Department for Education

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Longitudinal evaluation of the Mathematics Teacher Exchange: China-England - Final Report

January 2019

Sheffield Hallam University

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Contents

List of figures

List of tables

Acknowledgements

The authors of the report wish to acknowledge the generosity of the research participants in giving their time to undertake interviews, complete surveys and provide other data. In some cases, participants organised and contributed to case study visits and then participated in follow-up telephone interviews over a period of three years, as well completing surveys and other reports, and administering a pupil attitude survey on two occasions. This represents a considerable time commitment for teachers and school leaders.

DfE staff also provided considerable support over the three years in managing the project, as did the NCETM. Members of the project steering group offered insightful and valued comments on research instruments, analysis and reports.

In addition to the Sheffield Hallam University (SHU) team named as authors of the final report, the contributions of the following SHU colleagues are also acknowledged:

- Baseline surveys design, administration and analysis: Anna Stevens
- Qualitative fieldwork and analytical discussions: Emily Perry, Ian Guest, Bernie Stiell, Ben Willis, Colin McCaig, Alan Potts.
- Administrative support: Judith Higginson, Louise Glossop, Ian Chesters and Lisa Clarkson.

Glossary

Affect - a term used in psychology to refer to feeling or emotion.

Bivariate - a statistical term that refers to analyses that involve only two variables.

Cluster - a statistical term that refers to the grouping of similar units of analyses together. For example, pupils are clustered into schools and schools are clustered into geographical areas. This is an example of natural (systemic) hierarchical pupil clustering.

CPD - continuing professional development.

High mastery - a category derived from application of implementation criteria related to a model of mastery pedagogy indicating implementation at a high level.

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

Linear Regression - a statistical modelling technique for examining variation in a scale/continuous outcome variable through the introduction of (scale or categorical) explanatory variables.

Logistic Regression - a statistical modelling technique for examining variation in a categorical outcome variable through the introduction of (scale or categorical) explanatory variables.

Mastery at or above threshold level - a category derived from application of implementation criteria related to a model of mastery pedagogy. When the meaning is clear in context this is shortened to implementation of mastery or similar.

Mastery specialist - an alumni of the Primary Mathematics Teaching for Mastery Specialists Programme with responsibility for leading change in their own school and supporting change in six to seven other schools, as well as collaborating with Maths Hub leadership and other mastery specialists.

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

Mathematics Teacher Exchange - exchange programme involving 48 English primary schools and teachers in Shanghai in 2014/15 and 70 English primary schools in 2016/17. This is abbreviated as '**MTE**' or 'the exchange'.

Mathematics Teacher Exchange cohort 1 school - a school selected by the local Maths Hub which participated in the exchange in 2014/15 and hosted a Shanghai teacher and in nearly all cases had one or more members of staff visit Shanghai. In the

first and third interim reports these schools were referred to as 'lead primary schools', however the change in terminology in the final report aims to avoid confusion with schools now identified in Maths Hubs as leading mastery developments, which in some cases are not the same. This is abbreviated as '**MTE cohort 1 school**'.

Mathematics Teacher Exchange cohort 2 school - a school that was involved in the exchange in 2016/17 by having one of their members of staff visit Shanghai and, in most cases, hosting a Shanghai teacher. Teachers rather than schools were recruited to participate in the exchange programme and were selected from the alumni of the Primary Mathematics Teaching for Mastery Specialists Programme. This is abbreviated as '**MTE cohort 2 school**'.

Mathematics Teacher Exchange lead - used to denote school staff who had been directly involved in the exchange programme and/or leading wider dissemination within their school and, in some cases, their local and wider Maths Hub Network. Note that in previous reports references were made to 'lead primary teacher'. However, as the Teaching for Mastery Programme has developed, leadership and promotion of teaching for mastery has extended to other teachers such as mastery specialists. This is abbreviated as '**MTE lead**'.

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 as of November 2015 there are 35 Maths Hubs.

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

MTE Mastery pedagogy - the name given in the report to teaching approaches aiming to develop mastery informed by East Asian practices and used, in particular, to refer to practices of MTE schools. MTE Mastery pedagogy is a more general description than the specific 'teaching for mastery' promoted by the NCETM.

Multilevel - a statistical term that relates to statistical modelling with more than one cluster level. A 2-level analysis might include school and individual pupil levels.

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

NCTL - National College for Teaching and Leadership.

Ofsted - Office for Standards in Education.

Primary Mathematics Teaching for Mastery Specialists Programme (PMTMSP) - intensive professional development programme for primary mathematics teachers led by

the NCETM with 140 (with 133 completing) teachers participating in 2015/16, and 140 per year for four further cohorts from 2016/17.

SEND - Special Educational Need or Disability

Substantial mastery - self-reported implementation of mastery by interviewees. This is particularly important in analysis of impact where self-reports of substantial implementation of mastery for two years for the Y2 and Y6 2016/17 cohorts is used to define a sub-sample of schools for exploratory analysis.

Teaching for mastery - NCETM-promoted East Asian informed mastery pedagogy that is the focus of the PMTMSP. This is abbreviated as **TfM**.

Teaching for Mastery Programme - NCETM led interconnected activities that includes the mathematics teacher exchange as one component part.

Technical report - used as a short reference to the 'Longitudinal Evaluation of the Mathematics Teacher Exchange: China-England: Technical report and supplementary data and analysis'. The technical report supports the main evaluation report.

TSA - Teaching School Alliance - alliances led by a Teaching School, including schools benefiting 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.

References to previous evaluation reports:

The **'first interim report'** refers to the report of Boylan, Wolstenholme, Maxwell, Jay, Stevens and Demack (2016) Longitudinal Evaluation of the Mathematics Teacher Exchange: China-England. Interim research report. (DfE)[1]

The **'second interim report'** refers to the report of Demack, Jay, Boylan, Wolstenholme, Stevens and Maxwell (2017) Longitudinal Evaluation of the Mathematics Teacher Exchange: China-England. Second interim research report. (DfE)[2]

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[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536003/Mathematics_Teacher_Exchange_Interim_Report_FINAL_040716.pdf

[2] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/666449/MTE_second_interim_report_121217.pdf

The **‘third interim report’** refers to the report of Boylan, Maxwell, Wolstenholme and Jay (2017) Longitudinal Evaluation of the Mathematics Teacher Exchange: China-England. Third interim research report. (DfE)[3]

3 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/666450/MTE_third_interim_report_121217.pdf

Executive Summary

Background and context

1. A longitudinal evaluation was commissioned by the Department for Education to examine: changes in practice in MTE cohort 1 schools (2014/15), influences on implementation of the MTE and associated activity, the impact on pupil attainment and effects on other schools. This was extended to capture early findings on the implementation of change in MTE cohort 2 schools (2016/17), and how their different experience of the Teaching for Mastery Programme influenced their learning.

2. The Mathematics Teacher Exchange (MTE) is a key part of what has developed into the Teaching for Mastery Programme aimed at learning from East Asian practices. It involves an exchange programme between English and Shanghai schools. The aim is for English schools to learn from Shanghai whole-class interactive teaching methods. The exchange between schools for MTE cohort 1 took place in 2014/15 and for MTE cohort 2 in 2016/17.

3. The Teaching for Mastery Programme, led by the National Centre for Excellence in the Teaching of Mathematics (NCETM), includes a number of interrelated initiatives, including a CPD course to train mastery specialists, financial support for schools to engage with these specialists and to take up the use of high quality textbooks, as well as the version of the MTE pertaining at the time of reporting. The Teaching for Mastery Programme was initiated after the first MTE.

4. The term mastery is used to refer to a variety of pedagogical approaches, including mastery learning developed in the USA. This evaluation focuses on East Asian informed teaching as implemented by MTE schools.

5. Interest in East Asian mathematics has developed over the last 10 years, with a variety of initiatives and programmes, informed initially by Singaporean practice and extended to an interest in Shanghai mathematics education.

6. Shanghai mathematics education has a number of distinctive features related to: culture and beliefs; organisation of mathematics teaching, pedagogy, curriculum, resources and assessment; as well as professionalism.

7. Shanghai practices differ from common English primary mathematics education practices, with an emphasis on whole-class interactive teaching to develop conceptual understanding and procedural fluency, using carefully designed tasks and skilful questioning. To ensure pupils progress together, tasks are designed to allow for extension by deepening understanding of concepts and procedures, and daily intervention is used to support those needing extra tuition.

8. There is prior evidence for the efficacy of East-Asian informed mastery pedagogies, or related practices, including when applied in England[4].

Evaluation and reporting

9. A longitudinal evaluation was commissioned by the Department for Education to examine: changes in practice in MTE cohort 1 schools, influences on implementation, the impact on pupil attainment and effects on other schools. This was extended to capture early findings on the implementation of change in MTE cohort 2 schools.

10. The evaluation objectives were:

- Evaluate the implementation and fidelity of the intervention against programme[5] objectives.
- Identify the types of activity undertaken by teachers from England in Shanghai host schools.
- Identify the types of activities undertaken by Chinese teachers in host schools in England.
- Identify the professional development outcomes for teachers[6].
- Determine whether teaching methods and practices have changed in host schools in England.
- Determine what activities have been most successful in meeting the aims of the programme.
- Identify lessons learned and the extent to which changes resulting from the exchange have been embedded in schools in England.
- Report on perceptions of pupil performance and depth of understanding of key concepts.
- Determine whether lessons have been shared among schools in the wider Maths Hub Network, and whether this has resulted in a change in teaching methods.

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[4] See for review, Boylan, M., Maxwell, B., Wolstenholme, C., Jay, T., & Demack, S. (2018). The Mathematics Teacher Exchange and 'Mastery' in England: The Evidence for the Efficacy of Component Practices. Education Sciences, 8(4), 202.
[5] 'Programme' is used in the objectives to refer to the MTE programme and not to the Teaching for Mastery Programme as implemented at the time of reporting, of which the MTE continues to be an aspect.
[6] The scope of the evaluation was focused on teachers from England which is implicit rather than explicit in the formulation of the objective.

- Review, assess and synthesise the findings from the MTE cohort 1 school reports prepared for NCETM.
- Determine whether the teacher exchange and its associated activities have had an impact on mathematics skills and ability in the short and long term.
- Identify initial patterns of effective change and early evidence of pupil impact.
- For MTE cohort 2 schools, identify patterns of implementation and the influence of the exchange on this relative to other influences.
- For MTE cohort 2 schools, identify lessons learned about factors influencing implementation, including in relation to work with other schools.

11. The focus of the evaluation is on the MTE, and not on what has now developed as teaching for mastery or the Teaching for Mastery Programme. However, later developments have influenced MTE cohort 1 implementation and have been important to the MTE cohort 2 experience, and so the evaluation provides insights about the wider policy for implementing mastery in mathematics in England.

12. The evaluation comprised: longitudinal multiple case studies of MTE schools; an impact analysis of the effect on pupil attainment based on comparison with a contrast sample of schools; pre and post surveys of mathematics coordinators in MTE 1 schools and a wider group of schools; and pre and post surveys of pupils' attitudes towards mathematics in a sample of MTE cohort 1 schools; and additional data collection from the NCETM, DfE and Maths Hubs. Considering cohort 1 schools, 83% of the original cohort of 48 schools provided sufficient data for inclusion in analysis in the implementation evaluation. In addition 27 MTE cohort 2 schools (39% of the cohort) provided data.

13. The longitudinal approach has allowed triangulation of data sources, respondent checking and tracking of trends over time, adding to reliability and confidence in findings. Whilst it was not possible to employ a randomised controlled design to measure impact, propensity matching and a robust approach to identifying sub-samples for sensitivity analyses add to confidence in findings.

14. The evaluation had four strands: strand one focused on examining changes in practice in MTE cohort 1 schools; strand two analysed impact on attainment in MTE cohort 1 schools; strand three was undertaken in the first year of the evaluation and assessed early evidence of change and impact in MTE cohort 1 schools; strand four extends the evaluation to consider MTE cohort 2 schools.

15. This final report follows three previous interim reports that provided evidence of changes in the first two years of the initiative and baseline statistical data and analyses and details of the data collection and analysis undertaken in years one and two of the evaluation.

16. In the third year of the evaluation: in strand one, 40 telephone interviews with teachers and school leaders in MTE cohort 1 schools were conducted and analysed and a survey of mathematics coordinators took place. Survey respondents were located in MTE cohort 1 schools and other schools with varying levels of engagement in the Teaching for Mastery Programme; in strand two, National Pupil Database (NPD) data were analysed and pupil attitude survey data collected; no evaluation activity took place in relation to strand three; in strand four, 27 interviews with MTE cohort 2 teachers were undertaken and the data analysed.

Mathematics Teacher Exchange school implementation findings

17. Some MTE cohort 1 schools implemented a Shanghai-informed mastery pedagogy that aims to develop conceptual understanding and procedural fluency to impact pupil attainment.

18. The key components of the reported pedagogy model were: varied and interactive teaching, mathematically meaningful and coherent activity, full curriculum access for all, and knowledge of mathematical facts and language. The model does not include all changes made in schools, but those that appeared distinctive, when compared to other schools, and related by interviewees to the exchange experience.

19. Since MTE cohort 1, the NCETM has developed a description of principles of mastery into a more detailed description of teaching for mastery, partially informed by MTE cohort 1 implementation. Teaching for mastery is now the focus for the Mathematics Teacher Exchange from cohort 2 onwards. Thus, unsurprisingly, the MTE mastery pedagogy, implemented by cohort 1 exchange schools, is distinct from the characterisation of teaching for mastery that was formulated after the first MTE. However, there are many overlapping features.

20. Implementation criteria were applied to determine the extent to which MTE mastery pedagogy had been implemented. There were sufficient data to make a determination for 38 of the original 48 MTE cohort 1 schools. Of these, 34 schools were identified as having implemented at least some aspects of mastery pedagogy, with 25 of these doing so at a high level.

21. Implementation was more comprehensive in both KS1 and lower KS2 than in upper KS2. Progressively, mastery pedagogy has been implemented with more year groups and classes in schools. Often in schools this involves practices following pupils from year

to year as they proceed up the school. Some 27 schools reported substantial implementation over two years as experienced by the 2017 Y2 cohort, and 16 schools with respect to the 2017 Y6 cohort[7]. Implementation increased from 2016 to 2017. Implementation in MTE cohort 2 cannot be directly compared with cohort 1, due to differences in data. This is because data for MTE cohort 1 were collected over three interviews and data for cohort 2 from one interview, so questions about some aspects of practice had to be condensed or omitted. However, there are indications that implementation in the first year after the exchange in cohort 2 schools is higher than in cohort 1 at the equivalent time.

Impact findings

22. Six impact analyses were conducted, comparing MTE cohort 1 schools with a set of comparison ('contrast') schools.

23. Analyses of impact of participation in the MTE alone do not indicate any effect on attainment, either at KS1 or at KS2.

24. Exploratory analysis of a sub-sample of MTE cohort 1 schools that had implemented MTE mastery pedagogy for two years with the 2016/17 Y6 cohort was conducted. The exploratory analysis considered the relationship between reported level of implementation of MTE mastery pedagogy practices and outcomes (see section 8.1). These also did not indicate any effect on attainment when compared to contrast schools.

25. Exploratory analysis of a sub-sample of 16 schools that appeared to have implemented a Shanghai-informed approach to maths teaching, described by the participants as 'mastery', and influenced by the Teaching for Mastery Programme, for both of the two years with the 2017/18 Y2 cohort did find a low positive effect on attainment when compared to contrast schools. Analysis revealed that pupils in these MTE cohort 1 schools were somewhat more likely to attain KS1 threshold compared with pupils in the matched contrast sample.

26. The positive finding in KS1 indicates potential for improvement in attainment through adoption of East Asian informed mastery practices. However, conclusions from this single positive finding should be treated tentatively, as the cause of the change in attainment may not be implementation of MTE mastery pedagogy; both changes in relative attainment and level of implementation may be related to other features of the

[7] Note that these data related to assessment of implementation. Sub-samples analysed in relation to impact in the follow on or sensitivity analyses are smaller than this due to the need for other requisite data on assessment being available.

sub-sample of schools, but not ones that were identified by the evaluation. Further, the KS1 assessment is undertaken by teachers in schools, and this means it may be a less reliable measure than KS2 measures, particularly given changes in curriculum and assessment since 2014.

27. Exploratory analyses found no evidence of differential impact relating to prior attainment, gender and free school meals status.

28. The two main limitations of the main analysis are: potential sample bias with regard to the set of schools selected to participate in the MTE; and lack of consistency in the way that changes to mathematics teaching have been implemented in MTE schools. These limitations affect the extent to which the findings of this study can be generalised.

29. Teachers' perceptions were that MTE mastery pedagogy implementation had a positive effect on attainment in both KS1 and KS2 and on a range of other affective dimensions.

30. A longitudinal analysis of Y6 pupil attitudes measured by a survey in summer 2015 and summer 2017 indicates no statistically significant change in cognitive affect towards mathematics, preference for working alone, or mathematics anxiety.

Supporting implementation findings

31. The visit to Shanghai and the visit to England by the Chinese teachers positively impacted MTE cohort 1 teachers' beliefs about mathematics teaching and commitment to learning from Chinese mastery teaching methods. Observing mastery teaching by Chinese teachers was seen as particularly impactful. Cohort 2 teachers, in particular, were positive about the visit to Shanghai, which deepened or challenged their previous understanding of Chinese mastery teaching methods. The visit by the Chinese teachers to England supported implementation.

32. For MTE cohort 1 teachers in the second and third year of implementation, NCETM and Maths Hub resources, textbooks and other mastery-aligned resources supported lesson design and medium-term planning, as well being a source of activities for use in MTE mastery lessons. These materials were also supports for MTE cohort 2 teachers.

33. The Primary Mathematics Teaching for Mastery Specialist Programme (PMTMSP) provided cohort 2 teachers with theoretical foundations and enabled them to gain more from the exchange than if they had not participated in the PMTMSP.

34. Analysis of data on forms of professional learning evident across the MTE cohort 1 and cohort 2 schools indicated that formal, embedded and informal professional development opportunities were all important. These generated teacher motivation,

deepened mathematical understanding, provided opportunities to plan and review implementation, and enabled in-depth learning in how to refine practices. Professional development outcomes as reported by teachers included enhanced subject and pedagogical content knowledge, cognitive affect, beliefs and confidence.

35. Mapping of implementation pathways, from the starting positions in 2015 to levels of implementation in 2017, indicates that the use of mastery-aligned textbooks or programmes and engagement in the PMTMSP were factors associated with high levels of MTE implementation, but were not always present.

36. Key barriers to effective implementation reported in the 2016 interviews related to teachers' beliefs about pupil learning, lack of confidence in their pedagogy and a lack of the required level of mathematics subject knowledge. These were less frequently reported in 2017. However, staff turnover was highlighted as an additional pressure which meant having to train new members of staff in mastery practices.

Findings about sharing learning with other schools and extending mastery practices beyond mathematics

37. The majority of MTE cohort 1 schools had shared their developing Shanghai-informed approach with other schools, although they were not formally obliged to do this. Ways of disseminating their learning included events such as workshops, in-school lesson demonstrations, and individual school support.

38. MTE cohort 2 schools had clear guidance on their responsibility to support a small number of schools, and therefore a fairly uniform approach was reported. Interviewees were funded to work with (usually) six local schools over a one-year period. Support was tailored to schools but followed a standardised pattern of teacher research groups related to demonstration lessons, and then guided support to implement aspects of MTE mastery pedagogy.

39. MTE cohort 1 and 2 teachers considered that aspects of learning from the Shanghai exchange could be applied to other areas of the curriculum. Teaching for depth, in small steps, and teaching the whole class together, were cited as classroom practices that could be applied in other subjects. Cohort 2 teachers focused also on the potential applicability of Shanghai-informed teacher learning, professional development and collaboration.

Interpretation

40. Even though established in a short timescale, the MTE programme has been successful in terms of catalysing change in a substantial proportion of schools

participating in MTE cohort 1, and informing the wider Teaching for Mastery Programme. Evidence from MTE cohort 2 identified a more consistent MTE experience both for directly participating schools and other schools who engaged with exchange-linked events.

41. In order to ensure change took place across the system, the DfE funded, and the NCETM devised and led, a wider Teaching for Mastery Programme, with the PMTMSP as a central component. There are indications from interviews with cohort 2 teachers that the arrangement of the PMTMSP being a prerequisite for recruitment to the MTE is appropriate.

42. The second exchange reached hundreds of schools and thousands of teachers. However, information was unavailable to provide a reliable estimate of numbers of participating schools or teachers and so an evaluation of the extent of the reach of the second exchange is not possible.

43. Participation in the exchange alone did not appear to lead to significantly different pupil attainment in MTE cohort 1 schools compared to contrast schools. Curriculum and assessment changes since 2014 have meant that primary schools in general have changed schemes of work and practices - for example, they are no longer using national assessment levels and sub-levels. In general, it is difficult to establish the relationship between innovation and possible impact at a time of national large-scale change. Thus, it may be that the finding of no impact could mean that the MTE mastery pedagogy, as implemented by MTE schools, was more impactful than the schools' previous practices, but that it was not more impactful than new practices implemented in contrast schools.

44. A plausible explanation for the lack of a measured impact of engagement in the MTE alone lies in variation of implementation. As reported, not all schools that participated in the first MTE went on to implement MTE mastery pedagogy, and of those that did, phased implementation meant that the Y2 and Y6 cohorts assessed in 2017, only experienced MTE mastery pedagogy for two years in a minority of schools.

45. The follow-on analyses identified some evidence that MTE mastery pedagogy, as implemented by MTE cohort 1 schools, if implemented to a sufficient degree, had an effect at KS1 (beyond any change in contrast schools) but not at KS2 when implemented to a similar degree by MTE 1 cohort schools. Possible explanations for the impact findings are considered. These span: reliability of the KS1 measure; differences in change in practices in KS1 and KS2; the possible applicability of the East Asian informed practices to KS1 but not KS2; that practices implemented in KS2 are not sufficiently different from comparison schools to lead to differences in impact; and that there has not been sufficient time yet for changes at KS2 to impact attainment, and it may be that it takes longer than two years of mastery approaches for measurable impact. It is notable

that the size of impact found in KS1 in the sub-sample of schools is similar to that reported at KS1 in the evaluation of the Mathematics Mastery programme[8].

46. The MTE mastery pedagogy implemented by MTE cohort 1 schools and the activities and materials that informed this are not the same as those that are found in MTE cohort 2, part of the developed Teaching for Mastery Programme. Thus, findings for MTE cohort 1 may not apply to MTE cohort 2. Further, only a minority of the KS1 and KS2 sub-samples included in the follow-on exploratory analyses had engaged with the PMTMSP cohort 1 or 2.. Counteracting this sample issue, it is notable that in addition to the schools in the sub-samples who had engaged with the PMTMSP, a similar number included in the sub-sample were leading mastery training in their local Maths Hubs. However, as reported, there is similarity between the type of changes made by schools in MTE cohort 1 and MTE cohort 2. On balance, it is more likely than not that findings for MTE cohort 1 are indicative of possible outcomes for cohort 2 in the given timescales of implementation.

47. With regard to validity of the interpretation, it is important to note that the nature of the impact study, using a quasi-experimental design with a matched comparison group, cannot establish causality. This is true both for the KS1 and the KS2 findings, and there remains the possibility of the outcomes being a 'false positive' or a 'false negative'.

Conclusion

48. The Mathematics Teacher Exchange has been important to the development of the Teaching for Mastery Programme and continues to be an important component. Early in the MTE programme, a variety of initiatives were put in place to provide further support for implementation. This was as a result of both interim evaluation findings, and the NCETM and DfE's internal evaluation and monitoring, which led to a recognition that the exchange programme alone was unlikely to be sufficient to lead to implementation by participating schools. Thus, the Teaching for Mastery Programme was developed and is leading to changes in practice in English schools through the activity of an increasing number of committed mastery specialists being trained.

49. The evaluation found positive impacts on pupil KS1 mathematics attainment in those schools most directly involved in the MTE exchange. However, there is no quantifiable evidence from this evaluation that the MTE or implementation of East Asian informed

[8] Vignoles, A., Jerrim, J. & Cowan, R. (2015) Mathematics Mastery primary evaluation report. London: EEF. Url https://v1.educationendowmentfoundation.org.uk/uploads/pdf/Mathematics_Mastery_Primary_(Final)1.pdf Retrieved March 2015.

teaching alone is leading to improvements in pupil attainment in mathematics at KS2 in comparison with other schools. This does not mean that if implemented differently or over a longer period that these approaches could not have an impact. Rather, no evidence of impact was found for the approaches as implemented over the time period of the evaluation.

50. The findings for the MTE are inconclusive and they cannot be generalised to the current MTE programme and the Teaching for Mastery programme. It is therefore important that further evidence is gathered to ascertain if the investment in Teaching for Mastery represents value for money, including whether the intended mechanism for system-wide change is likely to succeed.

1. Introduction

Section summary

The Mathematics Teacher Exchange (MTE) is a key part of the Teaching for Mastery Programme aimed at learning from East Asian practices. It involves an exchange between English and Shanghai schools. An aim is for English schools to learn from Shanghai whole class interactive teaching methods. An exchange of schools in MTE cohort 1 took place in 2014/15 and MTE cohort 2 in 2016/17.

A longitudinal evaluation was commissioned by the Department for Education to examine changes in practice in MTE cohort 1 schools, the impact on pupil attainment and effects on other schools. The evaluation was later extended to consider the experience of MTE cohort 2.

The focus of the evaluation is on the MTE, and not on what has now developed as teaching for mastery or the Teaching for Mastery Programme. However, later developments have influenced MTE cohort 1 implementation and have been important to the MTE cohort 2 experience, and so the evaluation provides insights about the wider policy.

This final report follows three previous interim reports that provided evidence of changes in the first two years of the initiative and baseline statistical data and analyses.

1.1 Origins of the Mathematics Teacher Exchange

There are long-standing concerns about the English primary mathematics curriculum and pedagogy, as well as the mathematics subject knowledge of many primary school teachers in England (Williams, 2008; Ofsted, 2008). Since 2014, the UK government have championed a mastery approach to mathematics in schools in England through the introduction of a mastery curriculum and a number of other initiatives. The rationale for a mastery focus in mathematics originated from observation of high achievement in mathematics in East Asian countries, where there is not only a smaller gap in attainment between pupils, but pupils are up to three years ahead of UK pupils in their mathematics ability by age 15, according to Programme for International Student Assessment (PISA) tests (OECD 2012).

This has led to interest in what can be learnt from high-scoring education systems, including Shanghai which had an outstanding performance on the PISA 2009 and 2012 tests. The National College for School Leadership led two study visits to the Shanghai region in relation to mathematics and science education (NCSL, 2013, 2014). In February 2014, a DfE-funded research trip took place, led by the former Parliamentary Under Secretary of State for Education and Childcare, Elizabeth Truss, with a representative

from Ofsted and other educational experts. This led to an agreement with the Shanghai Municipal Education Commission to hold a teacher exchange. The original aim of the exchange was to learn from Shanghai practices in order to raise standards in mathematics through improved pedagogy and teacher subject knowledge, a more refined and appropriately paced curriculum, and by ensuring all pupils achieve their full potential in mathematics and are not 'left behind'.

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 skilful use of teacher questioning and incremental progression. Teaching 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 of concepts and procedures, 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.

1.2 The Mathematics Teacher Exchange

The Mathematics Teacher Exchange (MTE) is an important component of the UK government's mathematics policy and which had evolved, by 2016, into an element of the teaching for mastery (TfM) programme. The TfM programme is a combination of initiatives, funded by the Department for Education (DfE), intended to develop a mastery approach to the teaching of mathematics, informed by East Asian practices, in English schools. The TfM programme consists of[9]:

- A professional development course - the Primary Mathematics Teaching for Mastery Specialists Programme (PMTMSP) - to train a cadre of mastery specialists who promote teaching for mastery in schools in their localities
- Activity led by these specialists with teachers from other schools in their local areas
- A subsidy to support the use of high quality mastery-aligned textbooks
- The production of materials and resources to support teaching for mastery, and
- The teacher exchange programme between Shanghai and England.

[9] Further details are given in section 2.1, below, and in section 3 of the technical report.

Central to the TfM programme, is an approach to teaching mathematics developed by the National Centre for Excellence in the Teaching of Mathematics (NCETM) informed by East Asian mathematics pedagogies (see section 5 below and technical report section 3).

Beyond the DfE's activity, a number of other organisations and bodies also promote East Asian informed practices and these also influenced some schools engaged in the exchange.

The MTE is run through the national Maths Hubs Network, and is led by the NCETM.

The main focus in this report is on the first cohort of schools and teachers that participated in the MTE in 2014/15. Teaching for mastery as a description of an approach to teaching mathematics, was articulated by the NCETM following the first MTE and informed by the implementation of schools that participated in Cohort 1 of the exchange.

As such, MTE cohort 1 schools were not tasked with implementing what is now described as teaching for mastery. Thus, this evaluation is **not** an evaluation of teaching for mastery. Nevertheless, the practices implemented by MTE cohort 1 schools are related to teaching for mastery and the implications of this are considered in the report.

This is because the MTE cohort 1 pre-dates the development of the full TfM programme. The aim of the original exchange was to learn from Shanghai mathematics education approaches. Participants developed, refined and deepened their own and others' understanding not only of Shanghai practices, but East Asian mathematics teaching more generally, and informed subsequently by NCETM materials to support TfM.

In September 2014, 60 teachers and leaders from 45 English primary schools visited Shanghai schools. Between November 2014 and March 2015, 59 mathematics teachers from China visited 48 English primary schools and modelled mastery teaching. Subsequently, the English schools made changes in their practices, they were designated as 'lead primary schools' in 2015/16 and in most cases they shared learning with other schools. Some 15 of the original MTE cohort 1 schools participated in the PMTMSP. Seven of these schools took leading roles in their Maths Hubs in promoting TfM; a further seven schools that had not participated in the PMTMSP were also identified as taking this leading role.

In addition to the MTE cohort 1 schools, this report also considers outcomes and learning from the experience and practices of MTE cohort 2 schools. All of the MTE cohort 2 schools had previously participated in the PMTMSP and then participated in the exchange in 2016/17. Consequently, teachers from these Cohort 2 schools all had undertaken training with the NCETM in teaching for mastery. However, the evaluation of MTE cohort 2 focuses on implementation and not on attainment outcomes for pupils experiencing teaching for mastery as currently articulated.

1.3 The evaluation

The Sheffield Institute of Education was commissioned by the DfE in December 2014 to undertake a longitudinal evaluation of the MTE. The objectives of the evaluation are presented below in Table 1. The key aim of the evaluation was to determine the potential of learning from Shanghai mathematics education to impact on teaching in England and improve pupils' mathematics attainment in both the short and long term. As stated in previous reports, the focus and scope of this evaluation was on the MTE and therefore does not extend to an evaluation of what has evolved into the TfM programme.

Thus, the term 'MTE mastery pedagogy' is used to refer to an abstraction from teacher reports of the enacted pedagogy found in the MTE cohort 1 schools. MTE mastery pedagogy was informed initially by Shanghai practices, and later by the teaching for mastery formulation. This helps to distinguish the practices refined after the MTE exchange from the 'teaching for mastery' formulation promoted by the NCETM generally and specifically through the PMTMSP. The use of the term 'mastery pedagogy' helps to avoid the incorrect interpretation that the evaluation is of the TfM programme or of schools' implementation of TfM, as this was not the original MTE evaluation objective. However, similarities and differences between the two formulations in the enacted practices of MTE cohort 1 schools is considered in section 5.4. The distinction between TfM and MTE mastery pedagogy is confounded in the evaluation of MTE cohort 1 schools, as 15 of these schools participated in either cohort 1 or cohort 2 of the PMTMSP, and furthermore the NCETM materials on TfM were reported as influences on the development of some of the MTE cohort 1 schools' practice; frequently, cohort 1 interviews referred to teaching for mastery. Indeed, for those schools which did implement mastery, the NCETM materials were important to developing their practice. The difference between the two cohorts is detailed below in 'theory of change' diagrams (Figures 2 and 3).

The evaluation employed a mixed methods design to collect data over three academic years. Interview and survey data informed analysis of how practices changed in exchange schools including perceptions of impacts and outcomes for pupils. KS1 and KS2 assessment data informed evaluation of impact on pupil attainment. Data on implementation and changes in teaching was combined with attainment data, in order to explore indications of the potential of East Asian informed teaching beyond simply participating in the exchange. Pupil survey data informed evaluation of impact on pupil affect.

The original evaluation objectives are presented in Table 1. Objectives 1 to 12 were formulated at the start of the evaluation. Objectives 13 and 14 were later additions following extension of the evaluation to collect data from a sample of MTE cohort 2 schools. A number of evaluation objectives focused on learning from the first year of the exchange to inform MTE programme developments and future exchange experiences,

namely objectives 2, 3, 10 and 12. Findings in relation to these objectives were reported in the first interim report and are not repeated here in the main body of the report, but are recapped in section 12 where final evaluation outcomes are summarised. Thus, the current report, with the accompanying technical report, addresses, in the main, the evaluation objectives in bold in Table 1.

Note that the reference to 'programme' in these objectives refer to the Mathematics Teacher Exchange programme as devised in 2014. It does not refer to the Teaching for Mastery Programme as currently implemented. However, both the engagement of some MTE cohort 1 schools in other aspects of the TfM programme, and the requirement for MTE cohort 2 schools to have engaged with the Primary Mathematics Teaching for Mastery Specialist Programme means that the TfM programme influenced both MTE cohort schools' implementation. In the case of MTE cohort 1 this extended to a greater or lesser extent to all schools reporting or assessed as having high levels of MTE mastery pedagogy implementation.

Table 1: Evaluation objectives

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

Objectives
13. For MTE cohort 2 schools, identify patterns of implementation and the influence of the exchange on this relative to other influences.
14. For MTE cohort 2 schools, identify lessons learned about factors influencing implementation, including in relation to work with other schools.

1.4 Scope of the evaluation

As noted above, in summary, the evaluation report provides:

- Analysis of outcomes of implementation of East Asian informed teaching approaches by schools involved in the first MTE cohort exchange, and of the consequences for pupil attainment at KS1 and KS2.
- Analysis of indications of impact on attainment at KS1 and KS2 for MTE cohort 1 schools in relation to levels of implementation and change.
- Consideration of the influences on MTE cohort 1 schools' implementation, including where relevant the Teaching for Mastery Programme.
- Analysis of implementation by Cohort 2 schools and the influences on this, including their engagement with aspects of the Teaching for Mastery Programme.

However, the focus was not evaluation of the Teaching for Mastery Programme, as this developed into its current form after the study was commissioned. Similarly, firm conclusions cannot be drawn about the potential impact on attainment of pupils following the current teaching for mastery pedagogical approach.

Nevertheless, 1) there is a relationship between the mastery approaches adopted by Cohort 1 schools and teaching for mastery pedagogy and 2) all MTE cohort 1 schools who reported implementation of Shanghai informed mastery were influenced, to a greater or less extent, by the Teaching for Mastery Programme. All MTE cohort 1 schools reporting high implementation reported at least some level of influence. Thus, the report does discuss the implications of the findings in relation to the potential of teaching for mastery and the TfM programme to meet current policy objectives.

1.5 Previous reports

This report, with the accompanying technical report, is the fourth and final report from the evaluation and follows the publication of three interim reports[10].

The first interim report (Boylan, et al 2016)[11] presented analysis of qualitative data collected in relation to teachers and headteachers from 48 MTE cohort 1 schools. It evaluated the efficacy of exchange activities and described and analysed the implementation of the MTE programme during 2014/15 at national, Maths Hub and school levels. It reported initial perceptions of impact on pupil engagement, learning and attainment outcomes and implementation issues to inform developments of the TfM programme.

The second interim report (Demack, et al 2017)[12] provided further details of the evaluation methodology to assess impact. The report detailed the quasi-experimental design, using the statistical technique 'propensity score matching' to compare MTE cohort 1 exchange schools with a group of contrast schools which were not participating in the exchange. Pupil outcome Key Stage 1 and Key Stage 2 baseline data were presented. The preliminary analysis included attainment data prior to the start of the intervention and from the end of the first year of the intervention. In addition, outcomes of a pupil attitude survey of Year 6 pupils in MTE cohort 1 schools were reported. Limitations of the analytical approach were discussed.

The third interim report (Boylan, at al., 2017)[13] presented findings from follow-up interviews with staff from 43 MTE cohort 1 schools about their continued implementation of Shanghai-informed pedagogy. Interviews took place in the year after the original exchange. Findings were organised by three key areas related to mastery: mathematically meaningful and coherent activity, diverse interactive teaching, and a whole-class focus. In addition, variation in implementation was reported, alongside details of supportive changes made in schools, work that had taken place with other

[10] https://www.gov.uk/government/publications/evaluation-of-the-maths-teacher-exchange-china-and-england

[11] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536003/Mathematics_Teacher_Exchange_Interim_Report_FINAL_040716.pdf

[12] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/666449/MTE_second_interim_report_121217.pdf

[13] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/666450/MTE_third_interim_report_121217.pdf

schools and perceptions of outcomes for pupils and teachers including professional learning.

1.6 The final report content and structure

This final report presents outcomes of the evaluation for the third year of the intervention as well as summary evaluation findings considering the three years as a whole. For accessibility of content, the report is presented as a main report and an accompanying technical report. However, the two documents, with the interim reports, should be considered as an integrated single evaluation output.

This main report presents an overview of current mathematics mastery innovation and how the MTE is embedded in this. A summary of the evaluation methodology is provided. Findings are reported in relation to the processes of implementing and developing Shanghai-informed mastery pedagogy. Two 'theory of change' models created by the evaluation team are included, one for MTE cohort 1 and one for MTE cohort 2.

The theory of change models inform the structure of the remainder of the report. Patterns and levels of implementation of mastery pedagogy are reported, firstly for cohort 1 and then for cohort 2. The exchange experience and immediate influences on practice and professional development outcomes are considered. Following this, the analysis of the impact of the innovation is reported in relation to pupil attainment and pupil attitudes for MTE cohort 1 schools. Then wider system-level effects are reported, including MTE cohort 1 and cohort 2 schools' work with other schools in their localities and what has influenced this work. Factors influencing implementation at school level and system level are then considered. Participants' views on policy implications are reported from both cohorts. Summary boxes are provided at the start of each section, and for sections 4-11 where findings are reported, relevant evaluation objectives are noted in these boxes.

The technical report provides details of the evaluation methodology and analytical processes used. Data tables are provided that support the evaluation findings and claims made. Updated sections are included in the technical report, comparing Shanghai and English practices, and providing a fuller account of mastery innovations and the Teaching for Mastery Programme and its evolution that were previously included in the first and third interim reports respectively. This is done for convenience. However, in general, material previously reported in detail in the interim reports is summarised and cross-referenced rather than included in full in either the main report or the technical report.

2. Background: Mastery, Shanghai and English mathematics education, mastery innovations and the Mathematics Teacher Exchange

Section summary

The term mastery is used to refer to a variety of pedagogical approaches. The evaluation focuses on East Asian informed teaching.

Shanghai mathematics education has a number of distinctive features related to: culture and beliefs; organisation of mathematics teaching', pedagogy, curriculum, resource as assessment; and professionalism.

Shanghai practices differ from common English primary mathematics education practices in; an emphasis on whole-class interactive teaching to develop conceptual understanding and procedural fluency, using carefully designed tasks and skilful questioning. To ensure pupils progress together, tasks are designed to allow for extension by deepening understanding of concepts and procedures, and daily intervention is used to support those needing extra tuition.

Interest in East Asian mathematics has developed over the last 10 years, with a variety of initiatives and programmes, informed initially by Singaporean practice and now extended to interest in Shanghai mathematics education.

The Teaching for Mastery Programme includes a number of interrelated initiatives including a CPD course to train mastery specialists, financial support for schools to engage with these specialists and to take up the use of high quality textbooks, as well as the MTE.

There is prior evidence for the efficacy of East-Asian informed mastery pedagogies, or related practices, including when applied in England.

2.1 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 the work of Benjamin Bloom, and involves the regular use of formative assessment (Guskey, 1997). Essential to mastery is the 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 (Guskey, 2010) are:

- Diagnostic pre-assessment
- High quality group-based instruction
- Monitoring of progress through regular formative assessment
- High quality corrective instruction for individuals or groups
- Further formative assessment, and enrichment or extension activities.

Thus, Western mastery approaches focus primarily on learning and opportunities to learn - that is, 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 in mathematics shares some features of the Western approaches: firstly, an expectation that everyone can achieve mathematically, and secondly, the use of frequent formative assessment to check understanding and guide supplementary instruction where needed. However, it differs from the Western approaches in its focus 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. These are the elements that are aimed for in the Teaching for Mastery Programme and underpins the NCETM name for the teaching approaches they promote - '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 pupils will learn and the role of the teacher is to design lessons and use practices that ensure that will happen. Consideration of the success in international comparisons 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.

2.2 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 is that most families in China now consist of two parents and one child, leading to a high level of involvement of both parents and usually four grandparents focused on supporting a single child's pre-school and school learning (Tobin, Hsueh & Karasawa, 2009).
- Very little time, if any, is 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) having observed peer talk in primary schools, in contrast with others who have found it 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 with 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 ongoing 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).

2.3 Differences from English primary mathematics education

In this section, differences are considered between Shanghai practices and commonplace approaches in English primary mathematics education, as found prior to the start of the exchange programme. 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, though given the Teaching for Mastery initiative, the extent of these differences is changing. These are summarised below.

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

Although recommended since the introduction of the National Numeracy Strategy, end-of-lesson plenaries have not always been used (with one study suggesting that they were 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 classes 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 have usually started 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). In English schools, a priority has been placed on demonstrating maximum coverage of content within a lesson and, consequently, often material is re-taught in subsequent years. Formative assessment in Shanghai is undertaken through written homework tasks. During a study visit to Shanghai (NCSL, 2014), it was reported that in-class assessment for learning activities were not used. However, this may have been a misinterpretation of what was seen, as the NCETM has identified that this is an important aspect of Shanghai practice.

Attainment grouping has become increasingly prevalent in English primary schools, either involving setting pupils (in the case of larger schools) 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 has been 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 in comparison with Shanghai, and many primary teachers lack in-depth subject knowledge and confidence (Williams, 2008).

Summary of differences between Shanghai and England

Differences between Shanghai and England (prior to mastery innovations) in classroom and school practices most salient to the exchange are summarised in Tables 2 and 3 below, reproduced from the first interim report. This summary may not reflect evidence or publications produced after 2016 or developing of understandings of the NCETM and others based on further exchange visits. For example, Shanghai primary teachers in some cases are reported to teach three rather than two 35 minutes lessons per day.

Classroom practices

Table 2: 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 as 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.	Aim to 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[14] with younger pupils, usually one model or visual representation used per topic/concept.

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

School practices

Table 3: 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 specialists with undergraduate study of mathematics and 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.

2.4 Origins of the Mathematics Teacher Exchange

Antecedents

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

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

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

One aspect of teaching for mastery is the promotion of variation theory. This also has been of interest to mathematics educators in England (see for example, Askew, 2015; Watson and Mason, 2006).

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

Singaporean informed initiatives

Prior to the Mathematics Teacher Exchange, two innovations informed by Singapore mathematics education were introduced in England. *Maths No Problem* started in 2007, and is based around translations of Singapore textbooks supported by a programme of professional development and online activities. In 2009-2010, the Ark Multi-Academy Trust began to develop a 'curriculum for depth'[15] influenced by Singaporean mathematics education. In 2010-11 the term mastery was first used in relation to the programme with Mathematics Mastery adopted as the name. The principles underlying the programme were published in a book aimed at school leaders, teachers and others (Drury, 2014). Mathematics Mastery has been subject to a randomised control trial funded by the Education Endowment Foundation which reported in 2015-16 (Jerrim and Vignoles, 2016; Vignoles, Jerrim and Cowan, 2015). The evaluation found a small positive effect on attainment, higher in KS1 than in KS3, over a two year implementation period that combined professional development and use of curriculum materials . The Mathematics Mastery programme continues to develop curriculum materials for more year groups; by 2016-17, curriculum materials have been developed for Y1 to Y5 and Y7 to Y10. Currently there are 264 primary schools and 103 secondary schools engaged in the Mathematics Mastery programme.

More recently, Inspire Mathematics[16], also based on translations of Singapore textbooks, has been developed. This has been subject to evaluation that found potential for positive impact, though the evaluation design means that caution is needed about ascribing causal relationships (Hall, Lindorff, and Sammons, 2016).

The Singaporean informed initiatives are relevant to the Mathematics Teacher Exchange, both as mastery innovations but also more directly. A number of schools were already engaged with these programmes or became so following the 2014/15 exchange (see section 2). Consequently, the emphasis in Singapore on using concrete, pictorial and abstract representations in mathematics teaching was important in these schools. This heuristic appears to have been taken up more widely. However, it is important to recognise that the importance of using multiple forms of representations in learning mathematics has been encouraged by English mathematics educators for some time (see for example Haylock and Cockburn, 2013); therefore such ideas will be familiar to many teachers from their initial teacher training. One particularly flexible representation - the bar model - has come to be associated with Singapore, although it is used in Shanghai, as well as being an important model in the Realistic Mathematics Education tradition developed in the Netherlands (Van Den Heuvel-Panhuizen, 2003). Notably, the

[15] http://www.mathematicsmastery.org/about-us/
[16] https://global.oup.com/education/content/primary/series/inspire-maths/?region=uk

Netherlands is a relatively high performer in international comparative tests relative to other European countries.

Establishing the Mathematics Teacher Exchange: China-England

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

Shanghai had outstanding performance on the Programme for International Student Assessment (PISA) 2009 and 2012 tests. Interest in Shanghai's success led the DfE to commission the National College for School Leadership[17] (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 took place, led by the former Parliamentary Under Secretary of State for Education and Childcare, Elizabeth Truss, with a representative from Ofsted and other educational experts. This led to the agreement with Shanghai Municipal Education Commission for a teacher exchange.

2.5 The Teaching for Mastery Programme

Policy development

In July 2014, the DfE established a network of 32 regional Maths Hubs (increased to 35 since October 2015) across England, tasked with supporting the supply of specialist mathematics teachers, professional learning, curriculum resource development, and support for mathematics subject leadership. Each Maths Hub is led by one or more schools with a successful record in mathematics teaching and learning, and experience in supporting improvements in other schools.

The mathematics teacher exchange was the first initiative coordinated through Maths Hubs and took place in 2014/15 in 48 primary schools. Alongside this were other

[17] Now the Teaching Regulation Agency (TRA).

initiatives (see main final report figure 1). These included teacher research into the use of high quality textbooks in primary schools. The textbooks used were translated or adapted from Singaporean textbooks. In 2015 the NCETM created a CPD course for teachers to become mastery specialists: The Primary Mathematics Teaching for Mastery Specialist Programme (PMTMSP), which would recruit 140 teachers a year. In 2016/17, 70 teachers participated in a second primary mathematics teacher exchange with Shanghai (MTE cohort 2). All teachers were part of the PMTMSP and the exchange experiences were different both due to a greater understating of mastery practices prior to the visit and in relation to the conduct of the exchange itself. A third exchange took place in 2017/18. A further cohort of 70 teachers (alumni of PMTMSP) will take part in further exchange visits, the next being in 2018/19 and then in 2020. The exchange programme has also been expanded to include up to 51 teachers in English secondary schools following a pilot group of 16 in 2018-19.

The Mathematics Teacher Exchange was developed following a number of previous developments in relation to initiatives to apply East Asian approaches in England. Since the first exchange, a more expansive teaching for mastery (TfM) programme has developed, coordinated through the network of regional Maths Hubs led by the NCETM. Maths Hubs are 35 partnerships, led locally by an outstanding school or college in mathematics teaching, that are also responsible for a range of other activities to improve the teaching of maths in all schools from primary school to age 18.

Since 2016 the DfE has committed £76 million to its Teaching for Mastery programme. The programme aims to reach at least 9,300 primary schools and 1,700 secondary schools by 2023. Amongst other things, DfE's funding covers:

- Further cohorts of the NCETM-led Primary Mathematics Teaching for Mastery Specialists Programme (PMTMSP), and establishment of a similar training programme for secondary teachers (SMTMSP).
- Providing support through Maths Hubs for PMTMSP and SMTMSP participants and alumni to work with other schools.
- Establishing a mastery readiness programme that will be offered to all Opportunity Area primary schools that need it.
- Providing funding to support the adoption of high quality textbooks in primary schools.
- Continuing with the MTE exchange programme as part of specialist training. 70 primary teachers will participate annually until 2019/20, with an additional 16 secondary maths teachers in 2018/19 and 35 in 2019/20.

Figure 1 provides a summary timeline of antecedents and initiatives related to the MTE and TfM programme and influences of East Asian mathematics education. A more

detailed account of the development of the TfM programme is found in section 3.1 of the technical report.

