Mathematics coordinator	Other senior leader or class teacher	Total
No. of Exchange teachers 1 school per hub (usually 2 teachers per school)	7	12	9	28
No. of Exchange teachers 2 school per hub (usually 1 teacher per school)	10	14	8	32
Total number of Exchange staff	17	26	17	60

Table 18 below shows whether the Shanghai teacher worked with the class of the Shanghai delegate's class. Given that many of the delegates were not classroom teachers it is not surprising that this was not so in all cases. In addition, schools made strategic decisions about which classes to place the Shanghai teacher with as a result of the exchange visit.

Table 18 Relationship between Shanghai teacher placement and exchange participant's classes

Did the Shanghai teacher work with the Shanghai visitor teacher's class?	Yes	No	Total
1 school per hub	7	21	28
2 schools per hub	13	19	32

As seen from Table 16 above, in three schools that had Shanghai teachers placed with them, no delegates from the school visited Shanghai. Further, as shown in Table 17, in ten schools where only one delegate visited Shanghai, it was the headteacher who went. In other schools where delegates were senior teachers this was also the case. This meant that teachers potentially employing Shanghai-informed teaching practices did not observe their use directly as part of an exchange visit. In table 18 it can be seen that Shanghai teachers were not always deployed to the classes of the visiting teachers, perhaps due to choices of which classes to initially apply teaching for mastery with, meaning the professional learning was similarly indirect. In total, in 20 of the 48 schools the form of initial engagement was somewhat indirect.

However, it is important to note that the initial plan was for there to be 32 schools involved in the exchange - one per hub. Therefore, the initial exchange aims were largely met, given the outcome of 28 schools in which there was a direct relationship.

Further, it is not necessarily the case that the direct form of implementation will have greater impact than the more indirect forms. In some schools which adopted the indirect form, senior teachers, mathematics coordinators or specialist teachers worked across the whole school and so this approach could have greater whole school impact or impact beyond the individual school. For example, in School 30, the mathematics coordinator who visited Shanghai taught year 6, but following the visit to Shanghai the school decided to place the Shanghai teacher with the year 3 class. The mathematics coordinator worked closely with the year 3 teachers and then mentored other teachers in other year groups. In School 8, a visitor to Shanghai had a role leading mathematics across a number of primary schools in an academy chain rather than have teaching responsibility in a particular school. Again this participant's role could mean a greater potential impact on practices of other teachers.

An emergent evaluation issue is the relationship between these forms of initial engagement and patterns of on-going implementation and impacts on schools, teachers and pupils.

A3.3 Pupil participation

Tables 18 and 19 provide data on the year groups with whom the Shanghai teachers worked[19].

Table 19 Year groups with whom the Shanghai teacher was deployed

Year group	EYFS	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
No. of schools	2	10	16	22	18	20	9

Visiting Shanghai teachers worked most frequently with a class or classes in year 3, as can be seen from Table 19. The rationale given by some schools was to implement the approach at the start of key stage 2 in 2014/15 and to progressively develop practices as pupils progressed through the school. However, as can be seen, with the exception of Reception classes, Shanghai teachers were deployed across all year groups to a significant extent. Most schools deployed their Shanghai visiting teacher(s) with a class or classes from more than one year group as shown in Table 20.

Table 20 Number of year groups Shanghai teachers worked with

No. of Year groups	1 year group	2 year groups	3 year groups	4 year groups
No. of schools	9	29	8	1

Tables 21 and 22 provide data on the year groups where schools report implementing at least some elements of Shanghai informed practices. Schools most often implemented teaching for mastery with classes in year 2 (Table 21) followed closely by year 1 and year 5. Schools were more likely to be implementing a Shanghai approach with two year groups (13 schools) and this is likely to be the two year groups which hosted the Shanghai teacher within their class (Table 22).

[19] Data collated from transcripts, school reports to NCETM, and DfE information.