The various mastery initiatives influenced many of the schools and teachers involved in the MTE alongside the impact of the actual exchange programme itself. As reported below, at least seven of the MTE cohort 1 schools had previously engaged with mastery programmes. Over the last three years, more schools have begun to use East Asian informed textbooks or engaged with other mastery curriculum developments. Furthermore, 15 of the original MTE cohort 1 schools had teachers who participated in the PMTMSP, and other schools led mastery CPD separately in their local Maths Hubs.

However, it is important to note that, as stated above, the main aim of the evaluation was to assess how the exchange influenced and prompted changes in practice, and to evaluate the impacts of these changes. The evaluation was not commissioned as an evaluation of the TfM programme as a whole, as this programme was not developed at the outset of the evaluation. Nor was the evaluation commissioned as a study of the efficacy of the NCETM's formulation of 'teaching for mastery'. The relationship between practices implemented by MTE cohort 1 schools and practices fitting NCETM's description of TfM is considered in section 5.4. At the end of the report, the applicability of the evaluation’s findings to the TfM programme is discussed, together with lessons for the programme.

Teaching for mastery

Initially the NCETM referred to this as 'mastery approaches' (NCETM 2014) and later the term 'teaching for mastery' was adopted (NCETM, 2016). Features of TfM in summary are:

- A foundational belief that all pupils can succeed
- Whole-class interactive teaching
- Rapid identification of pupils who need additional support to grasp a concept or procedure, and early intervention
- Lesson design to support 'back and forth' interaction including questioning, short tasks, explanation, demonstration and discussion
- Procedural fluency and conceptual understanding are developed together, including through practice which links the two
- Deep knowledge of key mathematical ideas with an emphasis on structure and connections
- Key facts are learnt to automaticity.

Important too in the NCETM and Maths Hubs programmes to develop mastery specialists has been the promotion of 'five big ideas' (NCETM, 2017):

- Coherence
- Representation and structure
- Mathematical thinking
- Fluency
- Variation.

However, the NCETM contends that:

> A true understanding of these ideas will probably come about only after discussion with other teachers and by exploring how the ideas are reflected in day-to-day maths teaching. (NCETM, 2017, no page)

Thus, TfM is not easily defined in text. The technical report at section 3.1 provides the content of three NCETM documents that provide further background (NCETM, 2014, 2016 and 2017). Below at section 5.4, the relationship between practices implemented in MTE cohort 1 schools and teaching for mastery pedagogy are discussed.

It is important to note, in relation to NCETM activity, that the promotion of 'teaching for mastery' as a set of principles and practices clearly has a significant overlap with MTE cohort 1 schools' implementation of lessons from the exchange with Shanghai. However, it is also important to recognise that they are distinct.

Maths Hub activity

The MTE and other mastery innovations are being implemented and shaped in the context of the move to a self-improving school system. Teaching School Alliances (TSAs) were central to the initial visits to Shanghai in 2013 and 2014. In July 2014, the DfE established a network of 32 Maths Hubs (increased to 35 since October 2015) coordinated by the NCETM. The Maths Hubs have a central role in the promotion of mastery, including: recruiting schools involved in the 2014/15 primary and 2015/16 secondary MTE; promoting the PMTMSP, including recruiting mastery specialists, and deploying them once trained and overseeing their work; coordinating a variety of professional development activities focused on mastery, including events linked to MTE cohort 2 Shanghai teacher visits.

Each Maths Hub is led by a lead school or college with a record of high quality mathematics teaching and high attainment of pupils, and experience in supporting and coordinating professional learning and improvement in other schools (DfE, 2014a). Hubs are tasked with supporting the supply of specialist mathematics teachers, professional

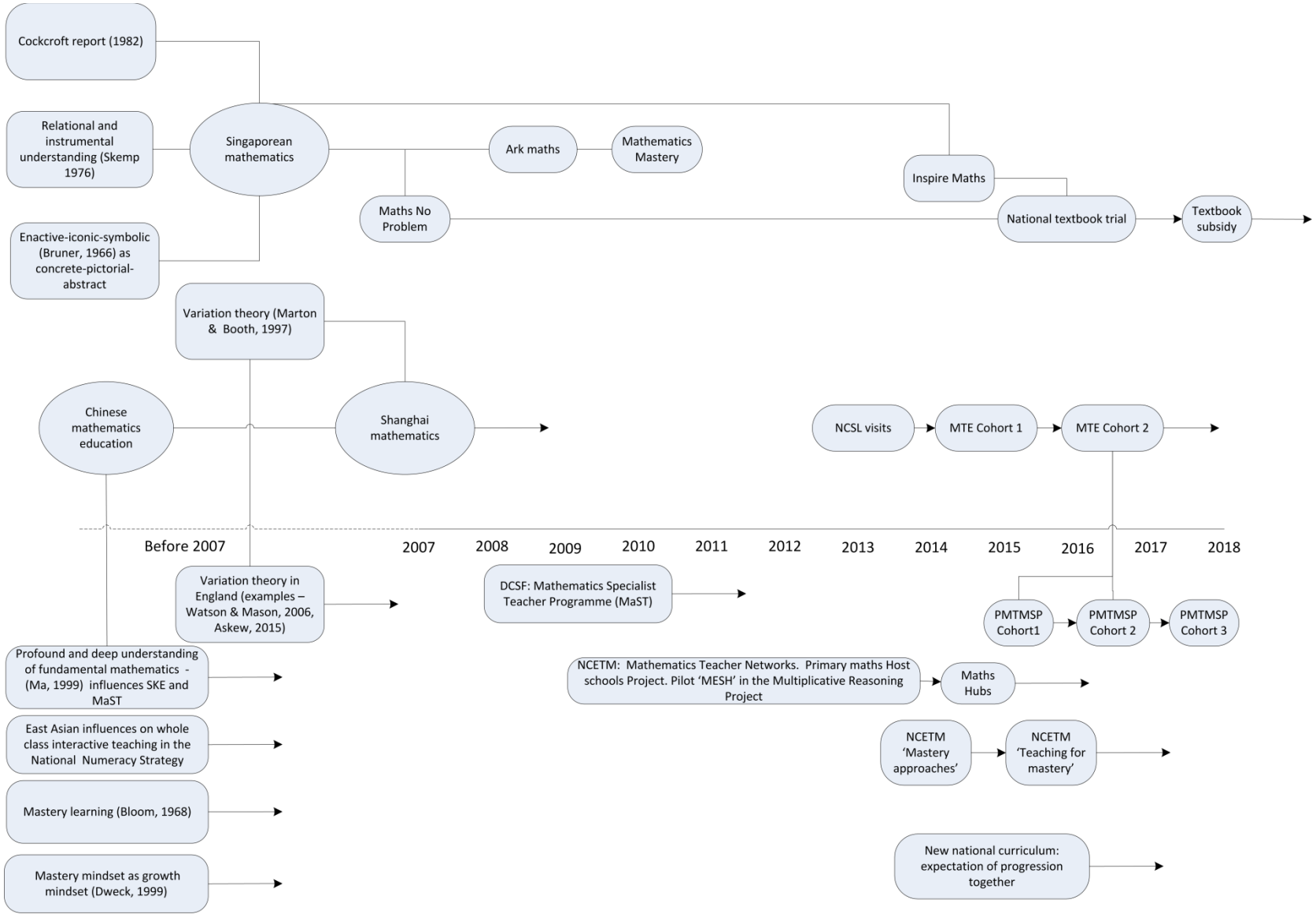
learning, curriculum resource development, and support for mathematics subject leadership. Hubs develop projects and activities related to priorities to meet local needs.

Textbook trial and scheme

The Maths Hub led a national textbook trial 2014-16 in which schools used either *Maths No Problem!* or *Inspire Maths* textbooks. The purpose of the trial was not to compare the textbooks, but rather to enquire into the potential of East Asian informed textbooks generally. Some of the schools in the textbook trial were also involved in the MTE. The outcomes of the textbook trial were positively viewed by the NCETM. Following this and on the basis of a variety of criteria, the DfE allocated resources to set up a scheme to support schools engaging in mastery to access textbooks to use with pupils[18]. A set of criteria has been developed for textbooks[19] to be eligible for this scheme, and an expert panel has assessed applications by publishers for inclusion.

[18] http://www.mathshubs.org.uk/what-maths-hubs-are-doing/teaching-for-mastery/textbooks/
[19] http://www.mathshubs.org.uk/media/5559/assessment-criteria-final-09012017.pdf

Figure 1: Mastery innovation timeline and influences



The role and activity of the NCETM in relation to mastery

The NCETM is funded by the DfE to manage and support the Maths Hubs Network. This section provides a short overview of the NCETM's main activities in relation to teaching for mastery[20]. Following the February 2014 research trip, the National Centre for Excellence in the Teaching of Mathematics began to develop resources and activities to support schools in learning from East Asian mathematics. Resources progressively became available in the year following the MTE cohort 1 exchange, during the main period of change implementation.

During the exchange year and subsequently, as well as coordinating the 2014/15 MTE, the NCETM engaged in a range of activities to support implementation. Activities included; visits to MTE cohort 1 schools, organising regional and national events focused on mastery, and contributing to other organisations' events. Since the exchange, the NCETM have developed a variety of online professional development activities, including video material, some of which focuses on exemplary practice in MTE cohort 1 primary schools. The NCETM have developed exemplar assessment materials for each primary year group (Askew et al., 2015). The NCETM regularly include articles on mastery in their newsletters and often it is the main focus of the 'Bespoke' newsletter focused on Maths Hub activity.

The Primary Mathematics Teaching for Mastery Specialist Programme (PMTMSP)

The Maths Hubs recruited 140 teachers to the (then) new two-year PMTMSP which ran for the first time in 2015/16. The PMTMSP is a comprehensive programme, introduced to support primary schools to understand and embed an expert-developed Shanghai informed mastery pedagogy. The programme has been further developed, with 140 teachers taking part each year from 2016/17 for the next four years. The programme includes online training/courses and three residential events. Whilst half of PMTMSP teachers take part in an exchange as part of their comprehensive training, this exchange looks different to the experience of the original 2014/15 exchange. For example, the original MTE cohort 1 schools were *encouraged* to share learning with other schools, however, this is a key feature of the PMTMSP. More information about PMTMSP is available in section 4.3.

In the region of 800 primary mastery specialists will be trained by 2020. The aim is for these mastery specialists will work with approximately 9,300 primary schools by 2023, allowing the programme to reach around 60% of primary schools in England Primary

[20] For fuller description of NCETM activity see https://www.ncetm.org.uk/

schools on the full Teaching for Mastery programme are eligible to apply for a textbook subsidy (see below).

The expectation on the specialists is that during their training year, they will run a teacher research group (TRG) in their own school, to begin to embed teaching for mastery. In the year immediately after training and the following year, they are expected (and funded) to run a series of TRGs with approximately six other schools, to support them in developing teaching for mastery. Mastery specialists are released for 30-33 days per year. School leaders are expected to support the specialist teacher in undertaking their work. See section 4.3 for further details. The programme promotes collaborative forms of development found in Shanghai, such as TRGs, and provides a forum through which teachers share learning and experiences.

A number of teachers from MTE schools have engaged with the PMTMSP, with a total of 15 teachers from MTE cohort 1 schools participating thus far. From 2015/16, the connection between the PMTMSP and the MTE has been and continues to be further strengthened, in that all 70 of the teachers that comprise MTE cohort 2 were participants in the first PMTMSP. The rationale for this is that participants will have participated in the MTE having already developed understanding of mastery and East Asian practices. Similarly, future participants in exchange visits will be recruited from PMTMSP cohorts.

2.6 Evidence for the efficacy of mastery pedagogy

Key to the rationale for the TfM policy and programme is the superior performance of East Asian education systems in international comparative tests. However, this is not the sole basis for believing that the pedagogical approach could lead to increased attainment, if adopted in England.

The EEF funded an evaluation of the Mathematics Mastery programme and this study reported an effect for Y1 pupils of two months' additional progress and one month's additional progress for Y7 pupils (Jerrim and Vignoles, 2016; Vignoles, Jerrim and Cowan, 2015). However, the finding for the Y1 pupils did not meet the standard degree of confidence for it to be reported as significant. A study of a project based on translation of a Singaporean textbook - Inspire Maths - in Y1 classrooms reports a small but significant effect on progress after two terms when compared to a control group (Hall, Lindorff, & Sammons, 2016).

Guidance published since MTE cohort 1, on effective practice in upper primary and lower secondary mathematics teaching, based on an evidence review, identified a number of practices that are similar or aligned to mastery pedagogy (Henderson, Hodgen, Foster and Kuchemann, 2017). In particular, the following aspects of the EEF guidance relate to mastery pedagogical practices: the use of representations, promotion of mathematical

thinking and problem-solving skills, strategic choice of tasks and resources and the importance of fluency[21].

[21] https://educationendowmentfoundation.org.uk/news/eef-blog-mastery-and-maths/

3. Evaluation methodology, data collection and analysis

Section summary

The evaluation employed a longitudinal multiple case study design with impact analysis based on comparison with a contrast sample of schools identified using propensity score matching.

The evaluation has four strands: strand one focuses on examining changes in practice; strand two analyses impact on attainment; strand three was undertaken and completed in the first year of the evaluation and assessed early evidence of change and impact; strand four extends the evaluation to consider MTE cohort 2 schools.

Details of data collection and analysis for previous years were reported in the interim reports. In the third year: in strand one, 40 telephone interviews were conducted and analysed and a survey of mathematics coordinators took place; in strand two, NPD data were retrieved and analysed and pupil attitude survey data collected; no evaluation activity took place in relation to strand three; in stand four, 27 interviews with MTE cohort 2 teachers were undertaken and the data analysed.

Strand 1 and Strand 2, the main components of the evaluation were carried out using a longitudinal approach. This has allowed triangulation of data sources, respondent checking and tracking of trends over time, adding to reliability and confidence in findings. Whilst it was not possible to employ a randomised controlled design, propensity matching and a robust approach to identifying sub-samples for sensitivity analyses add to confidence in findings.

In this section, the overall evaluation methodology is summarised, as is the data collection and analysis undertaken in the third year of the MTE. A more detailed description can be found in the technical report in which relevant sections in previous reports are referenced. The evaluation had four strands which are described below and the data corpus is summarised in Table 2.

3.1 Evaluation methodology

Strand one

To address objectives 1 to 10, a longitudinal multiple-case study design focusing on the MTE cohort 1 schools was undertaken, encompassing both exploratory and evaluative dimensions (Yin, 2013). Data were collected by the evaluators through a combination of site visits and telephone interviews in three periods in each of 2015, 2016 and 2017. This

set of data was supplemented in the first year of the evaluation by a set of interviews with Maths Hub leads and key NCETM and DfE stakeholders. In 2015 and 2017, mathematics coordinators in MTE cohort 1 schools and other schools within Maths Hubs were surveyed. For 28 schools, reports were received either directly from schools or via NCETM in 2015. The NCETM also provided an analysis and summary of all end-of-year reports received by them as well as of the schools' interim reports. Data from an NCETM survey in 2016 were also analysed.

Strand two

To address objective 11, strand two consisted of a longitudinal analysis of Key Stage 1 and Key Stage 2 attainment data, in comparison with a sample of 940 contrast schools[22]. Data used for the impact analysis were retrieved from the National Pupil Database (NPD) and the school census database. In addition, pupil attitudes to mathematics and to mathematics learning were surveyed in a sample of MTE cohort 1 schools in 2015 and 2017.

Strand three

Strand three sought to identify initial patterns of effective change and early evidence of pupil impact (objective 12). This involved follow-up telephone interviews with exchange teachers in a purposeful sample of MTE cohort 1 schools. Schools selected were ones where the initial case study visit indicated that notable changes in practices were occurring as a result of the exchange and this assessment could potentially be supported by school data. Outcomes of strand three were reported in the first interim report.

Strand four

Following the decision to extend the MTE to further cohorts and to embed it in the PMTMSP, the DfE commissioned an extension to the evaluation to consider the experiences and activities of a sample of MTE cohort 2 schools and teachers in relation to objectives 13 and 14.

[22] See below 'Analysis, reporting and samples' for further detail on the contrast school sample.

Data collection and data corpus

Table 4 below summarises data collection and the data corpus that informs the evaluation.

Table 4: Data collection and data corpus

Year	Data
2015	Interviews: 134 interviews of participants in MTE cohort 1 schools, comprising interviews with teachers, headteachers, Maths Hub leads, NCETM and DfE stakeholders and Shanghai teachers during exchange visits, giving a total of 88 face-to-face and 46 telephone interviews. Survey of mathematics coordinators in 48 MTE cohort 1 schools[23]. Retrieval of baseline 2013/14 KS2 school census data for propensity matching and analysis of balance for 47 MTE schools and 940 contrast schools. Pupil attitude survey distributed electronically to all MTE cohort 1 schools for administration to pupils in Year 6: 1191 surveys were completed online by participants in 36 schools.
2016	A review of 28 school reports prepared for NCETM in August 2015 and NCETM's analytical summary. Telephone interviews with teachers or school leaders from 43 MTE cohort 1 schools. Retrieval of 2012/13 & 2014/15 KS2 school census data for 47 MTE[24] schools and 940 contrast schools to examine balance prior to 2013/14 and examine school-level impact for KS2 maths in 2014/15. Retrieval of 2014/15 KS1 and KS2 pupil-level NPD for 47 MTE schools and 940 contrast schools to examine balance prior to 2013/14 and examine pupil-level impact in KS1 and KS2 maths in 2014/15 using multilevel analyses.

[23] The way schools have been described has changed during the project: variously as host schools, exchange schools and lead primary schools (to infer their leadership role in enacting change).
[24] School-level KS2 data was used to match the MTE schools to their contrast school sample using propensity scores. 47 of the 48 MTE schools taught KS2. The one infant school was not included in the impact analyses.

Year	Data
	Analysis of a further NCETM survey of 39 MTE cohort 1 schools.
2017	Telephone interviews with teachers or school leaders from 40 MTE cohort 1 schools. Telephone interviews with teachers from 27 MTE cohort 2 schools. Pupil attitude survey repeated, distributed electronically to all exchange schools: 593 responses were received. Retrieval of 2015/16 & 2016/17 KS2 school census data for 47 MTE schools and 940 contrast schools to examine balance prior to 2013/14 and examine school-level impact for KS2 maths in 2014/15. Retrieval of 2012/13, 2015/16 & 2016/17 KS1 and KS2 pupil-level NPD for 47 MTE schools and 940 contrast schools to examine pupil-level balance prior to 2013/14 and examine pupil-level impact at KS1 and KS2 maths in 2015/16 and 2016/17 using multilevel analyses.

3.2 Collection and analysis of year 3 data

Strand one

Fuller details of data collection and analysis for the third year of the evaluation are given in section 5.1 of the technical report. In the final year of the evaluation, a telephone interview was conducted with a teacher or school leader in each of 40 MTE cohort 1 schools. Interviews were recorded, transcribed and the transcriptions uploaded into NVivo 10 for analysis. Data from closed questions were also recorded for each school in a spreadsheet. Following a full fieldworker team analysis meeting, coding of the data began in NVivo, using existing codes and creating new ones where needed. In addition, a survey was conducted of mathematics coordinators in MTE cohort 1, MTE cohort 2 and PMTMSP schools as well as of mathematics coordinators more widely, via the Maths Hubs, 593 responses were received.

Strand two

Analysis of pupil attainment data for 2013 to 2017 from exchange schools and contrast schools was carried out using a multi-level modelling approach, accounting for variance at school and pupil level. Details of analysis and findings are included in section 8.1 of this report. Due to the evolving nature of the changes implemented by MTE schools, developing a full protocol that specified the statistical analysis plan at the outset of the evaluation was not feasible. However, the planned approach to statistical analysis was detailed in the second interim report, prior to final data collection and analysis. That approach practically provided conceptual distance between experimental and quasi-

experimental methodologies, whilst fulfilling good practice guidelines of pre-specifying planned impact analyses.

Data from pupil attitude surveys completed in 2017 were compared with data from 2015. The survey measured three factors: *general affect towards mathematics, mathematics anxiety,* and *preference for working alone*.

Strand three

No data collection or analysis was undertaken in the third year for strand three as this strand pertained to the first year of the evaluation only (see above).

Strand four

In autumn 2017, interviews were undertaken with the exchange teacher (where possible) in 27 MTE cohort 2 schools. Interview schedules were created drawing on cohort 1 schedules and the MTE cohort 2 research questions. The procedure for selecting this sample of 27 schools was as follows. Data were collated on the teachers from 70 schools (two per Maths Hub) who took part in the cohort 2 exchange visit to Shanghai (35 of whom also hosted a Shanghai teacher in their schools). The 35 Maths Hubs were sampled by using a random number generator. Within each sampled Hub, one school was selected using the same randomisation method, to generate 27 schools to approach. Teachers in these 27 schools who had taken part in the exchange were contacted for interview. Where teachers were unable to take part, the second school in the Hub was contacted, or a new Hub was randomly selected from the sample. The process continued until interviews with 27 teachers were completed. Cohort 2 interviews were recorded (with one exception where the teacher asked not to be recorded), fully transcribed and uploaded onto NVivo 10. Analysis began with higher level coding of all interviews in accordance with codes created using the initial set of MTE cohort 2 research questions, plus two additional research questions formulated after the interviews. More fine-grained coding of responses to each question was then completed by different members of the analysis team, using the detailed coding system created for the cohort 1 interviews.

3.3 Ethics and data protection

The study was approved by Sheffield Hallam University's (SHU) Research Ethics Committee and was conducted in line with SHU's ethics procedures which conform to guidelines of the British Educational Research Association (BERA, 2011) and the British Sociological Association. Information on which schools are involved in the exchange is publicly available, but schools have been anonymised in reporting the evaluation. Details of contrast schools are not shared with DfE and school names are not reported. All data, including pupil data such as test results, were held securely and confidentially and in

compliance with the Data Protection Act 1998 and the protocols for storage and use of NPD data.

3.4. Robustness and limitations of the findings

In this section, the extent to which the findings of the evaluation are robust is considered, as are the limitations for strand one and strand two of the evaluation.

Strand one

The evaluation had a longitudinal design which allowed for outcomes of analysis to be confirmed and amended via subsequent data collection. In particular, in relation to the findings about levels of implementation, categorisations in the analysis of 2016 data were confirmed in interviews in 2017. Additional data sources supported triangulation. However, a significant limitation is that interview data consisted of self-report of practices in schools. Nevertheless, interviewees were often reflective about the challenges of implementing mastery pedagogy and described instances of inconsistency or reported that practices had not yet been fully taken up.

Strand two

Whilst it was not possible to employ a randomised controlled design, propensity matching adds to confidence in findings. Further a robust approach to identifying sub-samples for sensitivity analyses was used, as was restricting final analysis to those schools for which there was a full set of 'listwise' data - that is data from baseline through the time period of the evaluation.

A discussion of the limitations of the impact analysis was included in section 4 of the second interim report. The two main limitations were: potential sample bias with regard to the set of schools selected to participate in the MTE, and lack of consistency in the way that changes to mathematics teaching have been implemented in MTE schools. These limitations affect the extent to which the findings of this study can be generalised.

In addition, as noted in section 8.1, with regard to the KS1 attainment findings, attainment data relies on teacher assessment. Schools which had implemented mastery fully and consistently over two years with the 2017 Year 2 cohort, were more likely to be ones that were invested in mathematical outcomes in general, and the mastery approaches in particular. Thus the risk of bias in teacher assessments is arguably greater than for other schools including the contrast schools. In addition, the finding is one of association and not causation. It may be that there are features of these schools that are the reasons for both the high levels of implementation of mastery and the higher levels of attainment.

Section 13 discusses potential interpretations of the findings, taking account of these limitations.

Despite the limitations of the impact analysis, there are several aspects of the design and analysis of this research that add confidence in the results. The propensity matching approach is robust, and section 8 reports sensitivity and alternative matching analyses that suggest that the matching of contrasts to exchange schools has lent itself to a valid and meaningful comparison. The use of data from strand one, regarding schools' degree of change in their teaching following the exchange has also been important in increasing the validity and robustness of the findings.

4. The Mathematics Teacher Exchange as a change innovation

Relevant evaluation objectives

Evaluate the implementation and fidelity of the intervention against programme objectives.

Section summary

Theories of change for both MTE cohort 1 and MTE cohort 2 are similar in terms of the importance of other influences on the development of practice and contextual factors. Important differences in cohort 2 are the more defined focus on teaching for mastery and the greater expectation to support change in other schools.

MTE cohort 1 and cohort 2 theories of change highlight assumptions about casual mechanisms related to the effectiveness of mastery practices and their implementation in schools participating in the MTE.

A variety of professional development opportunities are available for those engaging with the TfM programme in relation to the Primary Mathematics Teaching for Mastery Specialists Programme and the MTE.

In this section, the purpose and change mechanism underlying the Mathematics Teacher Exchange is considered. First, simplified 'theory of change' models for both cohort 1 and cohort 2 are presented, along with a more general change model for the TfM programme at a system level. Finally, the various professional development experiences for different participants in the TfM programme are presented. These various models and details serve to further describe the relationship of the MTE to other mathematics teaching innovation activities, as well as the policy purposes of the MTE. Understanding of the relationships supports interpretation of the findings.

4.1 MTE theories of change

Implementation models

Figure 2 provides an implementation model in the form of a theory of change (Weiss, 1997; Rogers, 2008) for MTE cohort 1. Figure 3 is a model for MTE cohort 2. In Figure 4, work with other schools is modelled using dotted lines to indicate that the expectation on MTE cohort 1 schools to work in this way was not of the same magnitude as the expectation on MTE cohort 2.

It is important also to note that the actual exchange experience reported by MTE cohort 2 schools when visiting Shanghai and when hosting Shanghai teachers had developed from the first exchange, resulting in a more coherent and uniform experience across participants. Professional development activities built upon each other, beginning with participation in the PMTMSP.

There is some evidence of the development of a common understanding between participants emerging from the shared experience of the PMTMSP and the exchange. As reported in section 7 below, MTE cohort 2 schools viewed the PMTMSP as an important theoretical foundation for their understanding of mastery, one that helped them to understand the detail of the practice they observed in Shanghai. Although only half of the MTE cohort 2 teachers hosted a Shanghai teacher in their school, compared to the majority of cohort 1 teachers, the cohort 2 teachers reported that this experience played a significant role in helping them continue to implement approaches to mastery in their own schools. There was an expectation that cohort 2 teachers establish teacher research groups themselves and they reported more opportunities to observe or participate in teacher research groups in Shanghai than cohort 1 teachers did. Cohort 2 teachers also had a longer period of time in primary schools in Shanghai, and spent less time in sessions at the Shanghai Normal University than cohort 1 teachers.

Causal assumptions

The MTE cohort 1 theory of change implies the following interconnected and overlapping assumptions about the change mechanism - that is how the MTE programme may lead to improved attainment outcomes.

- Difference in how mathematics is taught in East Asia is at least part of the explanation for comparatively greater attainment than in England.
- That the MTE programme and supporting influences/activities are sufficient to support teachers and school leaders to attempt to implement practices similar to those in East Asia.
- That the teachers and school leaders directly involved in the exchange will implement professional development activities to support change in practices
- That the school based professional activities are effective in changing teachers practices in MTE schools in general.
- The implemented practices by teachers in MTE schools are more effective than previous practices.

Further, in the context of this evaluation, for a measurable effect to be found, practices implemented in the timescale of the evaluation, would also need to be more effective than any practices implemented in contrast schools. This is particularly relevant at a time

of curriculum change when schools were generally changing mathematics teaching in response to new assessment arrangements and the new primary national curriculum.

For MTE cohort 2, a similar set of causal assumptions are implicit in the theory of change model. However for MTE cohort 2, the focus is on the implementation and effectiveness of teaching for mastery. As reported above, the focus of strand four of the evaluation - on MTE cohort 2 - is implementation and not impact on attainment. Given the differences between MTE cohort 1 and cohort 2 theories of change, any findings of impact for MTE cohort 1 cannot be simply read as applying to cohort 2. Nevertheless, as reported in section 5.4 below, whilst the ways that MTE cohort 1 and cohort 2 interviewees discussed changes in practices were different, these differences were subtle and it was not possible to easily identify which cohort interviewees were part of from transcripts alone.

Figure 2: MTE cohort 1 Theory of change

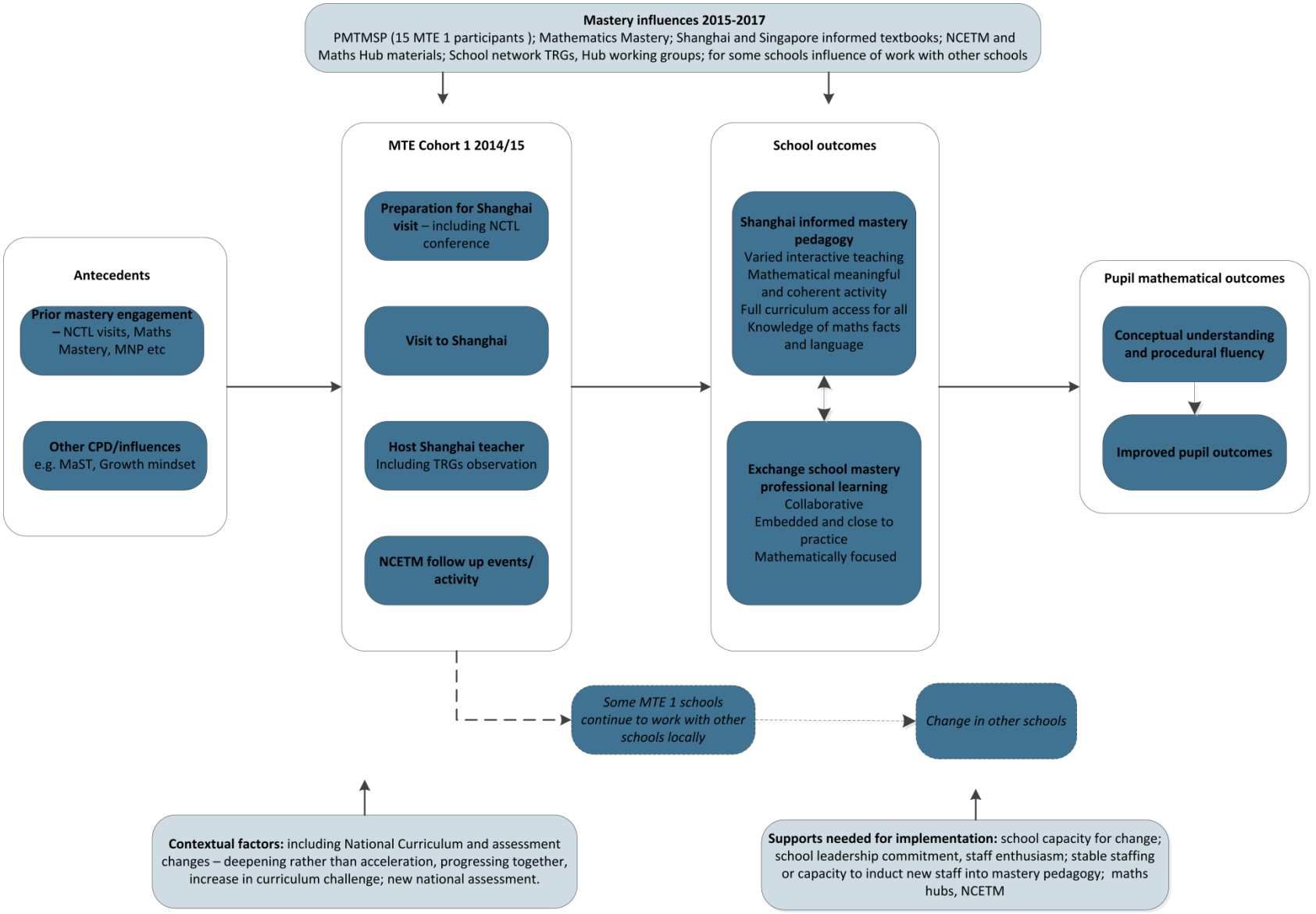
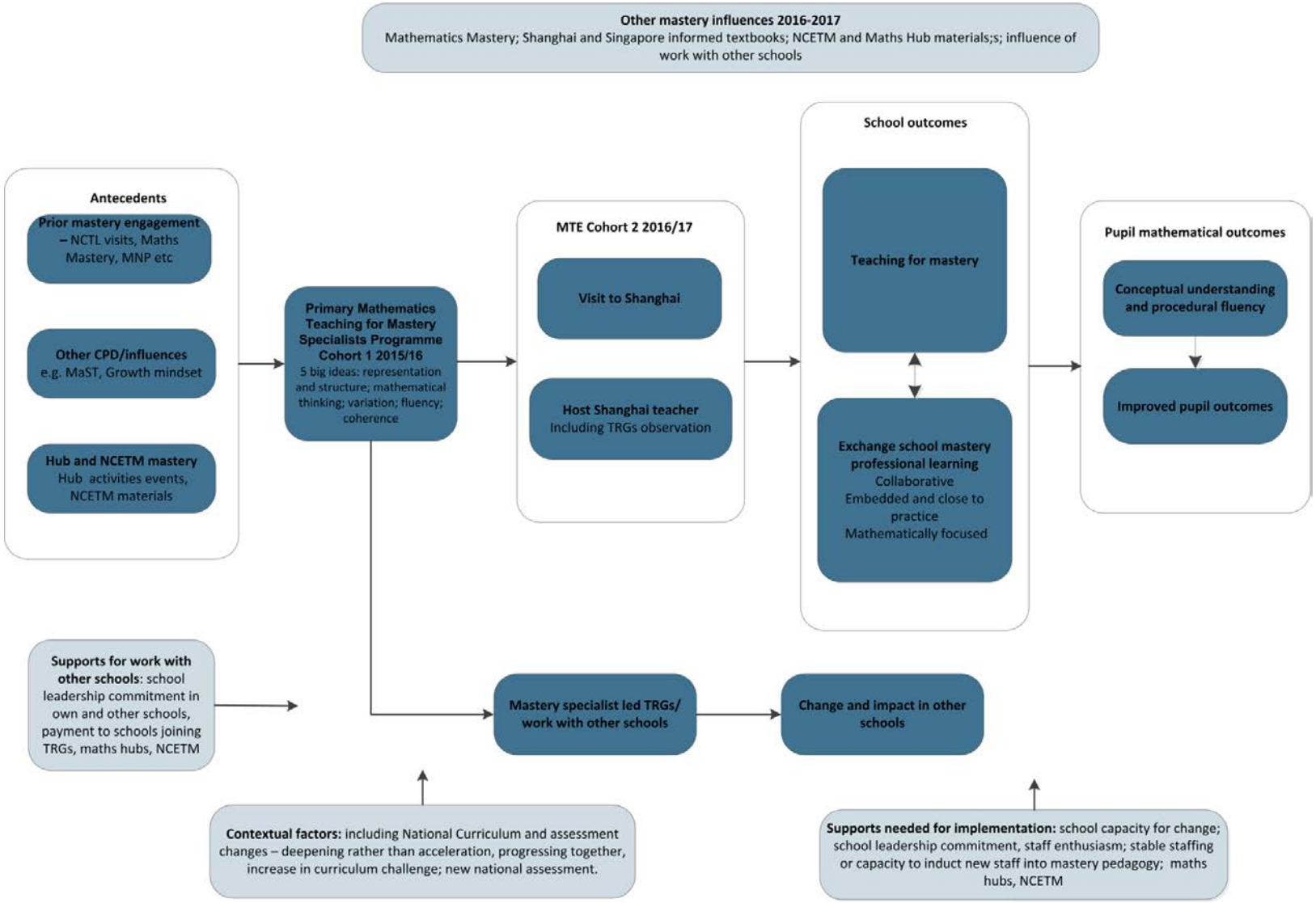


Figure 3: MTE cohort 2 Theory of change



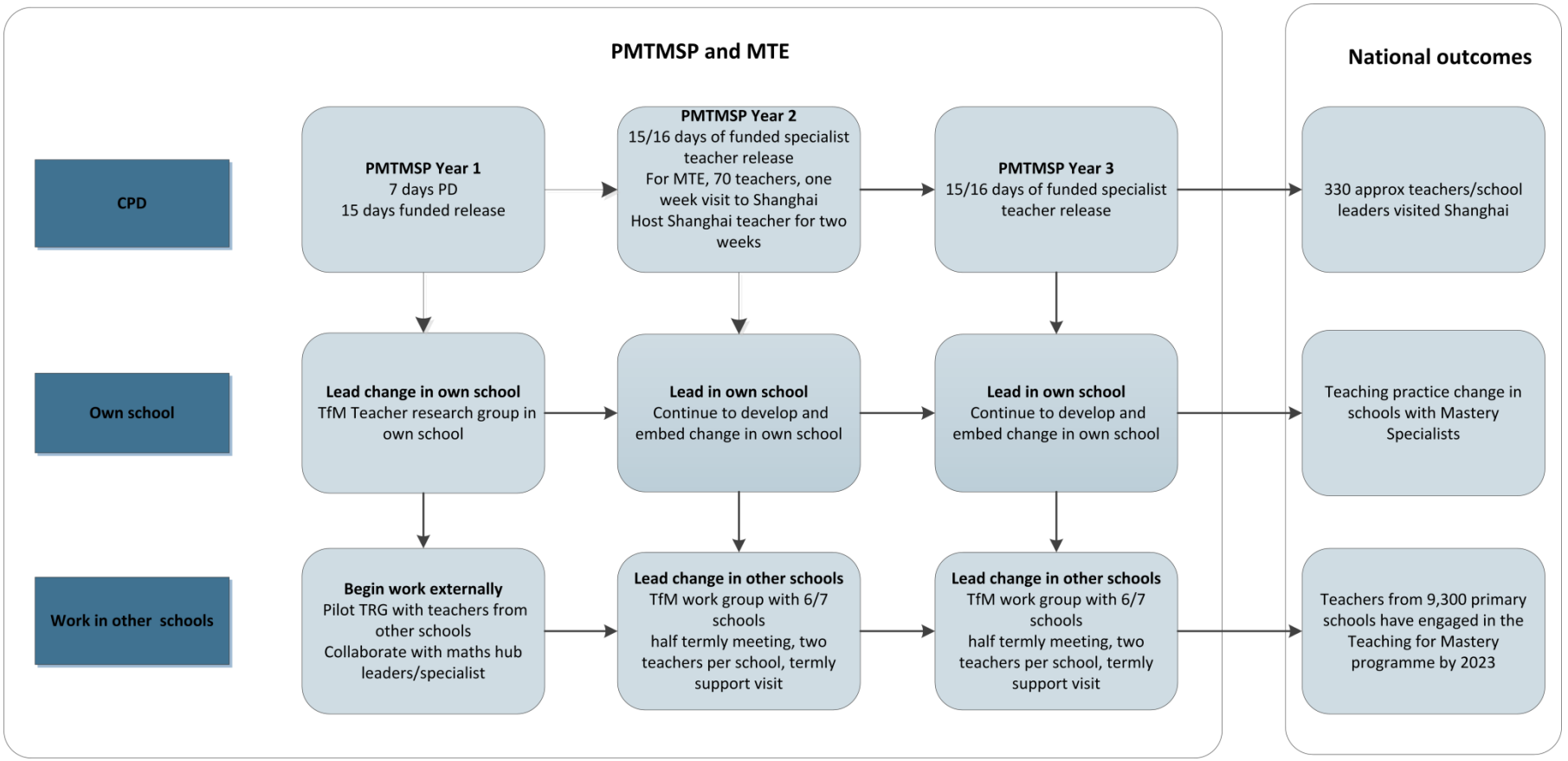
4.2 The PMTMSP, the MTE and system change

The theories of change, modelled in Figures 2 and 3, focus on the exchange schools as the unit of analysis. However, the MTE, as part of the TfM programme, is intended to support system-wide change. Figure 4 details the change mechanism at this level. With regard to the relationship between the PMTMSP and the MTE, all PMTMSP participants and alumni have the opportunity to engage and benefit from the visits to England of Shanghai teachers (as do teachers from other schools, for example those engaged in work-groups). Thus, even for those mastery specialists who do not visit Shanghai, the exchange is potentially an influence on their practice.
The change model is based on training teaching for mastery specialists through the PMTMSP. In the first year of the CPD programme, the focus is on developments in participants own schools, whilst beginning to work externally. In the second and third year, specialists are expected to lead change in other schools. The MTE is now embedded in the second year of the programme and helps to deepen development both for teachers visiting Shanghai and for all PMTMSP participants through observation of Shanghai teachers in England.

At the system level, causal assumptions for change to occur are that:

- Professional development led by mastery specialists is effective in supporting the professional learning of participants in the teacher research groups they lead.
- That those teachers who have worked with mastery specialists are able to lead professional development and implement change in their own schools sufficient to change practice.
- That the practices implemented by schools supported by mastery specialists are sufficiently close to teaching for mastery or other effective practices for impact on attainment to occur.

Figure 4: PMTMSP and MTE and system change



National intended outcomes of the programme are that by 2023, 11,000 primary and secondary schools in total will have engaged in the Teaching for Mastery programme. This includes 358 teachers taking part in the MTE as of November 2018. This level of engagement is intended to lead to system-wide change.

4.3 Professional development opportunities in the Teaching for Mastery Programme

Table 5 below summarises the quantity and type of formal professional development that is specified by the NCETM for:

- MTE cohort 2 school teachers participating in the PMTMSP
- Colleagues participating in the PMTMSP but who are not participating in the exchange
- Teachers working in schools in which a mastery specialist is based, and
- Teachers in schools who are working with mastery specialists in Maths Hub Work Groups.

The row in Table 5 for teachers in schools in which PMTMSP/MTE participants are based, does not include other school-level professional development or activities accessed due to involvement in other mastery pedagogy initiatives, so the activities listed for this row should be considered the minimum taking place in a school where a teacher is participating in the PMTMSP. As may be expected, variations in professional development opportunities were found and are reported in section 7.

Table 5: Professional development experiences

Professional development opportunity by participant	Activity
PMTMSP participants	7 days CPD in year 1 (and one day for school headteacher). Further support is given in year 2.
MTE participants	One week visit to Shanghai, host Shanghai teacher for two weeks.
Teachers in schools in which PMTMSP/MTE are based	CPD activities when hosting Shanghai teachers. Half-termly school TRGs, often with demonstration lesson or lesson observation, weekly collaborative lesson plan with consultation/support from specialist.
Maths Hub Work Group	Half-termly meetings for two years, termly visits by the mastery specialist.

5. Shanghai-informed mastery pedagogy

Relevant evaluation objectives

Evaluate the implementation and fidelity of the intervention against programme objectives.

Determine whether teaching methods and practices have changed in host schools in England.

For MTE cohort 2 schools, identify patterns of implementation and the influence of the exchange on this relative to other influences.

Section summary

MTE cohort 1 schools have implemented a Shanghai-informed mastery pedagogy that aims to develop conceptual understanding and procedural fluency to impact pupil attainment.

The key components of the MTE pedagogy are: varied and interactive teaching, mathematically meaningful and coherent activity, full curriculum access for all, and knowledge of mathematical facts and language.

The model does not include all changes made in schools, but those that appear distinctive and closely related to the exchange experience.

The mastery pedagogy is informed by but differs from the NCETM's teaching for mastery formulation that is now the focus on the Mathematics Teacher Exchange since cohort 2. However, there are many overlapping features.

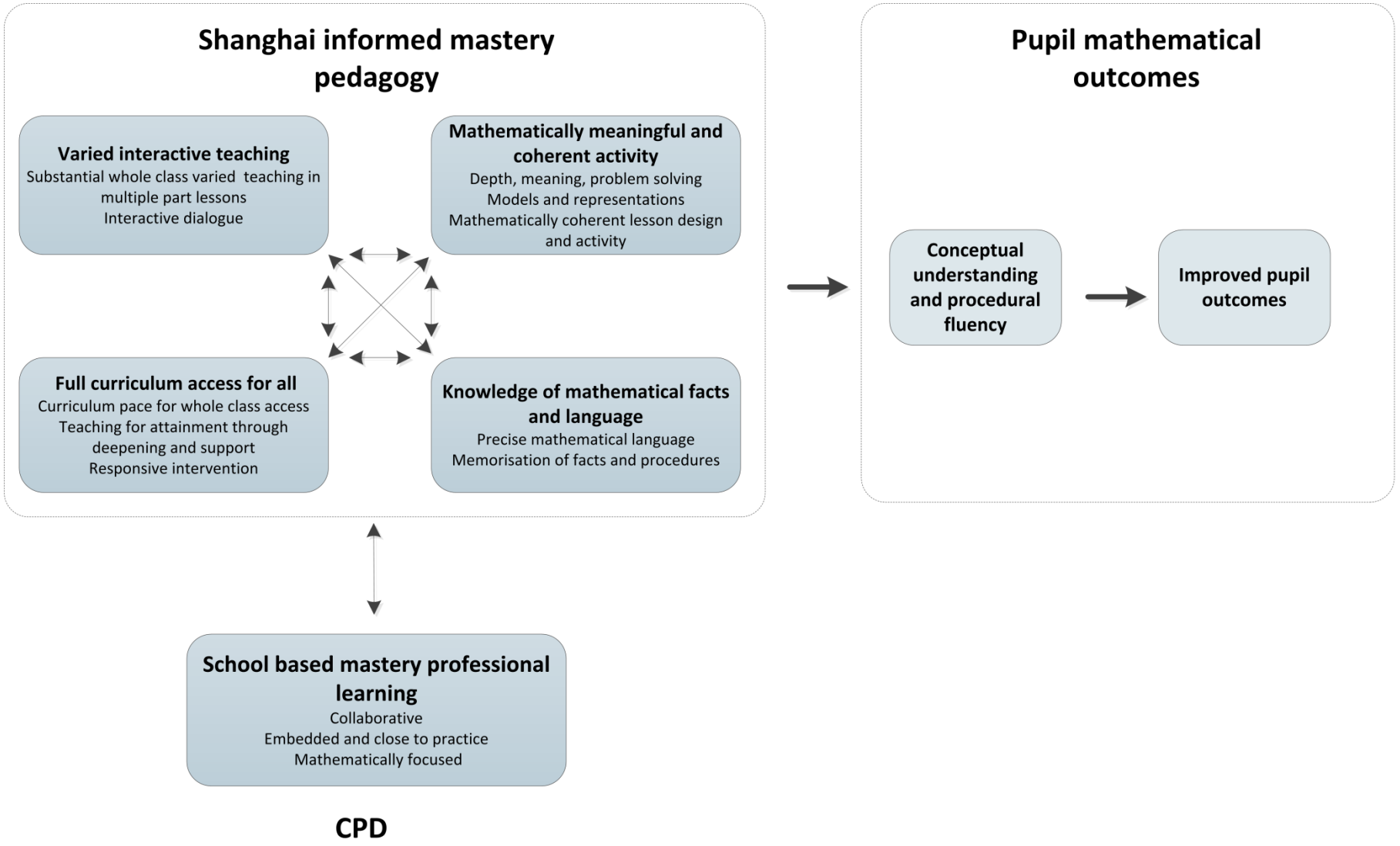
In this section, a model of pedagogical and supporting practices implemented by MTE cohort 1 schools is presented and those practices described. The relationship of the model of mastery pedagogy to the formulation of 'teaching for mastery' is then considered.

5.1 Mastery pedagogy

The model of MTE mastery pedagogy was derived from analysis of practices implemented by MTE cohort 1 schools as a result of the exchange and other influences, and referred to by them as constituting substantial implementation. The organisation of the different elements of mastery pedagogy into four main components reflects connections identified in participants' descriptions. However, the different practices were clearly interconnected between components and this is represented by the nest of connecting arrows in the left-hand side of figure 5. An example of interconnection of

components is that interactive dialogue supports the efficacy of using mathematical models and representations, which in turn creates opportunities for rich mathematical discussion.

Figure 5: Shanghai-informed MTE mastery pedagogy



5.2 Implemented practices

The model of MTE mastery pedagogy is organised into four components which each have a number of sub-components. Practices that align with these components and sub-components are now described. The purpose of this description is to provide a general account of implemented practices. The level of implementation of practices is reported later in section 6 and for clarity is not provided in each of the descriptions below.

1. Varied interactive teaching

1a Substantial whole-class varied teaching in multiple part lessons

Schools reported increasing the amount of time spent in whole-class or teacher-led activity, though the nature of this varied in the form of teacher and pupil activity. Prior to engagement in the exchange, schools generally followed a National Numeracy Strategy three-part lesson (or four-part lesson if the teacher explanation of the main activity is considered as a separate part), unless they had already engaged with mastery programmes, projects or initiatives (seven of the original 48 schools). Schools adopting a mastery pedagogy typically described six or more parts in a lesson. Further, each individual part of the lesson would have an episodic quality. A common phrase used to describe this was 'I do, you do', or alternatively 'to and fro'. These two different formulations may reflect more or less transmissive interpretations of Shanghai practices. Episodes were sometimes also described as 'chunks'. Similarly, whole-class teacher-led episodes would consist of working on a series of carefully chosen problems. The episodes had a rhythm of teacher led-activity followed by short periods of independent work by pupils before plenary discussion. This approach was linked to what was often referred to as a 'step by step' approach or taking small steps. Participants spoke about greater variety in lessons and a varied approach[25]. However, varied here does not mean that lessons lacked structure or continuity of structure.