Table 21 Year groups that schools are implementing a Shanghai approach with [20]

Year groups implementing a Shanghai approach	EYFS	1	2	3	4	5	6	Whole school	Classes not specified or missing data
No. of schools	1	19	20	17	13	19	11	5	6

Table 22 Number of year groups implementing a Shanghai approach in each school

No. of year groups	1	2	3	4	5	6	Whole school	Changes not reported or missing data
No. of schools	8	13	5	6	4	1	5	6

However, Tables 21 and 22 should be read with caution. Data presented here is from a variety of sources, namely: the strand one fieldwork; the school reports; and, in a small minority of cases, data reported by schools to DfE in the initial stages of the exchange. Schools may have extended aspects of implementation since early data collection. These tables are included to provide an indication of the overall picture of implementation; however numbers presented may not fully represent what is happening in lead primary schools. A further caveat is that for some schools it was too early to discuss implementation at the time of interview as the exchange visit from the Shanghai teachers was either in progress or had only recently taken place.

[20] Shanghai approach' refers to schools that reported adopting Shanghai teaching methods and those that reported deploying Shanghai influenced approaches such as daily intervention.

Annex 4 Survey figures and tables

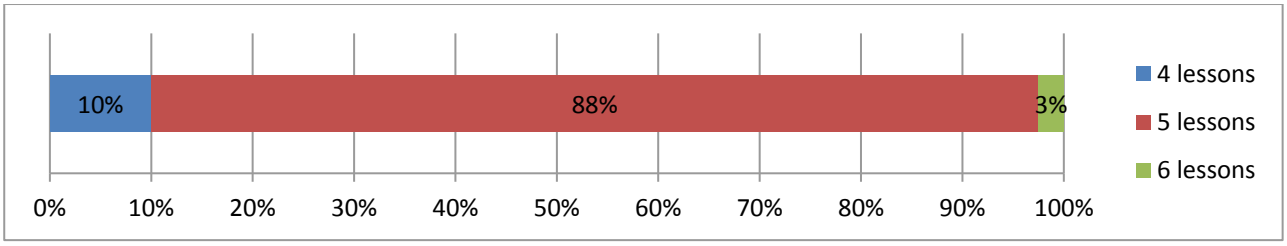
In summer 2015 mathematics coordinators in the 48 schools which hosted Shanghai visiting teachers were surveyed with a response rate of n=43[21]. In this Annex, summary data for key questions is presented. As discussed in Section 6, generally this provides a base-line in relation to school practices, although some responses may reflect changes that have already taken place. Contrast schools and other schools in the hubs were also surveyed and in the autumn report comparative analysis will be provided.

Lesson timing and structure

The survey shows that the majority (88%) of lead primary schools had five maths lessons per week for both year 2 and year 6 classes (Figure 3).

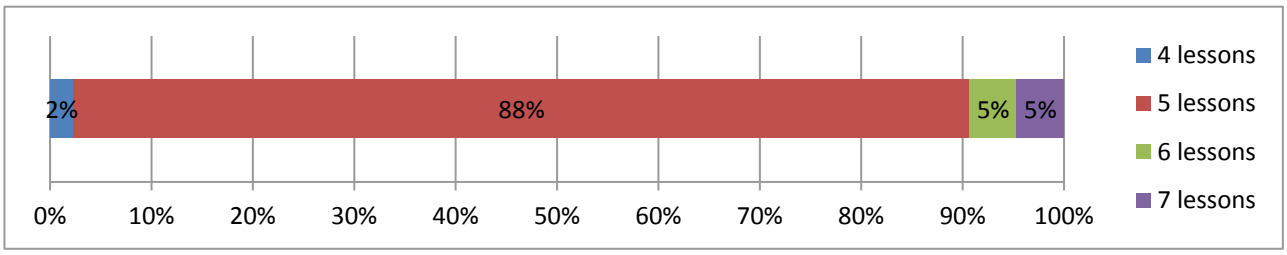
Figure 3 Mathematics lessons taught in lead primary schools in a typical week for year 2 and year 6

Year 2



total n = 40[22]

Year 6



total n= 43

Mathematics lessons lasted for one hour in both year 2 and year 6 in most lead primary schools (68% for Year 2 and 67% for Year 6) (Table 21).

[21] Note that tables on lead primary schools' practices are based on 43 survey responses. Current initial analysis of surveys completed by wider hub schools had led to finding that three lead primary schools used a different survey link. In the autumn report their data will be included to provide data from 46 schools.

[22] Not all survey respondents answered all questions.