1b Interactive dialogue

As intimated in relation to lesson structure, whole-class teaching episodes emphasised interaction, for substantial portions of time. This was described as 'to and fro' or 'ping pong'. Interactive dialogue was not only promoted *between* the teacher and pupils but also pupil-to-pupil. Interactive dialogue practices noted were:

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[25] The use of the term varied reflects participants description of the form of whole class interactive teaching, contrast with single episodes of teacher led interaction prior to practice - a common approach before the exchange. It does not refer specifically to the use of the term 'variation' in relation to variation theory. The latter has been used to analyse Shanghai practices and is an important aspect of NCETM's Teaching for Mastery formulation. In the model of mastery pedagogy, variation in this sense is a sub component of mathematically meaningful and coherent activity.

- Pupils being asked to discuss with a partner before answering, including justifying or explaining their reasoning
- Teachers asking for explanations of how answers were obtained and for details of methods used
- Pupils being encouraged to communicate in mathematical terms to the whole class, for example by coming out to the board.

To elicit and encourage mathematically accurate talk, a variety of techniques were used, for example the use of stem sentences. A stem sentence provides a scaffold which children can extend to make a mathematical statement.

The quality of teachers' questioning of pupils was developed through careful choice of questions, for example to identify or address misconceptions or by considering a taxonomy of question types.

2. Mathematically meaningful and coherent activity

2a Depth, meaning, problem-solving

Schools enacted many approaches to support the development of conceptual understanding. Activities were carefully chosen to promote understanding, often starting from a problem. Classroom talk focused on additional challenges aimed at deepening understanding or providing conceptual variation, which involves introducing a similar but meaningfully different task to support pupils' sense-making of concepts, procedures or underlying mathematical structures. Practice questions to promote fluency were similarly carefully selected to provide meaningful variation. Links were made by interviewees between meaning, understanding and fluency.

2b Models and representations

Prominent in the approaches to develop conceptual understanding was the use of models and representations. With regard to representations, schools adopted Shanghai practices and also drew on formulations of the concrete-pictorial-abstract principle found in Singapore (Hoong, Kin and Pien, 2015). Those schools already engaged with Singapore-informed resources had already developed their practice in this area. Use of models and representations can be divided into use of visual representations and the use of concrete models and materials. Visual representations referred to by participants included: arrays, bar models, 10 frames, whole-part diagrams, and number lines, as well

as various forms of representations of objects[26]. Multiple and varied visual models were used and linked mathematically. The use of models was linked to other practices such as questioning or variation theory. Some schools had formulated the approach in school policy, for example the recommendation always to use two representations in every lesson or to use the concrete-pictorial-abstract rubric in lesson design.

Concrete models and materials referred to by participants included: Dienes/Base 10 equipment, Numicon, Cuisenaire rods, generic counters as well as double-sided and place value counters, Multilink and Unifix cubes, physical 10 frames, place value cards, small world objects (bears, toys and so on), and number beads[27]. A common change reported was for the use of concrete materials to be extended from use with younger children to the full primary age range. Similarly, in some schools, use had been extended by attainment: concrete materials were no longer viewed as being more appropriate for low-attaining and/or SEND pupils, but were viewed as important for the full attainment range. Routinely, concrete materials would be on desks for students to use during explanations, at the teacher's direction, to help develop understanding. Some teachers reported creating their own specialised concrete materials for particular topics.

2c Mathematically coherent lesson design

Mathematically coherent lesson design, in keeping with East Asian pedagogy, was informed in schools by the use of East Asian informed textbooks or other commercially available mastery material. These were used either for planning, often drawing on multiple sources of mastery materials, or directly with the pupils. Schools also used NCETM materials and those produced by the Maths Hub Network. In some cases, schools selected from the latter materials and other resources but did not make extensive use of East Asian informed materials. In those cases, lesson design still accorded with mastery pedagogy lesson design due to the systematic use of representations, planning informed by variation theory, or in relation to deepening understanding - for example, using NCETM assessment materials. Other features of coherence in focus on mathematical understanding included, planning for provoking and addressing misconceptions.

[26] Barmby et al. (2013) provides an overview of the use and types of visual representations in primary mathematics.
[27] Moyer (2001) provides an introduction to teachers' use of concrete materials in mathematics teaching.

3. Full curriculum access for all

3a Curriculum pace for whole-class access

In the mastery pedagogy, the pace of coverage of curriculum content was slowed with an emphasis on ensuring mathematical understanding before moving on to new topics and materials. This ensured that the whole class could access the curriculum.

3b Teaching to attainment by deepening and support

Schools embraced a focus on teaching to attainment rather than thinking in terms of ability. This was linked to a mastery mindset and a belief that all learners could succeed with effort and appropriate support. There was a conscious attempt to change the way pupils were spoken about, moving from language referring to ability and related notions, to language referring to pupils in terms of attainment. Typically, prior to adopting a mastery pedagogy, different activities for different children would be planned in advance. Instead, in mastery, differentiation happened through a process of deepening and support. Often this meant that in those classes in which mastery pedagogy was implemented, an all-attainment teaching approach was adopted with pupils, for example, sitting in mixed-attainment pairs. Where all-attainment teaching was not adopted, teachers put emphasis on ensuring that all students could access challenging material and described being more fluid in grouping practices than previously.

3c Responsive intervention

Schools adopted or adapted the Shanghai practice of daily intervention. This involves identifying pupils daily for additional support, depending on observed learning and the provision of additional support outside of the lesson. The practice of splitting the lesson was used by some schools to facilitate this cycle of identification and intervention. There was greater emphasis on the class teacher, rather than a teaching assistant, working with those pupils given additional support.

4. Knowledge of mathematical facts and language

4a Memorising facts, relationships and structures

Schools identified specific time slots for developing factual knowledge, either in lessons or frequently as additional, short (5-10 minute) daily periods. Strategies for supporting the development of factual knowledge included recitation of key ideas and concepts. Further, specific strategies were used for different groups of pupils such as those identified as SEND or those having English as an additional language.

4b Precise mathematical language

Teachers modelled the use of precise mathematical language in full sentences when explaining or responding to pupils. Pupils in turn were encouraged to use precise mathematical language in full sentences when responding to questions.

5.3 Limitations of the model

The model of mastery pedagogy does not include all changes made in schools (see section 6.5 technical report for supplementary data). For example, generally schools reported an increase in the total amount of time spent teaching and learning mathematics. However, this does not appear intrinsic to a mastery pedagogy and may be indicative of a general response by schools to changes in the primary curriculum.

In addition, as reported in the third interim report, approximately a quarter of the original 48 MTE cohort 1 schools reported changed homework practices in 2015 and a similar number in 2016. An alternative in some schools was to split lessons and have a clearly identified time for practice following intervention.

The way children were seated for mathematics was also not included in the model. This was a change that happened in a minority of schools implementing mastery, where pupils would be seated in rows. It is also a recommendation by the NCETM in their description of TfM (NCETM, 2016). However, other schools with high implementation did not adopt this practice. The model does include a component relating to whole-class interactive teaching, and seating strategy is subsumed as one indicator, but not a necessary condition, of schools' adoption of this form of teaching.

5.4 Mastery pedagogy and teaching for mastery

As noted in the introduction, when the MTE was initiated, schools' practices were influenced by the NCETM's initial descriptions of 'mastery approaches' to mathematics (NCETM, 2014). This influenced MTE schools' understandings of Shanghai practices and so implementation of changes in practices. Teaching for mastery as teaching approach was discussed in section 3.2

For MTE cohort 2 schools - as for all participants in the PMTMSP - TfM has been important to their conception of East Asian mathematics education. This is represented in Figure 5. TfM is formulated differently to the model of MTE mastery pedagogy as implemented by MTE cohort 1 schools. However, both descriptions have clear overlaps. This should not be surprising as NCETM materials published after the first exchange have influenced MTE cohort 1 schools (see for example, third interim report, page 58), and 15 of the MTE cohort 1 schools have participated in the PMTMSP.

One way of considering the similarities and differences is from the perspective of the participants in cohort 1 and cohort 2 schools. Interviewees in both cohorts were asked what were the most important changes made in practices in their schools. For cohort 1, responses can be broadly categorised as changes to classroom practice, changes to school practices, and outcomes. In addition, answers varied from focusing on the single most important change made, to discussing a variety of changes implemented. Although individual responses were diverse, they broadly reflect the components of the mastery pedagogy model presented in Figure 5.

Teachers who spoke about changes to classroom practice referred to conceptual understanding, including variation theory, with a small number discussing the concrete-pictorial-abstract rubric, and others referring to the use of multiple representations. Other important changes mentioned were taking small steps and changing differentiation approaches.

Those who talked about changes to school practices focused mainly on all-attainment teaching or emphasised changes made to planning, in both structure and consistency as well as a collaborative approach to planning. Other changes to practices mentioned by a small number of interviewees were the use of a textbook, intervention practices and changing the lesson structure.

Outcomes related to teaching staff included increased subject knowledge. Perceived changes for pupils included their attitudes to and perceptions of mathematics; pupils were said to enjoy maths more and were more engaged and enthusiastic. An increase in both pupil and teacher mathematics confidence was also reported.

There was less variety in MTE cohort 2 interviewees' answers about the most important changes made in their schools. Whereas in cohort 1 teachers referred to changes in grouping and differentiation practices, cohort 2 teachers were more likely to link this explicitly to the belief that all pupils can achieve in mathematics. The focus in class was on depth and keeping the class learning together, rather than moving on to new materials to ensure that subject knowledge was secure for all.

'I think the move from what we now call ‘rocket ship maths’, you know – pushing children on, move on, move on, move on.' (MTE cohort 2, school 2A34, interview 2017)

This connected to the importance of a small step approach to curriculum coverage.

Changes to classroom practices being implemented to support learning and depth of understanding in mathematics were said to be: a focus on conceptual learning, including the importance of pictorial representations, the use of variation, and a focus on fluency.

For some cohort 2 interviewees, as in cohort 1, the most important changes related to outcomes - for teachers, pupils or the whole school. Teacher outcomes were around

enthusiasm and confidence to teach mathematics coming from collaborative learning. Pupils were said to have increased confidence, resilience and problem-solving abilities, as well as stronger mathematical vocabularies with the ability to articulate what they know and what they don't understand in mathematics. Lastly, a small number of teachers talked about the profile of mathematics having been raised more generally throughout the school with the focus on mastery.

Thus, although there were differences in emphasis and terms used between the two sets of interviews, these were not so substantial that a school could be identified from the transcripts alone whether it was in cohort 1 or cohort 2. Differences within the cohorts were greater than between the cohorts.

6. Patterns of implementation and change over time

Relevant evaluation objectives

Evaluate the implementation and fidelity of the intervention against programme objectives.

Determine whether teaching methods and practices have changed in host schools in England.

For MTE cohort 2 schools, identify patterns of implementation and the influence of the exchange on this relative to other influences.

Section summary

Implementation criteria were applied to determine the level of MTE mastery pedagogy implemented at 38 of the original 48 MTE cohort 1 schools for which there was sufficient data to make a determination. Of these, 34 schools were identified as having implemented MTE mastery pedagogy, with 25 of these doing so at a high level.

Implementation is greater in KS1 and lower KS2 than upper KS2. Some 27 schools reported substantial implementation over two years as experienced by the 2017 Y2 cohort and 16 schools with respect to the 2017 Y6 cohort.

Implementation increased from 2016 to 2017.

Although implementation in MTE cohort 2 cannot be directly compared with cohort 1, due to differences in data, there are indications that implementation of changes aligned with mastery practices in general in the first year after the exchange in cohort 2 schools is higher than in cohort 1 at the equivalent time.

In this section, patterns of implementation are reported for MTE cohort 1 schools and then for MTE cohort 2 schools. For cohort 1, firstly the overall implementation category is indicated: whether or not mastery pedagogy had been put in place in the school. Following this, levels of implementation by year group are described, as are changes in implementation for specific practices over time.

6.1 MTE cohort 1: levels of implementation

School-level implementation

Relative levels of implementation using MTE mastery pedagogy criteria

Here the analysis of implementation at a school level is presented based on the model of MTE mastery pedagogy and description of implemented practices given in section 5.2. In the technical report, section 7 provides further details of levels of implementation of components of MTE mastery pedagogy, not reported below. In addition, section 7 of the technical report provides details of implementation criteria, how schools were categorised and methods used to ensure the reliability of judgements, including rating by a researcher external to the evaluation team, without knowledge of judgements already made and using an alternative analytical approach for triangulation[28].

Tables 6 and 7 show the mastery implementation categorisations determined for cohort 1. These data related to classes in which the schools reported that substantial implementation of mastery pedagogy practice had taken place. Thus it represents a summary of the *quality* of implementation.

Table 6: MTE cohort 1 relative levels of mastery implementation for the original 48 schools

Level of implementation	Number of schools
Mastery	34
Not meeting threshold criteria	4
Unknown/missing data	10

Table 7: MTE cohort 1 High or threshold levels of mastery implementation

Level of implementation	Number of schools
High mastery implementation	25
Above threshold, but not high	9
Total mastery	34

Thus, for 71% of the schools in the original sample, there is evidence that they have met the threshold criteria and 52% of schools have implemented a high level of MTE mastery.

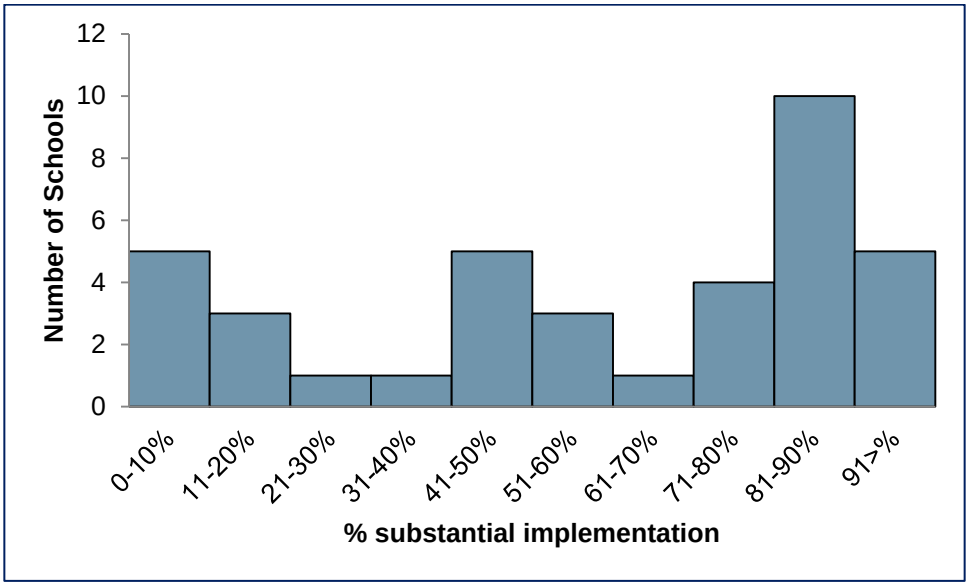
[28] Ins school reports submitted to the NCETM in summer 2015, the NCETM asked schools to identify levels of implementation. However, the analysis undertaken for the evaluation is separate from that. The concept of different levels of implementation is informed by common practices in implementation and process evaluation methodology.

With regard to this finding, it is important to note that recruitment of schools to MTE cohort 1 was done in a short time-scale and while Maths Hubs were in the process of being established. It appears that some schools did not have the capacity to fully engage with changing practice. As reported below, implementation rates are higher in MTE cohort 2.

MTE Mastery implementation as a percentage of classes

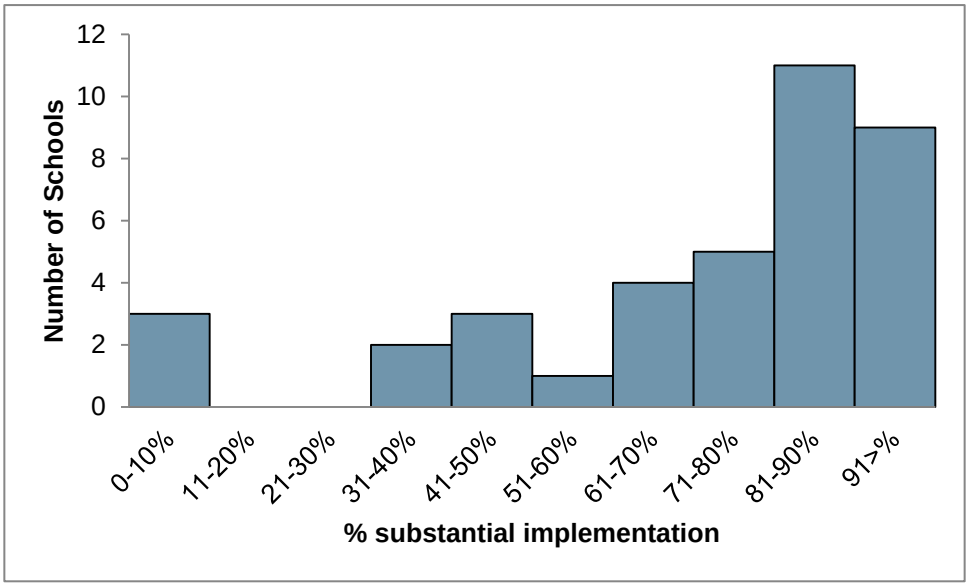
Figures 6 and 7 below show the percentage of classes for which interviewees reported in 2016 and 2017 that 'substantial' implementation was taking place. Note that these self-reported data do not represent an application of the implementation criteria referred to above. As the figures show, although the samples of schools changed from 2016 to 2017, the overall pattern is that substantial implementation was increasing over time.

Figure 6: Number of schools with substantial implementation by percentage of classes 2015/16



Source: MTE cohort 1, 2016 interviews, n=38

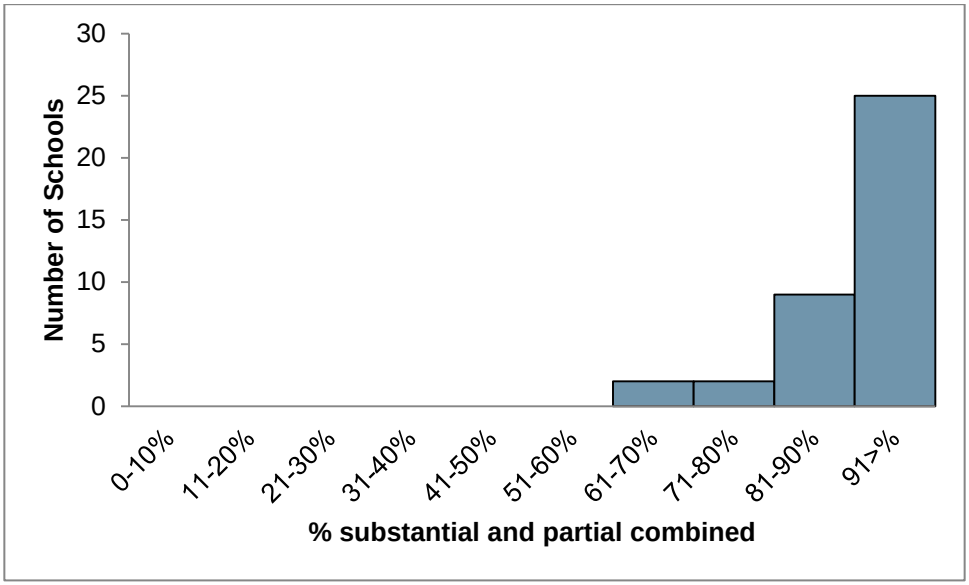
Figure 7: Number of schools with substantial implementation by percentage of classes 2016/17



Source: MTE cohort 1, interviews 2016, n=38

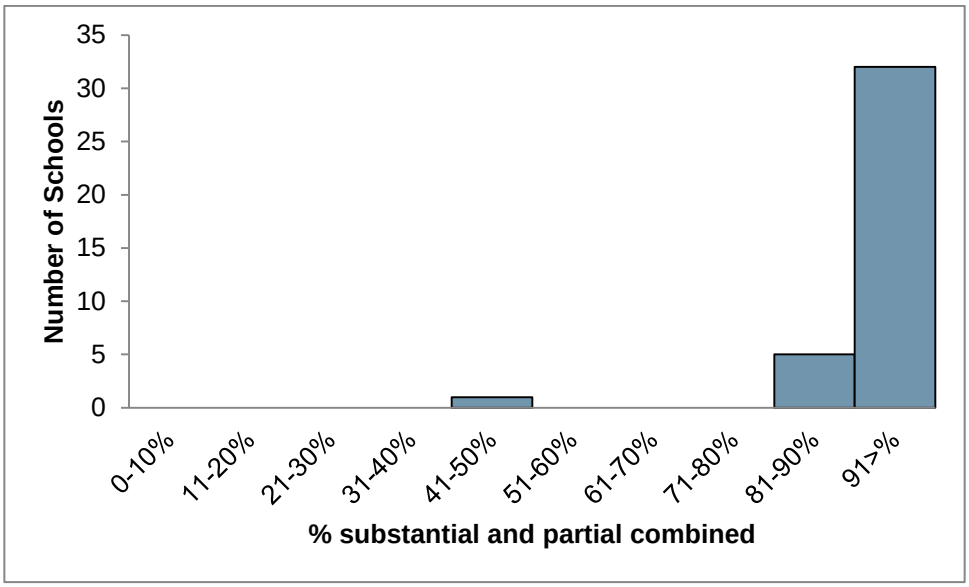
Figures 8 and 9 provide data in the same format as Figures 10 and 11, but encompassing data from self-reports of partial ('some') implementation of MTE mastery as well as substantial (in combination) as a percentage of classes. These figures show not only that there is an increase in implementation over time (as found for substantial implementation), but also that by 2017, mastery pedagogy has impacted to some extent on nearly all classes in the sub-sample of schools.

Figure 8: Number of schools with substantial/partial implementation by percentage of classes 2015/16



Source: MTE cohort 1, 2016 interviews, n=38

Figure 9: Number of schools with substantial/partial implementation by percentage of classes 2016/17



Source: MTE cohort 1, interviews 2016, n=38

Participants were asked in which classes there had been substantial or some implementation of MTE mastery practices. Analysis of responses is shown in Table 8. This represents the *quantity* of implementation.

Table 8: MTE cohort 1 percentage of classes in which MTE mastery has been implemented

	Substantial	Some	None
2015/16	57	37	5
2016/17	72	25	3

Implementation by year groups

In those schools implementing MTE mastery pedagogy, the number of year groups in which implementation has been happening has increased over time. The percentage of classes in 38 schools for which there is full data (interviews in 2015/16 and 2016/17) is shown in Table 9 below.

Table 9: Implementation by year groups (percentage of classes) for 38 schools

	2015/16			2016/17		
	None	Some	Substantial	None	Some	Substantial
R	22	56	22	1	63	36
Y1	0	18	82	0	13	87

	2015/16			2016/17		
Y2	0	25	75	0	12	88
Y3	3	26	71	3	15	82
Y4	0	32	68	4	13	83
Y5	0	60	40	5-[	20	75
Y6	12	49	39	12	37	51

Source: MTE cohort 1, interviews 2016 and 2017

Implementation in Year 2 and Year 6 for at least two years

Table 10, below, provides data for schools with substantial implementation such that the Y2 and Y6 cohorts have experienced mastery pedagogy for at least two years. These data are important later for exploratory analysis, see section 8.

Table 10: MTE cohort 1 substantial implementation for at least 2 years with Y6 and Y2 cohorts

Implementation	Schools
Substantial implementation of mastery with the Y6 cohort for at least 2 years (with Y5 in 2015/16 and Y6 in 2016/17)	16
Substantial implementation of mastery with Y2 cohort for at least 2 years (with Y1 in 2015/16 and Y2 in 2016/17)	27

Source: MTE cohort 1, interviews 2017, (out of n=38)

Fifteen of the schools with substantial implementation with the Y6 cohort for at least two years also had substantial implementation of mastery with the Y2 cohort for at least two years.

6.2 MTE cohort 1: change in implementation of individual practices over time

In order to determine the final categorisation of schools' implementation reported in Tables 6 and 7, data from both the 2016 and the 2017 interviews was used. Thus, it is not possible to categorise the overall level of a school's implementation for 2016 and to then compare this with the level of implementation in 2017. However, this can be done for some key indicators, such as the use of mastery-aligned textbooks or schemes, and for grouping arrangements for 2015. In this section, indicators of change are reported, focusing on the sample of 38 schools for which there is full data available.

Change in use of textbooks or coherent mastery materials

Table 11 below provides data on the use of mastery-aligned textbooks or Mathematics Mastery materials in 2015, 2016 and 2017. The table presents the number of the 38

schools for which there is full data. It shows whether textbooks or Mathematics Mastery materials were used either as a main resource for use directly with pupils, or as an important source for lesson planning. Further details are provided in the technical report, section 6.2, for all schools providing data in any of the three years.

Table 11: Change in mastery textbook or scheme use for 38 schools

Use of mastery textbooks/schemes	Number of schools
2015	5
2016	29
2017	29

In addition, one of the other 10 schools of the original 48 reported using mastery textbooks.

Change in setting or attainment grouping patterns

In 2015, MTE cohort 1 school respondents were asked by survey about what their grouping practices were in terms of setting or attainment grouping within classrooms by year group. Responses were summarised to determine the overall prevalence of grouping patterns. Table 12 below presents the findings for 42 schools.

Table 12: Attainment grouping in 2015

Form of grouping	Percentage of schools 2015
Heterogeneous grouping (pupils not set or grouped by attainment within class)	38%
Pupils set by class (pupils allocated to classes based on prior attainment and/or perceptions of 'ability')	22%
Pupils grouped by prior attainment within class (pupils of similar attainment sat together)	40%

Source: Mathematics coordinator survey, 2015, n=42

In 2016 and 2017 interviews, participants were asked about grouping arrangements for those pupils who were taught in classes where mastery pedagogy was being implemented to a substantial degree. Table 13 below presents data for 38 schools that participated in both interviews. Details of all responses are in the technical report, section 6.2.

Table 13: Forms of grouping in mastery pedagogy classroom in 2015 and 2016

Form of grouping	2016	2017
Heterogeneous grouping (pupils not set or grouped by attainment within class)	71%	75%
Pupils set by class (pupils allocated to classes based on prior attainment and/or perceptions of 'ability')	13%	11%
Pupils grouped by prior attainment within class (pupils of similar attainment sat together)	16%	14%

Source: MTE cohort 1 interviews 2016 and 2017

In classes which were not following the mastery pedagogical approach, setting or attainment grouping within the classroom was more likely to occur. This was the case for higher years (in which setting and attainment grouping had been more prevalent in 2015 also). However, as shown below in Table 14, the number of classes in which mastery pedagogy was implemented, increased year by year, thus progressively more heterogeneous grouping practices were adopted.

Change in use of representations and concrete materials

Based on the 2016 interviews, a determination was made of the extent to which visual and concrete representations respectively were used in MTE cohort 1 schools. The third interim report contained analysis of the extent to which use of representations was variously embedded, in the process of embedding, or was only limited. In this analysis, visual and concrete representations were considered separately. The definitions and the

relevant table are reproduced in the technical report section 6.5, along with the equivalent table for 2017 - in both cases for all schools providing data. Embedded use indicates use across all year groups and levels of attainment with multiple representations routinely used to support the development of conceptual understanding. To compare 2016 with 2017, a composite category is presented in Table 14 below for 38 schools for which there is data for both years.

Table 14: Level of implementation of use of representations for 38 schools

Level of implementation of use of representations	2016	2017
Both concrete and visual representations are embedded	9	15
One of concrete and visual representations embedded	6	6
Concrete and visual representations embedding	12	13
One or other or both limited use	13	4

Source: MTE cohort 1, 2016 and 2017 interviews

The table shows that over the two years there has been an increasing level of integration of use of concrete and visual representations.

Patterns of implementation over the three years

The overall pattern of implementation in the 38 schools is of changed practices in attainment grouping and textbook use in 2016. A more sophisticated use of representations occurs as the use of textbooks and other mastery-aligned resources becomes established in 2016/17. Progressively, mastery pedagogy has been implemented with more year groups and classes in schools. Often in schools this involves practices following pupils from year to year as they proceed up the school. For example, one school, which has fully implemented mastery in some classes, chose to experiment in Key Stage 1 and lower Key Stage 2 in 2014/15 (the exchange year). It then fully implemented mastery pedagogies in Year 1 and Year 3 in 2015/16 and then additionally in Year 2 and Year 4 in 2016/17 with some practices being applied in other year groups. However, there are other schools that have fully implemented mastery pedagogies with all year groups.

6.3 MTE cohort 2: levels of implementation

In this section, levels of implementation for MTE cohort 2 schools are reported.

School-level implementation

Patterns of implementation reported by MTE cohort 2 interviewees show slightly higher rates of implementation than in the sub-sample of 38 schools in cohort 1. The percentage of classes in 26 of 27 schools (with accurate data) with substantial or some

implementation of mastery pedagogy reported is set out in Table 15. Note that some schools had mixed age classes - in these cases the classes were treated as being a class for both year groups.

Table 15: Implementation in MTE cohort 2 - percentage of classes

Category	Substantial	Some	None
Percentage	78	20	2

Source: MTE cohort 2, interviews 2017

Implementation by classes

Table 16 below shows percentage implementation by year group for 26 of the 27 schools interviewed.

Table 16: Implementation in MTE cohort 2 - percentage by year group

Cohort 2	Substantial	Some	None
Reception	41	55	5
Year 1	71	29	0
Year 2	98	2	0
Year 3	91	9	0
Year 4	94	6	0
Year 5	78	22	0
Year 6	78	23	0

Source: MTE cohort 2 interviews

MTE cohort 2 relative levels of implementation

MTE cohort 2 data do not allow the same rigorous application of implementation criteria as for cohort 1. This is because there was only one data collection point rather than two, and also because these schools framed implementation in terms of teaching for mastery rather than adopting Shanghai practices. This is particularly salient in terms of assessing high levels of MTE mastery implementation. However, using similar implementation criteria, and considering overall implementation, it was found that out of 27 schools, 20 participants reported practices that are in keeping with at least threshold levels of implementation of mastery. Many of these have characteristics of full implementation, five appeared to show lower levels (for example, in one rural school adaptations had been made) and for two the data were unclear (for example, in one case the headteacher rather than the mastery specialist was interviewed).

Thus, there are high levels of implementation in the MTE cohort 2 schools sample. However, caution is needed here, as the cohort 2 teachers were selected from those who had undertaken the PMTMSP and then agreed to be interviewed (so arguably these

individuals were highly committed to mastery). In some schools, the MTE teacher had left, and levels of implementation in such schools are not included in the data.

7. Supporting implementation

Evaluation objectives addressed in this section

Identify the professional development outcomes for teachers.

Determine what activities have been most successful in meeting the aims of the programme.

For MTE cohort 2 schools, identify patterns of implementation and the influence of the exchange on this relative to other influences

For MTE cohort 2 schools identify lessons learned about factors influencing implementation, including in relation to work with others schools.

Section summary

The visit to Shanghai and the visit to England by the Chinese teachers impacted MTE cohort 1 teachers' beliefs about mathematics teaching and commitment to mastery. Observing mastery teaching by Chinese teachers in England was seen as more impactful than observation in Shanghai.

Cohort 2 teachers, in particular, were positive about the visit to Shanghai, which deepened or challenged their previous understanding of mastery. The visit by the Chinese teachers supported implementation.

NCETM and Maths Hub resources, textbooks and other mastery-aligned resources supported lesson design, medium-term planning and were a source of tasks for MTE cohort 1 schools during the second and third year of the evaluation, as well as for cohort 2.

The PMTMSP provided cohort 2 teachers with theoretical foundations and enabled them to gain more from the exchange than if they had not participated in the PMTMSP.

Formal, embedded and informal forms of professional learning were evident across the MTE cohort 1 and 2 schools. These generated teacher motivation, deepened mathematical understanding, provided opportunities to plan and review implementation and enabled in-depth learning on how to refine practices.

Professional development outcomes for teachers included: enhanced subject and pedagogical content knowledge, affect, beliefs and confidence.

Mapping of implementation pathways, from the starting positions in 2015 to levels of implementation in 2017, indicates that the use of mastery-aligned textbooks or

programmes and engagement in the PMTMSP were factors which supported high levels of implementation by MTE cohort 1 schools, but were not always present.

In this section, key findings are reported regarding the important factors that informed and supported the implementation of MTE mastery pedagogy, namely: the exchange experience, NCETM and Maths Hub materials, textbooks and other mastery-aligned resources, the PMTMSP, and other external professional development and school-based professional development. Outcomes of professional development and implementation pathways are also reported.

As set out in the third interim report, professional development, which is also an outcome of the MTE, was the enabler most frequently mentioned by MTE cohort 1 teachers as supporting the implementation of Shanghai-informed mastery pedagogy. In the 2017 cohort 1 interviews, professional development was again the most frequently mentioned enabler. However, as reported above, engagement in supportive CPD such as the PMTMSP or the use of textbooks, does not by itself explain levels of implementation. Schools that adopted these supports did not necessarily implement mastery pedagogy fully. Some schools which relied on their own professional development activities and synthesised a range of resources for themselves did report full implementation of MTE cohort 1 pedagogy.

7.1 The exchange experience as professional development

MTE cohort 1

Visiting Shanghai

MTE cohort 1 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.

As well as the lesson observations which were the central focus of the Shanghai visit, most exchange teachers also reported taking part in post-lesson discussions and teacher research groups. Activities outside the schools included having lectures at the Shanghai Normal University for around four days, and meeting with other visiting teachers from England for reflection.

A minority (just over a fifth) of interviewees expressed some dissatisfaction with aspects of the Shanghai visit 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. A large majority of exchange

teachers reported that observing ordinary lessons was more useful 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 teacher exchange visits and subsequently the MTE cohort 2 school exchanges.

Shanghai mathematics teacher visits to England

On balance, it appears that the visits of the Shanghai teachers to England had more impact on teacher beliefs and motivation to change practice than the visits to Shanghai. However, it was clear that the visits to Shanghai were an important foundation for the second part of the exchange.

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 MTE cohort 1, the extent to which teachers from other schools had the opportunity to benefit from the exchange varied across the Maths Hubs. In 9 hubs, more than a hundred teachers benefited from observing Shanghai teachers, in 15 hubs, smaller numbers were reported with teachers drawn from fewer schools (in 1 hub that reported other teachers observing the number is not clear). In 7 hubs, it appears that observation of the Shanghai teachers was limited to the exchange schools. However, of these schools in the latter 7 hubs, other activity took place to share learning through the hubs later.

MTE cohort 2

Visiting Shanghai

More than half of the MTE cohort 2 teachers interviewed found the visit to Shanghai the most valuable of the professional development opportunities offered as part of the mastery specialist training, although many also stressed that they were able to benefit so much from it only because they had taken part in the PMTMSP training and had been trying out mastery approaches in their own schools. Reported professional learning gains

from the visits to Shanghai centred on the enhanced understanding of mastery that the mathematics teachers from England gained through opportunities to observe the practice of the Chinese teachers. Although much of this focused on the lesson observations, teachers also reported how important it had been to participate in the teacher research groups in Shanghai schools. Teachers reported that what they had observed in Shanghai deepened or challenged their previous understanding of mastery.

One thing that we were trying to do before we went was variation – the use of variation theory. We knew we had to do it before we went to Shanghai, but then while we were out there, the penny dropped that we weren't doing it very well. (MTE cohort 2, school 2A13, interview 2017)

Teachers noted the attention to detail that went into planning, acknowledging the Shanghai teachers' superior subject knowledge. This was attributed to the very different conditions that the teachers in the two countries experience. At least one teacher noted that there was some variation in experience on the visits, with some of the English teachers seeing fewer lessons than others, or lessons with less experienced Shanghai teachers.

Shanghai mathematics teacher visits to England

Cohort 2 teachers valued the reciprocal visits in the exchange, describing how they affected their own practice and highlighting the importance of the visits for other teachers, school leaders and teaching assistants. For the cohort 2 teachers, hosting Shanghai teachers helped them to see how they might continue to develop approaches to mastery in their own schools.

The most powerful experience is then bringing those teachers back here so we can see those teachers teach our children and that really supports us in terms of thinking about how can this realistically work in our school in our culture with our curriculum. (MTE cohort 2, school 2A16, interview 2017)

Interviewees reported that the opportunity to observe Shanghai teachers demonstrate the approach to mastery in English schools had an important impact on teachers, headteachers and teaching assistants in the host schools and in other cluster or Maths Hub schools.

They just suddenly got it. They got what we were trying to say. They got that if we focus on the very small steps of learning, one step at a time, we can pull the children with us. If we make sure we address misconceptions in the lesson, we can move the vast majority of children forward. (MTE cohort 2, school 2A15, interview 2017)

For MTE cohort 2, Maths Hubs were more consistent in ensuring that a large number of teachers from other schools benefited from the exchange visits by Shanghai teachers.

7.2 NCETM and mastery resources

The White Rose Maths schemes of work were frequently cited as an important resource for medium-term planning by schools, particularly those that had chosen not to use a mastery-aligned textbook scheme. NCETM assessment materials were cited as sources for identifying deepening tasks or informing selection of tasks from elsewhere.

7.3 Textbooks and mastery-aligned resources informing practice

The NCETM is promoting the term 'lesson design' (NCETM, 2016) as an alternative to 'lesson planning' which is the usual term in English primary schools. The concept of design points to the Shanghai practice of crafting a carefully sequenced journey through mathematical content with the focus on key concepts and procedures, and consequently tasks, activities and questions focused on these. Following the exchange, mastery-aligned textbooks and other resources were used to support lesson design (use of different textbooks and resources is reported in the third interim report). However, generally schools reported using textbooks as a basis for design, but then supplementing this with additional resources. Commonly, teachers would plan collaboratively, discussing choices of problems and sequencing of materials. Interviewees reported that the way problems were structured and the way models and representations were used in the textbooks helped support the development of teachers' subject knowledge.

7.4 The Primary Mathematics Teaching for Mastery Specialists Programme

As reported earlier, 15 of the MTE cohort 1 teachers also joined the PMTMSP. For MTE cohort 2 interviewees, the PMTMSP had provided an important theoretical foundation for their learning about mastery, enabling them to gain more from their subsequent involvement in the exchange than they would have without the PMTMSP.

The experiences we had before I went to Shanghai, I think that really benefited everyone… because a lot of what you do in China, it's so well-orchestrated and it's very subtle… I think you need to know what you're looking for to get the most out of that. (MTE cohort 2, school 2A1, interview 2017)

Following the PMTMSP training, teachers had implemented practices in their own classrooms and were beginning to share these with colleagues in their own schools. The opportunities the training provided for teachers to discuss mathematics with other specialist teachers was important, as was the course structure which provided training followed by time to try out new ideas in the classroom before coming back to share

experiences. Teachers reported that the PMTMSP had impact beyond their own practice through the work they were doing supporting other schools.

7.5 Other external mastery professional development

MTE cohort 1 teachers, and in some instances a small group of other teachers with responsibilities for leading mathematics, attended a range of other external courses. These were predominantly provided by NCETM or the local Maths Hub. Interviewees reported that course attendance was important in supporting the development of subject knowledge in their school and provided demonstration lessons or CPD activity that they could replicate in school. External conferences, particularly national conferences, were valued as opportunities to find out what others were doing, as well as helpful opportunities to talk and reflect on their own practices.

A link was traced between staff who had the opportunity to observe mastery teaching in other schools and signs of enhanced in-school professional development as those teachers discussed their experiences with others in their own school:

For staff, that's been a huge journey for us to be able to do that. In someone else's classroom you're always learning. The conversation as a staff when we come back, so they've gone in groups of five and actually that's really powerful because five people have seen that and five people have got an opinion and five people who have got their own mastery journey are having those discussions. (MTE cohort 1, school 17A, interview 2017)

There was some evidence that MTE cohort 2 teachers also participated in external conferences in addition to their participation in the PMTMSP.

7.6 School-based professional development

Since the exchange, there has been a sustained focus on school-based professional development in MTE cohort 1 schools. In the final year of the evaluation, approximately one half of interviewees reported that there was more school-based professional development, or a wider range of it, than in the previous year. A further quarter of interviewees reported that levels were similar, and a quarter reported reductions in the amount of professional development. There were no discernible differences in changes to the amount of school-based professional learning that occurred in schools where the MTE cohort 1 teacher had also participated in the PMTMSP.

Formal, embedded and informal forms of professional learning were evident across all the MTE cohort 1 schools. Common characteristics across all these forms of professional

development as they were deployed within schools were a mathematical focus, closeness to practice and a collaborative approach.

In-school CPD events and staff meetings were perceived to 'get people on board', 'ensure they got the same message', and build subject knowledge, as well as providing the opportunity to plan changes to practice and review implementation. Teacher research groups, in-class support, modelling and observation were perceived to enable in-depth learning on how to implement or further refine specific practices. The modelling of mastery teaching was regarded as important, whether delivered to a group of teachers or as part of a normal lesson, and the associated discussion was also valued. Across these formal professional development activities, the underpinnings of successful implementation lay in the combination of being able to observe how mastery should be implemented, observe peers to support consistent implementation, and have opportunities for discussion.

Embedded CPD activities, particularly collaborative lesson planning and the use of a textbook or other resources, were also identified as supporting the implementation of mastery. The detailed attention to developing conceptual and procedural fluency in lesson planning was perceived to enhance subject knowledge and support teachers in developing detailed and appropriate questions. Textbooks were perceived to improve teacher confidence and subject knowledge.

The increasing level of teacher talk about teaching mathematics, reported for MTE cohort 1 schools in the 2017 evaluation, was both an outcome of other forms of professional learning and a trigger for further professional learning.

The informal is happening all the time. Every time I'm in the staff room there are people discussing different things that they've tried, different things that have worked, things that haven't worked. I think that informal thing is really important – people just sharing things that have worked well with the children and then deciding whether or not those things are relevant up or down the school as well. (MTE cohort 1, school 27B, interview 2017)

Formal, embedded and informal forms of professional learning were also evident in the MTE cohort 2 schools. These were characterised by a deepening focus on mathematical knowledge, an iterative approach to developing practice and a collaborative approach to professional development.

An increase in talk about teaching and learning mathematics among teachers was also reported in the MTE cohort 2 schools, particularly in relation to planning. Associated with this was a shift in affect, with interviewees noticing greater enthusiasm for mathematics from both teachers and teaching assistants.

There's much more professional dialogue about maths and how to teach. There are lots of conversations in the staff room and people grab me to ask me things. … Some of our

staff are really taking it on board and are really excited about maths. (MTE cohort 2, school 2A2, interview 2017)

Engagement in the MTE contributed to a change in the way that lesson observations were both conducted and experienced, with evidence that teachers were beginning to see these as developmental and supportive, in contrast to their previous experience of being observed. Exchange teachers opened up their classrooms to teachers in their own schools and conducted supportive observations of other teachers, building on the practice they had seen in Shanghai.

In the Shanghai exchange we saw a lot of teachers observing other teachers. …We tend to do it, in our schools in England, very much as a senior leadership team, we're always doing the observing - well not always…but it's very often that. It's got to be that mixture so that everyone is observing good practice….I've tried to pick up on their way of observing lessons a bit more to help with professional development in school. (MTE cohort 2, school 2A25, interview 2017)

Teacher research groups, in-class support and modelling were also important in the MTE cohort 2 schools.

7.7 Professional development outcomes

MTE cohort 1

MTE cohort 1 teachers at the end of years two and three of the evaluation reported professional development outcomes for teachers in their schools related to enhanced subject and pedagogical content knowledge, affect, beliefs and confidence. These outcomes were highly interconnected and many participants mentioned all of them in their interviews. However, there was a noticeable difference in the outcomes that were reported as most significant at different stages of the evaluation.

Analysis of interviews conducted in 2016 found that the most widespread outcome was the perception of enhanced subject knowledge. In many instances interviewees pointed to a general improvement in teachers' subject and pedagogic subject knowledge, but where they made specific links between knowledge development and the critical components of MTE mastery teaching, they most frequently referred to developing mathematically meaningful and coherent activity - spanning conceptual and procedural fluency, visual and concrete representations and how to use resources. Changes in belief and affect at this stage were also highlighted. Recognising that all children have the potential to achieve was regarded as a particularly important outcome. Improved confidence was mentioned less frequently.

In the 2017 interviews, the MTE cohort 1 teachers were asked to identify any changes in professional development outcomes for teachers over the preceding year. While the impacts on knowledge, affect, beliefs and confidence were again reported, the main change was that confidence had become the most significant outcome. The development of confidence was often attributed to improvements in knowledge and deeper understanding of mastery pedagogy and growing familiarity with approaches:

Teachers are constantly gaining confidence with this style of maths teaching, but also in terms of predicting misconceptions of children that are coming up, and also thinking about the learning journey that the children need to go to reach an end point, or at least to reach a point where they feel like they're meeting the objective in terms of the curriculum. Teachers are obviously, with a couple of years' experience, knowing the different concepts that children need to master in order to achieve on the curriculum. There's a lot more subject knowledge confidence in terms of that, that teachers have now compared to two years ago. (MTE cohort 1, School 19A, interview 2017)

Change in beliefs was mentioned less frequently than in earlier stages of the evaluation. In 2017, teachers in some MTE cohort 1 schools felt that teachers now 'bought into' mastery values so change in beliefs was a given, although in schools with high staff turnover it remained a more significant outcome.

MTE cohort 2

Across all cohort 2 interviews, there was agreement that beliefs about how pupils learn mathematics had changed, both for exchange teachers and other teachers in the school. The most commonly reported change was a belief that all children could succeed.

We change our belief to be that actually, although children might need more scaffolding and support on memorisation, there is this expectation that everyone can learn this concept. (MTE cohort 2, school 2A7, interview 2017)

Teachers reported a realisation that the pedagogy was key to finding a way to support all children and several mentioned a move away from using terminology associated with fixed-ability thinking. Others reported changes to beliefs including greater receptivity to mastery techniques, an acknowledgement of the importance of conceptual understanding and coherence, and a need to slow things down.

The MTE lead teachers' understanding and appreciation of the role of teachers' subject knowledge changed through their participation in the exchange, particularly through their visits to Shanghai.

It was shocking and disturbing all at the same time, just how proficient they were with every single concept and just how deep their subject knowledge and their love for the subject. (MTE cohort 2, school 2A16, interview 2017)

Other changes included a better understanding of how children learn mathematics, an understanding of fluency and of variation, and an appreciation of the value of slowing down and of using conclusions. There was a clear sense that teachers' deeper understanding gave them increased confidence in the way they were leading changes in practice. The visit of the Shanghai teachers to schools in England had the biggest impact on other teachers and school leaders, both within the MTE lead teacher's school and beyond.

7.8 Implementation pathways

In this section, analysis of implementation pathways is presented in relation to schools' initial relationships to MTE mastery pedagogy in 2015 and final levels of implementation. Two key supports to implementation, as discussed above, were engagement in the PMTMSP and the use of mastery-aligned textbooks or schemes. Both of these supports are integral to the wider TfM programme.

In 2015, based on analysis of interviews, schools were categorised by the extent of their commitment to mastery. The following groups were identified:

- Already committed
- Newly committed
- Cautious.

In 2016, the categorisation was checked with respondents and adjusted in some cases. The data were then used in the analysis that follows. How the level of implementation was determined was reported earlier and is explained in more detail in section 7.1 of the technical report. This categorisation was made without considering whether or not schools had engaged with the PMTMSP; this information was integrated at a later stage. Thus, the allocation to a category is based on the report of practices in those schools. A table with further detail of implementation pathways is included in the technical report in section 7.3.

Figure 10, below, shows implementation pathways of schools already committed to mastery before the exchange. As can be seen, five schools were judged and later confirmed to be already committed to a mastery approach before participating in the exchange. In two cases this was because they had participated in a National College for School Leadership or another study visit to Shanghai. In three cases their commitment was related to their role in the new Maths Hubs. A further four schools were already using mastery textbooks or schemes.

Of these nine schools, it is notable that although eight were categorised as having implemented mastery, only four of these were determined to have implemented it to a

high level. This was the case even though seven schools had used mastery textbooks[29] or schemes and/or the PMTMSP to support implementation. It is also notable that one school, even though it had engaged with the PMTMSP, was judged not to be implementing mastery. In the 2017 interview, the interviewee reflected that work to promote mastery in other schools was not always being matched by implementation in their own school.

[29] The term 'mastery textbook' was commonly used during the interview process to refer to textbooks based on translations of Singaporean or Shanghai texts. Data collection was undertaken largely before the introduction of a DfE approval processes for textbooks eligible for subside as part of the TfM programme.