Table 23 Length of time of an average mathematics lesson in lead primary schools in Year 2 and Year 6

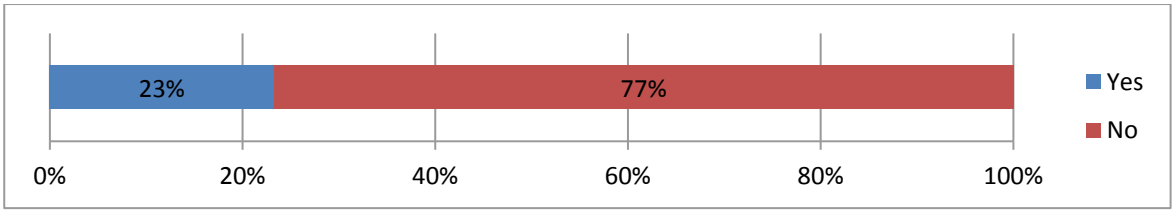
Year 2			Year 6		
Minutes per lesson	**n**	**%**	**Minutes per lesson**	**n**	**%**
40	1	3	45	1	2
45	2	5	50	1	2
50	6	15	60	29	67
55	1	3	65	2	5
60	27	68	70	2	5
75	1	3	75	6	14
80	1	3	80	1	2
110	1	3	110	1	2
Total	**40**	**100**	**Total**	**43**	**100**

Note: Where there is more than one mathematics lesson in a day the survey asked schools to indicate total time per day

Specialist mathematics teachers

As might be expected, most lead primary schools (77%) do not appear to have specialist maths teachers (Figure 4).

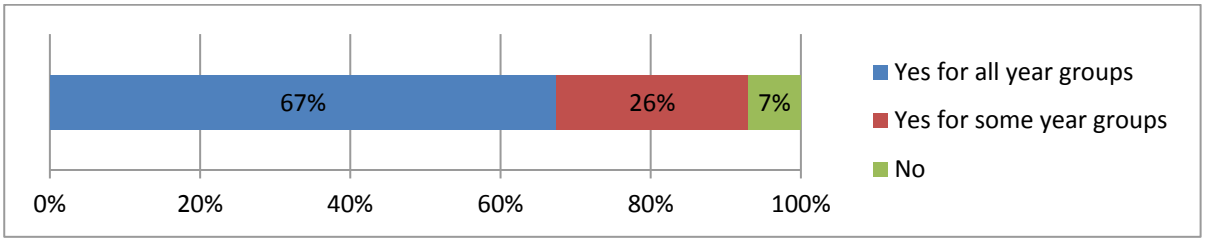
Figure 4 Do you have teachers in your school who only teach mathematics?



Total n = 43

As Figure 5 shows, for 67% of the lead primary schools mathematics was reported to be taught by a class's usual classroom teacher. However, 26% reported that this is not the case for all mathematics teaching.

Figure 5 Is mathematics taught by a class's usual classroom teacher?