Figure 10: Implementation pathways of schools already committed to mastery before the exchange

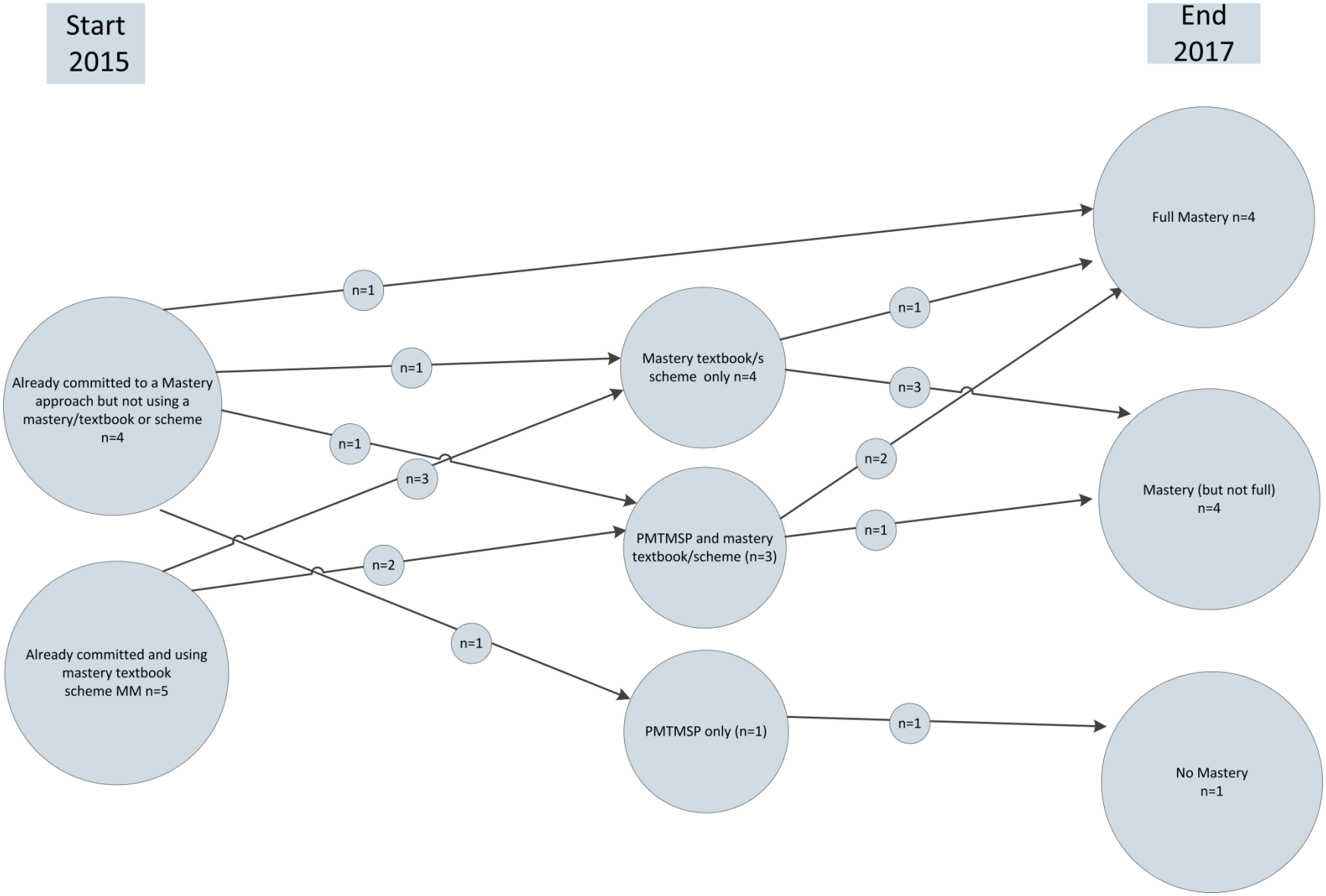


Figure 11: Implementation pathways of schools newly committed to mastery due to the exchange

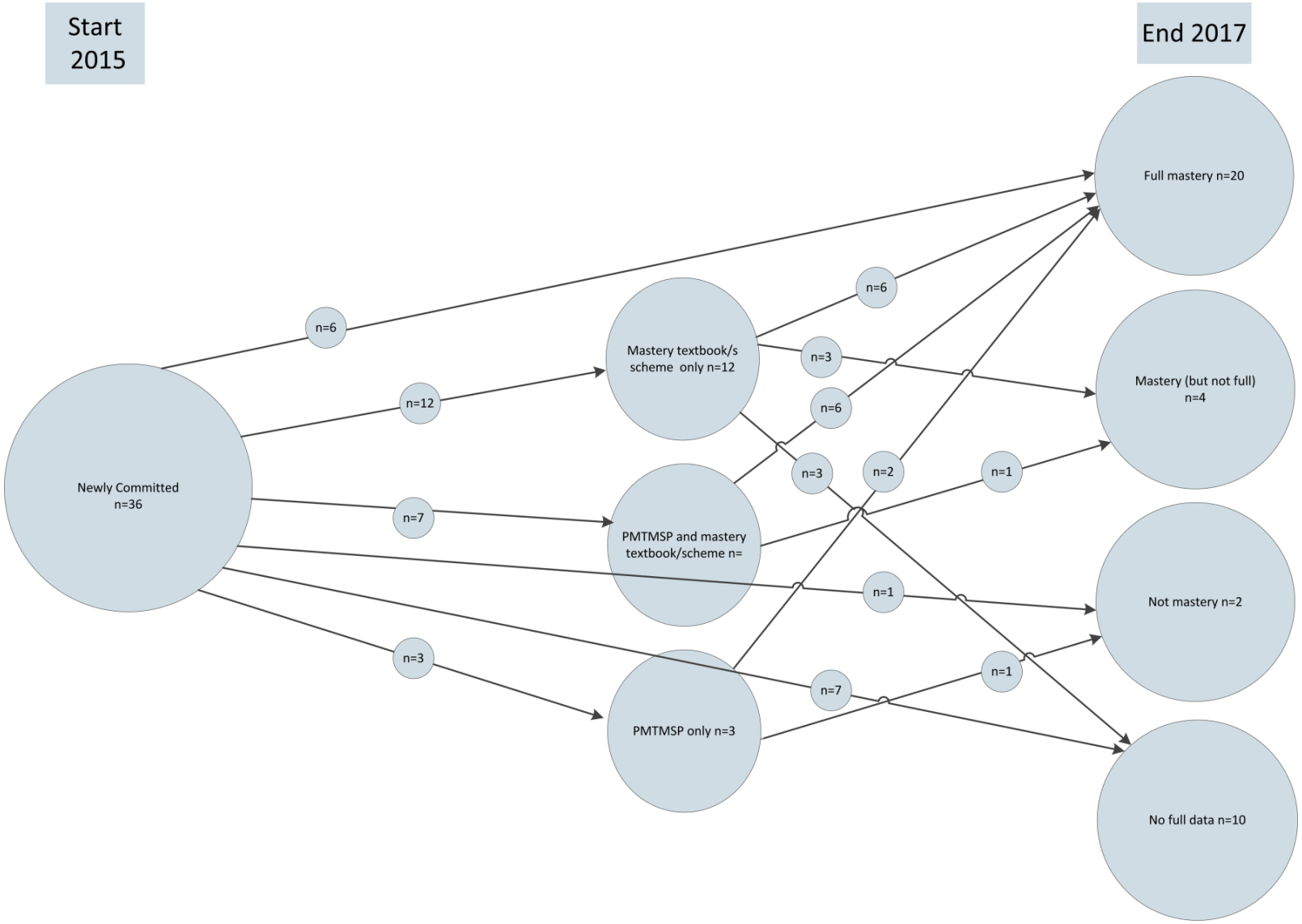


Figure 11 presents a map of implementation pathways for schools newly committed to mastery. Twenty of 36 schools engaged with one or other or both of the key forms of support for mastery implementation. Of these, 14 schools went on to implement MTE mastery pedagogy to a high level and four schools progressed to above the threshold level.

However, it is also noteworthy that six schools implemented MTE mastery pedagogy fully without using any of these supports. This suggests that the supports may not be a necessary condition for full mastery implementation if schools have leadership capacity to develop their own staff and to successfully implement significant curriculum change in mathematics. Further, research would be needed to understand in detail implementation patterns and supporting factors in such schools. In the absence of using textbooks or schemes, these schools used a variety of materials in order to support lesson design in accordance with mastery principles. These resources included White Rose Maths materials as well as NCETM assessment materials. Reasons for not adopting textbooks or schemes appeared to lie in a teaching culture which valued teacher school-level collaborative production of teaching materials. As with schools already committed to implementing mastery, engagement with the PMTMSP was not a guarantee of mastery implementation, as one school that did so engage, was not judged to be implementing mastery pedagogy in 2017. In this case, the school themselves expressed ambivalence about teaching for mastery. This was because they viewed mathematics attainment as already high and improving mathematics was not considered a current strategic priority.

In addition to those schools identified as already committed and newly committed, three schools were categorised as cautious about mastery approaches. Of these three schools, one had a teacher who participated in the PMTMSP and had also begun to use mastery-aligned textbooks to inform their practice. This school was judged to have implemented mastery fully. The two other schools adopted mastery textbooks and one was categorised as having implemented mastery but the other was judged to have low implementation below the implementation criteria threshold.

8. Impact of change on pupils

Key evaluation objectives addressed

Report on perceptions of pupil performance and depth of understanding of key concepts.

Determine whether the teacher exchange and its associated activities have had an impact on mathematics skills and ability in the short and long term.

Section summary

Six impact analyses were conducted comparing MTE cohort 1 schools with a set of comparison ('contrast') schools.

Analyses of impact of participation in the MTE cohort 1 alone do not indicate any effect on attainment.

Analysis of a sub-sample of schools that had implemented mastery pedagogy for two years with the 2016/17 Y6 cohort also did not indicate any effect on attainment.

However, analysis of a sub-sample of 16 schools that had implemented mastery pedagogy for two years with the 2017/18 Y2 cohort did find a positive effect on attainment. Analysis revealed that pupils in MTE cohort 1 schools were more likely to attain KS1 threshold compared with pupils in the matched contrast sample.

Teachers' perceptions were that mastery implementation had a positive effect on attainment in both KS1 and KS2 and on a range of other affective dimensions.

A longitudinal analysis of Y6 pupil attitudes measured by a survey in summer 2015 and summer 2017 indicates no statistically significant change in affect towards mathematics, preference for working alone, and mathematics anxiety between 2015 and 2017.

In this section, assessment of impact of changes in practice in MTE cohort 1 schools are reported firstly with regard to pupil attainment and secondly in connection with other kinds of pupil outcomes. The technical report in section 8 provides a more detailed account of the impact analysis and outcomes.

8.1 Attainment outcomes

In December 2017, NPD pupil-level data were obtained for Key Stage 1 (KS1) and Key Stage 2 (KS2) pupils in MTE schools or matched contrast schools (as a proxy for a control group) for 2013, 2016 and 2017. A previous request had obtained pupil-level KS2 data for 2014 and 2015. In total, the pupil-level KS1 and KS2 impact analyses cover five academic years between 2013 and 2017. The impact analyses compare the

mathematics attainment of pupils in MTE cohort 1 schools with the attainment of pupils in the contrast schools over the period 2015 to 2017, representing the three years following the start of the exchange, and the period 2013 to 2014, representing the two years immediately prior to the start of the exchange.

The second interim report provides a more detailed overview of the quasi-experimental research design that was used to statistically examine whether a primary school's participation in the MTE led to greater improvement in pupil-level KS1 and KS2 maths attainment compared with no participation. As explained in the second interim report, 'propensity scores' were used to match each of the 47 MTE cohort 1 schools considered in strand two (see section 3 for details of samples) with 20 statistically 'similar' contrast schools using school-level data for 2014. The purpose of the contrast school sample is to capture temporal change in KS1/KS2 maths attainment (known technically as the 'counterfactual') in the absence of the intervention. A positive impact would be indicated when the change in attainment observed in the sample of MTE schools is greater than the change observed in the sample of contrast schools which did not participate in the exchange.

KS1 and KS2 maths attainment of pupils in MTE schools will be compared with the attainment of pupils in the contrast schools. Analyses which show very similar levels of attainment in 2013 and 2014 but an increasing difference from 2015 to 2017 would suggest that school participation in the exchange led to a positive pupil-level impact for KS1 or KS2 maths attainment.

Six analysis stages were undertaken:

1. School-level descriptive analyses - 2013 to 2017
    - A statistical comparison of MTE and contrast schools using school-level KS2 school census data.
2. Pupil-level descriptive analyses - 2013 to 2017
    - A statistical comparison of KS1 and KS2 maths attainment for pupils in MTE schools with pupils in contrast schools using NPD data.
3. Main (headline) multilevel[30] impact analyses - 2013 to 2017
    - Multilevel (school and pupil) analysis of KS1 and KS2 maths attainment comparing pupils in MTE schools with pupils in contrast schools.
4. Sensitivity analyses

[30] Statistical modelling with more than one cluster level; a two-level analysis might include school and individual pupil levels.

- The main (headline) KS1 and KS2 maths attainment impact analyses are statistically scrutinised for robustness.

5. Scrutinising impact across the separate MTE school and contrast school samples
    - Analyses that look at each MTE school and compare attainment for pupils at that school with the attainment of pupils in one of the sample of matched contrast schools.
6. Mastery implementation exploratory analyses
    - Using data gathered in strand one, the relationship between fidelity to mastery pedagogy and KS1/KS2 maths attainment is examined.
    - This stage of analysis was undertaken because initial descriptive analyses identified a sub-sample of MTE schools identified to have met high or minimum mastery implementation thresholds. KS1 and KS2 impact analyses were re-run using only these schools.

School-level and pupil-level descriptive analyses - 2013 to 2017

The analyses began with the examination of patterns at the school level in terms of KS2 attainment, KS1 attainment for the KS2 pupil cohort, percentage of pupils entitled to Free School Meals (FSM), percentage of female pupils, and school size. The school-level analyses provide the first perspective on KS2 maths attainment differences in MTE schools compared with contrast schools, but do not take any account of within-school (pupil-level) attainment variations.

The pupil-level descriptive analyses provide the second perspective on KS2 maths attainment differences and the first perspective on KS1 attainment differences. While these analyses do directly acknowledge (and examine) variations in attainment at the pupil level, they do not take account of how pupils are clustered into primary schools. In not taking account of how pupils are clustered together into schools, the standard errors used within tests of statistical significance are likely to be smaller than they should, which leads to an increased risk of making a type 1 error (that is, falsely concluding a statistically significant difference).

These descriptive analyses found no evidence that a school's participation in the MTE led to pupil-level gains in maths attainment at KS1 or KS2.

Main (headline) multilevel impact analyses 2013 to 2017

The multilevel analyses acknowledge both school-level clustering and within-school pupil-level attainment variations and provide the most robust analyses from which to estimate the impact of the exchange on KS1 and KS2 maths attainment.

For the descriptive and main (headline) multilevel impact analyses, a similar approach was taken for dealing with missing data as was taken for the analyses reported in the second interim report. Specifically, a school-level 'listwise-deletion' approach was adopted. This was done to best ensure that the analyses were undertaken on the same samples of MTE and contrast schools across the five years (2013 to 2017). In doing this, schools that did not appear on the school-level KS2 census in one of the five years were excluded from the analysis. This brings an additional advantage in terms of internal validity: schools that underwent substantial change during the five years (for example, they became an academy or they closed down) will not be included. This helps to ensure that the samples of MTE and matched contrast schools were consistent and none will have undergone a substantial change in governance structure for the five years of the analyses.

> These analyses found no evidence that a school's participation in the MTE led to pupil-level gains in maths attainment at KS1 or KS2.

Sensitivity analyses

Following the main (headline) multilevel impact analyses, two sensitivity analyses were conducted. First, the listwise deletion approach to missing values criteria was dropped and all analyses were re-run on the raw samples of KS1 and KS2 pupils across the five years. Second, school-level KS2 data from 2013 were used to re-match the MTE schools so that the exchange-contrast samples were matched using data from both 2013 and 2014.

> These analyses found no evidence that a school's participation in the MTE led to pupil-level gains in maths attainment at KS1 or KS2.

Scrutinising impact across the separate MTE-contrast school samples

The next analyses examined the difference in KS2 maths attainment of pupils in MTE cohort 1 schools and pupils within contrast schools across the separate MTE-contrast group samples.

> These analyses found no evidence that a school's participation in the MTE led to pupil-level gains in maths attainment at KS1 or KS2.

Patterns by pupil characteristics

Further follow on analyses were undertaken that explored whether participation in the MTE exchange had a stronger (or weaker) impact for different groups (or sub-samples) of pupils. These analyses were exploratory and were not specified within the analysis plan in the second interim report. They found no evidence of differential impact relating to prior attainment, gender and socioeconomic background.

To summarise, the differential impact of the MTE exchange on KS1 and KS2 attainment was examined with respect to pupil gender and FSM status. These analyses found no evidence of impact across all pupil sub-samples at KS1 or KS2. For the KS2 attainment analyses, differential impact was also examined with respect to prior (KS1) maths attainment. Similarly, these analyses found no evidence that participation in the MTE exchange led to pupil gains in KS2 attainment across different levels of KS1 maths attainment.

Mastery implementation exploratory analyses

Analytical approach

Data about the level of implementation of MTE mastery for 2016 and 2017 were obtained from 37 of the 47 MTE schools that were in the strand two sub-sample (35 primary and two junior schools[31]). Sub-samples of schools which were identified using the implementation criteria set out in section 6. Firstly, schools were identified whose implementation of MTE mastery was judged to be above the threshold level criteria. Secondly within the sub-sample, those schools with high implementation were identified. This sub-sample was then further refined by considering data concerning the self-reported implementation of mastery by year group. Schools were identified if interviewees had, in 2017, reported that either the 2016/17 Y2 cohort had experienced substantial implementation of mastery practices for two years (that is, in Y1 in 2015/16 and Y2 in 2016/17) or the 2016/17 Y6 cohort had experienced two full years of substantial implementation. To enhance reliability, as reported in section 6, 2016 interview data were used to check the responses about mastery implementation for the Y1 experience. Thus, a KS1 sub-sample was identified by combining the *threshold and high mastery* criteria with the *self-reported substantial mastery for two years* criterion. A KS2 sub-sample was identified by combining the *threshold and high mastery* criteria with self-reported data on *substantial implementation for two years* for the 2016/17 Y6 cohort.

Follow-on statistical analyses focused on these sub-samples of schools. The analyses examined if and how KS1 and KS2 maths attainment of pupils within this sub-sample of schools differs from the mathematics attainment of pupils in matched contrast schools.

[31] Three junior schools were included in the original matching analysis to identify contrast schools as required KS2 data was retrieved for these schools. However, only two reported implementation of a sufficient degree and for two years with the KS2 cohort and so were included in the sub-sample analysis. In relation to KS1 analysis undertaking matching of the single infant school with other infant schools was deemed to be overly resource intensive during the matching process and so they were not included (see page 34 in the Second Interim Report.

Given that schools with high implementation of mastery and mastery above the threshold were identified using data from 2016 and 2017, the follow-on impact analyses focused only on KS1 and KS2 maths attainment in 2017. KS1 and KS2 maths attainment in 2014 was also examined in order to provide a baseline. Full details of the analysis and data tables are reported in the technical report. Table 17 below provides details of the sub-samples. 'Mastery' is the term used in the analyses tables to indicate schools designated to have implemented mastery above the threshold criteria, including those which have implemented mastery to a high level. High mastery is used to identify those schools with a high level of implementation.

Table 17: Numbers of schools & pupils in high implementation/mastery analyses 2014 & 2017

Mastery & high Implementation in KS1 and substantial implementation for two years								
	2014				2017			
	MTE		Contrast		MTE		Contrast	
	Schools	Pupils	Schools	Pupils	Schools	Pupils	Schools	Pupils
High mastery	12	671	208	9,574	12	659	205	9.916
Mastery	16	925	271	12.396	16	913	265	12,870

Mastery & high Implementation in KS2 and substantial implementation for two years								
	2014				2017			
	MTE		Contrast		MTE		Contrast	
	Schools	Pupils	Schools	Pupils	Schools	Pupils	Schools	Pupils
High Mastery	9	418	153	6,530	9	437	153	6,929
Mastery	10	450	171	7,169	10	467	171	7,614

KS1 analysis

KS1 attainment data are reported in terms of numbers of pupils who meet or are above age-related expectations. Because of this, calculating effect sizes is not appropriate. So, as an alternative, an ‘odds ratio’ is used in the analysis that follows. This ratio is a calculation of how many times more likely it is that pupils in MTE cohort 1 schools will achieve a given level of mathematics attainment than pupils in the contrast schools.

First, descriptive analyses are reported that examine the KS1 attainment of pupils in the sub-sample of MTE schools with high implementation and pupils in the matched contrast school sample in a simple bivariate[32] way. This is followed by the main multilevel analyses that statistically take account of how pupils are clustered into schools, including levels of FSM as a covariate.

From the bivariate descriptive analyses, in 2014, pupils in MTE schools with high KS1 implementation were seen to be equally as likely to reach the expected KS1 level as pupils in matched contrast schools. However, by 2017, pupils in MTE schools with implementation for Y2 pupils in both their Y1 and Y2 teaching are seen to be *more* likely to reach the expected KS1 level than pupils in matched contrast schools. The difference is even greater for pupils in MTE schools with both high implementation of mastery overall and two years of KS1 teaching; in 2017 these pupils are 1.49 times as likely to attain the expected KS1 level in maths compared with pupils in matched contrast schools. Pupils in mastery schools with high KS1 implementation are observed to be 1.39 times as likely as pupils in matched contrast schools to attain the expected KS1 level in maths.

In 2014, pupils in MTE schools with two years of KS1 implementation were more likely to exceed the expected KS1 level than pupils in matched contrast schools and this difference is seen to widen by 2017. Again, the difference is greater for pupils in MTE schools with both high implementation of MTE mastery and two years of KS1 implementation. In 2014, these pupils are observed to be 1.42 times as likely to exceed the expected KS1 level in maths compared with pupils in matched contrast schools. In 2017 these pupils were observed to be 1.72 times as likely to exceed the expected KS1 level in mathematics compared with pupils in matched contrast schools. Pupils in mastery schools with two years of KS1 implementation are observed to be 1.34 times more likely than pupils in matched contrast schools to exceed the expected KS1 level in mathematics in 2014 which is seen to increase to being 1.46 times as likely in 2017.

Analysis shows that the MTE sample and contrast sample remained relatively balanced in terms of gender. However, while the proportion of disadvantaged pupils (as indexed by FSM) in MTE schools is comparable with the proportion of disadvantaged pupils in matched contrast schools in 2014, a difference was evident in 2017. Specifically, in 2017, pupils in the contrast schools were more likely to be classed as FSM compared with pupils in MTE schools.

[32] Bivariate descriptive analysis' refers to analyses that only include two variables and do not take account of clustering of pupils into primary schools.

While these descriptive bivariate analyses do provide the first evidence that participation in the MTE led to pupil gains in KS1 maths attainment, some caution is advised due to four issues. First, as noted above these are bivariate descriptive analyses that do not take account of the clustering of pupils into schools; second, there was an observed FSM imbalance in 2017. The first two issues were addressed within statistical techniques (multilevel logistic regression analyses) that directly acknowledged the clustering of pupils into schools and will allow the inclusion of a pupil-level FSM factor (covariate) to address the observed 2017 imbalance. The third issue is that KS1 maths attainment is a teacher assessment that uses broad/course attainment categories[33]. This third issue cannot be addressed statistically but does need to be kept in mind when interpreting impact at KS1. Additionally, a fourth issue, being the generalisability of the finding to other school samples, is discussed below in the section on limitations.

The subsequent multilevel regression analysis directly acknowledged how pupils are clustered into schools. Additionally, through the inclusion of a pupil level FSM covariate into the model, the observed imbalance of pupils classed as FSM in the contrast sample compared with the MTE sample was statistically controlled for. When this was done, no statistically significant difference in KS1 maths attainment thresholds are observed between the MTE school sample and the matched contrast school sample in 2014. This is the picture for the high MTE mastery and two year implementation sub sample as well as the mastery and two year sub sample.

In 2017, pupils in the 12 high MTE mastery and two year implementation sub sample were observed to be statistically significantly more likely to attain the KS1 maths attainment thresholds, compared with pupils in the matched contrast school sample. Similarly, when the level of mastery is relaxed, pupils in the 16 mastery and two year implementation sub sample were observed to be statistically significantly more likely to attain the KS1 maths attainment thresholds compared with pupils in the matched contrast school sample. The difference is greater at the higher attainment threshold and remains positive and statistically significant when the FSM covariate is included in the analysis. That the difference is greater at the higher threshold provides some evidence to counter a concern of teachers reported by some interviewees in cohort 1. This concern is that the mastery approach may be beneficial to the lowest-attaining pupils but might hold back the highest-attaining pupils. This does not appear to be the case, at least in this sample of schools implementing the MTE mastery pedagogy.

[33] Changes to the KS1 teacher assessments in 2016 resulted in KS1 maths attainment being changed from levels and KS1 points to just broad attainment categories (e.g. working within expected level; working beyond the expected level) - see https://www.gov.uk/guidance/2016-key-stage-1-assessment-and-reporting-arrangements-ara/section-2-key-changes

In summary, these implementation analyses have yielded some evidence that participation in the MTE, when followed by implementation of MTE mastery pedagogy, is associated with positive gains in KS1 mathematics attainment for some MTE schools. Further, implementation at a high level is associated with higher positive gains in pupil KS1 maths attainment than implementation that is not at a high level. This helps to give confidence that the association is real, although this still does not establish a causal relationship.

KS2 analysis

The same analytical approach was taken to examine the sample of schools reporting two years of substantial experience of mastery pedagogy for Year 6 and categorised as mastery or high mastery implementation.

In 2014, the KS2 mathematics attainment of pupils in MTE schools with high implementation was slightly lower than pupils in matched contrast schools, but in 2017 this pattern was seen to reverse.

For schools with both mastery implementation at threshold or high levels, in terms of the mean overall KS2 mathematics score, a negative effect size is observed in 2014 (d=-0.07) but this changes to a slightly larger positive effect size by 2017 (d=+0.13). In terms of pupil demographics, the MTE schools sample and matched contrast schools sample seem reasonably comparable in terms of gender, but there was a slightly larger proportion of disadvantaged pupils (FSM) in MTE schools compared with the matched contrast schools.

However, although a small increase in overall KS2 mathematics score is shown in the descriptive statistics, multilevel linear regression analyses did not identify any statistically significant differences between the two samples.

In 2014, no statistically significant difference is observed between the MTE school sample and the matched contrast school sample. This was seen for the high MTE mastery and substantial implementation for two years sub-sample as well as the mastery and substantial implementation for two years sub-sample.

In 2017, no statistically significant difference is observed between the MTE school sample and the matched contrast school sample. This was seen for the high mastery and substantial implementation sub-sample as well as the mastery and substantial implementation sub-sample. The same pattern of no statistically significant difference was found across attainment on the three KS2 maths papers and when FSM was factored into the analysis.

In summary, while there is descriptive evidence that KS2 maths attainment was higher in high implementation / mastery schools compared with the attainment of pupils in

matched contrast schools, the multilevel analyses revealed that this difference is not statistically significant.

Exploratory analyses of attainment at KS1 and KS2 were undertaken for schools where the 2017 cohorts for Y2 and Y6 respectively had experienced substantial mastery implementation for two years, and in schools judged also to have implemented mastery or a high level of mastery. Analysis found no evidence of a significant difference at KS2. However, a significant difference was found at KS1, both in relation to pupils achieving age-related expectations and pupils achieving above age-related expectations. These findings yield indications of evidence of the positive effect of MTE mastery implementation. However, it is important that this is treated cautiously.

Summary of impact findings

Tables 18 and 19, below, provide a summary of the impact findings.

Table 18: Summary table for KS1 maths attainment models

Cohen's d effect size statistics for mean difference in KS1 maths attainment between MTE and matched samples

Main KS1 Attainment Impact Analyses					
	2013	**2014**	**2015**	**2016**	**2017**
KS1 Maths Average Points Score	**+0.13***	+0.03	+0.04	-	-
Exceeded expected KS1 level[1]	**+0.15***	+0.08	+0.07	+0.08	+0.09
Meeting expected KS1 level[1]	**+0.20***	-0.03	0.00	+0.05	+0.08

Sensitivity Analyses						
		2013	**2014**	**2015**	**2016**	**2017**
1 - Raw data[2]	Exceeded expected KS1 level[1]	**+0.15***	+0.06	+0.07	+0.13	+0.10
2 - 2013 rematch[3]	Exceeded expected KS1 level[1]	+0.08	+0.02	+0.01	+0.02	0.00

Exploratory 'high implementation' Analyses						
		2013	**2014**	**2015**	**2016**	**2017**
High Implementation	Exceeded expected KS1 level[1]	-	+0.13	-	-	**+0.31***
	Meeting expected KS1 level[1]	-	+0.02	-	-	**+0.22***
Mastery+	Exceeded expected KS1 level[1]	-	+0.12	-	-	**+0.23***
	Meeting expected KS1 level[1]	-	-0.01	-	-	**+0.19***

*** statistically significant from zero, p<0.05**

The figures shown here are Cohen's d effect sizes that have been converted from odds-ratio statistics obtained from the logistic regression models. Fuller KS1 model details can be found in the MTE evaluation technical report.

To ensure comparability over time, the main analyses took a list-wise deletion approach to missing data across the five years that the attainment analyses covered. These sensitivity analyses re-run the KS1 attainment models using the raw samples, which fluctuate in size over the five years

These sensitivity analyses re-run the KS1 attainment models on the sub-sample of schools matched using both 2014 and 2013 KS2 data.

Odds-ratio statistics for passing or exceeding KS1 maths attainment thresholds (MTE: matched sample)

Main KS1 Attainment Impact Analyses					
	2013	**2014**	**2015**	**2016**	**2017**
Exceeded expected KS1 level	**1.31***	1.16	1.14	1.15	1.17
Meeting expected KS1 level	**1.44***	0.95	1.00	1.10	1.15

Sensitivity Analyses						
		2013	**2014**	**2015**	**2016**	**2017**
1 - Raw data	Exceeded expected KS1 level	**1.30***	1.12	1.15	1.28	1.21
2 - 2013 rematch	Exceeded expected KS1 level	1.15	1.03	1.01	1.04	1.01

Exploratory 'high implementation' Analyses						
		2013	**2014**	**2015**	**2016**	**2017**
High Implementation	Exceeded expected KS1 level	-	1.27	-	-	**1.77***
	Meeting expected KS1 level	-	1.04	-	-	**1.50***
Mastery+	Exceeded expected KS1 level	-	1.24	-	-	**1.53***
	Meeting expected KS1 level	-	0.99	-	-	**1.41***

*** statistically significant from zero, p<0.05**

Table 19: Summary table for KS2 maths attainment models

Cohen's d effect size statistics for mean difference in KS2 maths attainment between MTE and matched samples

Main KS2 Attainment Impact Analyses						
		2013	**2014**	**2015**	**2016**	**2017**
Main Impact analyses	KS2 Maths FPS					
	Outcome only	**+0.14***	+0.01	+0.09	n/a	n/a
	Value added[1]	**+0.13***	+0.02	+0.05		

Main KS2 Attainment Impact Analyses						
	Scaled KS2 Maths Score					
	Outcome only	n/a	n/a	n/a	+0.03	+0.07
	Value added				+0.02	-0.02
	Raw KS2 Maths Test Score					
	Outcome only	+0.12	-0.02	+0.08	+0.04	+0.06
	Value added	+0.11	-0.01	+0.04	+0.02	-0.01

Sensitivity Analyses						
		2013	**2014**	**2015**	**2016**	**2017**
1 - Raw data[2]	Raw KS2 Maths Test Score					
	Outcome only	**+0.14***	+0.01	+0.10	+0.06	+0.07
	Value added	**+0.12***	-0.01	+0.08	+0.04	0.00
2 - 2013 rematch[3]	Raw KS2 Maths Test Score					
	Outcome only	0.00	-0.08	+0.07	-0.03	+0.03
	Value added	+0.07	+0.01	+0.09	+0.02	+0.01

Exploratory 'high implementation' Analyses						
		2013	**2014**	**2015**	**2016**	**2017**
High Implementation	Raw KS2 Maths Test Score					
	Outcome only	-	+0.01	-	-	+0.16
	Value added	-	+0.05	-	-	+0.07
Mastery+	Raw KS2 Maths Test Score					
	Outcome only	-	-0.01	-	-	+0.20
	Value added	-	+0.01	-	-	+0.10

Outcome only models only included a dummy variable that identified whether a pupil was in an MTE (=1) school or not (=0). Value added models also included a KS1 maths attainment covariate.

To ensure comparability over time, the main analyses took a list-wise deletion approach to missing data across the five years that the attainment analyses covered. These sensitivity analyses re-run the KS2 attainment models using the raw samples that fluctuate in size over the five years.

These sensitivity analyses re-run the KS2 attainment models on the sub-sample of schools matched using both 2014 and 2013 KS2 data.

* $p<0.05$

8.2 Other outcomes

Teacher perceptions of pupil attitudes and soft skills

Teachers' perceptions on the whole were that pupils enjoy their maths lessons. For some, this had historically been the case, but most teachers described this enjoyment as coming from the new way maths was being taught, encouraging pupils to tackle maths problems and instilling a resilient attitude where pupils are willing to make mistakes:

Most children would say it's their favourite subject now… that engagement in maths and their belief that they can achieve and that mistakes are valuable (MTE cohort 1, school 17a, interview 2017)

Some teachers described particular pupils who had struggled with maths previously, as having grown keen and enthusiastic and feeling more able to learn. A small number of teachers had undertaken pupil voice surveys internally which they reported as conveying more positive feelings and enjoyment. Some teachers had attributed these outcomes to teaching for all attainment, enabling certain pupils to access different types of maths problems and to sit with learning partners they may never have got the chance to work with previously:

Those children aren't labelled and aren't going out and aren't being sat in a group together, that's gone. They're loving the opportunities of all being able to access challenges… confidence, self-esteem, lack of labelling has really benefited the children. They like the fact that they can sit next to somebody that's possibly a different ability to them, to be able to share work. (MTE cohort 1, school 25b, interview 2017)

Teachers were asked about pupils' learning skills and their disposition towards mathematics now. Confidence, depth of thinking and mathematical language were all discussed and these aspects are interlinked, for example pupils having the confidence to explain their reasoning using mathematical language. Teachers commented on pupils' reasoning skills having improved through being required to explain their thinking verbally or to write down their ways of working through a problem, instead of just providing the answer. There was discussion from teachers about pupils having more confidence to solve problems and think through different methods to solve one problem:

I think as a whole the children have absolutely loved doing maths this way... they feel really a part of the process of solving problems (MTE cohort 1, school 16a, interview 2017)

They're enjoying it more… You go into classes and you see the children talking about it and being enthused and wanting to solve problems… It's a range of pupils as well, whereas before it was the ones who were good at maths (MTE cohort 1, school 6a, interview 2017)

The predominant pupil outcome mentioned by MTE cohort 2 teachers was a narrowing of the attainment gap, with pupils working together as a class, and all pupils being able to access the same work. For some teachers this was said to have a profound impact on pupils' abilities in mathematics and their confidence and enjoyment in lessons.

The way children view each other is brilliant now because they feel like they're on a level playing field and they're all learning together, whereas before it was very separate. They weren't really able to help each other because they were all learning different things, but now it's a whole class approach where everybody helps each other to get better at maths, which is really nice. (MTE cohort 2, school 2A18, interview 2017)

I think for them not being singled out that at the beginning of the lesson… has a big psychological impact on them, because they do feel that they are part of the class and maybe they can do it, and in terms of building that belief in the children, that power that if you work hard, if you keep going you will get there eventually. (MTE cohort 2, school 2A23, interview 2017)

Children's ability to articulate their learning and their use of precise mathematical language was also a key outcome. Pupils were said to be able to explain their reasoning both to each other and in front of the class using an impressive range of vocabulary. This was even thought to be impacting positively on pupils' reading and writing ability in other curriculum areas.

Teachers also talked about pupils having a greater depth of understanding, which was demonstrated in the way they solved problems using a variety of strategies and could articulate how they got to an answer, justifying their methods. This was also linked in some cases to an increase in resilience, as pupils were prepared to try different methods to solve a particular problem if they were not able to succeed on their first attempt. This use of different methods was also reported to help some of the pupils who were visual learners and needed to see real-world examples before going straight to abstract representations.

Most of the evidence was anecdotal, drawing on teachers' observations and work completed in pupils' books, however there were some reports of SATs results being higher and in particular a closing of the gap with more pupils reaching age-related expectations.

We're now regularly getting 30% getting greater depth, which beforehand was probably in the 20s, so we've seen a marked improvement in that. Diminishing the gaps has happened quite rapidly as well. The first year we'd put it in, our Year 1 cohort would be about a 20% difference between boys and girls, in that first year. By the end of that year, it had diminished to 0%, so there was no difference between boys and girls. (MTE cohort 2, school 2A20, interview 2017)

Pupil attitude survey 2015-2017 comparison

MTE cohort 1 schools were invited to administer a pupil attitude survey (PAS) to Year 6 pupils in summer 2015 and 2016 and details were reported in the second interim report. The survey addressed three areas: general affect towards mathematics, mathematics anxiety, and preference for working alone.

The first analysis presented here in Table 20 includes all valid responses in 2015 and 2017.

Table 20: Analyses of pupil attitude survey

	Year	N	Mean	Std. Deviation	Std. Error Mean
Affect	2015	1039	7.02	1.92	.059
	2017	533	6.76	2.01	.087
Anxiety	2015	1023	3.78	1.80	.056
	2017	530	3.76	1.96	.085
Working alone	2015	1103	4.38	2.38	.072
	2017	582	4.33	2.63	.109

Source: pupil attitude survey 2015 and 2017

We see lower levels of positive affect towards mathematics (t=2.57, df=1570, p=.01, Hedges' g=0.14) in 2017 compared to 2015. However, there was no difference in levels of mathematics anxiety (t=0.23, df=1551, p=.82), or in preference for working alone on mathematical tasks (t=0.35, df=1683, p=.72) between the two data collection points.

The table above shows that a larger number of pupils (from a larger number of schools) responded to the pupil attitude survey in 2015 than in 2017. It is possible that there could be bias due to attrition at school level. Therefore analyses were repeated, but including data from only those schools that responded in both years.

Table 21: Analysis of pupil attitude survey for school that responded in both years

	Year	N	Mean	Std. Deviation	Std. Error Mean
Affect	**2015**	518	6.77	1.95	.086
	2017	468	6.76	2.01	.093
Anxiety	**2015**	514	3.91	1.83	.081
	2017	466	3.80	1.97	.091

Working alone	**2015**	560	4.52	2.33	.098
	2017	514	4.33	2.69	.119

Source: pupil attitude survey 2015 and 2017

Analysis presented in the table shows there is no significant difference in affect (t=0.13, df=984, p=.89), no significant difference in anxiety (t=0.89, df=978, p=.37) and no significant difference in preference for working alone (t=1.26, df=1073, p=.21).

Therefore there is no evidence for any change in pupil attitudes to mathematics resulting from the teacher exchange. This appears to contradict, at least for this sample of schools, the claims made by teachers about the positive impacts they had observed on pupil attitudes. Nevertheless, given that in comparative studies, pupils in East Asia have been found to show less favourable attitudes to mathematics than pupils in England (e.g. Leung, 2006) it appears that the phenomenon of less favourable pupil attitudes (at least as measured in surveys) is not a critical or intrinsic consequence of the pedagogical approach.

9. Promoting mastery and sharing learning with other schools

Relevant evaluation objectives

Identify lessons learned and the extent to which changes resulting from the exchange have been embedded in schools in England.

Determine whether lessons have been shared among schools in the wider Maths Hub Network, and whether this has resulted in a change in teaching methods.

For MTE cohort 2 schools, identify lessons learned about factors influencing implementation, including in relation to work with other schools.

Section summary

The majority of MTE cohort 1 schools had shared their developing Shanghai-informed approach with other schools, although they were not formally obliged to do this. Ways of disseminating their learning included events such as workshops, in-school lesson demonstrations, and individual school support.

MTE cohort 2 schools had clear guidance on their responsibility to support a small number of schools, and therefore a fairly uniform approach was reported. Interviewees were funded to work with (usually) six local schools over a one-year period. Support was tailored to schools but followed a standardised pattern of teacher research groups related to demonstrated lessons, and then guided support to implement aspects of mastery in the local schools.

Analysis of the 2017 mathematics coordinator survey illustrates that implementation is highest in schools that participated directly in either of the MTE cohorts or the PMTMSP (cohorts 1-3) or both programmes. There is evidence that there is a body of schools beyond these that are also substantially implementing mastery pedagogical practices.

In this section, the promotion of mastery and implementation beyond MTE schools is considered.

9.1 MTE cohort 1 schools' work with other schools

There was no contractual obligation on MTE cohort 1 teachers to share their learning with other schools, but they were encouraged to do so by the NCETM. Interview data collected in 2016 indicated that 39 MTE cohort 1 schools had led or contributed to activities that shared learning from the exchange with other schools. The four schools participating in interviews that had not done any such sharing reported that they lacked

capacity within their own schools due to the mathematics leader leaving, or a more general lack of leadership capacity.

The main approaches to sharing learning were: presenting and leading workshops at external events (21 MTE cohort 1 schools); modelling mastery teaching in their own school (25 MTE cohort 1 schools) usually taking a teacher research group approach; and customised support focused on supporting schools to implement mastery in their own context (19 MTE cohort 1 schools). Presentations and workshops were limited in duration but had wide reach. Modelling and teacher research groups were sometimes one-off activities and in other cases were sustained over time. In the period between the exchange visits and the 2016 interviews, most MTE cohort 1 teachers estimated that between 50 and 100 schools had visited their school to observe and take part in teacher research groups or associated workshops. Customised support typically spanned a term or more, but reach was more limited, usually involving work with between one and 10 schools. Support focused on the specific needs of participant schools and included opportunities for schools to trial and review implementation. Some MTE leads in cohort 1 led this activity as part of their PMTMSP. As noted in section 4, this involved half-termly Maths Hub Work Group meetings with two lead teachers from six or seven schools, and termly visits to the schools. In other instances, customised support was an integral part of school improvement activity, for example across a federation of schools or Teaching School Alliance (TSA).

The 2017 interviews included follow-up questions on work with other schools, targeting a sub-sample of 21 schools that had reported substantial activity with other schools in 2016. Of these 21 MTE cohort 1 teachers who had provided data in 2017, 18 reported that they were undertaking at least as much work with other schools. The three schools who reported doing no work or more limited work with other schools attributed this to staffing changes. The types of work with other schools continued to mirror what was reported in 2016. There were three stimuli for MTE cohort 1 teachers working with other schools: their participation in the PMTMSP; a system role in addressing the CPD and/or school improvement needs across a group of schools (such as a TSA, multi-academy trust or more informal local grouping); and a Maths Hub role.

MTE cohort 2 schools' work with other schools

There was greater consistency in the nature of work with other schools undertaken by MTE cohort 2 teachers compared to cohort 1. This was expected, as MTE cohort 2 teachers largely followed the plan prescribed for cohort 2 in the NCETM information and application documentation and detailed in Figure 3 (MTE cohort 2 theory of change). Participating teachers were expected to lead teacher research groups and had funded release time to support work with other schools. The structured teacher research groups, involving the same group of schools working together over a year, appeared to provide

opportunities for teachers to consider local practice and circumstances when planning how best to develop teaching in their own schools. Professional development support was provided in other schools in a variety of ways by MTE cohort 2 teachers, including staff meetings, observations, model lessons, training and workshops. A typical pattern of working with other schools is illustrated below:

As part of the teacher research group, we have schools coming in to us each half term. They come and observe the teaching here. We run that as a session to reflect on practice and then also to unpick the different elements of mastery. Then those schools have an opportunity to go back and try to introduce that practice in their classes and then within their schools too ... in addition … I go to each school for one day a term and have an opportunity to look at practice there and then to think about how mastery can be introduced within their context. Some schools have developed one element, but not another, and it's trying to guide and give support so that they can really implement in their school. The first year I worked with four [schools]. Last year I worked with six. Then this year I'm working with another six. (MTE cohort 2, school 2A1, interview 2017)

There was some adaptation by MTE cohort 2 teachers, for example one moved the meeting place for teacher research groups from their own school to participants' schools to ensure greater relevance and applicability:

It became clear by the third [TRG] that... they were coming to see a lot of maths teaching in my own school and that wasn't particularly effective anymore, because they understood what it looked like in my school. So we spent time then delivering the TRGs in other people's schools. I think they found that really powerful, seeing the same approach in different schools and different cultural areas of the hub. That gave teachers a lot of food for thought in terms of how it could work for their schools… it's really supported teachers and leaders in terms of understanding how they can choose the best bits that will have the greatest impact for them first. (MTE cohort 2, school 2A16, interview 2017)

The schools involved in the PMTMSP teacher research groups are those that were already convinced of the benefits of mastery:

[The schools] applied through the hub and had to give their reasons why mastery had to be on their school development plan agenda. It's working with the schools who are up for it really. Nobody is sent. They have to choose to come. (MTE cohort 2, school 2A26, interview 2017)

Some of the MTE cohort 2 teachers also undertook a broader range of work with other schools including presentations, conferences, demonstration lessons in their own schools, and contribution to courses for maths subject leaders as well as additional customised CPD or support for other schools. This was usually associated with a more

substantive role with their local Maths Hub or a system responsibility across schools through a TSA or multi-academy trust. Interviewees were not always able to provide specific details of participation numbers by schools or teachers across the full range of opportunities that they made available to other schools including informal activities

9.2 Mastery implementation in hubs beyond MTE schools

In the 2017 mathematics coordinator survey conducted by the evaluators, maths coordinators/teachers in MTE cohort 1 and 2 schools and other schools within the Maths Hubs were asked 'which of the following closely matches the position in your school in relation to mathematics teaching this academic year?'. Table 22 reports these data.

Cross-checking of survey data with DfE-supplied data on participation in the MTE and PMTMSP, including using postcodes as identifiers, demonstrated that there were some reliability issues evident in self-reporting of involvement with the MTE exchange and/or PMTMSP. These should be taken into account when interpreting Table 22 and the general pattern should be considered rather than the actual numbers.

Table 22: Implementation status - Number of responses by MTE cohort and PMTMSP status

	Group 1: MTE cohort respondents and/or PMTMSP training	Group 2: No MTE cohort or PMTMSP training
Mastery approaches have been implemented across ALL classes	118	99
Mastery approaches have been implemented in some classes	49	103
We are intending to implement mastery approaches in the future	11	36
We are interested but have not accessed enough information	1	8
Thought about it but it is not right for our school at this time	1	5
Other	5	10
Total	185	261

Source: Mathematics coordinator survey, 2017, n=446 responses to the question.

Analysis was also undertaken to compare implementation of specific practices across the different samples. In order to make meaningful comparisons from the 2017 mathematics coordinator survey data, the analysis presented is based on survey respondents being split into one of the below three groups:

Group 1: Those respondents who reported being involved in one of the exchange cohorts, or having completed the PMTMSP, or both.

Group 2: Those respondents who reported not being in an exchange cohort or PMTMSP cohort, but having substantial mastery practices in their school.

Group 3: Those respondents not involved in any of the above and not reporting substantial mastery.

The analysis groups the survey question responses into the four areas related to the mastery pedagogy model presented in section 5 above.

Varied interactive teaching

In the 2017 mathematics coordinator survey, teachers were asked about the level of whole class-pupil interaction and teacher-pupil interaction taking place in maths sessions, alongside whether lessons were formally structured in three parts (that is, starter activity followed teacher explanation/practice followed by a plenary) or were more varied in structure (multiple periods of questioning with teacher-pupil dialogue interspersed with pupils working on one to two problems and tasks, possibly with a separate time for practice). In the sample that responded to the question, those from group 1 (MTE and/or PMTMSP) reported the greatest degree of alignment with the MTE mastery pedagogy model. Those in group 2 reported slightly less alignment and group 3 reporting the least alignment. The difference between groups as a whole is statistically significant (Table 28 in section 6.5 of the technical report).

Full curriculum access for all

Teachers were asked about their curriculum pace, differentiation practices and how often children needing interventions were identified in relationship to this mastery pedagogy component. Of the sample that responded, those from group 1 (MTE and/or PMTMSP) reported the greatest degree of alignment with mastery pedagogy, with those in group 2 reporting slightly less alignment and group 3 reporting the least alignment. The difference between groups as a whole is statistically significant (Table 27 in section 6.5 of the technical report).

Knowledge of mathematical facts and language

In relation to this MTE mastery pedagogy component, teachers were asked about how often the following happened: precise mathematical language was used by teachers and pupils; key ideas and concepts were recited individually or as a class; teachers asked for clarification about how answers were obtained; and pupils were encouraged to communicate mathematically to the whole class. Of the sample that responded, those from group 1 (MTE and/or PMTMSP) reported the greatest degree of alignment with

mastery pedagogy, with those in group 2 reporting slightly less alignment and group 3 reporting the least alignment. The difference between groups as a whole is statistically significant (Table 29 in section 6.5 of the technical report).