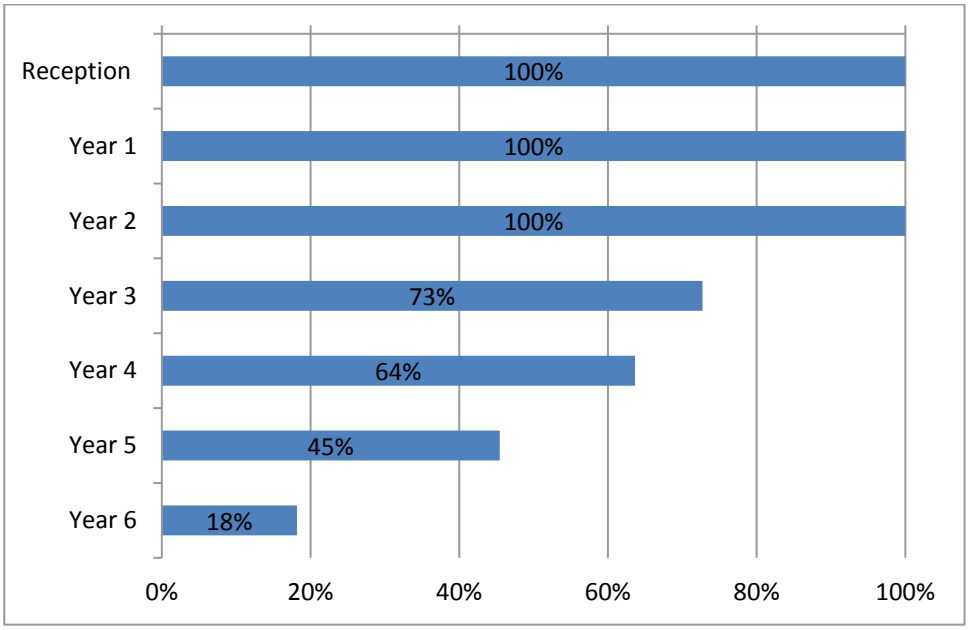


Total n = 43

Figure 6 shows that mathematics is more likely to be taught by a class's usual classroom teacher in the younger year groups. By year 3 there is a decline and by year 6 only 18%

of schools reported this year group being taught mathematics by their usual classroom teacher.

Figure 6 Year groups where mathematics is taught by a class's usual classroom teacher



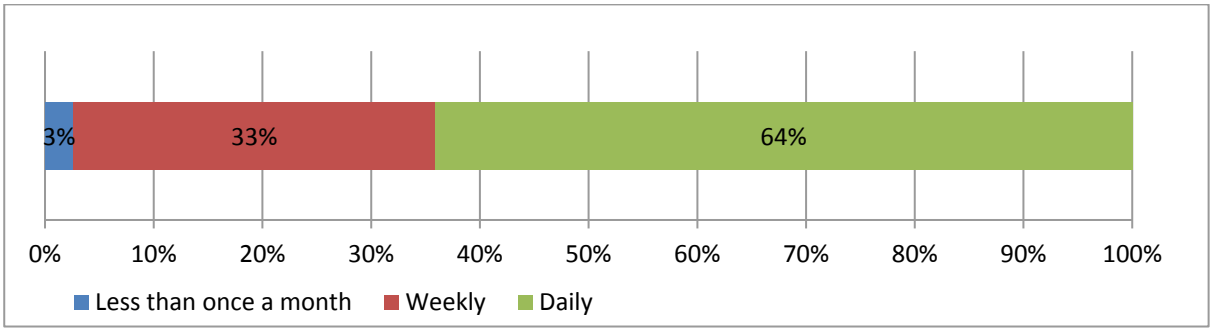
Total n = 11

Intervention

The survey asked how often additional support (one-to-one or in small groups) is given to pupils whose progress in mathematics is not at the expected rate. This was stated as being in addition to their normal mathematics lessons. Figure 7 shows that this happened on a daily basis in 64% of year 2 classes and 60% of year 6 classes.

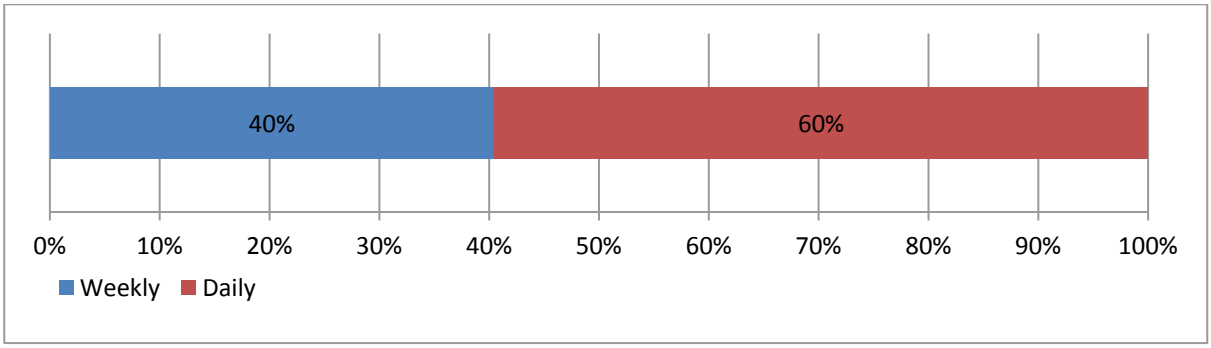
Figure 7 Frequency of additional support given to pupils not progressing to expected level in year 2 and year 6