Mathematically meaningful and coherent activity

Finally, in the 2017 mathematics coordinator survey, teachers responsible for coordinating or leading mathematics in their schools were asked about their use of representations (concrete and pictorial), textbooks or schemes, and planning for and addressing misconceptions in relationship to this mastery pedagogy component. In the sample that responded, there was a mixed picture. Whilst those in group 3 (no substantial mastery) consistently reported the least degree of alignment with mastery pedagogy, group 1 (MTE and/or PMTMSP) and group 2 (reporting substantial mastery) were similar in their responses across the majority of questions, with group 1 reporting greater alignment than group 2 on some questions and vice versa. The difference between groups as a whole is statistically significant (Table 30 in section 6.5 of the technical report).

Implications of the survey findings

The survey findings indicate that schools engaging in the aspects of the TfM programme and/or committed to mastery are implementing practices that are different to other schools.

10. School and contextual factors influencing implementation

Relevant evaluation objectives

Determine what activities have been most successful in meeting the aims of the programme.

For MTE cohort 2 schools, identify lessons learned about factors influencing implementation including in relation to work with other schools.

Section summary

School-level enablers, frequently cited by MTE cohort 1 schools during the first two years of the evaluation, were: staff responsiveness; resources; senior leadership commitment; and implementation leadership by the MTE teachers. Two additional enablers identified in the 2017 interviews were: an enhanced enthusiasm for mastery attributed to staff having seen its benefits first-hand; and work with other schools that supported professional development within the MTE school.

Key barriers to effective implementation reported in the 2016 interviews related to teachers' beliefs about pupil learning, lack of confidence in their pedagogy and a lack of the required level of mathematics subject knowledge. These were less frequently reported barriers in 2017. However, staff turnover was highlighted as an additional pressure as implementation continued, which meant having to train new members of staff in the mastery approach.

Similar issues were identified by cohort 2 and in addition issues related to the challenge of working externally whilst working to fully embed new practices in their own school.

10.1 School factors

The most frequently mentioned enabling factors in MTE cohort 1 schools reported in the 2016 interviews were staff responsiveness, resources, senior leadership commitment, and implementation leadership by the MTE leads. The 2017 interview data confirmed that the same enablers were supporting the implementation of a Shanghai MTE mastery pedagogy, and placed particular emphasis on the importance of senior leadership commitment:

So at an Executive Principal level we have quite high level support, so it's not something I'm trying to implement as a middle leader. It's coming from the top as well. I've got that back up … so that helps a lot. (MTE cohort 1, school 19A, 2017 interview)

Further analysis of data in relation to the leadership undertaken by the MTE teachers indicates that the most effective scenario appeared to be where implementation was led by a committed, experienced teacher with expertise in mathematics teaching but who did not have responsibility for their own class. Often this would be a deputy or assistant head, or alternatively a designated mathematics leader outside the normal timetabling structure. In these circumstances, the teacher leader had the time to work closely with other colleagues to support them in changing practice.

Two further school-level enablers evident in the 2017 cohort 1 interview data were enhanced enthusiasm for mastery, arising from a critical mass of teachers seeing the benefits over time, and the impact on in-school professional development of the work done by the MTE teacher (and sometimes other teachers) with other schools.

I think being able to communicate with other schools has helped because we've shared good practice between the schools and I think that always plays a big part in what we're trying to do to see if other schools are experiencing the same things. (MTE cohort 1, school 25A, 2017 interview)

The most frequently mentioned barriers to implementation in the MTE cohort 1 schools 2016 interviews were teachers' beliefs, teachers' subject knowledge weaknesses, and/or low teacher confidence levels. Challenges were also encountered in higher year groups where the attainment gap was wider and teachers' priority was to ensure high SATs results. Other significant barriers were the lack or inappropriateness of available resources, lack of staff time, staff turnover and staffing organisation.

In 2017, similar influencing factors were reported but there were notably fewer references to teachers' beliefs, subject knowledge weaknesses and low confidence levels. However, staff turnover issues became more prominent, with teachers reporting the need to induct new staff into mastery approaches. The most extreme example was a school where almost the entire staff including the mathematics leader had changed since 2015. The 2017 interviewee referred to having to "start again" and was drawing on CPD through a commercial mathematics mastery scheme to support the process.

In MTE cohort 2 similar issues were identified. In addition, interviewees identified the following factors:

- The challenge of supporting change across the hub whilst at the same time paying attention to implementing in their own school.
- A request that funding for participation in TRGs could be extended to their own school. This would help embed and extend change but also mean school leaders and governors would be more supportive about releasing experienced teachers to work with other schools.
- The level of payment to work with other schools did not cover the costs of more experienced and senior staff.

10.2 Relationship between school characteristics and levels of implementation

To identify any relationships between characteristics of MTE cohort 1 schools and levels of mastery implementation, the data were analysed statistically. In summary, no significant relationships were found. Details of this analyses are reported in the technical report section 8.2. School 'characteristics' here refer to factors such as attainment, proportions of FSM pupils and EAL pupils (which were used as variables in the propensity score matching process) rather than a school's role or designation such as Teaching School or Maths Hub lead. The proportion of schools designated as Teaching Schools implementing mastery was compared with the proportion of other schools implementing mastery; they were found to be not significantly different.

10.3 Contextual and system factors

Participants were asked about the barriers to implementing their learning from the MTE. 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 was that because expertise across subjects is expected in primary teaching, becoming a specialist in mathematics has the potential for a teacher to be perceived to be less skilled in other subject areas. Further, teachers who would now not be teaching mathematics to their classes might be viewed as less skilled than generalist teachers. In both cases this might have implications for future employment or career prospects. This pertained both to those who become mathematics specialists as well as those non-specialists who do not therefore teach mathematics. Early indications are that schools are aiming to develop the mathematics expertise of all teachers as an alternative to having 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 times 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 mastery approach. Of these four teachers, two referred to pace and/or progress in lessons and two talked about possible perceptions of lack of differentiation. Although assurances had been given at national meetings that there would be no such

criticism or other ramifications, and guidance had been given to inspectors, the concern persisted in some schools in the third round of interviews.

11. Participant views on policy implications

Relevant evaluation objectives

Determine which activities have been most successful in meeting the aims of the programme.

Identify lessons learned and the extent to which changes resulting from the exchange have been embedded in schools in England.

For MTE cohort 2 schools, identify lessons learned about factors influencing implementation, including in relation to work with other schools.

Section summary

MTE cohort 1 and 2 teachers considered that aspects of learning from the Shanghai exchange could be applied in other subjects beyond mathematics, namely: teaching for depth; progression in small steps; and teaching the whole class together. Cohort 2 teachers focused also on the potential applicability of Shanghai-informed teacher learning, professional development and collaboration.

Both the MTE cohort 1 and cohort 2 teachers valued the exchange as a professional development experience. Some also identified a need for further investment in staff release time for collaboration, including planning, intervention, and further professional learning and development, to ensure the mastery approach can become embedded in exchange schools and other schools.

In both sets of MTE cohort 1 and cohort 2 interviews in 2017/18, participants were asked firstly to consider if lessons from the Shanghai exchange had wider applicability to primary education in England to inform school improvement beyond mathematics. Secondly, they were invited to convey any advice or views they wanted to communicate to those responsible for policy in relation to primary mathematics education. Responses are summarised in this section.

Cohort 1 participants' views

For MTE cohort 1, most (35) teachers' answers indicated that they felt there were aspects of mastery pedagogy that could be adopted in other lessons, with some teachers saying this had already happened, and some stating that pupils had begun to transfer their learning approaches to other lessons. The most common areas of transfer were: teaching for depth, with an emphasis on understanding; and linked to this, instances of unpicking the learning and taking a small steps approach in lessons. The quote below illustrates this:

It's more the breaking down into smaller chunks. That's applicable across any lesson. Rather than bombard the children with fifteen minutes of input and then get them off to go and do it. (MTE cohort 1, school 9b, interviewee 2017)

Thinking differently about differentiation and ability groups, including the concept of growth mindsets, was raised as an area that was seen to be fairly easy to implement and could 'go across the board in other subjects'. Some teachers talked specifically about the application of questioning techniques being used in other subject areas, and about precise use of language by pupils, with some focus on oracy. A small number of teachers spoke about the possible use of variation theory and use of representations such as concrete or pictorial in other lessons.

Just under half of MTE cohort 1 interviewees named a subject in which they could see the application of Shanghai-informed approaches, and the majority of these mentioned English (language and/or literacy), with fewer (eight) teachers identifying science, and one teacher mentioned engineering with science.

Some answers referred to a collaborative approach both to teacher planning and sharing professional learning, such as the use of research groups across other subjects and teachers planning and working together.

Conversely there were six interviewees who were less sure or who could not see the potential application of aspects of Shanghai-informed teaching beyond maths. The barriers raised included lack of resources and the difficulty of application within the UK context.

Cohort 2 participants' views

MTE cohort 2 teachers were asked about the potential application of "mastery approaches" beyond mathematics. Generally, they talked about areas which reflected the most important changes their school had made. Approaches to CPD were referenced multiple times, such as teacher research groups for other subjects, teachers' observations, and collaborations in planning. The key areas of classroom practices that were thought to be useful in subjects other than maths were: teaching in small steps and for depth of understanding; pupil talk; and keeping the whole class together rather than accelerating particular pupils and restricting access to learning for other pupils. Some interviewees highlighted the policy differences in Shanghai, such as primary teachers being specialists with a single subject to teach as well as having time for planning and collaboration; these factors made adoption of mastery more difficult in the UK context. Some teachers were not sure if mastery approaches had a place beyond mathematics and some felt that it was dependent on members of the school's senior leadership team and the ethos of the school.

Participants' advice for government and policy-makers

Interviewees were also asked to reflect back on their professional development experience as a whole, and asked for any advice they had for government or key stakeholders on what has worked well or is working well and what could be improved upon.

For MTE cohort 1 interviewees, this invitation provided an opportunity to develop points offered about enablers and barriers to implementation that were discussed in section 10. However, in response to the specific prompt, participants focused on issues that were largely outside, or felt to be outside, the schools' control. These barriers centred on the need for further investment in resources, including funding for staff release time to plan together and meet teachers from other schools. Funding was also important for schools to implement certain aspects such as daily intervention, particularly in smaller schools. Although it was acknowledged by some that there had been high levels of investment, one interviewee compared this to previous initiatives which were more generously funded:

I used to be a national strategies consultant before I was in this job. Yes, we probably could have done things more efficiently in some cases. There was a lot of money sloshing around, but even if you had half that money from national strategies, it would be amazing, but it's nowhere near that. (MTE cohort 1, school 22b, interviewee 2017)

The Singapore approach was discussed by a small number of teachers (three), who felt that there was perhaps more to learn from this approach due to the similarities with the UK context, and therefore suggested an exchange to Singapore instead of Shanghai. Other teachers focused on the need for a national textbook to facilitate the teaching of mastery more consistently through the use of standard materials. One teacher emphasised the importance of the textbooks being produced by experts and not for profits. Consistency was also viewed as important where teachers from both cohort 1 (MTE mastery pedagogy) and cohort 2 (teaching for mastery) talked about the Maths Hubs and the need for a coherent approach across Hubs working with schools to implement mastery.

The need for acknowledgement of the cultural differences between English schools and Shanghai schools and therefore the need to adapt the approach was raised by two interviewees.

Two teachers praised the exchange experience and the power of this to stimulate change, with other teachers emphasising the need for more teachers to experience the exchange directly in order to see the approaches in action before they could make changes in their schools. Other factors identified as potential supports for the exchange experience and the implementation of mastery were: slimming the curriculum, having

specialist primary maths teachers, and ensuring that national tests were in line with mastery principles.

The advice that MTE cohort 2 teachers offered on the exchange experience was also diverse. However, three important points were frequently raised. These were:

- The mastery approach should continue for a substantial amount of time, and be allowed time to 'bed in' before being judged.
- There is a need for consistency in the approach across schools - that is, all schools should be implementing teaching for mastery fully.
- The government needs to take into account the cultural and policy differences between Shanghai and the UK, acknowledging that Shanghai teaching cannot be replicated to the same degree in the UK.

On the whole, the exchange experience was appreciated by the participants and seen to be immensely valuable. It was widely felt that more teachers needed to experience the approaches first-hand, meaning further exchange cohorts were advised. It was also felt that more support and resources were needed for mastery specialist teachers who had undertaken the exchange to make changes in their own school and share the approach more widely. Resources were needed for textbooks, same-day intervention and releasing staff for training. Reflecting on lessons from the exchange, there was some discussion about the need to slim the curriculum to be in line with mastery teaching. Further, it was suggested that there is a need to ensure that assessment systems are updated to fit the curriculum, due to the perception of the implications of age-related expectation meaning there are different expectations for different pupils. Lastly, two interviewees stated that Ofsted were still not up-to-date with approaches such as variation theory and teaching for depth. This was seen as a significant barrier to implementation by those two teachers.

12. Evaluation outcomes

Section summary

Evaluation outcomes are summarised. The MTE programme has been successful in terms of catalysing change in a substantial proportion of schools participating in MTE cohort 1 and informing the wider Teaching for Mastery Programme, including MTE cohort 2. Whilst participation in the exchange alone did not appear to lead to improved attainment, there is some evidence that when a MTE mastery pedagogy is implemented there is an effect at Key Stage 1.

In this section, evaluation outcomes are summarised in relation to the evaluation objectives. Objectives 1 to 12 were originally specified for MTE cohort 1. Objectives 2 and 3 were subsequently extended to include MTE cohort 2. Objectives 13 and 14 relate only to MTE cohort 2. As noted in the introduction to the report, these objectives were formulated with respect to the Mathematics Teacher Exchange programme, and not the Teaching for Mastery Programme that has subsequently developed and that includes the MTE.

1. Evaluate the implementation and fidelity of the intervention against programme objectives

The objectives of the Mathematics Teacher Exchange were to learn from primary mathematics education in Shanghai and, through the adoption and adaptation of East Asian pedagogies, to effect changes in primary school practice initially in the exchange schools in England. Fidelity and level of implementation have been variable across the MTE schools; however the majority of schools involved in the original exchange programme had adopted a MTE mastery pedagogy clearly informed by Shanghai mathematics education. Implementation criteria were carefully formulated using a model of Shanghai-informed mastery pedagogy. Application of the criteria to the MTE schools shows that of the original 48 schools, 34 had implemented mastery practices; of these, 24 had done so at a high level of fidelity. By 2017, of the 38 schools for which there were full data, interviewees reported that 72% of classes were experiencing substantial implementation of what they described as a mastery pedagogy or mastery teaching. Implementation tended to be less well-established in upper Key Stage 2.

2. Identify the types of activity undertaken by teachers from England in Shanghai host schools

Both MTE cohorts of teachers spent time in primary schools in Shanghai observing mathematics lessons (and in some case other lessons) and taking part in teacher

research groups as well as other activities. Cohort 1 teachers spent longer in university sessions; this feature was refined for cohort 2 teachers after feedback that this activity was less useful than time spent in primary schools.

3. Identify the types of activities undertaken by Chinese teachers in host schools in England

Nearly all of the MTE cohort 1 schools hosted a Shanghai teacher as part of the exchange. However, in cohort 2 only half the schools received a visiting Shanghai teacher. During their time in the English schools, the Shanghai teachers taught mathematics lessons in particular year groups chosen by the host school. Lessons were demonstrated by Chinese teachers and observed by English teachers. Chinese teachers planned lessons collaboratively with English teachers and in some schools engaged in teacher research groups and lesson study activities. In the cohort 1 exchange, the extent to which teachers from other schools had the opportunity to benefit from the exchange varied across the hub. In cohort 2, best practices in engaging schools (identified in feedback from cohort 1 participants) were replicated across hubs.

4. Identify the professional development outcomes for teachers

A variety of professional development outcomes were identified from the exchange and the subsequent implementation of changes in practices and associated professional development activity. This was true both for exchange teachers themselves and other teachers in the exchange schools. Improved subject and pedagogical knowledge were the predominant outcomes for teachers. There were also increases in teachers' capacities to engage in collaborative planning and forms of professional learning such as teacher research groups. Changes in beliefs, particularly in relation to pupils' abilities being fluid rather than fixed, were also reported alongside increased teacher confidence. For exchange teachers, participation also offered opportunities to develop their subject leadership capacities, both in their own schools and through supporting change in other schools.

5. Determine whether teaching methods and practices have changed in host schools in England

Substantial changes made to teaching methods and practices were reported across the exchange schools. Levels of change differed across the schools depending on level of adoption of learning from the MTE programme, and influences of the Teaching for Mastery Programme depending on levels of engagement. Key changes were:

- Increase in episodes of whole-class interactive teaching in multiple-part lessons and an increase in interactive dialogue.
- Enhancement of mathematically meaningful and coherent activity, through an emphasis on depth of understanding and problem-solving, supported by increased use of models and representations. Activities are embedded in carefully designed lessons taking a ‘small steps’ approach to concepts and procedures, recognising the importance of misconceptions and using skilful teacher questioning. Lesson design and delivery often involves the use of East Asian informed textbooks or curriculum materials.
- Fuller curriculum access for all pupils, by adopting a curriculum pace achievable for the whole class; teaching for and to attainment rather than perceived ability; differentiation by deepening and support and through responsive intervention.
- Increased emphasis on the precise use of mathematical language by teachers and pupils and also on memorisation of facts and procedures to support procedural fluency.

To support these changes in classroom practices, school-based professional learning focused on initially learning from the MTE experience and later using East Asian informed resources and Teaching for Mastery Programme recommendations and materials to support their Shanghai-informed approach to maths teaching. MTE cohort 1 schools implementing a mastery pedagogy have engaged in collaborative, embedded, mathematically-focused professional development that is close to practice.

6. Determine what activities have been most successful in meeting the aims of the programme

The exchange experience was a key catalyst for change. NCETM materials and resources, local Maths Hub activities and materials, the PMTMSP, as well as activities drawn from mastery-aligned textbooks and resources, have also supported MTE mastery implementation. However, local school-based mastery learning, initially from the exchange and subsequently as part of the Teaching for Mastery Programme, as well as local subject leadership, are regarded as essential to successful implementation.

7. Identify lessons learned and the extent to which changes resulting from the exchange have been embedded in schools in England

Since MTE cohort 1 schools embarked on the programme in 2014/15, a much more extensive Teaching for Mastery Programme has been developed. Central to this expansion is the PMTMSP and the support for mastery specialists to lead change in their

own schools and to support change in others. Additionally, a textbook subsidy is available for those engaging in TfM. The scope of the TfM programme means that it is not possible to separate out the extent to which the MTE cohort 1 exchange alone has led to change embedding in schools in England. However, the changes made by the first MTE cohort and the ways that they adopted and adapted mastery practices, have influenced the NCETM's formulation of TfM and also the PMTMSP curriculum. The first exchange was an important milestone in the development of the TfM programme. It is also clear that the number of schools engaging with East Asian informed mathematics pedagogies has increased considerably since 2014.

8. Report on perceptions of pupil performance and depth of understanding of key concepts

The majority of teachers felt that their pupils had progressed more since the exchange than they would have without the exchange. However, it was difficult for teachers to evidence changes in attainment, in part due to England-wide curriculum and assessment changes. Teachers felt that pupils' self-efficacy benefited from being taught in less differentiated groups and that the new practices improved pupils' engagement and confidence. They also believed that pupils' depth of understanding of key concepts had improved.

Analysis of pupil attitude survey data does not indicate any significant change in general affect towards mathematics, mathematics anxiety or preferences for working alone.

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

The majority of schools that have fully implemented MTE mastery pedagogy have reported considerable ongoing work with other schools. In 15 cases this is supported by engagement in the PMTMSP. However, there is limited specific evidence of the extent of the changes made to teaching in schools supported by MTE cohort 1 schools. What evidence there is suggests that changes in other schools are not as extensive as in MTE schools.

10. Review, assess and synthesise the findings from the MTE cohort 1 reports prepared for NCETM

School reports were received and reviewed from MTE cohort 1 schools in the first and second year of the evaluation. School reports were not produced in year three. The

report details were used to triangulate findings from other evaluation data and to inform data collection instruments.

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

There is no evidence that participation in the exchange on its own led to impact on pupils' mathematical skills and ability between 2014 and 2017. However, there is evidence that in a sub-sample of schools which implemented MTE mastery pedagogy at a high level or at above-threshold level, and whose Y2 pupils had experienced two years of MTE mastery pedagogy, there was a positive impact on mathematics attainment of KS1 pupils.

12. Identify initial patterns of effective change and early evidence of pupil impact

In the first interim report, initial patterns of effective change were reported. Early evidence of pupil impact was anecdotal due to changes in assessment measures.

13. For MTE cohort 2, identify patterns of implementation and the influence of the exchange on this in relation to other influences

MTE cohort 2 schools were all participants in the PMTMSP and so focused on implementing TfM. Because of this and due to the nature of the interviews, it is not possible to determine the level of implementation in these schools in a way that is fully comparable with MTE cohort 1 schools. Of the 27 participants interviewed, 20 reported implementation that accords with at least the threshold level of MTE mastery pedagogy and many of these schools had characteristics of high implementation. These participants also reported a slightly higher proportion of classes (78%) in which substantial implementation was taking place, compared to the proportion for MTE cohort 1 (72%). Similar to the picture for cohort 1, implementation was lower in Year 6 than in other years.

Key to implementation in MTE cohort 2 schools was the PMTMSP experience with the exchange acting as an opportunity to refine and enhance learning.

14. For MTE cohort 2, identify lessons learned about factors influencing implementation, including in relation to work with other schools

Factors influencing implementation by MTE cohort 2, including in other schools, were similar to those for MTE cohort 1. Notable additions were issues related to the arrangements for supporting cohort 2 teachers as PMTSMP mastery specialists to work with other schools, whilst continuing to embed change in their own schools.

13. Interpretation and implications

Section summary

Findings in relation to engagement with schools beyond the MTE are discussed and interpreted. Positive developments in the MTE in relation to increasing engagement of such schools are noted.

Possible explanations for the impact findings are considered. These span: reliability of the KS1 measure; differences in change in practices in KS1 and KS2; the possible applicability of the East Asian informed practices to KS1 but not KS2; that practices implemented in KS2 are not sufficiently different from comparison schools to lead to differences in impact; and that there has not been sufficient time yet for changes at KS2 to impact attainment.

Wider implications of the evaluation for schools and policy are discussed.

In this section, findings are interpreted, their implications discussed and recommendations made. Firstly, findings related to engagement are considered. This is followed by discussion of the impact findings for MTE cohort 1. Finally, wider implications of the evaluation for schools and policy are outlined.

In order to make use of the findings of the evaluation, it is important to recognise that the MTE experienced by cohort 1 is very different to that of MTE cohort 2, or that which will be experienced by future cohorts. In particular, the MTE as it is implemented at the time of reporting, needs to be considered in relation to the Teaching for Mastery Programme as a whole. Thus, findings for MTE cohort 1 may not be predictive of impact for MTE cohort 2. In general, as stated in the introduction to the evaluation report, the evaluation of the MTE cohort 1 programme does not extend to the full TfM programme and firm conclusions cannot be drawn about the latter.

13.1 Engagement

The Mathematics Teacher Exchange was introduced in 2014 and has since been extended to further cohorts, with the aim of changing the way mathematics is taught in England by learning from high performing East Asian education systems. The first exchange was organised when Maths Hubs were first being set up and in a short time scale (see first interim report). Many of the schools joining the exchange were unfamiliar with Shanghai-informed mastery approaches. The issue of rapid recruitment of schools in the context of establishing Maths Hubs means it is not surprising that all 48 schools initially involved in the exchange did not fully implement East Asian informed practices. Given the circumstances, the reported finding of approximately two thirds of the schools

implementing mastery practices in MTE cohort 1 represents an early success for the programme.

The DfE and the NCETM considered both external evaluation findings, as reported in the interim reports, other interim findings on early implementation, and NCETM internal feedback and data collection from participating schools. As a consequence, the MTE experience was further developed for cohort 2. Teachers participating in cohort 2 reported a more consistent experience when visiting Shanghai. In addition, when cohort 2 Shanghai teachers visited England, a more consistent pattern was reported, which involved many Maths Hubs creating opportunities for more than 100 teachers to observe Shanghai teachers. Providing opportunities for large numbers of teachers to benefit from the exchange experience was consistent across Maths Hubs. However, there was variation in the way this was organised. It was not possible, within the limits of this evaluation, to determine which were the most impactful approaches to involving other schools. This suggests there may be a need to further refine guidance offered by the Maths Hub network on the most effective ways of organising Shanghai teachers' visits for further MTE cohorts.

In addition, the first interim evaluation report, based on data from school leaders, teachers, Maths Hub leads and the NCETM, identified the need for an ongoing programme of support to ensure changes in practice could embed and spread beyond the MTE cohort schools. Informed by this, the DfE funded, and NCETM devised and led what has become the Teaching for Mastery Programme. A core component is the Primary Mathematics Teaching for Mastery Specialist Programme. All of the MTE cohort 2 teachers had previously experienced the PMTMSP. Findings in relation to MTE cohort 2 support the continuation of the arrangement of participation in PMTMSP being a prerequisite of application for the MTE. Approximately half of the PMTMSP cohort participated in the MTE. Local arrangements ensured that all mastery specialists participating in PMTMSP had the opportunity to benefit from the visits by Shanghai teachers to England.

It is clear that cohort 2 MTE reached hundreds of schools in England and thousands of teachers beyond those directly involved in the exchange. However, as noted in section 9, interviewees were not always able to provide specific details of participation numbers by schools or teachers across the full range of opportunities that they made available to other schools including informal activities. This suggests a need for the NCETM and the Maths Hubs network to supplement collation and recording of information on participation by teachers and schools with Shanghai teachers' visits with recording of more informal and supplementary activities.

13.2 Impact findings

Headline impact analysis found no evidence that engagement in the Mathematics Teacher Exchange (MTE) alone led to a significant difference in pupil attainment in the MTE cohort 1 schools.

In relation to this finding, curriculum and assessment changes made since 2014 have meant that primary schools in general have changed schemes of work and practices - for example, they are no longer using national assessment levels and sub-levels. Thus, the finding of no impact does not necessarily mean that the MTE mastery pedagogy as implemented by MTE cohort 1 schools was not more impactful than their previous practices; rather, that it was not more impactful than practices implemented in contrast schools.

A plausible partial explanation for the lack of a measured impact of engagement in the MTE alone lies in variation in implementation. As reported, not all schools that participated in the MTE went on to implement MTE mastery pedagogy, and of those that did, phased implementation meant that the Y2 and Y6 cohorts assessed in 2017 only experienced MTE mastery pedagogy for two years in a minority of schools.

However, further analyses suggest these may not be the only factors. Follow-on analyses were undertaken for impact in MTE cohort 1 and these found that:

- There were no significant differences in pupil attainment in schools that implemented MTE mastery pedagogy in KS2 (that is in the sub-sample of schools where pupils had experienced MTE mastery pedagogy in both Y5 and Y6).
- There was a small but significant difference in pupil attainment in schools that implemented MTE mastery pedagogy in KS1 (that is schools where pupils had experienced MTE mastery pedagogy in both Y2 and Y3).

There are a number of possible interpretations of these findings including the difference between the KS1 and KS2 impact.

The theories of change for MTE cohort 1, presented in section 4.1, are important to interpreting the findings. In section 4.1 causal assumptions were outlined. The causal chain for MTE cohort 1 supposes that for an impact on attainment to occur and be measurable, the following conditions need to be fulfilled:

1. The measures used must be reliable across the MTE cohort 1 and contrast samples. In the earlier discussion of limitations of the evaluation (section 3.4), it was noted that KS1 assessment is through teacher assessment and there is a possibility that in the sub-sample of schools which had implemented mastery for two years for pupils in the 2017 Y2 cohort, there is some unconscious systematic bias on the part of teachers undertaking assessments.

2. Engagement in the MTE and engagement in MTE mastery professional and curriculum development before and subsequent to the MTE leads to change in practice of teachers in MTE schools in general and not only the teachers or leaders directly involved in the exchange.
3. The practice enacted by these teachers is effective in improving attainment.
4. New practices, as well as being effective, must be both a) sufficiently different from the practices implemented in contrast schools, and b) more effective than practices implemented in contrast schools. If that is not the case then the new MTE mastery practice may be effective, but a difference from the contrast schools might not be observed because the alternative practices are also effective.
5. There needs to be sufficient time for change in practice to impact attainment and two years was not sufficient.

In the technical report, section 10, each of these five issues is considered in turn in relation to both the KS1 and KS2 findings for the sub-sample of schools that were judged to have implemented MTE mastery pedagogy. The plausibility of the interpretations is discussed, and possible approaches to gather further evidence are described that would confirm or eliminate the different interpretations. It is notable that the size of impact found in KS1 in the sub-sample of schools is similar to that reported at KS1 in the evaluation of the Mathematics Mastery programme (Jerrim and Vignoles, 2016; Vignoles, Jerrim and Cowan, 2015). Some caution is needed in relation to the Mathematics Mastery finding as the identification of a small impact (0.10 standard deviations) was not significant at the standard 95% confidence level. Thus, the evaluators determined that this means that the possibility that this was a chance effect is higher than generally desirable. However, the replication of a similar effect size in the MTE study adds to evidence that East Asian informed practices may have positive impacts at KS1.

Given the development of the Teaching for Mastery Programme, further evaluation might focus on the impact of the programme as a whole or of its components, for example teaching for mastery as a distinct approach to teaching mathematics.

As noted above, since the first exchange in 2014/15, the MTE has been embedded as part of the TfM programme. Prior to undertaking the exchange, all participants have previously participated in the PMTMSP. Thus, the MTE cohort 1 and cohort 2 experiences are significantly different and the interviews with MTE cohort 2 confirm implementation of practices more closely aligned with Teaching for Mastery. Further, of the cohort 1 KS1 and KS2 sub-samples included in the follow-on analyses, only six of 16 and three of 10 schools respectively had engaged with the PMTMSP cohort 1 or 2, though a similar number in each case were leading mastery training in their local Maths Hubs.

Nevertheless, as noted in section 5.4, although there were differences in emphasis and terms used between interviews with MTE cohort 1 and cohort 2 teachers to describe practices associated with MTE mastery pedagogy, these were not so substantial that a school could be identified from the transcripts alone whether it was in MTE cohort 1 or cohort 2. Differences within the cohorts were greater than between the cohorts.

Regardless of the extent to which findings for MTE cohort 1 provide indications or not of outcomes for subsequent cohorts, the impact (if any) on attainment of the design of the MTE as implemented at the time of reporting is not yet evidenced, as it has not been evaluated.

13.4 Wider implications for schools and policy

As discussed in the introduction to the report, the focus of the evaluation has been on the Mathematics Teacher Exchange. However, in section 10, school and contextual factors influencing implementation by both MTE cohort 1 and MTE cohort 2 (alumni of the PMTMSP) were reported. In section 11, participants' views on the overall mastery policy were reported. Together these provide valuable lessons in relation not only to the MTE, but also to the associated activities that have developed into the Teaching for Mastery Programme. Whilst no conclusions can be drawn or inferences made about how effectively the wider initiatives are operating at the time of reporting, there were a number of issues identified from the impact analysis that are worthy of further consideration by the DfE, the NCETM and other stakeholders.

Moreover, as discussed in section 5.4 and above, whilst MTE mastery pedagogy as implemented by MTE cohort 1 schools is distinct from teaching for mastery, there are overlapping features. As previously stated, this is not surprising given that MTE cohort 1 was influenced by NCETM's early thinking about mastery approaches and later NCETM materials on TfM. Further, approximately a quarter of the MTE cohort 1 schools participated in the PMTMSP. Thus, whilst evaluation of the MTE does not extend to the TfM programme as a whole (as implemented at the time of reporting), the evaluation of MTE cohort 1 combined with research on MTE cohort 2 (albeit limited) suggest matters for further consideration. These are now addressed.

Policy continuity

The mastery policy and programme are relatively new. A common theme in interviews with both MTE cohort 1 and cohort 2 was a request for continuity and for the policy approach at the time of the interviews to be maintained. A common response of those participants most enthusiastic about mastery approaches was that change would take a long time and quick results could not be expected. Therefore, in spite of there being little evidence of impact on attainment, at the time of reporting, sudden policy change would

not be welcomed by participants in the MTE; rather, outcomes should continue to be monitored and evaluated.

Mastery as a catalyst for change and professional learning

MTE cohort 1 interviewees, MTE cohort 2 interviewees, and the mathematics coordinators surveyed across Maths Hubs, report that the MTE and the TfM programme as well as other mastery initiatives and supports have informed considerable change in schools. Regardless of limited evidence as yet for impact of the MTE on attainment, participants in both MTE cohort 1 and cohort 2 report that engagement in the MTE programme and other aspects of the TfM programme had led to change in schools' practices and provided considerable opportunities for teachers' professional learning. This has led to implementation of East Asian informed teaching approaches and reflection on mathematics teaching more generally.

Teachers and school leaders report increases in teacher confidence, subject knowledge and knowledge of teaching mathematics as a result of engagement in MTE activities as well as the wider TfM programme and other mastery innovations. Thus, the MTE and the Teaching for Mastery Programme have the potential to support school leaders seeking ways to catalyse improvement in mathematics teaching. The role of school leaders, as in most innovations, has been identified by participants as central to the innovation's success. As part of the PMTMSP, school leaders attend events where TfM principles are outlined. MTE participants reported Maths Hub engagement with school leaders locally prior to engagement with the PMTMSP. However, both MTE cohort 1 interviews and MTE cohort 2 interviews identified the potential for such initiatives to be further developed.

MTE mastery pedagogy in KS2

There is a difference in impact of the MTE in KS1 and KS2, possibly related to a difference in the extent to which MTE mastery pedagogy has been implemented in KS1 versus KS2 or differences in the suitability of the approach in the two Key Stages. This implies that implementation of MTE mastery pedagogy in KS2 may be more challenging than in KS1, or may need to be adapted in order to be impactful in KS2. This may also be due to pupils in KS2 during the implementation period having already experienced a different approach to teaching mathematics and finding it challenging to adjust. It may be that if pupils had been taught mathematics in accordance with the MTE mastery approach during KS1, then implementation in KS2 would be more impactful. Regardless, the number of schools implementing MTE mastery pedagogy with Y6 is lower than for Y2, suggesting a possible need for additional support to overcome the pressure schools feel in relation to KS2 assessment outcomes (see section 10.3). Given the relationship between MTE mastery pedagogy and teaching for mastery, the finding of a difference

between KS1 and KS2 for MTE mastery pedagogy suggests the need for monitoring and further research with regard to this issue for TfM.

Ensuring alignment of accountability systems and policy

A common concern expressed by MTE cohort 1 teachers and to a lesser extent by cohort 2 teachers was the relationship between accountability systems and implementing mastery. This concern lessened from the first year of the evaluation to the third year. However, such concerns were still stated in the third year. For example, one MTE cohort 2 teacher described an episode during an Ofsted inspection where the inspector had an apparent lack of understanding of teaching for mastery. The teacher acknowledged that the Ofsted lead inspector for mathematics had communicated clearly that schools should not be penalised for adopting TfM practices. However, the school's experience did not accord with this. Whilst this is a single anecdote, such stories can have considerable power beyond the individual case and other respondents also discussed the potential risk of implementing new practices. In addition to concerns about inspection, other issues raised were about the alignment of assessment with mastery approaches. This suggests the need to consider how to continue to address these concerns and reassure schools.

The change mechanism at a system level

There is now some evidence that the MTE can impact at KS1 at least for those schools directly involved in the exchange. However, as yet, there is no evidence that this will also lead to changes in those schools working with mastery specialists in TRGs and similar. This would require a study that considers outcomes for schools that mastery specialists are working with.

As has been noted, TfM pedagogy as promoted at the time of reporting is different from, though related to, the mastery pedagogy that MTE cohort 1 implemented. Thus the impact findings for MTE cohort 1 may not apply to MTE cohort 2 schools implementing TfM. However, they may be more relevant to schools that have not experienced the PMTMSP directly, as the differences between MTE mastery pedagogy and TfM is not likely to be greater than the difference between TfM as envisaged and as enacted in schools supported by mastery specialists. A common feature of any programme or intervention that involves a degree of cascade or diffusion of innovation, is a dilution or weakening of fidelity, the more distant the relationship is to those who have designed the programme. In section 9, findings were reported of concerns raised by those supporting other schools, and specifically mastery specialists who were part of MTE cohort 2, about the challenges those they supported faced in making changes. To understand this in more depth and to examine in more detail effective activity by MTE schools in working with other schools would require a study that, for example, considers outcomes for schools that mastery specialists are working with.

14. Conclusion

Early in the MTE programme, a variety of initiatives were put in place to support implementation. This was as a result of both interim evaluation findings and the NCETM and DfE's internal evaluation and monitoring which led to a recognition that the exchange programme alone was likely to be insufficient to lead to implementation by participating schools. Furthermore, it became evident that support was needed in order for East Asian informed practices to be taken up more widely by other schools. Influenced by these findings, the Teaching for Mastery programme was developed, comprising various components.

The Mathematics Teacher Exchange has been important to the development of the Teaching for Mastery Programme and continues to be an important component. Arguably, this is the largest policy innovation in mathematics education since the introduction of the National Numeracy Strategy in the late 1990s. An increasing number of committed mastery specialists are being trained. There is evidence from the evaluation that where teacher leaders engage with the learning from the MTE programme (both cohort 1 and cohort 2) and with mastery innovations more generally (cohort 2, and the mathematics coordinator survey), this leads to change in their schools and beyond as well as impacting teacher professional learning.

From this evaluation, there is some evidence that for some of those schools involved in the MTE cohort 1 exchange, there were positive impacts on pupil KS1 mathematics attainment. However, as yet there is no quantifiable evidence that the MTE is leading to improvements in pupil attainment in mathematics at KS2 over and above changes that were being implemented in contrast schools. Further evaluation activity is needed to provide an evidential basis for the policy and programme at the time of reporting and to identify which elements of the innovation are most effective.

With regard to validity of the interpretation in relation to impact, it is important to note that the nature of the impact study in this evaluation, using a quasi-experimental design with a matched comparison group, cannot establish causality. This is true both for the KS1 and the KS2 findings, and there remains the possibility of the outcomes being either a 'false positive' or a 'false negative' respectively. However, in relation to MTE cohort 1, the credibility of the findings reported is supported by relatively high percentages of the original samples (in the case of the main headline result, 100% of the original cohort, and for the follow-on analyses 79% of the original cohort).

The findings for the MTE are inconclusive and they cannot be generalised to the current MTE programme and the TfM programme. It is therefore important that further evidence is gathered to ascertain if the investment in TfM represents value for money, including whether the intended mechanism for system-wide change is likely to succeed.

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Reference: DFE-RR902

ISBN: 978-1-78105-991-3

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Sheffield Hallam University | Sheffield Institute of Education

Mathematics Teacher Exchange: China-England. Technical report and supplementary data and analysis

January 2019

Sheffield Hallam University

Boylan, M., Wolstenholme, C., Demack, S., Maxwell, B., Jay, T., Adams, G. and Reaney, S.

Glossary

Bivariate - a statistical term that refers to analyses that involve only two variables.

Cluster - a statistical term that refers to the grouping of similar units of analyses together. For example, pupils are clustered into schools and schools are clustered into geographical areas. This is an example of natural (systemic) hierarchical pupil clustering.

CPD - continuing professional development.

High mastery - a category derived from application of implementation criteria related to a model of MTE mastery pedagogy indicating implementation at a high level.

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

Linear Regression - a statistical modelling technique for examining variation in a scale/continuous outcome variable through the introduction of (scale or categorical) explanatory variables.

Logistic Regression - a statistical modelling technique for examining variation in a categorical outcome variable through the introduction of (scale or categorical) explanatory variables.

Mastery at or above threshold level - a category derived from application of implementation criteria related to a model of mastery pedagogy. When the meaning is clear in context this is shortened to implementation of mastery or similar.

Mastery specialist - an alumni of the Primary Mathematics Teaching for Mastery Specialists Programme with responsibility for leading change in their own school and supporting change in six to seven other schools, as well as collaborating with Maths Hub leadership and other mastery specialists.

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

Mathematics Teacher Exchange - exchange programme involving 48 English primary schools and teachers in Shanghai in 2014/15 and 70 English primary schools in 2016/17. Abbreviated as '**MTE**' or 'the exchange'.

Mathematics Teacher Exchange cohort 1 school - a school selected by the local Maths Hub which participated in the exchange in 2014/15 and hosted a Shanghai teacher and in nearly all cases had one or more members of staff visit Shanghai. In the first and third interim reports these schools were referred to as 'lead primary schools', however the change in terminology in the final report aims to avoid confusion with

schools now identified in Maths Hubs as leading mastery developments, which in some cases are not the same. Abbreviated as '**MTE cohort 1 school**'.

Mathematics Teacher Exchange cohort 2 school - a school that was involved in the exchange in 2016/17 by having one of their members of staff visit Shanghai and, in most cases, hosting a Shanghai teacher. Teachers rather than schools were recruited to participate in the exchange programme and were selected from the alumni of the Primary Mathematics Teaching for Mastery Specialists Programme. Abbreviated as '**MTE cohort 2 school**'.

Mathematics Teacher Exchange lead - used to denote school staff who had been directly involved in the exchange programme and/or leading wider dissemination within their school and, in some cases, their local and wider Maths Hub Network. Note that in previous reports references were made to 'lead primary teacher'. However, as the Teaching For Mastery Programme has developed, leadership and promotion of teaching for mastery has extended to other teachers such as mastery specialists. Abbreviated as '**MTE lead**'.

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 as of November 2015 there are 35 Maths Hubs.

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

MTE Mastery pedagogy - the name given in the report to teaching approaches aiming to develop mastery informed by East Asian practices and used, in particular, to refer to practices of MTE schools. MTE mastery pedagogy is a more general description than the specific 'teaching for mastery' promoted by the NCETM.

Multilevel - a statistical term that relates to statistical modelling with more than one cluster level. A 2-level analysis might include school and individual pupil levels.

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

NCTL - National College for Teaching and Leadership.

Ofsted - Office for Standards in Education.

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

SEND - Special Educational Need or Disability

Substantial mastery - self-reported implementation of mastery by interviewees. This is particularly important in analysis of impact where self-reports of substantial implementation of mastery for two years for the Y2 and Y6 2016/17 cohorts is used to define a sub-sample of schools for exploratory analysis.

Teaching for mastery - NCETM-promoted East Asian informed mastery pedagogy that is the focus of the PMTMSP. Abbreviated as **TfM**.

TSA - Teaching School Alliance - alliances led by a Teaching School, including schools benefiting 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.

References to previous evaluation reports:

The **'first interim report'** refers to the report of Boylan, Wolstenholme, Maxwell, Jay, Stevens and Demack (2016) Longitudinal Evaluation of the Mathematics Teacher Exchange: China-England. Interim research report. (DfE)[34]

The **'second interim report'** refers to the report of Demack, Jay, Boylan, Wolstenholme, Stevens and Maxwell (2017) Longitudinal Evaluation of the Mathematics Teacher Exchange: China-England. Second interim research report. (DfE)[35]

The **'third interim report'** refers to the report of Boylan, Maxwell, Wolstenholme and Jay (2017) Longitudinal Evaluation of the Mathematics Teacher Exchange: China-England. Third interim research report. (DfE)[36]

[34] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536003/Mathematics_Teacher_Exchange_Interim_Report_FINAL_040716.pdf

[35] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/666449/MTE_second_interim_report_121217.pdf

[36] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/666450/MTE_third_interim_report_121217.pdf

Contents

List of figures

List of tables

1. Introduction

This technical report is intended to be read alongside the final published main report of the Longitudinal evaluation of the Mathematics Teacher Exchange: China-England – Final Report and both together constitute a single research output. The table below provides a summary of the content of the sections that follow, and refers to the sections in the main report that material or data are most closely connected to.

Table 23: Content of technical report and corresponding area in main report

Technical report section	Content/purpose	Link to main report
Section 2. Previous reports	Briefly outlines the aims, objectives and contents of previous reports.	Section 1.4. Previous reports
Section 3. NCETM descriptions of mastery	NCETM descriptions of teaching for mastery are provided before the insertion of a copy of the NCETM's information for applicants for the Primary Mathematics Teaching for Mastery Specialists Programme.	Section 2 Mastery innovations and the Teaching For Mastery Programme and the Shanghai teacher exchange Section 4 The Mathematics Teacher Exchange as a change innovation
Section 4. Overview of the evaluation methodology	The four strands of the evaluation are summarised.	Section 3. Evaluation methodology, data collection and analysis
Section 5. Strand one Year 3 data collection and analysis and strand one data corpus	Details of the data collection and analysis for strand one are outlined, with more detail given on Year 3 qualitative data collection which has not been reported in previous interim evaluation reports.	Section 3. Evaluation methodology, data collection and analysis
Section 6. Strand one supporting data	Data predominantly collected through strand one is reported here, supporting findings discussed in the main report.	Section 6. Patterns of implementation and change over time
Section 7. Strand one	Discussion on how levels	Section 6. Patterns of

Technical report section	Content/purpose	Link to main report
implementation criteria and analysis	of implementation of mastery between schools have been determined.	implementation and change over time
Section 8. Strand two analysis	Effect sizes are reported and explained before further details of the impact analysis. Pupil attitude survey analysis is presented.	Section 8. Impact of change on pupils
Section 9. Strand four cohort 2 - evaluation data collection and analysis	Details of data collection and analysis for strand four: MTE cohort 2 schools.	Section 3.2. Collection and analysis of Year 3 data. Cohort 2 findings also reported throughout main report alongside cohort 1 findings.
Section 10. Further research into mastery implementation and the Teaching For Mastery Programme	Furher development of issues considered in the main report about addressing the need to gather further evidence.	Sectioin 13. Interpreation of findings.

2. Previous reports

Three interim reports have been published prior to the final and technical report. The content of these interim reports is outlined below.

First interim report[37]

The first interim report (published July 2016) presented predominantly qualitative data analysis of interviews with the 48 MTE cohort 1 school staff. Reporting focused on experiences of the exchange and schools' and teachers' initial implementation of Shanghai-informed mathematics teaching. The report:

- described and assessed the early impact of the first exchange on practices
- described and assessed the perceptions of pupil outcomes
- evaluated the efficacy of exchange activities
- gave an overview of survey data collected in 2014 from the MTE cohort 1 schools, as well as data from contrast and other Maths Hub schools.

The purpose of the survey was to identify and compare levels of mastery-informed teaching in schools both directly involved and not involved in the exchange. The first report also:

- gave an overview of the background of the MTE initiative and the aims of the exchange
- provided details on the longitudinal evaluation methodology
- identified issues to consider for the future success of the initiative.

Second interim report[38]

The second interim report (published December 2017) described the quasi-experimental design employed to examine attainment outcomes. Using propensity score matching a group of contrast school were identified to compare outcomes with those of the MTE exchange schools. The matching process is described. Limitations of the analytical

37 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536003/Mathematics_Teacher_Exchange_Interim_Report_FINAL_040716.pdf

38 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/666449/MTE_second_interim_report_121217.pdf

approach are described in detail. The report then presents analysis of pupil outcome baseline data, through analysis of Key Stage 1 and Key Stage 2 attainment data. In order to form a baseline, data were utilised from a period prior to the start of the intervention until the end of the first year of the intervention. Data from the first Year 6 pupil attitude survey were also reported, providing a baseline to enable analysis of how the impact of any changes in practice influence changes in pupil attitudes to mathematics.

Third interim report[39]

The third interim report (published alongside the second report in December 2017) presented findings from analysis of follow-up interviews with lead teachers from the MTE cohort 1 schools. These took place during their second year of implementation in 2016. The report focused on changes in school-wide and classroom-based practice reported by teachers. The report also described variation of implementation across the schools, perceptions of teacher professional development outcomes and pupil outcomes.

39 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/666450/MTE_third_interim_report_121217.pdf

3. NCETM descriptions of mastery and teaching for mastery and the PMTMSP

For completeness and ease of reference, in this section the text of three NCETM descriptions of TfM are provided.

NCETM (2014). Mastery approaches to mathematics and the new national curriculum[40].

'Mastery' in high-performing countries

The content and principles underpinning the 2014 mathematics curriculum reflect those found in high-performing education systems internationally, particularly those of east and south-east Asian countries such as Singapore, Japan, South Korea and China. The OECD suggests that by age 15 students from these countries are, on average, up to three years ahead in maths compared to 15 year-olds in England.

What underpins this success is the far higher proportion of pupils reaching a high standard and the relatively small gaps in attainment between pupils in comparison to the picture in England.

Though there are many differences between the education systems of England and those of east and south-east Asia, we can learn from the mastery approach to teaching commonly followed in these countries. Certain principles and features characterise this approach:

- 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.

[40] https://www.ncetm.org.uk/public/files/19990433/Developing_mastery_in_mathematics_october_2014.pdf.

- 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.

The intention of these approaches is to provide all children with full access to the curriculum, enabling them to achieve confidence and competence – 'mastery' – in mathematics, rather than many failing to develop the maths skills they need for the future.

Curriculum changes

The 2014 national curriculum for mathematics has been designed to raise standards in maths, with the aim that the large majority of pupils will achieve mastery of the subject. Mathematics programmes of study state that:

- All pupils should become fluent in the fundamentals of mathematics, including through varied and frequent practice, so that pupils develop conceptual understanding and are able to recall and apply their knowledge rapidly and accurately to problems.
- The expectation is that the majority of pupils will move through the programmes of study at broadly the same pace. When to progress should always be based on the security of pupils' understanding and their readiness to progress to the next stage.
- Pupils who grasp concepts rapidly should be challenged through rich and sophisticated problems before any acceleration through new content. Those pupils who are not sufficiently fluent with earlier material should consolidate their understanding, including through additional practice, before moving on.

For many schools and teachers, the shift to this 'mastery curriculum' will be a significant one. It will require new approaches to lesson design, teaching, use of resources and support for pupils.

Key features of the mastery approach

Curriculum design

A detailed, structured curriculum is mapped out across all phases, ensuring continuity and supporting transition. Effective mastery curricula in mathematics are designed in relatively small, carefully sequenced steps, which must each be mastered before pupils move to the next stage. Fundamental skills and knowledge are secured first. This often entails focusing on curriculum content in considerable depth at early stages.

Teaching resources

A coherent programme of high quality curriculum materials is used to support classroom teaching. Concrete and pictorial representations of mathematics are chosen carefully to help build procedural and conceptual knowledge together. Exercises are structured with great care to build deep conceptual knowledge alongside developing procedural fluency.

The focus is on the development of deep structural knowledge and the ability to make connections. Making connections in mathematics deepens knowledge of concepts and procedures, ensures what is learnt is sustained over time, and cuts down the time required to assimilate and master later concepts and techniques.

One medium for coherent curriculum materials is high quality textbooks. These have the additional advantage that pupils also use them to return to topics studied, for consolidation and for revision. They represent an important link between school and home.

Lesson design

Lessons are crafted with similar care and are often perfected over time with input from other teachers, drawing on evidence from observations of pupils in class.

Lesson designs set out in detail well-tested methods to teach a given mathematical topic. They include a variety of representations needed to introduce and explore a concept effectively and also set out related teacher explanations and questions to pupils.

Teaching methods

Precise questioning during lessons ensures that pupils develop fluent technical proficiency and think deeply about the underpinning mathematical concepts. There is no prioritisation between technical proficiency and conceptual understanding; in successful classrooms these two key aspects of mathematical learning are developed in parallel.

Pupil support and differentiation

Taking a mastery approach, differentiation occurs in the support and intervention provided to different pupils, not in the topics taught, particularly at earlier stages. There is no differentiation in content taught, but the questioning and scaffolding individual pupils receive in class as they work through problems will differ, with higher attaining pupils challenged through more demanding problems which deepen their knowledge of the same content. Pupils' difficulties and misconceptions are identified through immediate formative assessment and addressed with rapid intervention – commonly through individual or small group support later the same day. There are very few 'closing the gap' strategies, because there are very few gaps to close.

Productivity and practice

Fluency comes from deep knowledge and practice. Pupils work hard and are productive. At early stages, explicit learning of multiplication tables is important in the journey towards fluency and contributes to quick and efficient mental calculation. Practice leads to other number facts becoming second nature. The ability to recall facts from long term memory and manipulate them to work out other facts is also important.

All tasks are chosen and sequenced carefully, offering appropriate variation in order to reveal the underlying mathematical structure to pupils. Both class work and homework provide this 'intelligent practice', which helps to develop deep and sustainable knowledge.

Implications for professional development and training of teachers

Teachers of mathematics in countries that perform well in international comparisons are mathematics specialists, including those in primary schools. They have deep subject knowledge, and deep knowledge of how to teach mathematics. They engage in collaborative planning and are continually seeking to improve their effectiveness.

Specialist mathematics teachers will therefore require:

- Deep structural subject knowledge of mathematics.
- Strong understanding of the structure of the curriculum and its aims: fluency, accuracy, precision, reasoning and problem-solving, and how to apply these to teaching.
- Insight of what is meant by mastery of the curriculum, the factors that contribute to it and how it is achieved.
- Appreciation of the importance of practice and the nature of intelligent practice to develop deep and sustainable understanding which contributes to mastery for all.
- Effective strategies to support pupils to learn, recall and apply multiplication tables.
- Knowledge of mathematics as a network of interconnected ideas and an appreciation that making connections reduces the amount of mathematics to learn, deepens knowledge and contributes to sustainability of understanding over time.
- The ability to select and employ effectively the use of mathematical representations to enable pupils to access the underlying structure of the mathematics.
- An appreciation of the features of good textbooks and when and how to use them appropriately to support high quality teaching.
- Opportunities to collaborate with other professionals.

- Knowledge of how effectively to deliver high quality whole-class teaching and provide access for all pupils.
- The ability to provide quick feedback to pupils and effective intervention to support all pupils to keep pace with the rest of the class.

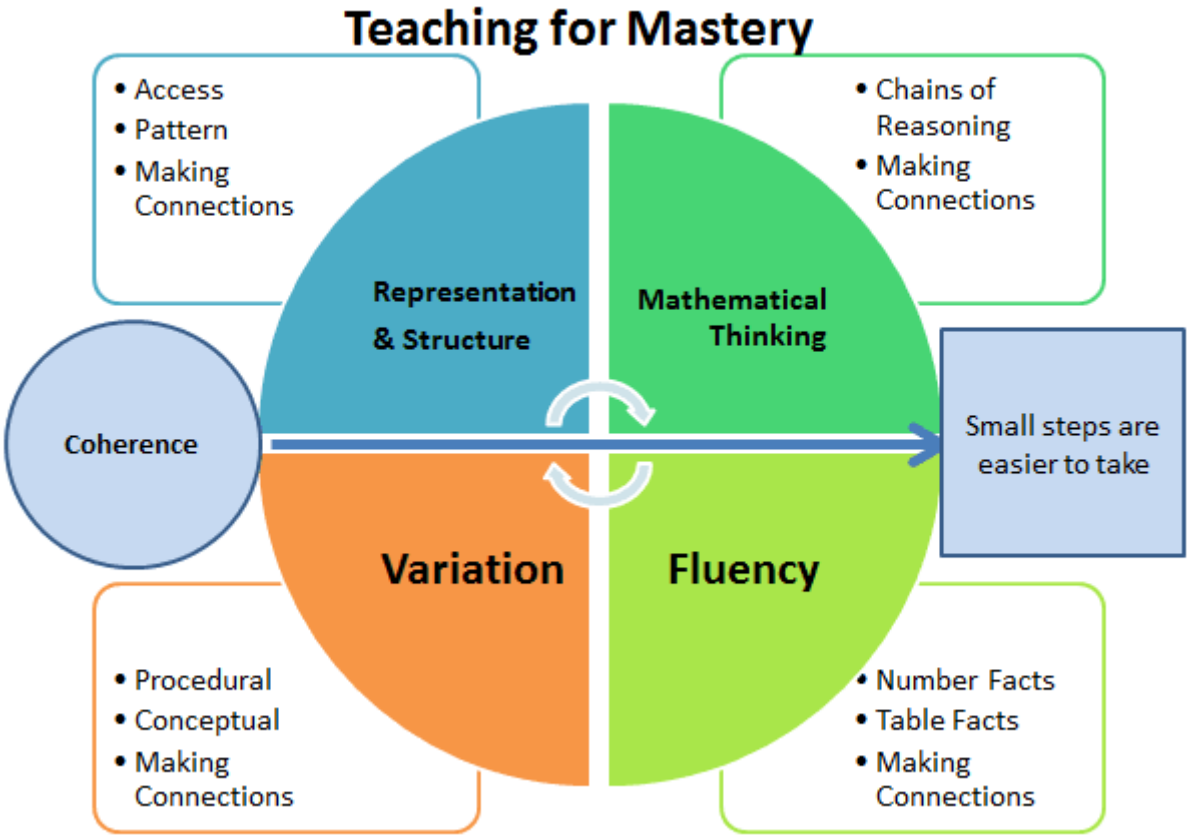
NCETM (2016). The essence of mathematics teaching for mastery[41].

- Maths teaching for mastery rejects the idea that a large proportion of people 'just can't do maths'.
- All pupils are encouraged by the belief that by working hard at maths they can succeed.
- Pupils are taught through whole-class interactive teaching, where the focus is on **all** pupils working together on the same lesson content at the same time, as happens in Shanghai and several other regions that teach maths successfully. This ensures that all can master concepts before moving to the next part of the curriculum sequence, allowing no pupil to be left behind.
- If a pupil fails to grasp a concept or procedure, this is identified quickly and early intervention ensures the pupil is ready to move forward with the whole class in the next lesson.
- Lesson design identifies the new mathematics that is to be taught, the key points, the difficult points and a carefully sequenced journey through the learning. In a typical lesson pupils sit facing the teacher and the teacher leads back and forth interaction, including questioning, short tasks, explanation, demonstration, and discussion.
- Procedural fluency and conceptual understanding are developed in tandem because each supports the development of the other.
- It is recognised that practice is a vital part of learning, but the practice used is **intelligent practice** that both reinforces pupils' procedural fluency and develops their conceptual understanding.
- Significant time is spent developing deep knowledge of the key ideas that are needed to underpin future learning. The structure and connections within the mathematics are emphasised, so that pupils develop deep learning that can be sustained.
- Key facts such as multiplication tables and addition facts within 10 are learnt to automaticity to avoid cognitive overload in the working memory and enable pupils to focus on new concepts.

[41] URL https://www.ncetm.org.uk/files/37086535/The+Essence+of+Maths+Teaching+for+Mastery+june+2016.pdf Retrieved July 2016.

NCETM (2017). Five Big Ideas in Teaching for Mastery[42].

A central component in the NCETM/Maths Hubs programmes to develop Mastery Specialists has been discussion of Five Big Ideas, drawn from research evidence, underpinning teaching for mastery. This is the diagram used to help bind these ideas together:



A true understanding of these ideas will probably come about only after discussion with other teachers and by exploring how the ideas are reflected in day-to-day maths teaching, but here's a flavour of what lies behind them:

Coherence
Connecting new ideas to concepts that have already been understood, and ensuring that, once understood and mastered, new ideas are used again in next steps of learning, all steps being small steps

[42] URL https://www.ncetm.org.uk/resources/50042

Representation and Structure
Representations used in lessons expose the mathematical structure being taught, the aim being that students can do the maths without recourse to the representation

Mathematical Thinking
If taught ideas are to be understood deeply, they must not merely be passively received but must be worked on by the student: thought about, reasoned with and discussed with others

Fluency
Quick and efficient recall of facts and procedures and the flexibility to move between different contexts and representations of mathematics

Variation
Varying the way a concept is initially presented to students, by giving examples that display a concept as well as those that don't display it. Also, carefully varying practice questions so that mechanical repetition is avoided, and thinking is encouraged.

Primary Mastery Specialist Programme: Cohort 3 (2017-18) – Information

The text below is taken from the NCETM's information for applicants for the Primary Mastery Specialist Programme

Following the very successful first two cohorts of the Mastery Specialist programme, the NCETM and Maths Hubs are now seeking to recruit a third cohort of 140 expert primary school teachers (4 per Maths Hub) to develop and work as **Primary Mastery Specialists**. This document gives information about the programme and how teachers and their schools can apply to be involved. The closing date for applications is Wednesday 19th April.

Background

Since 2014, The NCETM and Maths Hubs have been working together to develop approaches to teaching for mastery within primary mathematics. This has been informed by the teaching of mathematics in high performing South East Asian jurisdictions. Each year since 2015 the NCETM and Maths Hubs have recruited 140 Mastery Specialist teachers. The first year in post is a training and development year, establishing mastery in their own schools, with the support of the senior leadership team. In the following years, they lead Work Groups involving six or seven other schools in the development of teaching for mastery.

The programme

The NCETM and the Maths Hubs recruited a third cohort of 140 teachers to develop and work as Mastery Specialists. 2017-18 was the development year for the teachers and their schools and then, in 2018-19 and in 2019-20, the Mastery Specialists will each lead a Teaching for Mastery Work Group for their Maths Hub. It is expected that the Mastery Specialist's school becomes a leading exponent of teaching for mastery in this time and so the school needs to ensure that it has the capacity and desire to take on and develop a teaching for mastery approach in the next few years. Before a teacher applies for the role, head teachers might find it useful to look at the NCETM website where there are interviews with heads who have led the introduction of teaching for mastery in a school. (https://www.ncetm.org.uk/resources/49822)

In their development year, 2017-18, participating teachers will:

- attend the NCETM cohort induction day (Monday 10th July 2017) along with their head teacher
- participate in three two-day residential professional development events led by the NCETM (October 2017, January 2018, and June 2018)
- develop their own understanding and skills for teaching mathematics for mastery in their own class
- work with colleagues, supported by the head teacher, to develop teaching for mastery approaches across their school, using a range of professional development activity, including regular Teacher Research Group (TRG) meetings
- lead a pilot TRG with teachers from interested local schools
- collaborate with the Maths Hub's leadership and the other Maths Hub Mastery Specialists

This will require 15 days teacher release time and will be fully funded through the Maths Hubs.

In 2018-19 and 2019-20, the Mastery Specialists will:

- lead a Teaching for Mastery Work Group for their Maths Hub involving six/seven schools
- lead a half-termly Work Group meeting with 12/14 teachers (two lead teachers from each school)
- carry out a termly support visit to each school to observe teaching, support in-school TRGs, and work with the lead teachers and head teacher

- continue to develop and embed teaching for mastery approaches across their own school
- continue to collaborate with the Maths Hub's leadership and Mastery Specialists

This will require 30/33 days teacher release time and will be fully funded through the Maths Hubs.

Benefits for participating teachers and their schools

Participating in the programme will provide the following benefits to the Mastery Specialists and their schools:

- Mastery Specialists will develop:
  - understanding of the principles of mastery within the context of teaching mathematics
  - deep subject knowledge of primary mathematics to support teaching for mastery
  - skills of teaching, planning and assessment in order to effectively support pupils in developing a deep and sustainable understanding (i.e. mastery) of mathematics
  - ability to support teachers, within their own school and in other schools, to adopt a teaching for mastery approach, including leading Teacher Research Groups
- Mastery Specialists will have the opportunity to work closely with the NCETM team and the national and local communities of Mastery Specialists
- Mastery Specialists, who are not already accredited NCETM PD Leads, will be able to gain this accreditation through successful completion of the programme
- The Mastery Specialist's school will benefit from high quality and sustained support in embedding teaching for mastery across the school

Who should apply

Table 2 below shows the essential and desirable criteria for applicants to the programme. This should be evidenced in the application form, which includes both the applicant's statement and the head teacher's reference.

Table 24: Criteria for applicants to the mastery specialist programme

Essential	Desirable
Qualified Teacher Status	Additional Status, e.g. Mathematics SLE/MaST
Employed as a teacher in a	Mathematics Subject Leader

Essential	Desirable
Primary/Infant/Junior/Middle School, and regularly teaching mathematics to the same class of children at least three days/week	
Able to fulfil the programme requirements and time commitment outlined above	
Good teaching skills in mathematics as evidenced by internal/external/Ofsted observation	A minimum of four years teaching primary mathematics
Passion and enthusiasm for teaching for mastery	A desire to develop as a specialist teacher of primary mathematics
Ability to work collaboratively with others	
Successful track record of working with other professionals effectively within your own school	Successful track record of working effectively with other professionals across a group of schools
Excellent communication and interpersonal skills	The ability to grow leadership capacity in others
An understanding of what constitutes effective learning in mathematics and the ability and confidence to communicate this	

Maths Hubs will look to appoint Mastery Specialists so that they both meet the criteria as set out above but also fit into the Hub's strategic plan for developing teaching for mastery across the region.

Expectations of participating teachers and their schools

For teachers selected to be part of the programme, there are the following expectations of them and their schools:

- The head teacher and Mastery Specialist commit to developing and embedding mathematics teaching for mastery approaches across the school, supported by professional development activity, including regular TRG meetings in their own school
- The head teacher commits to supporting the Mastery Specialist with their outreach work with other schools in ensuring that they are given appropriate release time .
- The Mastery Specialist commits to developing their understanding and practice related to mathematics teaching for mastery including:
    - attending the cohort induction day (10th July 2017)
    - participating in the three two-day residentials

    - developing mathematics teaching for mastery within their own class
- The Mastery Specialist commits to all aspects of the role and the release time required (2017-18: 15 days; 2018-19: 30/33 days; 2019-20: 30/33 days) including:
    - supporting teachers within their own school and leading regular TRG meetings
    - running a pilot TRG with interested schools (2017-18)
    - leading a Teaching for Mastery Work Group (2018-19 and 2019-20) involving half-termly cross-school TRG meetings and termly support visits to Work Group schools
    - collaborating with the Maths Hub's leadership and Mastery Specialists
- The head teacher commits to support the Mastery Specialist, including:
    - attending the cohort induction day (10th July 2017)
    - helping the specialist develop and embed teaching for mastery within the school
    - ensuring the teacher receives the required release time
- The Mastery Specialist and head teacher will provide any reports required by the Maths Hub and participate in any evaluation processes required

Funding

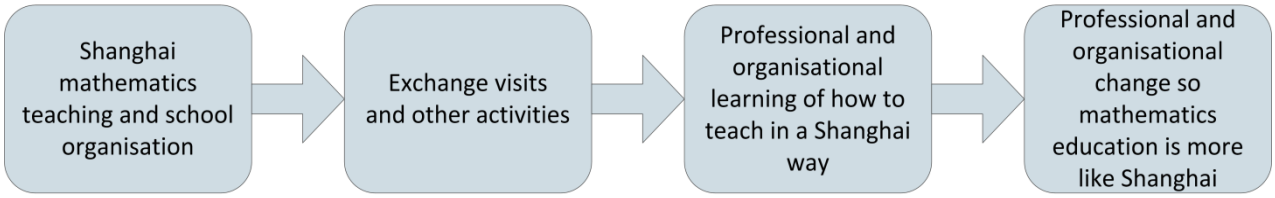
In the development year, 2017-18, your Maths Hub will fund the cost of 15 days release time for the Mastery Specialist's work and the cost of travel to the NCETM induction conference. There will also be £2000 matched funding for the school to purchase textbooks from the DfE approved list. In 2018-19 and in 2019-20, your Maths Hub will fund the cost of 30/33 days release time for the Mastery Specialist's work and the cost of travel for school support visits.

4. Overview of the evaluation methodology

4.1 The type of innovation

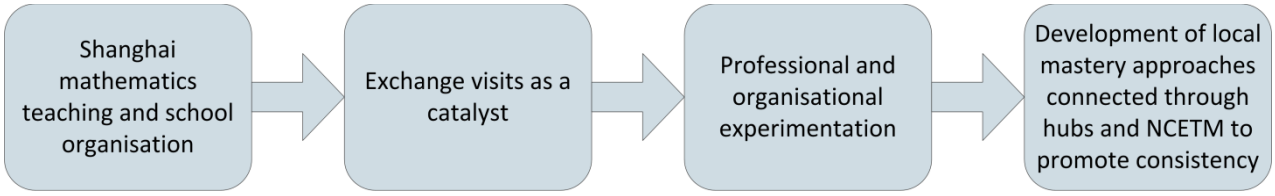
The MTE can be conceptualised in two different ways in terms of the nature of innovation and both of these perspectives inform the evaluation design. Firstly, the exchange has features of the implementation of a relatively well-defined innovation. From this perspective, the aim of the exchange is to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

Figure 12: The Mathematics Teacher Exchange as an adoptive innovation



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 13: 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 skills and knowledge 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 organisational learning through adaptation. Analysis of the exchange design, implementation and outcomes indicate that the exchange has features of both adoptive and adaptive innovation. Actual implementation of lessons from the exchange has been influenced by other factors including, importantly, NCETM's formulation and promotion of TfM.

4.2 Evaluation strands

The evaluation methodology is described in the main report, as are the evaluation objectives, and in more detail in the previous interim reports. In summary, the evaluation had four strands that are summarised here.

Strand one

Strand one consisted of a longitudinal multiple-case study design focused on MTE cohort 1 schools, encompassing both exploratory and evaluative dimensions (Yin, 2013). Data were collected through a combination of site visits and telephone interviews in three periods in the spring/summer of 2015, 2016 and 2017. This was supplemented, in the first year of the evaluation, by a set of interviews with Maths Hub leads and key NCETM and DfE stakeholders. In 2015 and 2017, mathematics coordinators in MTE cohort 1 schools and others within the Maths Hubs were surveyed. For 28 schools, reports were received either direct from schools or from NCETM in 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. Data from an NCETM survey in 2016 were also analysed.

Strand two

Strand two consisted of a longitudinal analysis of Key Stage 1 and Key Stage 2 attainment data, in comparison with a sample of 940 contrast schools[43]. Data used for the impact analysis were retrieved from the National Pupil Database (NPD) and the school census database. In addition, pupil attitudes to mathematics and to mathematics learning were surveyed in a sample of MTE cohort 1 schools in 2015 and 2017. The aim was to assess how changes to practices affect pupils' attitudes to mathematics over time. More detail is given in the main report in section 3.2.

Strand three

Strand three sought to identify initial patterns of effective change and early evidence of pupil impact in the first year of implementation. This involved follow-up telephone interviews with exchange teachers in a purposeful sample of MTE cohort 1 schools. Schools selected were ones where the initial case study visit indicated that notable changes in practices were occurring as a result of the exchange and this assessment could potentially be supported by school data. A thematic case analysis was conducted for each of the five MTE cohort 1 schools drawing on data collected during the strand one case study visit, together with data from the follow-up telephone interview. The five strand three cases also informed the analysis of patterns of implementation. Outcomes of strand three were reported in the first interim report.

[43] See below 'Analysis, reporting and samples' for further detail on the contrast school sample.

Strand four

Following the decision to extend the MTE to further cohorts and to embed it in the PMTMSP, the DfE commissioned an extension to the evaluation to consider the experiences and activities of a sample of MTE cohort 2 schools and teachers.

5. Strand one Year 3 data collection and analysis and strand one data corpus

In section 8, strand two data analysis is outlined. Below is the data collection and analysis for strand one.

5.1 Strand one Year 3 data collection and analysis

The final year of data collection in the MTE cohort 1 schools took place in spring/summer 2017 when schools were in their third year of implementation. A telephone interview was conducted with a member of staff from 40 of the 48 schools. The remaining eight schools withdrew from the research or did not respond to an invitation to be interviewed. The average length of the interviews was 59 minutes.

The 2017 interview schedule was made up of a mixture of 'checking' questions, closed questions and more in-depth, open questions. The checking questions were to confirm participants' answers from the 2016 interviews and to check if any particular practices had changed since then. For example, when asking about intervention, the interviewee would be read out the approaches to intervention they had described the previous year such as: intervention taking place daily, pupils being identified for intervention on a daily basis, lessons not being split, and intervention taking place after the lesson. Interviewees could then simply confirm this was the same or declare any changes to practice. This approach enabled a greater degree of confidence in the data, given that interviewees may have been substituted by colleagues over the course of the three-year project.

Closed questions were asked in order to help to quantify the changes made across the schools, and the open questions were used to gain in-depth information about the types of changes and the rationales for making them, and to obtain data in areas asked about in less detail in previous interviews such as changes to lesson preparation.

As was the procedure for the 2016 qualitative fieldwork, immediately following interviews, fieldworkers entered interviewees' answers to closed and checking questions into a spreadsheet. The spreadsheet data were then checked by the evaluation project manager to ensure these correlated with the transcripts. Where there was a discrepancy in the answers, a project director was asked to make the final decision. This process was utilised for ‘new’ closed questions as opposed to the checking questions as these were felt to be secure after the previous year’s checks.

All interviews recorded were then fully transcribed and the transcripts uploaded onto Nvivo 10 for analysis. An analysis meeting with the full team took place after the completion of all data collection, which enabled in-depth discussion about the implementation trends across the interviews, and aided in the development of a

conceptual framework. This early meeting helped to develop an emerging understanding of implementation of practices across the schools.

Within Nvivo, it was important to test if the codes already developed for the previous stage of data collection and analysis were relevant and sufficient for the 2017 data collection. To do this, each member of the evaluation team took an interview transcript and attempted to code the contents to existing higher-level codes. In addition, each member looked in depth at a specific area of implementation to decide if existing codes and child codes were sufficient or if new ones needed to be created. The evaluation team (consisting of project directors and the project manager) held a further analysis meeting to discuss the outcomes of this activity and the need for new codes in particular areas. New codes were created where needed. For example in 2017, participants were asked about lesson preparation in much greater depth than in previous interviews and therefore additional codes were created.

5.2 Strand one data corpus

MTE cohort 1 schools' participation in interviews over the three years is summarised in Table 3 below. As can be seen, a total of 38 (out of 48) interviewees have taken part in an interview in all three years of the longitudinal evaluation. Teachers from two schools re-engaged with the evaluation in year 3 after declining an interview in year 2. Reasons for non-participation in interviews were related to staff availability and workload.

MTE cohort 1 participation in longitudinal evaluation

Table 25: Participation in interviews over 3 years of evaluation

All 3 years	Years 1 and 2	Years 1 and 3	Year 1 only
38	5	2	3
79%	11%	4%	6%

Source: MTE cohort 1, interviews 2015, 2016 and 2017

Analysis, reporting and samples

In 2014/15, 48 schools from 32 Maths Hubs participated in the first MTE with a total of 64 teachers and school leaders visiting Shanghai alongside additional educators and NCETM delegates. All of these schools participated in interviews in the first year (2015). In 2016 and 2017, not all of these schools responded to invitations to participate in interviews. Figure 3 below shows the numbers participating in one or other year and in both years.

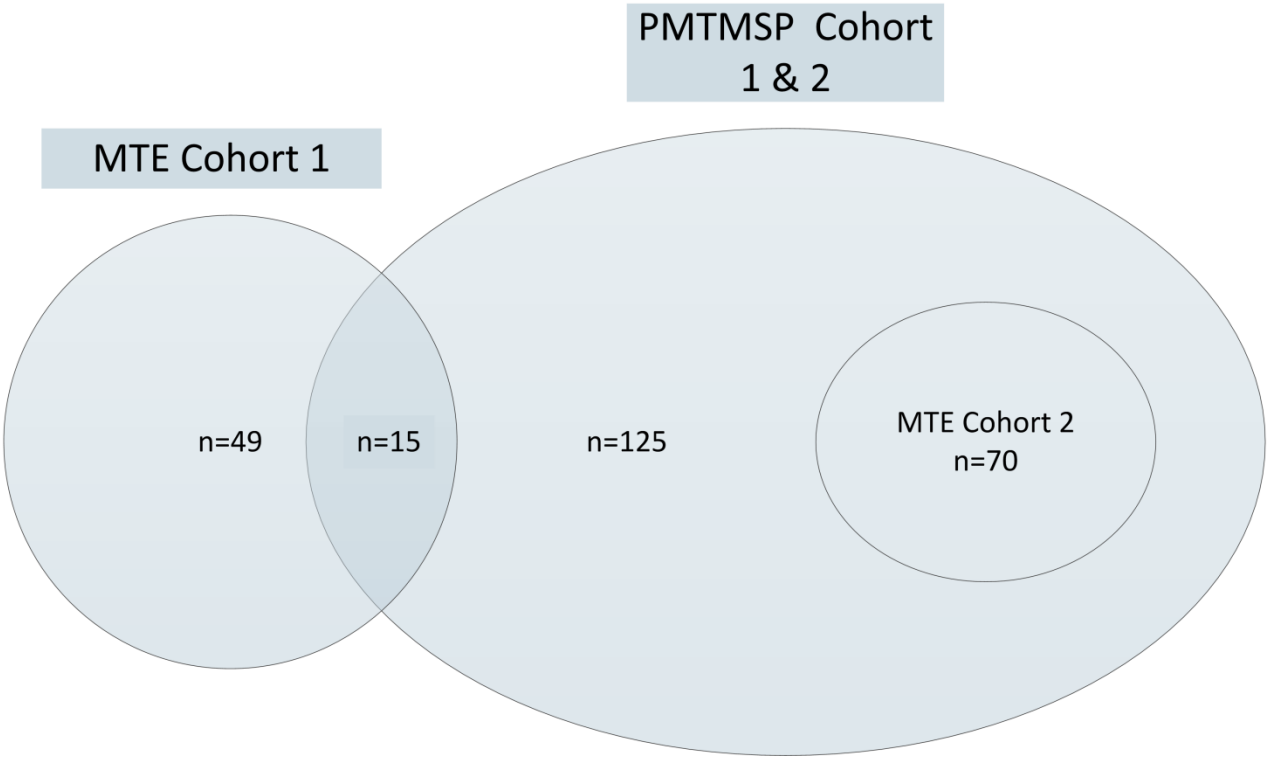
Figure 14: School participation in MTE cohort 1 interviews in 2016 and 2017

		2017		
		No	**Yes**	**Total**
2016	**No**	3	2	5
	Yes	5	**38**	43
	Total	8	40	

Data from 2016 and 2017 were used in the analysis of levels of implementation of some aspects of practice and the overall determination as to whether or not MTE mastery pedagogy had been put in place. Consequently, in relation to implementation, data are reported for 38 schools in the main report. The technical report provides data where relevant on the larger samples. In reporting other issues such as constraining influences and supporting influences on implementation, all data (where relevant) is reported.

As discussed in the second interim report, although 48 schools participated in the MTE in 2014/15, one of these was an infant school and another was a co-located junior school. As reported in the second interim report, this was the only infant school in the evaluation. The propensity score matching was undertaken using 2014 school-level Key Stage 2 data and so this infant school was not included in this matching process (and hence any of the impact analyses). The junior school was included along with two other junior schools and 44 primary schools. As a consequence, the impact analyses included 47 MTE schools (44 primaries, three juniors). Figure 4 below provides details of the overall samples for number of teachers involved. Teachers from the sample of 48 MTE cohort 1 schools which participated in the PMTMSP may have been different to those who went on the exchange to Shanghai.

Figure 15: Number of teachers in the MTE cohort 1 and cohort 2 sample and PMTMSP



The figure described - for the PMTSMP recruited totals not those completing the programme which may be slightly lower. Details of other samples, such as schools that returned pupil attitude survey data, and other survey samples are reported in the relevant sections with further detail in the technical report.

In addition to data collection via interviews, 28 school reports were received either direct from schools or from NCETM in August 2015 in the first year of the evaluation. The NCETM also provided an analysis and summary of all end-of-year reports received by them as well as of schools' interim reports. In 2016 (the second year of the evaluation) these data were collected by an NCETM survey and passed to the evaluators by the NCETM. There were a total of 39 responses from schools; these data were used to triangulate findings form the second round of data collection. In 2017 no school report data were collected.

Other data collection methods for strand one, as described earlier in section 4 were:

- **Maths Hub lead interviews**: In year 1, telephone interviews with 12 Maths Hub leads took place between February and March 2015. Hubs were randomly selected and then contacted to invite them to interview. A thematic analysis of the Maths Hub lead interviews was undertaken.

- **Key stakeholder interviews**: In year 1, between February and March 2015, four interviews with key stakeholders from the NCETM and DfE were undertaken. Interviews were analysed thematically.
- **Mathematics coordinator survey**: A survey of all MTE cohort 1 schools, the 940 contrast schools, and other schools within Maths Hubs (identified by Maths Hub leads as having had some contact with Maths Hub activity and/or with the MTE schools) took place between June and July 2015 in year 1 of the evaluation. A total of 46 maths coordinators in the 48 MTE cohort 1 schools completed the first survey along with 218 Maths Hub schools, and 53 contrast schools. In order to identify change over time, the survey was repeated in June and July 2017 and was distributed to all MTE cohort 1 and 2 schools, 940 contrast schools and other schools within Maths Hubs (identified by Hub leads as having had some contact with Maths Hub activity and/or with the MTE schools). A total of 77 schools from cohort 1 and cohort 2 completed the first survey along with 33 contrast schools.

Table 4 below provides details of the data corpus for strand one of the evaluation for the MTE cohort 1 schools and pupil survey data collected for strand two.

Table 26: Data corpus MTE cohort 1 schools for strand one and pupil survey in strand two

Case code	2015 int (visit/tele int)	2016 int	2017 int	Coordinator survey 1	Coordinator survey 2	NCETM report Y1	NCETM report Y2	Pupil survey Year 1	Pupil survey year2
1a	V	Y	Y	Y	N	Y	Y	Y	N
1b	T	Y	Y	Y	Y	Y	Y	Y	Y
2a	V	Y	N	Y	Y	Y	Y	Y	N
2b	T	Y	Y	Y	N	Y	N	N	Y
3a	T	Y	Y	Y	N	Y	N	Y	Y
3b	T	Y	Y	Y	N	Y	Y	N	N
4a	V	Y	Y	Y	Y	Y	Y	Y	Y
5a	V	Y	Y	Y	Y	Y	Y	Y	N
6a	V	Y	Y	Y	Y	Y	Y	Y	N
7a	V	N	Y	Y	Y	Y	Y	Y	Y
8a	V	Y	Y	Y	N	Y	N	N	N
9a	V	Y	Y	Y	Y	Y	Y	N	N
9b	V	Y	Y	Y	N	Y	N	N	N
10a	V	Y	Y	Y	N	N	Y	Y	Y
10b	T	N	N	Y	N	Y	N	Y	N
11a	V	Y	Y	Y	Y	N	Y	Y	Y
12a	T	Y	Y	Y	N	N	Y	Y	N
12b	V	Y	Y	Y	Y	N	Y	Y	Y
13a	V	Y	Y	Y	N	Y	Y	Y	N
14a	V	N	N	Y	N	Y	Y	Y	N
14b	T	Y	Y	Y	N	N	Y	Y	N
15a	V	Y	N	Y	N	Y	Y	Y	N

Case code	2015 int (visit/tele int)	2016 int	2017 int	Coordinator survey 1	Coordinator survey 2	NCETM report Y1	NCETM report Y2	Pupil survey Year 1	Pupil survey year2
16a	V	Y	Y	Y	Y	Y	Y	N	N
17a	V	Y	Y	Y	Y	Y	Y	Y	Y
18a	V	Y	Y	N	N	Y	Y	N	N
18b	T	Y	N	Y	N	N	N	N	N
19a	T	Y	Y	Y	N	Y	Y	Y	N
19b	V	Y	Y	Y	Y	N	Y	N	N
20a	V	Y	Y	Y	Y	Y	Y	N	Y
21a	V	Y	Y	Y	Y	Y	Y	Y	N
22a	T	Y	Y	Y	Y	Y	Y	Y	Y
22b	V	Y	Y	Y	Y	Y	Y	Y	Y
23a	T	Y	Y	Y	N	Y	N	N	N
24a	T	Y	Y	Y	N	N	Y	N	N
25a	V	Y	Y	Y	Y	N	N	Y	N
25b	T	Y	Y	Y	N	Y	Y	N	N
26a	V	N	Y	Y	N	Y	N	Y	N
27a	V	Y	Y	Y	Y	Y	Y	Y	Y
27b	T	Y	Y	Y	Y	N	Y	Y	Y
28a	T	Y	Y	Y	Y	Y	Y	Y	Y
29a	V	Y	Y	Y	Y	Y	Y	Y	Y
29b	T	Y	Y	Y	N	N	Y	Y	N
28b	V	Y	N	N	N	N	Y	Y	N
30a	V	Y	Y	Y	N	Y	Y	Y	N
31a	V	Y	Y	Y	N	Y	Y	Y	Y
31b	V	Y	Y	N	Y	Y	Y	Y	Y
32a	V	N	N	Y	N	N	N	N	N

Case code	2015 int (visit/tele int)	2016 int	2017 int	Coordinator survey 1	Coordinator survey 2	NCETM report Y1	NCETM report Y2	Pupil survey Year 1	Pupil survey year2
32b	T	Y	N	Y	N	N	N	Y	N
Total = 48	Total Visit=31	total yes =43	total yes =40	total yes= 45	total yes=22	total yes =34	total yes =37	total yes=34	total yes = 18

6. Strand one supporting data

In this section, additional data and findings are reported that supplement or support findings in the main report.

6.1 School and lead teacher interviewee characteristics

Data presented below are based on interviews with MTE cohort 1 teachers in 2016 and 2017. The number of interviews varied and therefore 2016 data are based on 43 interviews and 2017 data are based on 40 interviews. Consequently, the data are not directly comparable, as the schools involved varied slightly year on year, for example two schools were unable to commit to an interview in year 2 but did take part in year 3.

Of the 40 interviewees in 2017, 26 were the same as the person interviewed in 2016, and just over half (n=21) had been on the exchange visit in 2015. Of the 19 who did not go on the visits, 10 were maths leads, five were assistant head teachers, three were classroom teachers and one was a head teacher.

Table 27: MTE cohort 1 Interviewee job roles 2017

Maths lead	Senior leader	Teacher
19	18	3
48%	45%	8%

Source: MTE cohort 1, interviews 2017 *Percentages may add up to more than 100 due to rounding.

Table 5 above shows that the majority of interviewees in the third year were maths leads (n=19), followed by senior leaders (n=18). A number of maths leads and senior leaders were also class teachers.

Table 6 shows the characteristics of the schools involved.

Table 28: MTE cohort 1 school characteristics

MTE cohort 1 school characteristics	
Teaching school	15
Maths Hub lead school	15
Part of a multi-academy trust which includes a Teaching School	18
Part of a multi-academy trust that includes a Maths Hub lead school	17

Source: MTE cohort 1, interviews 2017

MTE cohort 1 interviewees were asked in qualitative interviews about implementation of mastery in all year groups. Table 7 focuses on implementation in Year 4 and Year 6. This gives a picture of Year 6 classes which had experienced two full years of mastery (n=17).

Table 29: Level of implementation of mastery in MTE cohort 1 schools

	No mastery Y5	Partial mastery Y5	Full mastery Y5	unknown Y5
No mastery Y6	0	4	0	1
Partial mastery Y6	1	9	0	1
Full mastery Y6	0	6	17	0
Unknown Y6	0	4	1	0

Source: MTE cohort 1, interviews 2016 and 2017.

In order to corroborate data in strand two of the research, interviewees were asked if all Year 2 and Year 6 pupils in their school had experienced at least two full years of *substantial* teaching for mastery. Table 8 below provides this data, and shows that Year 2 pupils had experienced substantial teaching for mastery for a full two years in 26 of the 40 schools participating in 2017. This proportion was lower for Year 6 classes where 17 schools had substantially implemented the mastery approach for the full two years. Interviewees were asked to elaborate on their answers. The reasons given for Year 6 classes having been particularly less likely to have had substantial implementation were: the focus on teaching pupils for standard assessment tests (SATs) and/or new teachers joining who were less experienced in the mastery methods of teaching. Some teachers said that they were confident that many of their Year 6 classes had experienced 'some' teaching for mastery over the two years, but did not feel this had been 'substantial' for these reasons.

Table 30: Implementation of substantial teaching for mastery in Years 2 and 6 MTE cohort 1 schools

	Yes		No		unknown	
	N	%	N	%	N	%
All Year 2 pupils have had substantial teaching for mastery	26	54%	14	29%	6	13%
All Year 6 pupils have had substantial teaching for mastery	17	35%	22	46%	8	17%

Source: MTE cohort 1, interviews 2016 and 2017. Two schools are a junior school and therefore do not have a Year 2; one school was an infant school and therefore does not have a Year 6.

Percentages given out of 48 schools

Where data are unknown, this is because an interview was not conducted with a representative from the school.

6.2 Changes to practice 2016 and 2017 in MTE cohort 1 schools

Use of representations

Figure 5 provides descriptions of different levels of use of representations and is reproduced from the third interim report. Tables 9 and 10 present analysis of levels of use of representations in the MTE cohort 1 schools sampled for interviews in 2016 and 2017 respectively. These data informed the analysis presented in the main report section 5.

Figure 16: Use of visual and concrete representations

	Visual representations	Concrete representations
Limited	Using more visual aids such as photographs or clip art, but not linked to mathematical models or mathematical learning; or having intentions to introduce greater use in the future; more mathematically meaningful practices only appeared to be happening in the lead primary teachers' classes.	Used with younger learners or low attaining pupils and either did not refer to specific materials of such references are limited. Typically materials such as dienes blocks or counters are used for modelling addition or subtraction and simple arithmetic only. In some cases interviewees referred to intentions, or increased awareness rather than to changed practice.
Embedding	Increasing use of visual representation as mathematical models; aiming for consistency in every lesson; some reference made to challenge for some teachers; the Concrete-pictorial-abstract approach was mentioned by some as something that was being adopted. The bar model was frequently referred to as one specific example.	Increasing use including more use in KS2 and across the attainment range, but use inconsistent; more equipment purchased to give access to all classes or 'getting it out of the back of the cupboard'; references made to the concrete-pictorial- abstract with examples of concrete representation as the start of a topic; reporting that teachers are developing knowledge of how to use these with all years and a wider variety of mathematical content.

	Visual representations	Concrete representations
Embedded use	Multiple and varied visual models used and linked mathematically; different forms of representation were linked, for example referring to concrete-pictorial-abstract as a triangle or to be used alongside each other rather than a sequence; use of models linked to other practices such as questioning, or variation theory; some schools had formulated the approach in policy, for example, to always use two representations in every lesson; patterns of use are consistent across the school.	Used in every lesson and/or across whole school and/or full attainment range; a wide variety of materials are discussed with reference to appropriateness for different mathematical content; routinely, concrete materials are on desk for students to use during explanation; the importance of moving between different representations was discussed, and referring to concrete-pictorial-abstract as a triangle or to be used alongside each other; some discussed creating their own specialised concrete materials for particular topics.

Frequency of use of representations

Table 31: Frequency of types of use of representations 2016 (n=43)

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

Source: MTE cohort 1, interviews 2016

Table 32: Frequency of types of use of representation 2017 (n=38)

		Visual			
		Limited	Embedding	Embedded	**Total**
Concrete	Limited	2	1	0	**3**
	Embedding	1	13	4	**18**
	Embedded	0	2	15	**17**
	Total	**3**	**16**	**19**	

Source: MTE cohort 1, interviews 2017

Note that for the two schools which participated in the 2017 interviews but not the 2016 interviews there was insufficient data to categorise their use of representations.

Promoting conceptual and procedural fluency at school level

In 2017, interviewees were asked about their approaches to promoting conceptual understanding and procedural fluency. After outlining the ways in which teachers in their school achieved this, they were asked whether these approaches were an individual teacher's choice or an expectation across the school or school policy. Responses are summarised in Table 11. Although many interviewees answered that there was a mix of formal expectation and teacher discretion (n=13), the majority of teachers said that the approaches outlined were an expectation across the school or school policy (n=24). This indicates that strategies to promote conceptual understanding and procedural fluency were being embedded throughout the school, not simply advised as best practice or used only by those teachers most experienced with teaching for mastery.

Table 33: Approaches to promoting conceptual understanding and procedural fluency 2017

An expectation across the school	School policy	Teacher choice	Mixed
18	6	3	13
45%	15%	8%	33%

Source: MTE cohort 1, interviews 2017

Use of textbooks

Although textbooks were used for a variety of purposes by the majority of MTE cohort 1 schools in 2017 (n=29), the extent and type of use varied between schools as Table 12 indicates. Some teachers for example used textbooks for planning only (n=9). Interviews revealed that the use of textbooks varied between year groups also.

Table 34: Use of textbooks in 2016 and 2017

Use of textbooks	No. of schools 2016	No. of schools 2017
Use with children	8	1
Used for planning only	9	9
Used for planning for some year groups/classes and with children in others	8	19

Source: MTE cohort 1, interviews 2016 and 2017

Lesson activities

As outlined in the interim reports, a typical English mathematics lesson would involve a three-part structure of: teacher input, pupil practice and a final plenary. In contrast, Shanghai mathematics lessons are made up of multiple short activities based on more whole-class teacher-pupil interaction. In an attempt to gauge the extent to which teachers were adopting this Shanghai style of lesson structure, in 2017 interviewees were asked how many different changes in activities happened during the course of a typical mathematics lesson. Most teachers (n=23) answered that there were between four and six changes in activity, compared to only two teachers reporting only one to three changes in activity. This indicates a partial move away from the standard three-part lesson, but does not necessarily suggest a move to a Shanghai-style structure. Fifteen teachers, however, answered that they have more than six changes in activity during a lesson. Table 13 summarises these data.

Table 35: Number of different activities in a typical mathematics lesson

1-3	4-6	7-9	10-12	12 +
2	23	10	4	1
5%	58%	25%	10%	3%

Source: MTE cohort 1, interviews 2017

* Percentages may add up to more than 100 due to rounding.

Differentiation

Teachers were asked a number of questions about differentiation in the second round of interviews. As part of the analysis process for the 2016 interviews, teachers' answers to these questions were categorised as one of three different approaches to differentiation. These categories are specified in Table 14 below. During the 2017 interviews, teachers were asked to confirm whether they felt they had been categorised correctly and if anything had changed in their approach to differentiation. As can be seen in Table 16, the majority of interviewees had been categorised as, or felt that their approach now was in line with, 'Differentiation by deepening and support'. This is a substantial departure from an average English mathematics lesson where teachers would be expected to provide perhaps four different tasks differentiated according to their perceptions of pupils' abilities, with the most difficult tasks moving pupils on to a higher level or even a different topic area. Differentiation by deepening and support provides more challenging tasks for those who have successfully completed the core activity, but through depth activities instead of moving on. Those pupils who find the core task difficult are supported and possibly given intervention to support learning.

Table 36: Approaches to differentiation 2016 and 2017

Differentiation	No. of schools 2016	No. of schools 2017
Differentiation by deepening and support	31	32
Differentiation in transition	5	4
Differentiation by allocated task	7	7

Source: MTE cohort 1, interviews 2016 and 2017

Grouping

In the first round of data collection, survey data showed how MTE cohort 1 schools were grouping their pupils, indicating the percentage of schools grouping by class, within class or not grouping by ability at all (heterogeneous grouping). More information was then collected on grouping via qualitative interviews in 2016 and 2017. The data on grouping from all three years are presented in Table 15 below.

Table 37: Grouping arrangements for pupils in mastery classes 2016 and 2017

Form of grouping	Percentage of schools 2015 (majority of all classes)	Percentage of schools 2016 (substantial mastery classes)	Percentage of schools 2017 (substantial mastery classes)
Heterogeneous grouping (pupils not set or grouped by attainment within class)	38%	67%	70%
Pupils set by class (pupils allocated to classes based on prior attainment and/or perceptions of 'ability')	22%	14%	10%
Pupils grouped by prior attainment within class (pupils of similar attainment sat together)	40%	19%	13%
Mixed across year groups or classes	N/A	N/A	8%

Source: MTE cohort 1 2015 survey; interviews 2016, 2017

As can be seen from Table 15 grouping arrangements in classes where MTE mastery pedagogy is implemented are considerably different from the usual practices in schools prior to the MTE. Although the figures are not strictly comparable year to year due to a slight variation in respondents, the increase in heterogeneous grouping from 38% to 70% over the three-year period represents a substantial change in practice.

There had been a slight increase in schools reportedly moving away from grouping pupils by attainment from 2016 to 2017. A caveat to note here is that for a small number of schools, despite choosing not to group pupils by ability in most year groups, grouping was still happening in Year 6. This was said to be due to SATs preparation or a large gap in ability already in place in this year group from previous setting arrangements. A small number of teachers explained how the classes/years in the school were sometimes split whereby half would be grouped by ability and half would not. Other teachers simply stated that practice would vary around the school dependent on the class and the teacher. (MTE cohort 1, school 16A, interview 2017).