Year 2



Total n = 39

Year 6

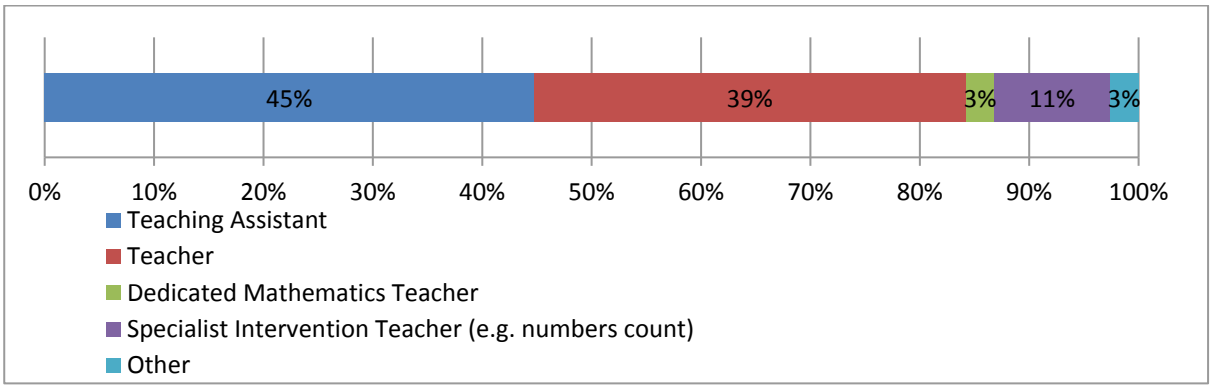


Total n = 42

In year 2 teaching assistants (45%) worked more frequently with pupils during the daily/weekly intervention time, than the classroom teacher (39%) - see Figure A8. However, in year 6 the classroom teacher more frequently undertook the intervention (59%).

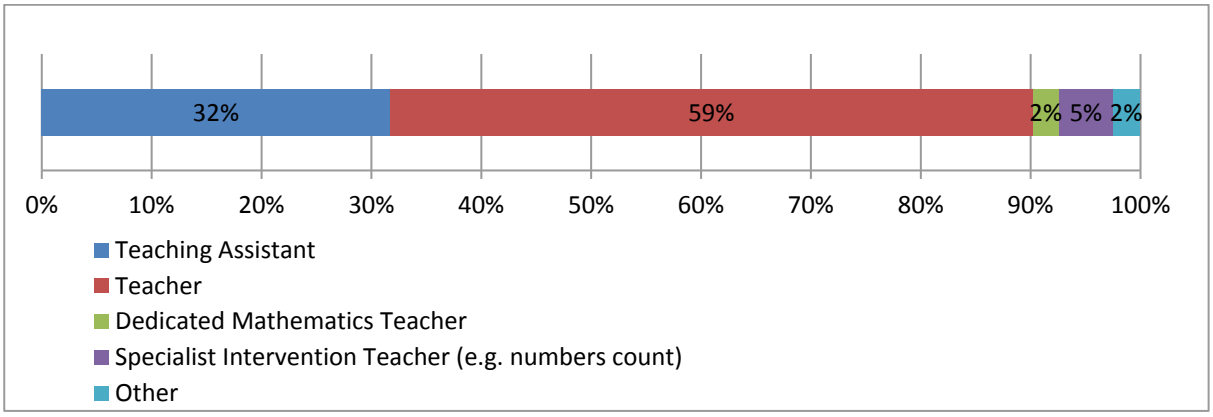
Figure 8 Staff members working with pupils in year 2 and year 6 during this time (where weekly/daily)