The rationale for schools to move away from grouping was stated by some teachers to be linked to their knowledge of empirical evidence outlining the benefits for pupils of being in heterogeneous groups:

The research says that setting isn't successful; it isn't the right thing to do. (MTE cohort 1, school 18A, interview 2017)

Basically the Sutton Trust and their research, all different academic research shows that streaming doesn't work. (MTE cohort 1, school 22A, interview 2017)

Teachers talked about how grouping did not fit into a mastery approach to teaching and felt that they could not rationalise continuing to group pupils while teaching for mastery:

It just became really apparent that what we were modelling to the children was neither growth mind-set nor mastery. (MTE cohort 1, school 22A, interview 2017)

This was also related to the potential impact on pupils of being put into a lower ability group:

You're saying to a child at the age of six, 'You're not very good at maths. To give a child that impression at the age of six is completely wrong. It's about giving aspiration to all of them so they've all got the same. (MTE cohort 1, school 18A, interview 2017)

Similarly to the previous year's findings, there was a shift in mind-sets about how pupils learn mathematics. Some interviewees articulated this as a move to viewing pupils as learners who may have greater ability in some aspects of learning mathematics than other aspects, and therefore no particular pupils should be labelled as higher or lower ability. Having heterogeneous groups, and sometimes sitting pupils in mixed-ability/attainment pairs or groups, was said to facilitate learning by exposing pupils to all aspects of learning and having maths 'modelled' for them by a learning partner. This enabled certain pupils to access areas of the curriculum which were effectively barred from them previously because they were designated to a lower ability group. Some teachers described how they felt the approach was narrowing the gaps, but was also providing appropriate challenge to their higher-attaining pupils due to them being asked

to think deeply about concepts and articulate their understanding, as the example below describes:

We've done some work on slow thinking and fast thinking. Being fast isn't what makes good maths. That's the fluency issue. Our children who are fluent think that makes them good at maths, because they think that's all that good maths is about. (MTE cohort 1, school 31b, interview 2017)

Seating

Similarly to the reports in 2016, the majority of MTE leads in 2017 (n=19) stated that for most mathematics lessons across their school, pupils were seated in small groups (see Table 16 below). In addition to questions about seating arrangements, in 2017 interviewees were asked who decides how children are seated in mathematics classes. Table 17 below conveys that for the majority of schools the class teacher decides seating arrangements.

Table 38: Seating arrangements 2016 and 2017

Seating	No. of schools 2016	No. of schools 2017
Small groups	22	19
Rows	12	8
Other/mixed	9	13

Source: MTE cohort 1, interviews 2016 and 2017

Table 39: Who decides how children are seated in mathematic classes in 2017

Teacher	School policy	Year group leader	Pupil
27	10	1	2
68%	25%	3%	5%

Source: MTE cohort 1, interviews 2017

Intervention

Interviewees were asked to confirm whether or not their intervention practices were the same as the previous year. The three tables below provide details for 2016 and 2017. In terms of daily intervention, practices appeared to have remained the same or very similar, as 29 interviewees (as for the last year) stated that intervention happens on a daily basis. The roles of staff who deliver the interventions appears to be fairly consistent with the previous year, with a mix of teachers and TAs being the most likely answer (n=20). Similarly, information about how frequently pupils needing additional support are identified was broadly similar to the last year, with identification happening daily in the vast majority of schools (n=33).

Table 40: Frequency of intervention and frequency of pupil identification for intervention 2016 and 2017

Frequency of intervention	No. of schools 2016	No. of schools 2017
Daily	29	29
Less than daily	15	9
Unknown	0	2

Frequency of pupil identification	No. of schools 2016	No. of schools 2017
Daily	31	33
Less than daily	12	6
Unknown	0	1

Source: MTE cohort 1, interviews 2016 and 2017

Table 41: Staff working with pupils during intervention 2016 and 2017

Staff	No. of schools 2016	No. of schools 2017
TA	6	6
Teacher	16	17
Teacher and/or TA	20	20

Source: MTE cohort 1, interviews 2016 and 2017

2017 saw a slight increase in the number of schools which had split mathematics lessons (13) up from 11 the previous year. The majority of schools (n=28) still have one mathematics lesson a day and only a small proportion (n=7) have two lessons. Consistent with last year, the time spent on mathematics each day was just over an hour (64 minutes), with 22 of the 40 schools having 60-minute lessons.

Table 42: Split lessons 2017

Lessons are split into two parts	Lessons are not split
13	27
32%	68%

Source: MTE cohort 1, interviews 2017

Timetabling

Table 21 presents data on timetabling of mathematics lessons and interventions. It is notable that there is a slight decrease in the number of schools undertaking intervention after a lesson. In interviews, a number of participants indicated that their schools had experimented with same-day intervention after the lesson but had reverted back to previous practices. Nevertheless, generally the approach to intervention in schools had changed as a result of engagement in the MTE programme.

Table 43: Timing of intervention 2016 and 2017

Timing of intervention	No. of schools 2016	Percentage 2016	No. of schools 2017	Percentage 2017
After lessons	26	60.5	21	52.5
Before lessons	1	2.3	0	0.0
During lessons	9	20.9	13	32.5
Mixed	7	16.3	6	15.0

Source: MTE cohort 1, interviews 2016 and 2017

Table 22 presents data on the number of mathematics lessons per day in MTE cohort 1 schools.

Table 44: Number of mathematics lessons in a day 2017

1 lesson per day	1 lesson + mental arithmetic	2 lessons per day	2 lessons + mental arithmetic
28	5	4	3
70%	13%	10%	8%

Source: MTE cohort 1, interviews 2017 *Percentages may add up to more than 100 due to rounding.

Table 45: Time spent on mathematics on an average day in 2017

	Time
Mean	66 minutes
Median	60 minutes
Mode	60 minutes
Range	45 minutes

Lesson preparation and design

Interviewees were asked in more depth in 2017 about how lessons are prepared than in the 2016 interviews. They were asked how often they plan mathematics lessons in pairs or in groups. Consistent with lesson preparation in Shanghai, as Table 24 illustrates, 27 (68%) interviewees reported preparing lessons either in a pair or in a group once a week or more often.

Table 46: Lesson planning in pairs or groups 2017

More than once a week	Once a week	once or twice per half term	Never	Unknown
11	16	7	5	1
28%	40%	18%	13%	3%

Source: MTE cohort 1, interviews 2017 *Percentages may add up to more than 100 due to rounding.

Whether teachers planned in pairs or groups was often said to be related to the school size. Where schools were one-form entry, group or paired planning was seen as more difficult. In schools where teachers did plan with one or more colleagues, they often used their PPA (planning, preparation and assessment) time for this. Some teachers described how planning had become more standardised across the school, and a smaller number talked about working with other schools to prepare lessons, or standardising lesson plans across a trust. Teachers explained that detailed planning might happen for the first couple of lessons in the week and then planning would be adapted or tailored to needs as the week went on, depending on pupils' responses to these first lessons:

Within our PPAs we have a brainstorming map which is where we map out the learning. Then we have daily lesson plans that include things like key questions, vocabulary, resources and support that's given to individual children and to extend, but those plans are done by individual teachers. Every class will access it at a different rate of learning. Also those are annotated on and adapted as the week goes on. (MTE cohort 1, school 23A, interview 2017)

Interviewees were asked about whether planning had changed. Responses were mixed, with some teachers said that the way they planned was the same, but the content of the lessons being planned for had changed greatly. However, other teachers felt that their planning had changed dramatically as a result of the exchange. Teachers talked mostly about how they were now planning for understanding instead of simply planning the activities to be worked through. This was explained as a change from a procedural approach to planning, focusing on 'how we teach', to a conceptual approach centred on how pupils learn:

Move away from what the children are going to do, to thinking about what the children are going to learn.' (MTE cohort 1, school 31b, interview 2017)

This approach was seen by some teachers to be facilitated by their school having moved away from setting or traditional approaches to differentiation.

Teachers cited the White Rose and Maths No Problem schemes as the main resources they would go to when planning. However a number of teachers described how they would pick out different aspects from a variety of resources to create their own materials. What constituted a 'lesson plan' varied: some teachers were planning in greater detail than they did previously, while other teachers saw the lesson plans more as a guide with notes to support teaching than as something they would stick to rigidly:

I literally have moved away from a planning proforma, because I felt that moved teachers towards what are the children going to do? So we just go to a big blank piece of A3 paper and they draw an S on it and they just plan the journey from that. (MTE cohort 1, school 31b, interview 2017)

6.3 Implementation pathways

In the main report (section 7.8) a model of implementation pathways was included. Table 25 below provides detail of the analysis that supports that discussion. Note that in order to preserve anonymity school codes are not included. The categorisations of 'full' and 'mastery' refer to implementation of MTE mastery pedagogy.

Table 47: Implementation pathways table

Pathways			Frequency
Start	**Pathway**	**Categorisation**	
Already committed and mastery textbook/scheme	Mastery textbook/scheme	Full	1
Already committed and mastery textbook/scheme	Mastery textbook/scheme	Mastery	2
Already committed and mastery textbook/scheme	Mastery textbook/scheme and PMTMSP	Full	1
Already committed and mastery textbook/scheme	Mastery textbook/scheme and PMTMSP	Mastery	1
Already committed		Full	1
Already committed	mastery textbook/scheme	Mastery	1
Already committed	mastery textbook/scheme and PMTMSP	Full	1
Already	PMTMSP	Not mastery	1
Newly committed		Full	6
Newly committed	PMTMSP	Full	2
Newly committed	Mastery textbook/scheme	Full	6
Newly committed	Mastery textbook/scheme and PMTMSP	Full	6
Newly committed	Textbook	Mastery	3
Newly committed	Mastery textbook/scheme and PMTMSP	Mastery	1
Newly committed	PMTMSP	Not mastery	1
Newly committed		No full data	7
Newly committed		Not mastery	1
Newly committed	Textbook	No full data	3
Cautious	Textbook	Low	1
Cautious	Textbook	Mastery	1
Cautious	mastery textbook/scheme and PMTMSP	Full	1

Note that the attribution of commitment was based on checking judgements made on the basis of the 2015 interviews, during the 2016 interviews. If a 2016 interview was not completed then the 2015 researcher judgement was used.

6.4 Pupil outcomes

Table 26 (below) shows that the majority of MTE leads felt that pupils had progressed more than expected.

Teachers were more confident that their pupils' attainment had been influenced positively by the mastery approach to teaching. In 2016, 18 teachers answered that they perceived their pupils' attainment to be more than expected; in 2017 this had increased to 27 teachers (despite the lesser number of interviewees). This suggests that the impact of the exchange on pupils has increased as schools have had a longer period of time in which to embed the approach across the school.

Table 48: Perceptions of pupil outcomes 2016 and 2017

Perception of pupil outcome statements	More than expected	About as expected	Below expected	Not able to answer
Pupils' attainment. N 2016	18	14	1	10
Pupils' attainment. N 2017	27	3	0	10

Source: MTE cohort 1, interviews 2016 and 2017

6.5 Mathematics Coordinator Survey 2017: supplementary data

Survey responses from the 2017 Mathematics Coordinator Survey were firstly looked at stratified by Cohort (1&2) and by PMTMS involvement (1&2). However, stratification by these components yields unequal and small sample sizes. Response data was therefore re grouped. Group 1, those respondents reporting being in cohort one or two and/or having undertaken the PMTMS training, group 2, those respondents not involved in an MTE cohort or PMTMS but reporting substantial mastery and group 3, those not involved in an MTE cohort or PMTMS training and NOT reporting substantial mastery. The below tables show the percentage of responses to each question answer stratified by group. Kruskal Wallis (for ordinal variables) and Chi-Square tests (for nominal variables) for significance were ran to determine whether differences between groups were significant, but do not illustrate where the difference lies. Statistical test results are included in parentheses after each survey question, a p-value of <0.05 is considered significant.

Table 49: Full curriculum access for all mastery component

Full curriculum access for all			
	Group 1 (MTE and/or PMTMS cohort	**Group 2 (No MTE and/or PMTMS but reported substantial mastery)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery)**
Differentiated tasks are set for pupils (X2 (2)=81.82, P<0.01)			
Always	4.0	10.2	17.6
Often	16.2	27.6	41.2
Sometimes	22.0	22.4	25.5
Rarely	43.4	30.6	13.7
Never	14.5	9.2	2.0

Full curriculum access for all			
	Group 1 (MTE and/or PMTMS cohort	**Group 2 (No MTE and/or PMTMS but reported substantial mastery)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery)**
Main activities would be the same, differentiation by outcome (X2 (2)= 20.17, P<0.01)			
Always	17.4	13.7	6.8
Often	46.1	36.8	35.4
Sometimes	27.5	34.7	40.8
Rarely	8.4	12.6	16.5
Never	0.6	2.1	0.5
Pupils learn the main content first, tasks are set to deepen understanding (X2 (2)= 35.75, P<0.01)			
Always	55.9	59.8	32.2
Often	35.5	35.1	47.6
Sometimes	5.9	5.2	17.3
Rarely	1.6	0.0	1.9
Never	1.1	0.0	1.0
Frequency of identification of additional support (X2 (2) 18.49, P<0.01)			
Daily	45.7	41.8	28.2
A number of times per week	38.3	31.6	39.9
Weekly	5.3	10.2	12.2
Half termly	9.0	15.3	14.1
Less often than half termly	1.6	1.0	5.6

Full curriculum access for all			
	Group 1 (MTE and/or PMTMS cohort	**Group 2 (No MTE and/or PMTMS but reported substantial mastery)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery)**
Who gives additional support (X2 (4)=11.95, P<0.05)			
Teacher	11.7	5.1	6.1
TA	11.2	20.4	21.2
Teacher and a TA	77.1	74.5	72.6
Amount of curriculum covered in the last three years (X2(2)=55.65, P<0.01)			
Increased	27.8	37.4	59.1
Stayed the same	26.2	27.3	28.0
Decreased	46.0	35.4	13.0

Table 50: Varied interactive teaching mastery component

Varied Interactive Teaching			
	Group 1 (MTE and/or PMTMS cohort	**Group 2 (No MTE and/or PMTMS but reported substantial mastery)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery)**
Whole class teacher-pupil interaction (X2(2)=41.66, P<0.01)			
Increased	73.3	53.1	39.8
Decreased	20.9	32.7	45.4
Stayed the same	5.9	14.3	14.8

Varied Interactive Teaching			
	Group 1 (MTE and/or PMTMS cohort	**Group 2 (No MTE and/or PMTMS but reported substantial mastery)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery)**
Lesson structure (X2(2)=63.19, P<0.01)			
Starter, introduction, activity, teacher explanation, practice then plenary	22.0	38.4	62.2
Multiple periods of questioning, teacher pupil dialogue, pupils working on 1/2 problems/tasks	78.0	61.6	37.8
Teacher-pupil interaction frequency (X2(2)=25.51, P<0.01)			
Increased	82.9	79.8	61.1
Decreased	15.5	18.2	34.7
Stayed the same	1.6	2.0	4.1

Table 51: Knowledge of mathematical facts and Language mastery component

Knowledge of Mathematical Facts and Language			
	Group 1 (MTE and/or PMTMS cohort	**Group 2 (No MTE and/or PMTMS but reported substantial mastery)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery)**
Precise mathematical language by teachers and pupils (X2(2)=27.53, P<0.01)			

Knowledge of Mathematical Facts and Language			
	Group 1 (MTE and/or PMTMS cohort	**Group 2 (No MTE and/or PMTMS but reported substantial mastery)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery)**
Always	31.6	19.2	12.5
Often	51.9	63.6	54.9
Sometimes	16.6	16.2	27.2
Rarely	0.0	1.0	5.4
Never	0.0	0.0	0.0
Key ideas and concepts recited individually or as a class (X2(2)=28.52, P<0.01)			
Always	13.4	8.1	5.4
Often	44.1	41.4	28.6
Sometimes	35.5	40.4	44.3
Rarely	6.5	8.1	18.4
Never	0.5	1.0	2.2
Not sure	0.0	1.0	1.1
Teachers ask for explanations about how answers were obtained (X2(2)=30.51, P<0.01)			
Always	55.1	42.4	27.9
Often	40.6	54.5	61.2
Sometimes	4.3	3.0	9.8
Rarely	0.0	0.0	0.5
Never	0.0	0.0	0.0
Not sure	0.0	0.0	0.5

Knowledge of Mathematical Facts and Language			
	Group 1 (MTE and/or PMTMS cohort	**Group 2 (No MTE and/or PMTMS but reported substantial mastery)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery)**
Pupils are encouraged to communicate mathematically to the whole class (X2(2)=19.76, P<0.01)			
Always	32.6	16.2	18.0
Often	54.5	64.6	53.6
Sometimes	10.7	19.2	26.2
Rarely	2.1	0.0	2.2
Never	0.0	0.0	0.0

Table 52: Mathematical and meaningful coherent activity mastery component

Mathematically Meaningful and Coherent Activity			
	Group 1 (MTE and/or PMTMS cohort (%)	**Group 2 (No MTE and/or PMTMS but reported substantial mastery) (%)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery) (%)**
Multiple representations for a mathematical concept or procedure are used in a single lesson (X2(2)=63.38, P<0.01)			
Always	28.5	22.2	5.1
Often	55.4	47.5	45.8
Sometimes	16.1	27.3	41.8
Rarely	0.0	3.0	5.6
Never	0.0	0.0	1.7

Mathematically Meaningful and Coherent Activity			
	Group 1 (MTE and/or PMTMS cohort (%)	**Group 2 (No MTE and/or PMTMS but reported substantial mastery) (%)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery) (%)**
Concrete materials are used with all year groups in the school (X2(2)=27.90, P<0.01)			
Always	27.8	33.3	16.4
Often	55.6	47.5	44.6
Sometimes	14.4	16.2	28.8
Rarely	2.1	3.0	10.2
Never	0.0	0.0	0.0
Concrete materials are used with pupils of all attainment levels in the school (X2(2)=44.54, P<0.01)			
Always	30.5	35.4	14.1
Often	50.8	46.5	39.0
Sometimes	15.5	14.1	35.0
Rarely	3.2	3.0	11.3
Never	0.0	0.0	0.0
Not sure	0.0	1.0	0.6

Mathematically Meaningful and Coherent Activity			
	Group 1 (MTE and/or PMTMS cohort (%)	**Group 2 (No MTE and/or PMTMS but reported substantial mastery) (%)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery) (%)**
Concrete/pictorial and symbolic representations are used together in all lessons (X2(2)=58.09, P<0.01)			
Always	26.9	29.3	9.6
Often	52.7	52.5	38.4
Sometimes	18.8	15.2	39.5
Rarely	1.6	2.0	12.4
Never	0.0	0.0	0.0
Not sure	0.0	1.0	0.0
The sequence of concrete-pictorial abstract forms of representation is used to structure teaching (X2(2)=48.46, P<0.01)			
Always	23.7	32.3	10.2
Often	54.8	44.4	37.9
Sometimes	17.7	21.2	39.5
Rarely	2.7	1.0	10.7
Never	1.1	0.0	0.6
Not sure	0.0	1.0	1.1

Mathematically Meaningful and Coherent Activity			
	Group 1 (MTE and/or PMTMS cohort (%)	**Group 2 (No MTE and/or PMTMS but reported substantial mastery) (%)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery) (%)**
Teachers move back and forth between different forms of representation in order to connect them and support understanding (X2(2)=63.66, P<0.01)			
Always	25.5	26.3	5.6
Often	52.7	47.5	39.0
Sometimes	20.2	23.2	42.4
Rarely	1.1	2.0	11.9
Never	0.0	0.0	0.0
	0.5	1.0	1.1
Using representations and models to introduce concepts (X2(2)=44.41, P<0.01)			
Always	41.2	42.4	16.4
Often	50.8	50.5	58.5
Sometimes	7.5	7.1	24.0
Rarely	0.5	0.0	1.2
Never	0.0	0.0	0.0

Mathematically Meaningful and Coherent Activity			
	Group 1 (MTE and/or PMTMS cohort (%)	**Group 2 (No MTE and/or PMTMS but reported substantial mastery) (%)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery) (%)**
Using teacher questioning and classroom dialogue (X2(2)=21.51, P<0.01)			
Always	57.8	64.6	40.4
Often	40.6	35.4	52.6
Sometimes	1.6	0.0	6.4
Rarely	0.0	0.0	0.6
Never	0.0	0.0	0.0
Making understanding an explicit focus in lesson preparation (X2(2)=32.14, P<0.01)			
Always	48.1	47.5	23.8
Often	44.4	47.5	58.1
Sometimes	7.5	5.1	16.3
Rarely	0.0	0.0	1.7
Never	0.0	0.0	0.0

Mathematically Meaningful and Coherent Activity			
	Group 1 (MTE and/or PMTMS cohort (%)	**Group 2 (No MTE and/or PMTMS but reported substantial mastery) (%)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery) (%)**
Starting from a problem or carefully selected task (X2(2)=30.06, P<0.01)			
Always	27.3	25.3	4.4
Often	39.0	37.4	42.1
Sometimes	28.9	36.4	48.0
Rarely	4.8	1.0	5.3
Never	0.0	0.0	0.6
Connecting different mathematical concepts and procedures (X2(2)=35.56, P<0.01)			
Always	29.4	23.2	9.9
Often	49.7	59.6	48.0
Sometimes	19.3	16.2	38.0
Rarely	1.1	1.0	4.1
Never	0.0	0.0	0.0
Not sure	0.5	0.0	0.0

Mathematically Meaningful and Coherent Activity			
	Group 1 (MTE and/or PMTMS cohort (%)	**Group 2 (No MTE and/or PMTMS but reported substantial mastery) (%)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery) (%)**
Emphasising the precise use of Mathematical language (X2(2)=29.31, P<0.01)			
Always	42.2	45.5	24.6
Often	47.1	47.5	48.0
Sometimes	10.2	7.1	24.0
Rarely	0.5	0.0	3.5
Never	0.0	0.0	0.0
Planning for and addressing misconceptions (X2(2)=41.51, P<0.01)			
Always	42.2	48.5	17.1
Often	47.1	42.4	59.4
Sometimes	10.7	9.1	19.4
Rarely	0.0	0.0	3.5
Never	0.0	0.0	0.6

Mathematically Meaningful and Coherent Activity			
	Group 1 (MTE and/or PMTMS cohort (%)	**Group 2 (No MTE and/or PMTMS but reported substantial mastery) (%)**	**Group 3 (No MTE and/or PMTMS and no substantial mastery) (%)**
Using a textbook, scheme or designed resource (X2(2)=9.92, P<0.01)			
Always	15.6	17.3	5.3
Often	31.7	28.6	32.0
Sometimes	34.9	32.7	34.3
Rarely	15.6	16.3	20.7
Never	2.2	5.1	7.1
Not sure	0.0	0.0	0.6
Using in-class formative assessment (X2(2)=24.93, P<0.01)			
Always	50.3	49.0	26.0
Often	41.2	40.8	57.4
Sometimes	8.0	10.2	15.4
Rarely	0.5	0.0	1.2
Never	0.0	0.0	0.0

7. Strand one: Implementation criteria and analysis

7.1 Process for determining implementation criteria

All MTE cohort 1 schools which contributed interviewees in 2017 described substantial implementation of mastery approaches in at least some classes. However, the detailed responses about practices suggested that implementation levels varied. Consequently, a set of implementation criteria was devised based on data analysis and informed by benchmarking against schools that appeared to have high levels of implementation and which in many cases had participated in the PMTMSP.

Table 31 below specifies the implementation criteria in terms of the four main components of MTE mastery pedagogy and their indicators. Table 32 sets out how sub-components were combined to form the categories of *high mastery, mastery and low/not implemented.* Lastly, Table 33 shows how the four main components were combined to determine the final categorisation for a school. Greater weight was given to component 1 (varied interactive teaching) and component 2 (meaningful and coherent activity) than to the other two components. This reflected the focus in MTE cohort 1 schools (and NCETM's formulation of TfM) on pedagogical and classroom practice with other practices such as intervention policy designed to support this.

To ensure reliability of analysis, an independent researcher without knowledge of the schools was contracted to rate 12 schools separately. They did this by taking a more holistic view, rather than using Nvivo for detailed coding, using the implementation criteria grid as a matrix to shade patterns of implementation based on 2016 and 2017 data.

The outcome of this independent rating was agreement in nine cases. In the other three, the independent researcher had rated one as *high mastery* which the evaluation team had rated as *mastery*. In the other two cases, the independent researcher reported that although there was the appearance of mastery implementation, this was not fully convincing - for example, a school was using a textbook scheme as the main resource that did not align well with a mastery approach. In one of the cases, the school reported that mastery practices were being used only with a small number of classes. Thus, these were rated independently as borderline. The evaluation team had rated these two schools as *low/not implemented*.

This inter-rater checking process indicates that, depending on definitions, the categorisations made by the evaluation team may have under-estimated, in up to four cases, the number of schools in MTE cohort 1 which have implemented mastery approaches to a substantial extent - that is high mastery. However, this does not affect the strand two analysis, as this is based on comparison of the MTE mastery/high mastery

schools with contrast schools rather than with schools in the MTE cohort 1 sample categorised in other ways If a less stringent application of criteria was taken and one or more of these found schools were included in the high mastery sample for the impact analysis then this would mean that the size of impact reported in section 8 of the main report would be potentially lower. This is because the impact identified was a little higher for the high mastery sample than for the mastery sample.

Table 53: MTE Mastery pedagogy implementation criteria

	Full MTE mastery pedagogy indicators	MTE Mastery pedagogy implementation indicators	Low or no implementation of component
1a Substantial whole-class varied teaching in multiple part lessons	Multiple part lessons, whole-class teacher-led episodes are a substantial part of the lesson but with interaction, clear sense of different purposes of lessons	Mixture of lesson forms with some multiple part lesson teaching with whole-class as central Multiple part lessons or other if clear that whole-class teaching central	Three-part lessons or unclear about lessons
1b Interactive dialogue	In whole-class teaching episodes use of to-and fro, interaction for substantial portions of time, pupils routinely talk to other pupils, pupils come to the front	To and fro, and similar patterns occur but not necessarily as an essential lesson feature and focus of lesson design, teacher-pupil interaction likely to be consistently happens in lessons; pupils talking to each other reported as a regular feature of lessons.	Lower levels of dialogue. For example responding sometimes or rarely when asked about dialogue practices
2a Depth, meaning, problem solving	Multiple approaches to developing conceptual understanding - using approaches to developing procedural fluency that support conceptual understanding as well e.g. models and representations, reference to conceptual and procedural variation (in a way that shows understanding of this), consistently starting from a problem, using deepening tasks that focus on mathematical	At least one approach to developing conceptual understanding is indicated alongside a conceptual approach to procedural fluency (e.g. using models, or choice of questions - overall three or more), may refer to problem solving but not central to practice	No particular focus on conceptual understanding and procedural fluency or unclear - less than 3 mentioned for developing conceptual understanding and procedural fluency

	Full MTE mastery pedagogy indicators	MTE Mastery pedagogy implementation indicators	Low or no implementation of component
	structure.		
2b Models and representations	Multiple use of models and representations, not just for low attaining or young children but consistently - might use CPA as a heuristic	Embedding use of models and representations and/or concrete materials - being used more widely, but not yet consistent	Limited implementation in one or both or unclear
2c Mathematically coherent lesson design	Use of East Asian informed materials or equivalent consistently or lesson design consistently that accords with MTE mastery pedagogy - interaction, aim for conceptual understanding and procedural fluency, deepening etc.	Some relationship of materials to mastery, mastery is informing choice Lesson activities informed by MTE mastery pedagogy Use of compatible materials CPA as heuristic, White Rose, NCETM mastery assessment materials, or choice of problems and/or some use of East Asian informed materials for lesson design but not consistent	Other materials or unclear
3a Curriculum pace for whole class access	Slowing curriculum pace	Slowing curriculum pace	No change to curriculum pace
3b Teaching to attainment by deepening and support	All-attainment teaching and differentiation by deepening and support	Setting plus differentiation by deepening and support or not setting with differentiation in advance	Differentiation in advance / give different activities
3c Responsive intervention	Daily intervention and decided daily, intervention outside lessons	Two of three of these aspects present - less frequently than daily, decided weekly, and/or intervention during lessons	Intervention less frequently

	Full MTE mastery pedagogy indicators	MTE Mastery pedagogy implementation indicators	Low or no implementation of component
4a Memorising facts, relationships and structures	Specific times for developing factual knowledge - strategies for this	Specific times for developing factual knowledge - strategies for this sometimes	Not emphasised or discussed
4b Precise mathematical language	Use of precise language - always in lessons, stem sentences	Precise language - sometimes	Not discussed or mentioned

Table 54: Combining sub-components of mastery

Component	High mastery	Mastery implementation	Low/not implemented with indicators
Component 1 combined	1a mastery and 1b full	Mastery in 1a and 1b	Not meeting criteria Does not meet criteria for mastery in 1a and/or 1b or both
Component 2	High - Meets two out of three subcomponents at full	Meets all three at mastery	One or more not met at mastery
Component 3 combined	High - Meets two out of three subcomponents at full criteria, other at medium or full	Mastery - meet all three at medium, or one high, one medium, one low	Not meeting criteria Two low, or one low and two medium
Component 4	High mastery - both present	Mastery - one or other (this due to evidence issue with amount of data)	Not meeting either

Table 55: Determining an overall mastery categorisation

Category	Criteria
High	Components 1 and 2 - both judged as high mastery, and at least one of 3 or 4 high mastery and the other at least mastery
Mastery	Components 1 and 2 - mastery Components 3 and 4 - mastery
No/low implementation	Not meeting the above criteria

7.2 Analysing the relationship between variation in implementation and school characteristics

We have data on 37 of the 47 MTE schools (35 primary and two junior). Of these, a majority are identified as having 'high mastery' (25 schools, 68%) and the vast

majority as ‘mastery’ or higher (33 schools, 89%). Only four schools (11%) are identified as having ‘low mastery’.

For the Key Stage 1 (KS1) analyses, schools that are judged to have implemented mastery/high mastery in general and also self-report substantial implementation two years for the Year 2 2017 cohort, will be included in the analyses. Implementation data from 35 of the 44 primary MTE schools[44] were obtained and a majority of these are identified as implementing mastery in both 2016 and 2017 (26 schools, 74%). Among these 26 schools, 19 (73%) are identified as having high mastery, and 24 (92%) with mastery level or higher.

For the Key Stage 2 (KS2) analyses, schools are judged to have implemented a mastery/high mastery level in general and also self-report substantial implementation specifically for two years for the Year 6 2017 cohort will be included in the analyses. Implementation data from 37 of the 47 MTE schools were obtained. A minority of these are identified as implementing mastery in both 2016 and 2017 (16 schools, 43%). Among these 16 schools, 15 (94%) are identified as having high mastery and all 16 with mastery level or higher.

Table 34 uses two further measures of implementation to compare the two mastery thresholds: the percentage of classes identified as having full or partial implementation; and PMTMSP attendance.

Table 56: Levels of mastery & MTE implementation

	Full % mean (sd)	Partial % mean (sd)	PMTMSP n (%)
Complete Sample (n=37 schools)[1]			
High Mastery (n=25)	80.3 (24.05)	17.8 (21.92)	11 (44%)
Mastery or Higher (n=33)	74.8 (29.49)	23.2 (27.38)	14 (42%)
KS1 Analyses - 26 schools implementing in Y2 in both 2016 & 2017			
High Mastery (n=19)	81.9 (25.85)	17.0 (24.20)	8 (42%)
Mastery or Higher (n=24)	78.0 (29.00)	20.5 (27.98)	10 (42%)
KS2 Analyses - 16 schools implementing in Y2 in both 2016 & 2017			
High Mastery (n=15)	85.1 (24.73)	14.9 (24.73)	5 (33%)
Mastery or Higher (n=16)	86.1 (24.14)	13.9 (24.14)	6 (38%)

[44] Excluding the three junior schools (two of which have mastery data)

Note 1: whilst we have implementation data for 37 of the 47 schools, data were only available for 36 schools concerning the proportion of classes exhibiting full/partial implementation in 2016 and 2017.

The measures seem to cross-validate reasonably well, although the difference between high mastery and mastery is fairly small.

The mastery implementation detail was then attached to the main school-level data file for statistical analysis. Using the 2014 KS2 school census data, Table 35 shows a school-level comparison of KS2 attainment, KS1 to KS2 maths value-added scores and %FSM across the four mastery levels.

Table 57: Comparison of samples with differing levels of mastery 2013/14 KS2 school census data

	KS2 Points	KS1-KS2 Maths VA	%FSM
High Mastery (n=25)	29.9 (1.74)	100.7 (1.17)	20.6 (18.47)
Mastery (n=8)	29.1 (1.78)	100.5 (1.52)	31.4 (24.08)
Low Mastery (n=4)	29.9 (0.41)	100.1 (1.10)	11.7 (7.45)
Missing Data (n=10)	29.5 (1.63)	100.4 (1.50)	24.7 (9.08)
Mastery or higher (n=33)	29.7 (1.76)	100.6 (1.24)	23.2 (20.12)

Table 36 presents the pupil-level comparison at KS1. At KS1, in 2014 the mean KS1 maths score is shown alongside two threshold measures: numbers and percentages of pupils exceeding the expected KS1 maths level; and numbers and percentages of pupils meeting/surpassing the expected KS1 maths level. In 2017, following assessment changes in 2016, only the two threshold measures are available.

Table 37 presents the pupil-level comparison at KS2. At KS2, in 2014 the mean KS2 fine points maths score, mean raw KS2 maths score and mean scores in each of the three KS2 maths papers are shown. In 2017, following assessment changes in 2016, the mean KS2 fine points maths score is replaced by a new mean maths points score. The mean raw KS2 maths score along with mean scores in each of the three 2017 KS2 maths papers are also shown.

Table 58: KS1 Comparison of samples with differing levels of mastery NPD Pupil Level Data, 2014 & 2017

2014	KS1 Maths Score	Exceed	Expect
High Mastery	16.8 (3.50)	370/1,190 (31.1%)	1,132/1,190 (95.1%)
Mastery	16.4 (3.59)	101/396 (25.5%)	369/396 (93.2%)
Low Mastery	17.3 (3.29)	63/180 (35.0%)	175/180 (97.2%)
Missing Data	16.1 (3.61)	101/440 (23.0%)	393/440 (89.3%)
Mastery or higher	16.7 (3.52)	471/1,586 (29.7%)	1,501/1,586 (94.6%)
2017	**KS1 Maths**	**Exceed**	**Expect**
High Mastery	n/a	298/935 (31.9%)	777/935 (83.1%)
Mastery	n/a	75/394 (19.0%)	307/394 (77.9%)
Low Mastery	n/a	42/160 (26.3%)	141/160 (88.1%)
Missing Data	n/a	72/412 (17.5%)	295/412 (71.6%)
Mastery or higher	n/a	373/1,329 (28.1%)	1,084/1,329 (81.6%)

Table 59: KS2 Comparison of samples with differing levels of mastery NPD Pupil Level Data, 2014 & 2017

2014	Fine Points Score	Raw KS2 Maths Score
High Mastery	5.08 (0.858)	76.0 (18.08)
Mastery	4.93 (0.871)	72.4 (19.74)
Low Mastery	5.06 (0.645)	76.3 (14.00)
Missing Data	5.00 (0.904)	74.6 (17.77)
Mastery or higher	5.04 (0.863)	75.1 (18.56)

2017	Maths Points Score	Raw KS2 Maths Score
High Mastery	106.3 (7.59)	81.6 (22.26)
Mastery	104.6 (8.53)	76.0 (25.76)
Low Mastery	104.7 (6.68)	76.5 (21.16)
Missing Data	104.4 (7.56)	74.9 (24.09)
Mastery or higher	105.8 (7.89)	80.0 (23.41)

2014	Arithmetic	Paper 2	Paper 3
High Mastery	15.8 (4.13)	30.5 (7.89)	29.6 (7.30)
Mastery	15.5 (4.08)	29.3 (8.61)	27.6 (8.12)
Low Mastery	16.0 (3.25)	30.7 (6.02)	29.5 (6.19)
Missing Data	15.7 (3.70)	29.9 (7.85)	29.1 (7.40)
Mastery or higher	15.7 (4.12)	30.2 (8.09)	29.1 (7.56)

2017	Arithmetic	Paper 2	Paper 3
High Mastery	32.7 (7.61)	25.9 (7.82)	23.0 (8.37)
Mastery	32.3 (8.18)	22.9 (9.59)	20.8 (9.62)
Low Mastery	31.8 (6.50)	24.0 (7.67)	20.7 (8.31)
Missing Data	30.6 (8.26)	23.6 (8.61)	20.6 (8.87)
Mastery or higher	32.6 (7.77)	25.1 (8.45)	22.4 (8.78)

8. Strand two analysis

8.1 Effect sizes

For both the descriptive and multilevel analyses discussed below, the difference between the MTE exchange and contrast control school samples is converted into an effect size measure.

When an outcome variable is a continuous scale (i.e. KS1 maths between 2013 and 2015; KS2 maths 2013 to 2017), the mean difference is converted into a Cohen's d effect size statistic.

Cohen's d is a widely used standardised statistic that enables effect sizes to be compared across outcomes on differing scales and across different studies, time points etc. According to the teaching and learning toolkit developed by the Educational Endowment Foundation (EEF[45]), a 'very high impact' is indicated by an effect size of (d=) +0.70 standard deviations or greater; 'high impact' by an effect size between +0.45 to less than +0.70 sds; 'moderate impact' by an effect size between +0.19 to less than +0.45 sds; 'low impact' by an effect size between +0.02 to less than +0.19 sds and below +0.02 sds 'very low or no impact'.

When an outcome variable is a categorical attainment threshold (i.e. whether a pupil reaches or exceeds the KS1 maths expected level 2013 to 2017) the percentage difference between the exchange school and matched samples is converted into a (odds-ratio) effect size statistic.

Odds-ratios are widely used statistics that measure the difference between one percentage and another as a ratio of the odds for these percentages. Conveniently, it is possible to convert odds ratios into Cohen's d effect size statistics (Sanchez-Meca et al 2003[46]). Table 38 compares odds-ratio and Cohen's d effect size statistics within reference to the EEF teaching and learning toolkit.

[46] Sanchez-Meca, J., Marin-Martinez, F. & Chacon-Moscoso, S. (2003) Effect-size indices for Dichotomized Outcomes in Meta-Analysis. Psychological Methods 8(4) pp448-467.

Table 60: Comparing Cohen's d & Odds-Ratio effect size statistics

EEF 'size of effect'		Cohens d	Odds Ratio
+VE	Very High	+0.70 or higher	3.56 or higher
	High	+0.45 to <+0.70	2.26 to < 3.56
	Moderate	+0.19 to <+0.45	1.41 to < 2.26
	Low	+0.02 to <+0.19	1.03 to < 1.41
Zero	Very Low / zero	-0.02 to < +0.02	0.96 to < 1.03
- VE	Low	-0.02< to -0.19	0.96< to 0.71
	Moderate	-0.19< to -0.45	0.71< to 0.44
	High	-0.45< to -0.70	0.44< to 0.28
	Very High	-0.70 or lower	0.28 or lower

8.2 Detail of the impact analysis

Overview

In December 2017, NPD pupil level data was obtained for KS1 & KS2 pupils in exchange or matched contrast control schools for 2013, 2016 and 2017. A previous request obtained pupil level KS2 data for 2014 and 2015. In total, the pupil level KS1 and KS2 impact analyses covers five academic years between 2013 and 2017. The impact analyses compares the maths attainment of pupils in exchange schools with the attainment of pupils in the matched schools over this period; 2015 to 2017 representing the three years following the start of the exchange and 2013 & 2014 representing the two years immediately prior to the start of the exchange.

The second interim report[47] provides a more detailed overview of the quasi-experimental research design that was used to statistically examine whether a primary schools participation in the MTE led to greater improvement in pupil level KS1 and KS2 maths attainment compared with none participation. As explained in the second interim report, propensity scores were used to match each of the 47 exchange schools[48] with 20 statistically 'similar' contrast control schools using

[47] See second interim report available at https://www.gov.uk/government/publications/evaluation-of-the-maths-teacher-exchange-china-and-england

[48] As detailed in section 5, 48 schools participated in the Mathematics Teacher Exchange in 2014/15. Of these 48 schools, one was an infant school and not included in the propensity matches because this was based on school level KS2 data, this means that all of the impact analyses relate to 47 MTE schools (44 primary and 3 junior) .

school-level data for 2014. The purpose of the contrast sample is to capture temporal change in KS1/KS2 maths attainment (known technically as the 'counterfactual'). A positive impact would be indicated when the change in attainment observed in the exchange school sample is greater than the change observed in the contrast school sample.

KS1 or KS2 maths attainment of pupils in exchange schools is compared with the attainment of pupils in the contrast schools. Analyses that showed very similar levels of attainment in 2013 and 2014 but an increasing difference 2015 to 2017 would point to evidence that school participation in the exchange led to a positive pupil level impact for KS1 or KS2 maths attainment.

This section is organised into five subsections:

1. School level descriptive analyses 2013 to 2017.
    - A statistical comparison of MTE and contrast control schools using school level KS2 School Census data.
2. Pupil level descriptive analyses 2013 to 2017.
    - A statistical comparison of KS1 and KS2 maths attainment for pupils in MTE schools with pupils in contrast control schools using NPD data.
3. Main (headline) multilevel impact analyses 2013 to 2017.
    - Multilevel (school and pupil) analysis of KS1 and KS2 maths attainment comparing pupils in exchange schools with pupils in contrast control schools.
4. Sensitivity Analyses
    - The main (headline) KS1 and KS2 maths attainment impact analyses are statistically scrutinised for robustness.
5. Scrutinising impact across the separate exchange-contrast school samples
    - Analyses that look at each MTE school and compare attainment for pupils at that school with the attainment of pupils in one of the sample of matched contrast control schools.
6. In addition further sensitivity analysis will be undertaken with regard to high implementation / mastery exploratory analyses
    - Using data gathered in strand one, the relationship between fidelity and KS1 / KS2 maths attainment will be examined
    - The initial descriptive analyses will identify a sub-sample of exchange schools identified to have met high or minimum MTE implementation thresholds, KS1 and KS2 impact analyses will be re-run using these school

The analyses began with the examination of patterns at the school level in terms of KS2 attainment, KS1 attainment for the KS2 pupil cohort, %FSM, %Female and school size. The school level analyses provide the first perspective on KS2 maths

attainment differences in exchange schools compared with contrast schools, but do not take any account of within-school (pupil level) attainment variations.

The pupil level descriptive analyses provide the second perspective on KS2 maths attainment differences and first perspective on KS1 attainment differences. Whilst these analyses do directly acknowledge (and examine) variations in attainment at the pupil level, they do not take account of how pupils are clustered into primary schools.

The multilevel analyses acknowledge both school level clustering and within-school pupil level attainment variations and provide the most robust analyses from which to estimate the impact of the exchange on KS1 and KS2 maths attainment.

For the descriptive and main (headline) multilevel impact analyses, a similar approach was taken for dealing with missing data as was taken for the analyses reported in the second interim report. Specifically, a (school-level) listwise deletion approach was adopted. This was done to best ensure that the analyses were undertaken on the same samples of exchange and contrast control schools across the (2013 to 2017) five years. In doing this, schools that did not appear on the school level KS2 census in one of the five years was excluded from the analysis. This brings an additional advantage in terms of internal validity, schools that underwent substantial change during the five years (e.g. became an academy, shut down) will not be included. This helps to ensure that the samples of exchange and matched contrast control schools were consistent and none will have undergone a substantial change in governance structure for the five years of the analyses.

Following the main (headline) multilevel impact analyses, two sensitivity analyses were conducted. First, the listwise deletion of missing values criteria was dropped and all analyses were re-run on the raw KS1 and KS2 pupil samples across the five years. Second, school level KS2 data from 2013 was used to re-match the exchange schools such that the exchange-contrast samples were matched using data from both 2013 and 2014.

The next analyses examined the difference in KS2 maths attainment of pupils in MTE schools and pupils within contrast control schools across the separate exchange-contrast control group samples.

School Level Descriptive Analyses 2013 to 2017

Table 1 in the second interim report presented school-level descriptive statistics for 39 of the 47 exchange schools with complete school level KS1 and KS2 attainment data for 2013, 2014 and 2015. The exchange school statistics are shown alongside

comparable statistics for the contrast school sample; 718 of the original 780 matches[49] with complete 2013 to 2015 KS1 and KS2 attainment data. This is known as a listwise deletion approach to missing cases (schools) and is done to best ensure the sample of schools shown across all five years of analyses are the same.

A similar listwise approach was adopted for the final analyses. Across the five years (2013 to 2017), school level KS1 and KS2 attainment data was available for 33 of the 47 exchange schools. Similarly, there are 798 contrast control schools with complete KS1 and KS2 for the five years. However, 242 of these contrast schools were matched to one of the 14 exchange schools without complete KS1/KS2 attainment data. This led to identifying a final (listwise) sample of 556 contrast control schools matched to 33 exchange schools where all schools had complete school-level KS1 and KS2 data. Table 39 below summarises the school-level comparison of the exchange school and matched samples. In Table 39 below, the mean difference between the exchange school and matched samples which are converted into (Cohen's d) effect size statistics.

At the school level, there are some suggestions of positive impact in Table 39 in 2017 relating to the scaled KS2 maths attainment outcome (d=+0.20). This needs to be considered alongside the fact that in 2017, the prior KS1 attainment of KS2 pupils in exchange schools was notably higher than pupils in matched schools (d=+0.33).

These school level analyses are insufficiently robust or sensitive to draw firm conclusions about the impact of MTE on KS2 maths attainment. Specifically, the school level analyses take no account of variation at the pupil level. The analyses that follow will examine the descriptive patterns at the pupil level but these will not take account of prior attainment or the clustering of pupils into schools. The final multilevel impact analyses acknowledge the clustering of pupils at both KS1 and KS2 and, for KS2, control for prior KS1 maths attainment.

[49] Each of the 39 exchange school were matched to 20 contrast schools, resulting in a total sample of (39 x 20) 780 primary schools but 62 schools were dropped because of absent KS1 or KS2 attainment data in 2013, 2014 or 2015.

Table 61: MTE Evaluation: School level descriptive analyses 2013 to 2017

	2013			2014			2015			2016			2017		
	MTE	**Match**		**MTE**	**Match**		**MTE**	**Match**		**MTE**	**Match**		**MTE**	**Match**	
KS1 APS of KS2 pupils	15.8	15.6	+0.11	15.7	15.8	-0.06	15.9	15.7	+0.13	16.0	16.0	+0.02	16.5	16.2	+0.33
KS2 APS*	29.9	29.3	+0.39	30.0	29.9	+0.03	30.1	29.8	+0.28	104.9	104.5	+0.16	106.3	105.8	+0.18
KS1-KS2 Maths Value Added**	101.0	100.4	+0.41	100.8	100.7	+0.07	100.7	100.5	+0.17	-	-	-	-	-	-
KS2 Scaled Maths**	-	-	-	-	-	-	-	-	-	104.5	104.3	+0.09	105.7	105.1	+0.20
%Female	49.0	49.1	-0.03	49.5	49.1	+0.13	49.5	49.3	+0.03	48.8	49.4	-0.07	46.5	48.8	-0.28
%FSM (6 years)	21.0	22.2	-0.07	19.9	22.4	-0.15	23.9	26.7	-0.16	26.2	27.0	-0.04	25.8	27.2	-0.07
Mean School size	381	323	+0.38	387	331	+0.36	395	338	+0.35	401	345	+0.34	409	351	+0.34

* The overall KS2 Average Points Score (APS) attainment measure changed scales in 2016.

**** KS1** to KS2 maths value added score was available for 2013 to 2015.

*** KS2 scaled maths score was available for 2016 and 2017

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Pupil Level KS1 and KS2 Descriptive Analyses 2013 to 2017

Prior to presenting the pupil level descriptive analyses, some changes in KS1 and KS2 assessments within the evaluation period are discussed. In 2017 the KS1 maths assessment moved from a scale[50] to a categorical[51] measure. This made it impossible to follow the same multilevel linear regression approach presented in the second interim report for our analyses of 2016 and 2017 KS1 data. In response to this, the analyses switch to focus on two categorical outcomes for KS1 maths and were undertaken across the full five years. Specifically, a multilevel logistic regression approach was adopted as summarised in Table 40.

Table 62: Approaches for measuring KS1 maths attainment 2013 to 2017

Analytical approach		2013	2014	2015	2016	2017
Multilevel linear regression	Scale KS1 maths average points score.	✓	✓	✓	n/a	n/a
Multilevel binary logistic regression	Whether Attained expected level or higher in KS1 maths	✓	✓	✓	✓	✓
	Whether exceeded expected level in KS1 maths	✓	✓	✓	✓	✓

The approach to identifying the expected and exceeded KS1 maths thresholds changed during the evaluation period. Between 2013 and 2014, pupils who attained level 2 or higher in KS1 maths are identified as having met or exceeded the expected level and pupils who attained level 3 or higher are identified as having exceeded the expected level. In 2016 and 2017, pupils who are identified as either "working at the expected KS1 standard" or "working at greater depth than the expected KS1 standard" in KS1 maths are identified as having met or exceeded the expected level and pupils who are identified as "working at greater depth than the expected KS1 standard" are identified as having exceeded the expected level.

Whilst it would have been ideal to have had the same (scale) outcome measure across all five years, switching to the binary categorical version does allow the five year KS1 maths impact analyses to be undertaken.

[50] KS1 NPD variable / field name = KS1_MATPOINTS
[51] KS1 NPD variable / field name = KS1_MATH_OUTCOME

Changes to KS2 assessments also took place in 2016; the KS2 maths fine points score[52] (used within the second interim report) was available for 2013 to 2015 but in 2016 a new scale was introduced[53]. This change means that a multilevel linear regression approach remained feasible for all five years. Whilst the change in scale from 2016 is not ideal, this change is likely to affect the exchange and matched pupil samples in a similar way. To provide greater consistency across the five years, the raw KS2 maths test score[54] was included as an outcome variable. Table 41 illustrates the approach taken for analyses of KS2 maths attainment.