Year 2



Total n = 38

Year 6

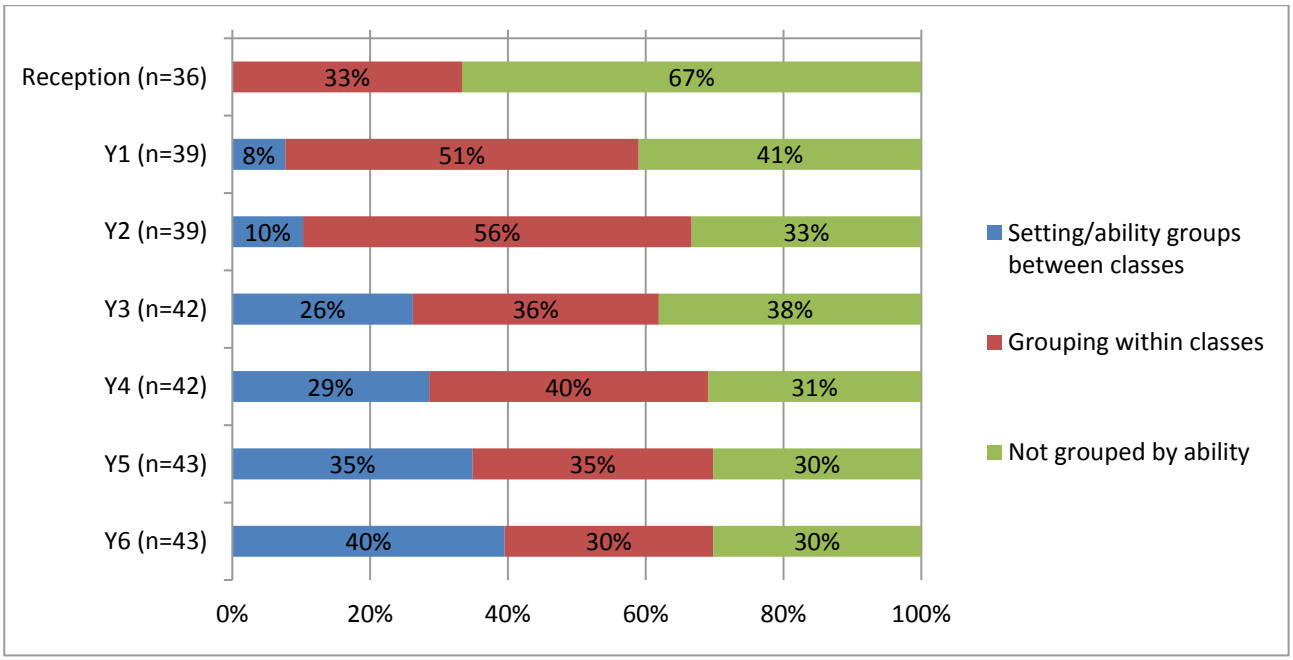


Total n = 41

Grouping

As can be seen in Figure 9, grouping, either between classes or within classes, was established in at least around two-thirds of lead primary schools by year 2.

Figure 9 Grouping of pupils according to prior attainment

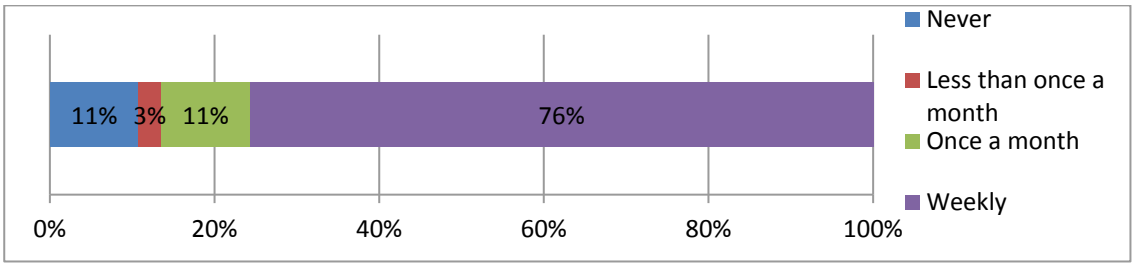


Homework

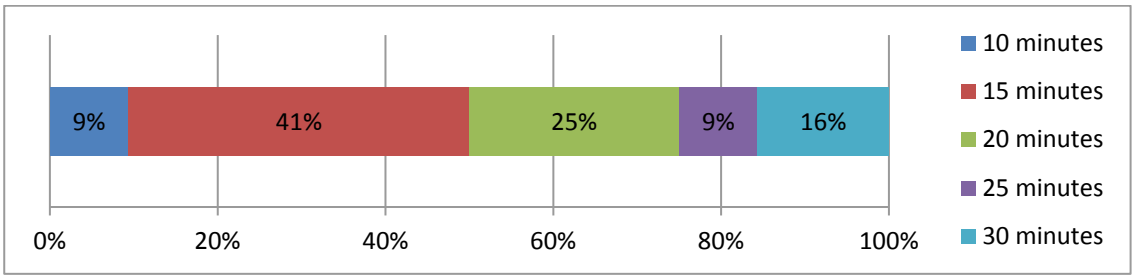
Pupils were most frequently asked to complete homework on a weekly basis in both year 2 (76%) and year 6 (81%). The most frequent length of time of the homework set was 15 minutes for year 2 (41%) and 30 minutes for year 6 (34%) (Figure 10).

Figure 10 How often pupils are asked to complete mathematics homework and the length of time expected to be spent on homework in year 2 and year 6

Year 2

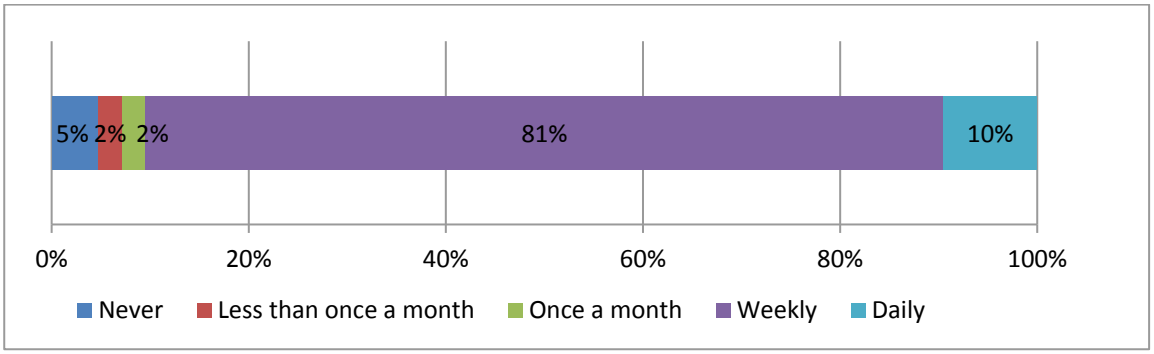


Total n = 37

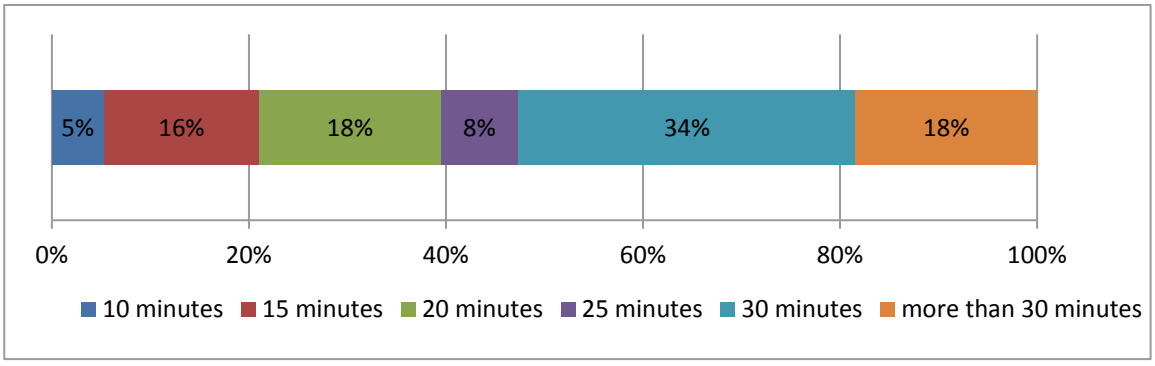


Total n = 32

Year 6



Total n = 42



Total n = 38

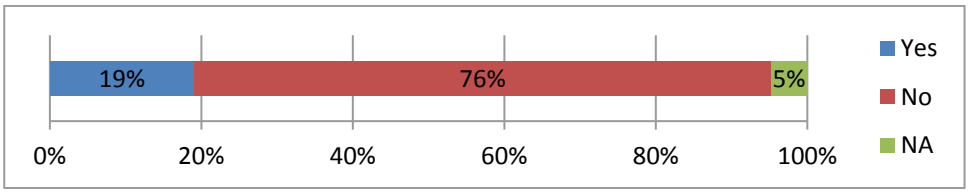
Resources and materials

In the survey respondents were asked about use of schemes and textbooks. The large majority of lead primary schools did not use a commercial scheme for teaching mathematics in year 2 (76%) or in year 6 (90%) (Figure 11). Of the eight schools which

indicated that they did use a commercial scheme for teaching in year 2 and the four schools which indicated this for year 6, half cited that they used it as a basis for instruction and half as a supplementary resource.

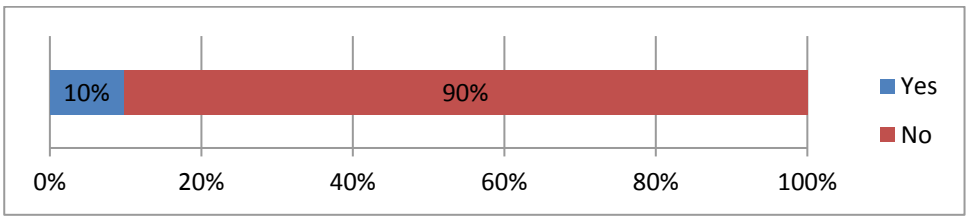
Figure 11 Do you use a commercial mathematics[23] scheme for teaching mathematics in Y2 and/or Y6?

Year 2



Total n = 42

Year 6



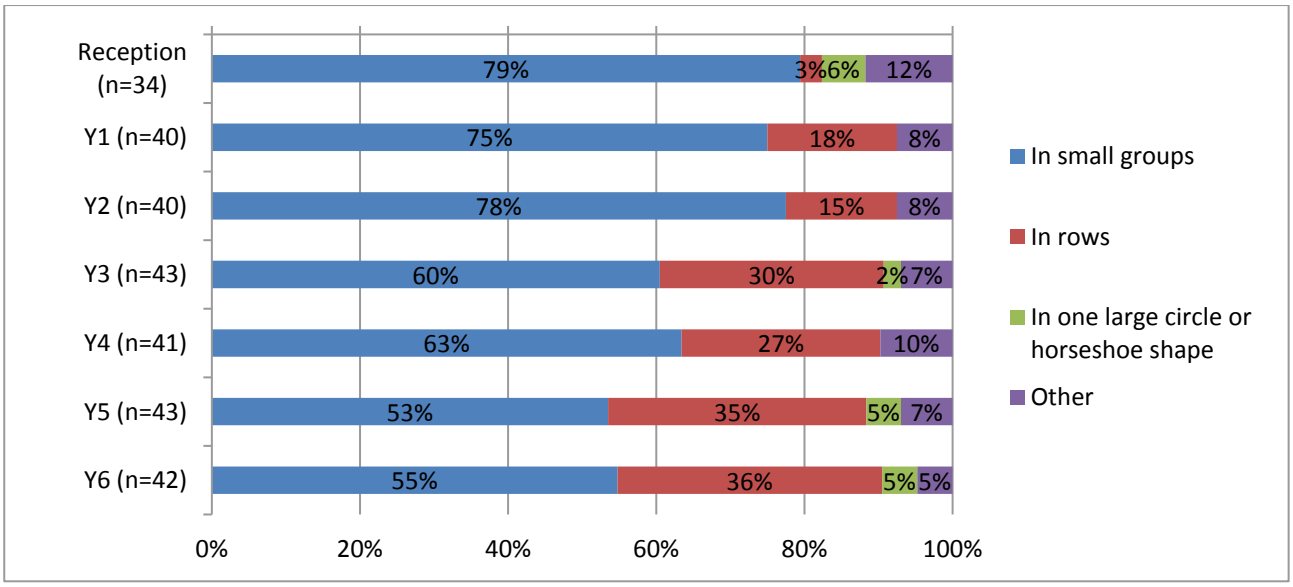
Total n = 41

Seating

Most year groups throughout the lead primary schools are seated in small groups; however there is an increase in sitting pupils in rows from year 3 onwards with 36% of schools choosing to seat pupils in rows in year 6 (see Figure 12).

[23]Commercial schemes may include textbooks, but would include any pupil materials with associated teacher guidance and resources.

Figure 12 How pupils are seated in most mathematics lessons



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Any enquiries regarding this publication should be sent to us at:
Kim.WILLIAMS@education.gsi.gov.uk or www.education.gov.uk/contactus

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