Table 63: Approaches for measuring KS2 maths attainment 2013 to 2017

Analytical approach		2013	2014	2015	2016	2017
All multilevel linear regression	KS2 Maths Fine points score	✓	✓	✓	n/a	n/a
	KS2 Maths Scaled Score	n/a	n/a	n/a	✓	✓
	KS2 Maths Raw Score	✓	✓	✓	✓	✓

The KS2 fine points score will be used to provide consistency with the interim report (but this outcome is contained to 2013 to 2015). The new KS2 scaled maths score will be used for 2016 and 2017 to reflect current practice in measuring pupil attainment at KS2. The KS2 raw maths score will be used across all five years to provide temporal consistency for the full evaluation period. All analyses will be drawn on to assess the impact of participation in the MTE programme on KS2 maths attainment.

The second interim report, reported pupil level descriptive analyses for 2014 and 2015 in terms of KS1 and KS2 attainment, %female and %FSM. Table 42 and Table 43 below extends these descriptive analyses to cover the full five year period for the KS1 and KS2 pupil samples respectively. No clear evidence of a difference between the exchange and matched school samples in terms of maths attainment between 2015 and 2017 was observed. In all but one instances, pupils in the exchange school samples attained higher on average in KS1 maths compared with pupils in the matched school samples - but the size of difference is small and in the 'Low' EEF effect size band.

[52] KS2 NPD variable / field name = KS2_MATFINE
[53] KS2 NPD variable / field name = KS2_KS2MATSCORE
[54] KS2 NPD variable / field names = KS2_MATTOTMRK [2013 to 2015] ; KS2_MATMRK [2016 & 2017]

The largest difference between the two samples is seen in 2013, two years prior to the start of the exchange. This might indicate a weakness in matching using just 2014 data and is explored further in the sensitivity analyses reported below.

For KS2, the descriptive analyses show even less evidence of a difference between the exchange and matched school samples in terms of maths attainment between 2015 and 2017. This is shown by the smaller effect sizes reported in Table 43.

Once again, the largest difference between the two samples is seen in 2013, and this is explored further in the sensitivity analyses reported below.

Table 64: MTE Evaluation: KS1 Pupil level descriptive analyses 2013 to 2017

KS1 Average Points Score (Overall and KS1 Maths)

	2013			2014			2015			2016			2017		
	MTE	**Match**	***d*[1]**	**MTE**	**Match**	***d***	**MTE**	**Match**	***d***	**MTE**	**Match**		**MTE**	**Match**	
KS1 APS[3]	16.5	16.0	*+0.15*	16.4	16.2	*+0.07*	16.6	16.3	*+0.09*	-	-	-	-	-	-
KS1 Maths APS[4]	16.9	16.5	*+0.14*	16.7	16.6	*+0.04*	16.9	16.7	*+0.06*	-	-	-	-	-	-

KS1 Maths Attainment Thresholds[5]

	2013			2014			2015			2016			2017		
	MTE	**Match**	***OR*[2]**	**MTE**	**Match**	***OR***	**MTE**	**Match**	***OR***	**MTE**	**Match**	***OR***	**MTE**	**Match**	***OR***
Expected+	95.2%	93.0%	*1.49*	93.3%	94.2%	*0.86*	94.5%	94.6%	*1.08*	78.1%	76.2%	*1.11*	80.4%	78.9%	*1.10*
Exceeded+	30.3%	24.9%	*1.31*	30.7%	26.6%	*1.22*	31.4	28.0	*1.18*	22.7%	19.9%	*1.18*	25.9%	23.2%	*1.16*

KS1 Pupil demographics

	2013		2014		2015		2016		2017	
	MTE	**Match**	**MTE**	**Match**	**MTE**	**Match**	**MTE**	**Match**	**MTE**	**Match**
% Female	47.3%	48.8%	47.7%	49.0%	49.9%	48.4%	51.2%	48.9%	49.4%	49.1%
% FSM (6)	23.0%	23.0%	22.0%	22.0%	20.0%	21.0%	18.0%	20.0%	17.0%	17.0%

1 - d = Cohens d effect size; **2 -** OR = Odds-Ratios; **3 -** Overall KS1 Average Points Score (APS) available 2013 to 2015; **4 -** KS1 Maths Average Points Score (APS) available 2013 to 2015; **5 -** Thresholds of KS1 maths attainment can be viewed across all five years. These identify when a pupil has reached a standard that

is expected at KS2 or not (expected+) and whether a pupil reached a standard that surpassed expectations in KS2 maths (exceeded+). Prior to 2015, a pupil was identified as reaching the expected standard when their KS2 maths attainment was at level 2 or higher (which linked to a KS1 maths APS of 13 points or higher). Similarly, prior to 2015, a pupil was identified as exceeding the expected standard when their KS2 maths attainment was at level 3 or higher (which linked to a KS1 maths APS of 21 points or higher). From 2016 KS1 maths tests became purely categorical (no scale measure available) and the change in methodology is seen to be reflected by the sudden change in statistics observed from 2016. From 2016, pupils who were categorised as 'Working at expected standard' or 'Working at greater depth than expected standard' are classed as expected+ whilst pupils who are categorised as 'Working at greater depth than expected standard' are classed as exceeded+.

Table 65: MTE Evaluation: KS2 Pupil level descriptive analyses 2013 to 2017

KS1 Pupil demographics

	2013			2014			2015			2016			2017		
	MTE	Match		MTE	Match		MTE	Match		MTE	Match		MTE	Match	
KS2 Maths FPS[1]	5.07	4.97	+0.12	5.06	5.07	-0.01	5.08	5.01	+0.08	-	-	-	-	-	-
KS2 Maths SMS[2]	-	-	-	-	-	-	-	-	-	104.6	104.1	+0.07	105.5	105.0	+0.07
KS2 Maths Raw Test Scores[3]:															
Total Score	76.0	74.1	+0.10	75.6	76.2	-0.04	76.3	75.0	+0.07	79.3	77.5	+0.08	78.9	77.6	+0.06
Mental Arithmetic	15.5	15.2	+0.07	15.8	16.0	-0.04	14.9	14.9	+0.01	31.6	31.3	+0.05	32.2	31.8	+0.05
Paper A	29.8	29.2	+0.08	30.3	30.7	-0.05	29.8	29.3	+0.08	24.3	23.6	+0.08	24.7	24.4	+0.05
Paper B	30.7	29.8	+0.12	29.4	29.5	-0.01	31.5	30.8	+0.10	23.3	22.6	+0.08	22.0	21.4	+0.06
KS2 APS[4]	29.8	29.3	+0.10	29.9	29.9	0.00	30.1	29.8	+0.08	-	-	-	-	-	-
mean KS2 score[5]	-	-	-	-	-	-	-	-	-	105.2	104.7	+0.07	104.7	104.1	+0.08
KS1 APS (KS2 cohort)[6]	15.7	15.7	0.00	15.6	15.8	-0.07	15.8	15.8	+0.02	16.1	16.1	+0.02	16.6	16.2	+0.11
KS1 Maths APS (KS2 cohort)[7]	16.1	16.2	-0.02	15.9	16.2	-0.08	16.2	16.2	+0.01	16.4	16.3	+0.02	16.8	16.5	+0.11

KS2 Pupil demographics

	2013		2014		2015		2016		2017	
% Female	48.7%	49.3%	49.9%	49.4%	48.7%	49.2%	48.3%	48.8%	46.5%	48.6%
%FSM (6)	27.0%	25.0%	24.0%	25.0%	26.0%	25.0%	27.0%	25.0%	26.0%	26.0%

1 - KS2 Maths Fine Points Score (FPS) available 2013 to 2015;

2 - KS2 Scaled Maths Score (SMS) available 2016 & 2017;

3 - The KS2 maths raw test scores are available for all five years (2013 to 2017) but there was a change in methodology in 2016 (and this is seen with the sharp change statistics in 2016 and 2017 compared with 2013 to 2015). The greatest change is observed with the mean Mental Arithmetic score which reflects how marks on this paper doubled from 20 points in 2015 to 40 points from 2016. Between 2013 and 2015, there were two written KS2 maths papers (Paper A and Paper B) which were renamed in 2016 to Reasoning 1 and 2 respectively. The marks attributed to these written papers reduced from 40 points in 2015 to 35 points from 2016. The result of the changes increased the total KS2 raw test marks available from 100 in 2015 to 110 from 2016. Prior to 2016, the 100 points were weighted 20 / 40 / 40 for arithmetic / paper A / paper B and from 2016 the 110 points were weighted 40 / 35 / 35 for arithmetic / reasoning 1 / reasoning 2.
4 - Overall KS2 Average Points Score (APS) available 2013 to 2015.
5 - Mean KS2 Score - derived from mean score of all (scaled) KS2 test scores - available 2016 & 2017.
6 - Overall KS1 Average Points Score (APS) for KS2 pupil cohort (i.e. for the 2013 KS2 cohort, the KS1 data stems from 2009 when this cohort sat their KS1 tests) - available for all years 2013 to 2017.
7 - KS1 Maths Points Score (APS) for KS2 pupil cohort - available for all years 2013 to 2017.

Main (headline) multilevel Impact analyses

The descriptive analyses showed little / no evidence that participation in the MTE programme resulted in gains in pupil level KS1 or KS2 maths attainment but the multilevel analyses provide a more comprehensive impact assessment. This is because the KS1 and KS2 multilevel analyses will statistically take account of how pupils are clustered into schools. Additionally, the KS2 analyses statistically controls for prior KS1 maths attainment at the pupil level.

Impact at Key Stage 1

For KS1 maths attainment, KS1 Maths Points Score (2013 to 2015) and KS1 expected thresholds (2013 to 2017) are modelled including a single school level binary variable that identified whether a pupil was located in an exchange school (=1) or not (=0). This is known as an outcome-only model.

Table 44 reports the main impact analyses for KS1 maths attainment. For the 2013 to 2014 KS1 maths points score models, Table 45 shows the estimated model coefficient and standard error for the exchange school pupil sample. The coefficient is then converted into Cohen's d effect size statistics with 95% confidence intervals.

For the 2013 to 2017 KS1 maths attainment threshold models, Table 44 shows the estimated model coefficient and standard error for the exchange school pupil sample. The coefficient is then converted into odds-ratio statistics[55] with 95% confidence intervals. The odds-ratios and confidence intervals are then converted into Cohens d effect size estimates using the formula set out by Sanchez-Meca et al (2003). Finally, Table 44 shows the number of primary schools and pupils included into the KS1 maths analyses.

The analyses found that whilst pupils in the exchange schools were more likely to meet or exceed the expected KS1 maths thresholds compared with pupils in the matched contrast school sample, the difference was very small and not statistically significant between 2015 and 2017. This leads us to conclude that from the main impact analyses, we found no evidence that a schools participation in the Shanghai mathematics teacher exchange resulted in gains in pupil attainment in KS1 maths.

[55] Relative odds of pupils in exchange schools reaching the threshold compared with pupils in the matched schools.

The largest difference shown in Table 44 was in 2013. This echoes the descriptive finding shown in Table 43 and may be an indication of a weakness in matching using just 2014 data and this is explored further in the sensitivity analyses reported below.

Table 66: Pupil Level KS1 Attainment Models

KS1 Maths Points Score (2013 to 2015)

Multilevel Linear regression Analyses

	Coef	s.e.	d	95% CIs for d	n schools	n pupils
2013	0.44*	0.200	+0.13*	+0.01; +0.24	551	24,509
2014	0.09	0.191	+0.03	-0.08; +0.14	552	25,435
2015	0.12	0.186	+0.04	-0.07; +0.14	553	26,348

KS1 Maths Attainment Thresholds (2013 to 2017)

Multilevel Logistic regression Analyses

Exceeding expected KS1 level in maths

	Coef	s.e.	OR	95% CIs for OR	d[1]	95% CIs for d	n schools	n pupils
2013	0.27*	0.128	1.31*	1.02; 1.69	+0.15*	+0.01; +0.29	551	24,509
2014	0.15	0.116	1.16	0.93; 1.46	+0.08	-0.04; +0.21	552	25,435
2015	0.13	0.111	1.14	0.92; 1.42	+0.07	-0.05; +0.19	553	26,348
2016	0.14	0.144	1.15	0.87; 1.53	+0.08	-0.08; +0.23	553	26,028
2017	0.16	0.113	1.17	0.94; 1.46	+0.09	-0.03; +0.21	540	26,010

Meeting expected KS1 level in maths

	Coef	s.e.	OR	95% CIs for OR	d[1]	95% CIs for d	n schools	n pupils
2013	0.36*	0.184	1.44*	1.00; 2.06	+0.20*	0.00; +0.40	551	24,509
2014	-0.05	0.177	0.95	0.67; 1.34	-0.03	-0.22; +0.16	552	25,435
2015	0.00	0.189	1.00	0.69; 1.45	0.00	-0.20; +0.21	553	26,348
2016	0.10	0.111	1.10	0.88; 1.37	+0.05	-0.07; +0.17	553	26,028
2017	0.14	0.095	1.15	0.96; 1.39	+0.08	-0.02; +0.18	540	26,010

* $p<0.05$

1 - converting Odds Ratio to Cohens d effect size

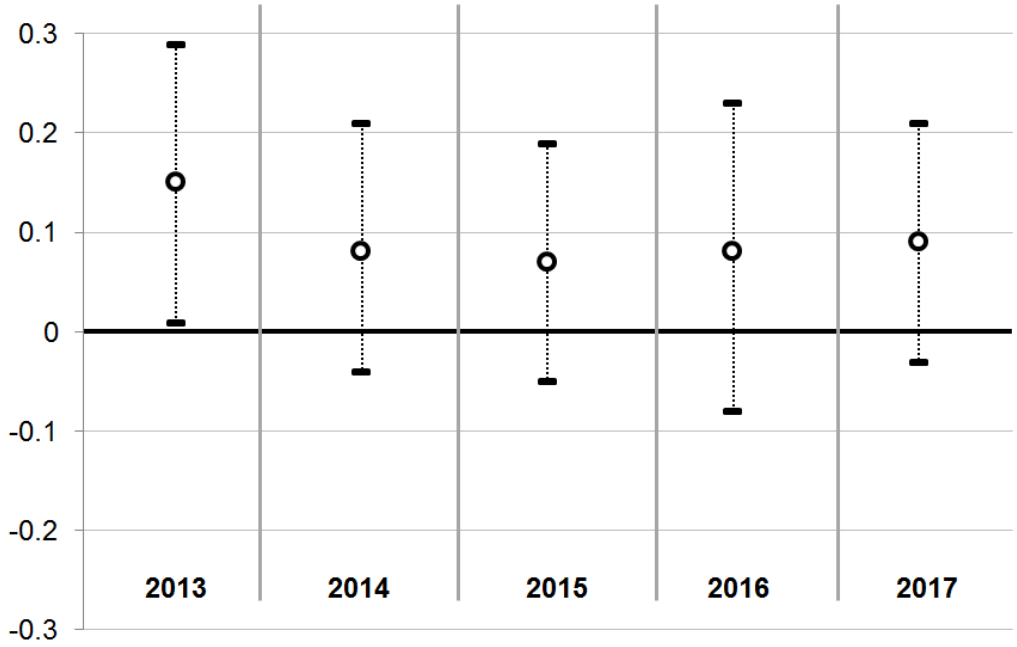
Figure 6 uses error bars to illustrate the Cohen's d effect size statistics from the multilevel models using the 'exceeding expected KS1 maths level' outcome variable. The estimated effect size is shown as the circle in the centre of an upper and lower bar which shows the 95% confidence intervals from the multilevel analyses.

As can be seen, a small positive effect is seen across all five years but this is not statistically significantly different from zero in 2014 to 2017. Further, the chart shows no evidence of an increasing difference between the exchange and matched samples between 2015 and 2017.

Figure 17: KS1 maths attainment difference between pupils in MTE schools and pupils in contrast control schools 2013 to 2017

Coefficient from multilevel logistic analyses, odds-ratios converted into Cohen's d effect size statistics

Outcome: *Whether a pupil exceeds expected KS1 maths level (=1) or not (=0)*



Impact at Key Stage 2

For KS2 maths attainment, KS2 Maths Fine Points Score (2013 to 2015); KS2 scaled maths score (2016 to 2017) and KS2 Maths Raw Score (2013 to 2016) are modelled. The models are constructed in two stages; First, an outcome-only model and then including KS1 maths attainment as an explanatory variable (creating a KS1 to KS2 value added model).

Table 45 reports the main impact analyses for KS2 maths attainment. For all models Table 45 shows the estimated model coefficient and standard error for the exchange school pupil sample. The coefficient is then converted into Cohen's d effect size statistics with 95% confidence intervals.

The analyses found that the KS2 maths attainment for pupils in the exchange schools was comparable with pupils in the matched contrast school sample, no statistically significant difference was observed between 2015 and 2017. This leads us to conclude that from the main impact analyses, we found no evidence that a schools participation in the Shanghai mathematics teacher exchange programme resulted in gains in pupil attainment in KS2 maths.

The largest difference shown in Table 45 was in 2013. This echoes the descriptive finding shown in Table 45 and may be an indication of a weakness in matching using just 2014 data and this is explored further in the sensitivity analyses reported below.

Table 67: Pupil Level KS2 Attainment Models Maths Fine Point Score (2013 to 2015)

	Coef	s.e.	d	95% CIs for d	n schools	n pupils
2013						
Outcome Only	0.12*	0.051	+0.14*	+0.02; +0.26	589	24,810
Value Added	0.11*	0.046	+0.13*	+0.02; +0.24	589	23,755
2014						
Outcome Only	0.01	0.048	+0.01	-0.11; +0.12	589	25,746
Value Added	0.01	0.040	+0.02	-0.08; +0.11	589	24,646
2015						
Outcome Only	0.07	0.049	+0.09	-0.03; +0.20	589	26,260
Value Added	0.04	0.042	+0.05	-0.05; +0.15	589	25,121

Scaled Maths Score (2016 to 2017)

	Coef	s.e.	d	95% CIs for d	n schools	n pupils
2016						
Outcome Only	0.25	0.470	+0.03	-0.09; +0.16	589	26,654
Value Added	0.13	0.420	+0.02	-0.09; +0.13	589	25,555

	Coef	s.e.	d	95% CIs for d	n schools	n pupils
2017						
Outcome Only	0.56	0.495	+0.07	-0.05; +0.19	589	27,506
Value Added	-0.13	0.437	-0.02	-0.12; +0.09	589	26,262

Maths Raw Point Score (2013 to 2017)

	Coef	s.e.	d	95% CIs for d	n schools	n pupils
2013						
Outcome Only	2.31	1.209	+0.12	0.00; +0.24	589	24,498
Value Added	2.20	1.135	+0.11	0.00; +0.23	589	23,518
2014						
Outcome Only	-0.35	1.036	-0.02	-0.13; +0.09	589	25,455
Value Added	-0.14	0.923	-0.01	-0.11; +0.09	589	24,439
2015						
Outcome Only	1.45	1.096	+0.08	-0.04; +0.20	589	25,937
Value Added	0.74	1.013	+0.04	-0.07; +0.15	589	24,884
2016						
Outcome Only	0.90	1.533	+0.04	-0.09; +0.17	589	26,363
Value Added	0.44	1.422	+0.02	-0.10; +0.14	589	25,311
2017						
Outcome Only	1.50	1.583	+0.06	-0.07; +0.20	589	27,196
Value Added	-0.33	1.434	-0.01	-0.13; +0.11	589	26,022

* $p<0.05$

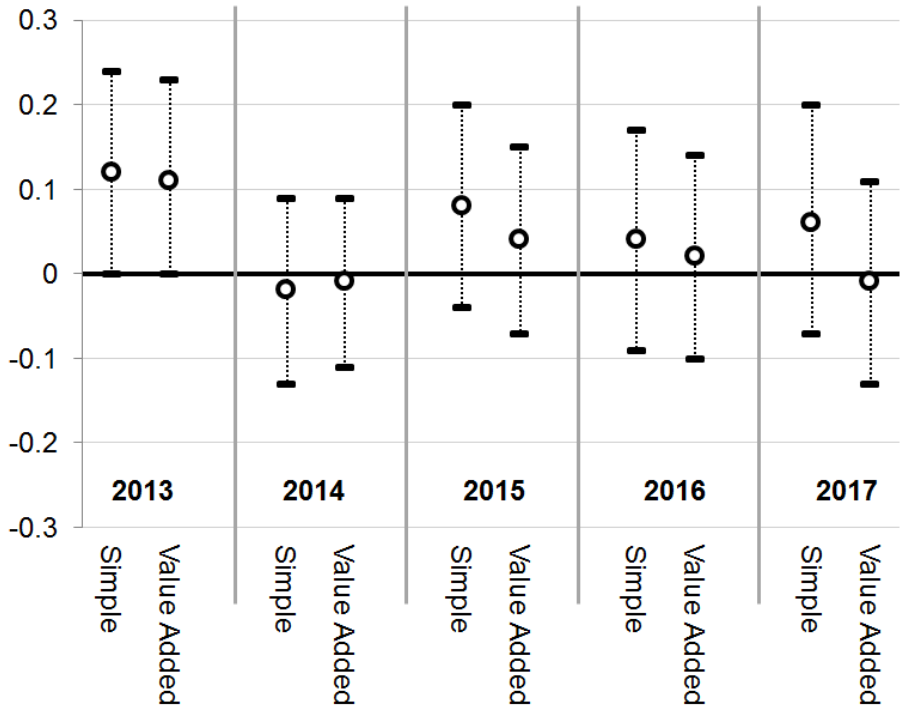
Figure 7 uses error bars to illustrate the Cohen's d effect size statistics from the multilevel models using the raw KS2 maths test outcome variable. The estimated effect size is shown as the circle in the centre of an upper and lower bar which shows 95% confidence intervals from the multilevel analyses.

As can be see, the effect size remains close to zero 2014 to 2017. Further, once prior KS1 maths attainment is controlled for, the effect size moves even closer towards zero between 2015 and 2017.

Figure 18: KS2 maths attainment difference between pupils in MTE schools and pupils in contrast control schools 2013 to 2017

Coefficient from multilevel analyses converted into Cohen's d effect size statistics with 95% confidence intervals

Outcome: *Raw KS2 maths test score*



Sensitivity analyses

As outlined above, the descriptive and main (headline) impact analyses were undertaken on a sub-sample of exchange and matched contrast control schools, restricted using a school-level listwise deletion approach to missing values. This led to a sample of 33 exchange schools matched to 556 contrast schools with school level KS1 and KS2 attainment data for the KS2 pupil cohort for the full (2013 to 2017) five year period. This approach best ensured that the same sample of schools were included in the analyses across the five years.

For sensitivity analyses, all of the impact analyses were re-run on two different samples:

The Raw sample: The size of the exchange and contrast control school sample will fluctuate over the five year period with a maximum size of all 47 exchange schools matched to 940 contrast control schools.

Re-matched Sample: Sample of exchange to matched schools were re-matched using 2013 school level data. This was done to ensure that the matched sample reflected the exchange school sample across 2013 and 2014 (the two years prior to the exchange) rather than just 2014 (used for the main analyses). Re-matching resulted in a sample of 27 exchange schools matched to 179 contrast schools.

Table 46 summarises the KS1 models for the raw and re-matched school samples. Specifically, Table 46 summarises the multilevel logistic models for the higher KS1 threshold outcome (whether a pupil exceeded the expected level in KS1 maths or not).

For KS1 maths, both sensitivity analyses echo the patterns observed in the main impact analyses. These findings re-affirm our conclusion that we found no evidence that participation in the exchange resulted in gains in KS1 maths.

Table 47 summarises the KS2 models for the raw and re-matched school samples. Specifically, Table 47 summarises the multilevel linear regression models for the raw KS2 maths test score outcome.

For KS2 maths, both sensitivity analyses echo the patterns observed in the main impact analyses. These findings also re-affirm our conclusion that we found no evidence that participation in the exchange resulted in gains in KS2 maths.

Table 68: KS1 Maths Attainment Sensitivity Analyses

Exceeding expected KS1 level in maths

Raw Sample

	Coef	s.e.	OR	95% CIs for OR	d[1]	95% CIs for d	n schools	n pupils
2013	0.26*	0.114	1.30*	1.04; 1.63	+0.15	+0.02; +0.27	906	39,952
2014	0.12	0.100	1.12	0.92; 1.36	+0.06	-0.04; +0.17	902	41,412
2015	0.14	0.095	1.15	0.95; 1.38	+0.07	-0.03; +0.18	874	41,578
2016	0.24	0.136	1.28	0.98; 1.67	+0.13	-0.01; +0.28	842	39,351
2017	0.19	0.107	1.21	0.98; 1.49	+0.10	-0.01; +0.22	800	38,364

Rematched sample

	Coef	s.e.	OR	95% CIs for OR	d[1]	95% CIs for d	n schools	n pupils
2013	0.14	0.161	1.15	0.84; 1.58	+0.08	-0.09; +0.25	192	9,391
2014	0.03	0.146	1.03	0.78; 1.38	+0.02	-0.14; +0.18	193	9,751
2015	0.01	0.140	1.01	0.77; 1.33	+0.01	-0.14; +0.16	193	9,951
2016	0.04	0.178	1.04	0.73; 1.30	+0.02	-0.17; +0.21	193	9,945
2017	0.01	0.132	1.01	0.78; 1.30	0.00	-0.14; +0.15	187	9,939

* p<0.05

Table 69: KS2 Maths Attainment Sensitivity Analyses

Maths Raw Point Score

Raw Sample

	Coef	s.e.	d	95% CIs for d	n schools	n pupils
2013						
Outcome Only	2.79*	1.182	+0.14*	+0.02; +0.26	932	37,989
Value Added	2.30*	1.077	+0.12*	+0.01; +0.22	932	36,444
2014						
Outcome Only	0.11	1.044	+0.01	-0.10; +0.12	986	42,310
Value Added	-0.28	0.878	-0.01	-0.11; +0.08	986	40,571
2015						
Outcome Only	1.86	1.014	+0.10	-0.01; +0.21	959	42,096
Value Added	1.52	0.879	+0.08	-0.01; +0.18	959	40,393
2016						
Outcome Only	1.42	1.402	+0.06	-0.06; +0.18	922	41,141
Value Added	0.92	1.248	+0.04	-0.07; +0.15	922	39,483
2017						
Outcome Only	1.59	1.473	+0.07	-0.05; +0.19	884	40,607
Value Added	-0.06	1.308	0.00	-0.11; +0.11	884	38,863

Re-matched Sample

	Coef	s.e.	d	95% CIs for d	n schools	n pupils
2013						
Outcome Only	-0.08	1.623	0.00	-0.17; +0.16	206	9,343
Value Added	1.29	1.392	+0.07	-0.07; +0.21	206	8,930
2014						
Outcome Only	-1.36	1.437	-0.08	-0.23; +0.08	206	9,799
Value Added	0.26	1.193	+0.01	-0.12; +0.14	206	9,399

	Coef	s.e.	d	95% CIs for d	n schools	n pupils
2015						
Outcome Only	1.24	1.466	+0.07	-0.09; +0.23	206	9,882
Value Added	1.66	1.196	+0.09	-0.04; +0.22	206	9,463
2016						
Outcome Only	-0.61	1.834	-0.03	-0.19; +0.13	206	10,162
Value Added	0.46	1.515	+0.02	-0.11; +0.15	206	9,741
2017						
Outcome Only	0.82	1.944	+0.03	-0.13; +0.20	206	10,548
Value Added	0.17	1.701	+0.01	-0.13; +0.15	206	10,053

* p<0.05

Scrutinising impact across the separate exchange-contrast school samples

The analyses presented prior to this section focused on comparing the KS1 and KS2 maths attainment for pupils located in a sample 47 MTE schools with the attainment for pupils located in the sample of matched contrast control schools. Impact at KS1 and KS2 was examined across all MTE schools, and these analyses found no evidence that participation in the exchange led to pupil gains in KS1 or KS2 maths attainment.

In this section we look closer at the separate exchange-contrast control school samples. These exploratory analyses focus solely on KS2 maths attainment. The shift towards measuring maths attainment using very blunt thresholds in 2016 limits the scope and value of follow on exploratory analyses for KS1 maths. Raw KS2 maths test scores are examined amongst the listwise sample of 33 exchange schools and 556 contrast control schools. For each of the 33 exchange schools, the mean KS2 maths attainment is compared with the 33 matched samples of contrast control schools from 2013 to 2017.

Table 48 below summarises these analyses by first indicating the number of instances when pupil KS2 maths attainment within an exchange school was greater (by an effect size of d=+0.02 or greater) than the pupil attainment of the matched contrast control sample. Table 48 also indicates the number of instances when pupil KS2 maths attainment within an exchange school was lower (by an effect size of d= -0.02 or lower) than the pupil attainment of the matched contrast control sample. Table 48 finally provides additional detail on the range of positive and negative effect sizes found across the 33 exchange-matched school sub-samples.

Table 70: Comparing KS2 maths attainment for pupils in 33 exchange schools with their 33 matched contrast control school samples.

	2013	2014	2015	2016	2017
Exchange > Matched Sample	21 (64%)	14 (42%)	23 (70%)	19 (58%)	18 (55%)
Exchange = Matched Sample	3 (9%)	5 (15%)	2 (6%)	1 (3%)	2 (6%)
Exchange < Matched Sample	9 (27%)	14 (42%)	8 (24%)	13 (39%)	13 (39%)
Cohen's d effect sizes for +VE Impact [Exchange > Matched Sample]					
High/V High (+0.45 or higher)	4 (12%)	0 (0%)	1 (3%)	2 (6%)	5 (15%)
Moderate (+0.19 to <+0.45)	9 (27%)	2 (6%)	13 (39%)	8 (24%)	7 (21%)
Low (+0.02 to <+0.19)	8 (24%)	12 (36%)	9 (27%)	9 (27%)	6 (18%)
Cohen's d effect sizes for -VE Impact [Exchange < Matched Sample]					
Low (+0.02 to <+0.19)	4 (12%)	14 (42%)	3 (9%)	5 (15%)	5 (15%)
Moderate (-0.19 to -0.45)	5 (15%)	0 (0%)	2 (6%)	7 (21%)	6 (18%)
High/V High (below -0.45)	0 (0%)	0 (0%)	3 (9%)	1 (3%)	2 (6%)

Table 48 shows a clear balance between the exchange school and contrast control school samples in 2014. In 2014, in 14 of the 33 exchange-contrast sub-samples, mean pupil KS2 maths attainment was higher in the exchange school sample (in two sub-samples, this equated to an effect size above +0.19 whilst for the remaining 12 it equated to an effect size between +0.02 and +0.19). At the same time, in 2014 there are 14 of the 33 exchange-contrast sub-samples where mean pupil KS2 maths attainment was lower in the exchange school sample (in all 14 sub-samples, the difference equated to an effect size between -0.02 and -0.19). Essentially, the exchange-contrast sub-samples are fairly tightly clustered either side of a zero effect size. This balance is good to see, and was expected given that 2014 was the year in which school level data was used to match the exchange schools with a sample of statistically similar contrast control schools.

Between 2015 and 2017, Table 48 shows the effect sizes across the 33 exchange-contrast sub-samples diverging - but this was in both directions.

For example, in 2017, in 18 of the 33 exchange-contrast sub-samples, mean pupil KS2 maths attainment was higher in the exchange school sample. Additionally, greater variation in the positive impact was observed in 2017 compared with 2014. Specifically, in five sub-samples, it equated to an effect size of +0.45 sds or higher; in seven sub-samples it equated to an effect size between +0.19 to less than +0.45, and for the remaining six sub-samples it equated to an effect size between +0.02 and +0.19. At the same time, in 2017 there are 13 of the 33 exchange-contrast sub-

samples where mean pupil KS2 maths attainment was lower in the exchange school sample. Once again, greater variation in the negative impact is observed in these 2017 13 exchange-contrast sub-samples compared with 2014. Specifically, in two sub-samples, it equated to an effect size of -0.45 sds or lower; in six sub-samples it equated to an effect size between -0.19 to greater than -0.45, and for the remaining five sub-samples it equated to an effect size between -0.02 to greater than -0.19.

In summary, looking across the separate exchange-contrast school sub-samples does not result in finding evidence that participation in the exchange led to gains in pupil KS2 maths attainment. Across the 33 sub-samples, the instances where mean attainment is greater amongst pupils in exchange school samples are offset by other instances where mean attainment is greater amongst pupils in the matched contrast control school samples.

In summary, from the analyses to this point we have found no evidence to suggest that a primary schools participation in the Shanghai mathematics teacher exchange programme led to gains in pupil attainment in KS1 or KS2 maths.

High implementation / mastery exploratory analyses

Implementation / mastery data for 2016 and 2017 was obtained from 37 of the 47 MTE schools (35 primary and 2 junior). Sub-samples of schools with high implementation / mastery at KS1 and KS2 were identified using the criteria set out in section 8. Follow-on statistical analyses will focus on the sub-sample of high implementation / mastery schools. These analyses will examine if/how KS1 and KS2 maths attainment of pupils within the high implementation / mastery MTE sub-sample of schools differs from the maths attainment of pupils in matched contrast schools. Given that schools with high implementation / mastery at KS1 and/or KS2 were identified using data from 2016 and 2017, the follow-on impact analyses will focus only on KS1 and KS2 maths attainment in 2017. KS1 and KS2 maths attainment in 2014 will also be examined in order to provide a baseline.

Table 49 provides a numerical summary of schools and pupils in the MTE and contrast samples for the KS1 and KS2. A listwise deletion approach has been taken for schools and pupils with data missing in either 2014 or 2017. At KS1, 12 schools are identified as having high implementation and mastery and with KS1 maths data

in both 2014 and 2017. These 12 high mastery & implementation schools are matched to 208 schools in 2014 and 205 schools in 2017[56].

Table 71: Numbers of schools & pupils in high implementation/mastery analyses 2014 & 2017

	Mastery & High Implementation in KS1							
	2014				2017			
	MTE		Contrast		MTE		Contrast	
	Schools	Pupils	Schools	Pupils	Schools	Pupils	Schools	Pupils
High Mastery	12	671	208	9,574	12	659	205	9,916
Mastery+	16	925	271	12,396	16	913	265	12,870

	Mastery & High Implementation in KS2							
	2014				2017			
	MTE		Contrast		MTE		Contrast	
	Schools	Pupils	Schools	Pupils	Schools	Pupils	Schools	Pupils
High Mastery	9	418	153	6,530	9	437	153	6,929
Mastery+	10	450	171	7,169	10	467	171	7,614

Table 50 presents some descriptive statistics comparing the MTE and matched contrast samples in 2014 and 2017. For both KS1 maths attainment thresholds, a gap is observed to open up between the MTE and contrast samples between 2014 and 2017. These analyses provide the first suggestion that participation in the MTE exchange led to pupil gains in maths attainment.

In 2014, pupils in MTE schools with high KS1 implementation are seen to be equally as likely to reach the expected KS1 level as pupils in matched contrast schools but by 2017, pupils in MTE schools with high KS1 implementation are seen to be more likely to reach the expected KS1 level as pupils in matched contrast schools. The difference is greater amongst pupils in MTE schools with both high mastery and high KS1 implementation; in 2017 these pupils are 1.49 times as likely to attain the expected KS1 level in maths compared with pupils in matched contrast schools. Pupils in mastery+ schools with high KS1 implementation are observed to be 1.39

[56] The slight (208 and 205) fluctuation is because KS2 data was used in the matching and some of these matches may be junior schools with no KS1 data. The numbers of schools in 2014 and 2017 for the KS2 analyses are exactly the same, reflecting the use of KS2 data in the match.

times as likely as pupils in matched contrast schools to attain the expected KS1 level in maths.

In 2014, pupils in MTE schools with high KS1 implementation are seen to be more likely to exceed the expected KS1 level as pupils in matched contrast schools and this difference is seen to widen by 2017. Again, the difference is greater amongst pupils in MTE schools with both high mastery and high KS1 implementation. In 2014, these pupils are observed to be 1.42 times as likely to exceed the expected KS1 level in maths compared with pupils in matched contrast schools. In 2017 these pupils are observed to be 1.72 times as likely to exceed the expected KS1 level in maths compared with pupils in matched contrast schools. Pupils in mastery+ schools with high KS1 implementation are observed to be 1.34 times as likely as pupils in matched contrast schools to exceed the expected KS1 level in maths in 2014 which is seen to increase to being 1.46 times as likely in 2017.

Table 50 also shows that the MTE and matched contrast sample remained relatively balanced in terms of gender. However, whilst the proportion of disadvantaged pupils in MTE schools is comparable with the proportion of disadvantaged pupils in matched contrast schools in 2014, a difference is evident in 2017. Specifically, in 2017 pupils in matched contrast schools were more likely to be classed as FSM compared with pupils in MTE schools.

Whilst these descriptive analyses do provide the first evidence that participation in the MTE led to pupil gains in KS1 maths attainment, some caution is advised. First, these are bivariate descriptive analyses that do not take account of the clustering of pupils into schools; second, the observed %FSM imbalance in 2017 and third, KS1 maths attainment is a teacher assessment that uses broad/course attainment categories. The first two of these will be addressed within the multilevel logistic regression analyses that directly acknowledge the clustering of pupils into schools and will allow the inclusion of a pupil level FSM covariate to address the observed 2017 imbalance. The second two cannot be statistically addressed but do need to be kept in mind when interpreting impact at KS1.

Table 72: MTE Evaluation: KS1 Pupil level descriptive analyses 2013 to 2017

KS1 Maths Attainment Thresholds

	2014			2017		
	MTE	**Match**	***OR***	**MTE**	**Match**	***OR***
High mastery & KS1 implementation MTE schools						
Expected+	94.5%	94.5%	1.00	85.1%	79.3%	1.49
Exceeded+	34.9%	27.4%	1.42	34.3%	23.3%	1.72
Mastery+ & high KS1 implementation MTE schools						
Expected+	94.2%	94.2%	1.00	83.9%	78.9%	1.39
Exceeded+	32.6%	26.5%	1.34	30.3%	22.9%	1.46

KS1 Pupil demographics

	2014		2017	
	MTE	**Match**	**MTE**	**Match**
High mastery & KS1 implementation MTE schools				
% Female	47.7%	48.7%	48.3%	48.4%
% FSM (6)	20.6%	20.6%	13.5%	17.1%
Mastery+ & high KS1 implementation MTE schools				
% Female	47.5%	48.8%	47.3%	48.7%
% FSM (6)	21.5%	22.4%	13.8%	18.1%

OR = Odds-Ratios

Table 51 presents the KS1 maths multilevel logistic analyses. Two KS1 maths attainment thresholds are shown; exceeding the expected level and meeting the expected level. **Please note** that these KS1 threshold analyses relate solely to the subsample of 12 MTE schools with High Mastery and KS1 implementation and/or the subsample of 16 MTE schools with Mastery+ and high KS1 implementation.

In 2014, no statistically significant difference is observed between the MTE and matched contrast samples. This is seen with both the high mastery & implementation sub-sample and with the mastery and high implementation sub-sample.

In 2017, pupils in MTE schools are observed to be statistically significantly more likely to attain the KS1 maths attainment thresholds compared with pupils in the matched contrast school sample. The difference is greater at the higher threshold and remains positive and statistically significant when the FSM covariate is included into the model (not shown in Table 51).

These high implementation and mastery analyses have revealed evidence that participation on the Shanghai exchange led to positive gains in KS1 maths attainment for some MTE schools. It seems that the level of implementation and mastery are important factors in determining impact on pupil KS1 maths attainment.

Table 73: KS1 Maths attainment models 2014 & 2017

High Mastery & KS1 Implementation

Exceeding expected KS1 level in maths

	Coef	s.e.	OR	95% CIs for OR	d[1]	95% CIs for d	n schools	n pupils
2014	0.24	0.182	1.27	0.89; 1.81	+0.13	-0.07; +0.33	220	10,235
2017	0.57*	0.188	1.77*	1.22; 2.55	+0.31*	+0.11; +0.52	217	10,562

Meeting expected KS1 level in maths

	Coef	s.e.	OR	95% CIs for OR	d[1]	95% CIs for d	n schools	n pupils
2014	0.04	0.288	1.04	0.59; 1.83	+0.02	-0.29; +0.33	220	10,235
2017	0.40*	0.169	1.50*	1.08; 2.08	+0.22	+0.04; +0.40	217	10,562

Mastery+ & High KS1 Implementation

Exceeding expected KS1 level in maths

	Coef	s.e.	OR	95% CIs for OR	d[1]	95% CIs for d	n schools	n pupils
2014	0.21	0.158	1.24	0.91; 1.69	+0.12	-0.05; +0.29	287	13,306
2017	0.42*	0.159	1.53*	1.12; 2.09	+0.23*	+0.06; +0.41	281	13,766

Meeting expected KS1 level in maths

	Coef	s.e.	OR	95% CIs for OR	d[1]	95% CIs for d	n schools	n pupils
2014	-0.01	0.238	0.99	0.62; 1.57	-0.01	-0.27; +0.25	287	13,306
2017	0.34*	0.139	1.41*	1.07; 1.85	+0.19	+0.04; +0.34	281	13,766

* $p<0.05$

1 - converting Odds Ratio to Cohens d effect size

The next analyses consider impact at KS2 amongst high implementation and mastery MTE schools. Table 52 presents descriptive statistics comparing MTE and contrast school samples in terms of maths attainment, gender and %FSM. As with KS1, MTE schools have a high level of implementation at KS2 and two levels of mastery are shown (high mastery and mastery+).

In 2014, the KS2 maths attainment of pupils in MTE schools with high implementation was slightly lower than pupils in matched contrast schools but in 2017 this pattern is seen to reverse.

For schools with both high implementation and mastery, in terms of the mean overall KS2 maths score, a negative effect size is observed in 2014 (d=-0.07) but this changes to a slightly larger positive effect size by 2017 (d=+0.13). In terms of pupil demographics, the MTE and matched sample seem reasonably comparable in terms of gender but there is a slightly larger proportion of disadvantaged pupils in MTE schools compared with the matched contrast school sample.

The multilevel linear regression analyses provide a more comprehensive assessment of the KS2 maths attainment differences between the MTE and contrast school samples. Specifically, these analyses will acknowledge the clustering of pupils into schools and statistically take account of (or control for) other explanatory variables (such as KS1 maths attainment and FSM status).

Table 74: MTE Evaluation - high KS2 implementation & mastery descriptive analyses

KS2 Attainment (Overall and KS1 Maths)

	2014			2017		
	MTE	**Match**	**d**	**MTE**	**Match**	**d**
High Mastery & KS2 implementation						
Total Score	75.8	77.1	-0.07	81.6	78.5	+0.13
Mental Arithmetic	15.6	16.3	-0.18	32.6	32.0	+0.08
Paper A	30.4	31.0	-0.08	26.1	24.7	+0.16
Paper B	29.9	29.8	+0.01	22.9	21.8	+0.12
KS1 Maths APS (KS2 cohort)	15.7	16.2	-0.15	16.7	16.4	+0.08
Mastery+ & high KS2 implementation						
Total Score	75.4	76.2	-0.07	82.0	78.2	+0.16
Mental Arithmetic	15.5	16.2	-0.17	32.7	31.9	+0.11
Paper A	30.2	30.9	-0.09	26.2	24.6	+0.18
Paper B	29.7	29.6	+0.01	23.1	21.7	+0.16
KS1 Maths APS (KS2 cohort)	15.7	16.2	-0.12	16.7	16.3	+0.09

KS2 Pupil demographics

	2014		2017	
High Mastery & KS2 implementation				
% Female	46.9%	49.8%	45.8%	49.7%
%FSM (6)	24.8%	23.8%	29.7%	24.6%
Mastery+ & high KS2 implementation				
% Female	46.9%	49.5%	45.4%	49.7%
%FSM (6)	24.3%	24.0%	28.7%	24.9%

Table 53 presents the KS2 maths multilevel linear analyses. The models presented are for the overall KS2 maths test score in 2014 and 2017. As with previous impact analyses, an outcome only and value added model are shown. The outcome only models just included a school level explanatory variable that identified whether a pupil was located in an MTE (=1) or contrast school (=0). The value added models include an additional pupil level KS1 maths attainment explanatory variable and therefore statistically control for pupil level variations in prior maths attainment. Following the slight FSM imbalance observed from the descriptive analyses (Table 52), a further model stage included pupil level FSM status but these are not shown in Table 53; any impact of including the FSM variable is noted in the text. All of these models were replicated across the three separate KS2 maths papers and any findings are discussed in the text.

In 2014, no statistically significant difference is observed between the MTE and matched contrast samples. This is seen with both the high mastery & implementation sub-sample and with the mastery and high implementation sub-sample.

In 2017, no statistically significant difference is observed between the MTE and matched contrast samples. This is seen with both the high mastery & implementation sub-sample and with the mastery and high implementation sub-sample. The same pattern of no statistically significant difference was found across the three KS2 maths papers and when FSM was included into the models (not shown in Table 53).

In summary, whilst there is descriptive evidence that KS2 maths attainment was higher in high implementation / mastery schools compared with the attainment of pupils in matched contrast schools, the multilevel analyses reveal that this difference is not statistically significant.

Table 75: MTE Evaluation: KS2 Pupil level descriptive analyses 2014 & 2017

Maths Raw Point Score

High Mastery & KS2 Implementation

	Coef	s.e.	d	95% CIs for d	n schools	n pupils
2014						
Outcome Only	0.12	2.309	+0.01	-0.25; +0.26	162	6,850
Value Added	0.81	1.971	+0.05	-0.17; +0.26	162	6,561
2017						
Outcome Only	3.73	3.551	+0.16	-0.14; +0.45	162	7,257
Value Added	1.57	2.900	+0.07	-0.17; +0.30	162	6,900

Mastery+ & KS2 Implementation

	Coef	s.e.	d	95% CIs for d	n schools	n pupils
2014						
Outcome Only	-0.20	2.119	-0.01	-0.24; +0.22	181	7,513
Value Added	0.23	1.817	+0.01	-0.19; +0.21	181	7,208
2017						
Outcome Only	4.65	3.281	+0.20	-0.08; +0.47	181	7,964
Value Added	2.43	2.697	+0.10	-0.12; +0.32	181	7,588

No statistically significant difference found across the three KS2 maths papers

Re-matching using 2013 school level KS2 data

As outlined in the second interim report, in response to the observed school level imbalance in 2013 (two years prior to the start of the MTE), the sample of 47 MTE and 940 matched contrast control schools were re-matched so that the matching process drew on school level data from both 2014 (as original) and 2013.

Using 2013 school level KS2 data, the original 47:940 school sample was re-matched. This was done by first creating a school-level binary outcome for 2013 for the KS2 APS score (1= above median of 29.2; 0=median or lower). The model included the following explanatory variables; KS1 attainment, School size; Maths KS1-KS2 VA Score; %FSM; %Female; %SEN. Propensity scores were then generated and within each of the 47 sub-samples, the matched schools were rank ordered according to how closely the propensity scores for the contrast schools matched their respective exchange school.

This resulted in a reduction in the exchange school sample from 47 to 33 schools, because 14 exchange schools did not have 2013 data. These 14 exchange schools and their 280 matched contrast schools were dropped.

This reduced the sample to 33 schools with 660 matches. The propensity scores were then used to exclude contrast schools that either did not have 2013 data or where the 2013 propensity scores did not match closely with the exchange school they were matched to using 2014 data. This process reduced the contrast control sample down to 218 schools; the 33:218 re-matched sub-sample.

Following the re-matching process, listwise deletion of missing cases was re-done to ensure that all exchange and control schools are matched using 2013 and 2014 data AND to ensure that all these schools had complete school level KS2 attainment data

for 2013 to 2017 inclusive. This reduced the sample of exchange schools further to 27 and the sample of matched contrast schools to 179.

Re-matched sample:
27 exchange schools matched to 179 contrast schools with complete KS1 and KS2 data for 2013 to 2017 inclusive.

Table 54 reconstructs the school level descriptive analyses shown in Table 2 of the second interim report but using the 27:179 re-matched sample.

Table 55 reconstructs the pupil level KS1 descriptive analyses shown in Table 3 of second interim report but using the 27:179 re-matched sample.

Table 56 reconstructs the pupil level KS2 descriptive analyses shown in Table 3 of second interim report but using the 27:179 re-matched sample.

Table 76: School level descriptive analyses 2013 to 2017 [re-matched sample]

	2013			2014			2015			2016			2017		
	MTE	**Match**		**MTE**	**Match**		**MTE**	**Match**		**MTE**	**Match**		**MTE**	**Match**	
KS1 APS of KS2 pupils	15.6	15.9	-0.19	15.5	15.9	-0.30	15.7	15.9	-0.10	15.9	16.2	-0.27	16.5	16.3	+0.12
KS2 APS*	29.8	29.7	+0.04	29.9	30.2	-0.19	30.2	30.0	+0.12	105.0	105.1	-0.01	106.4	106.2	+0.07
KS1-KS2** Maths Value Added	101.1	100.7	+0.25	101.0	100.8	+0.14	100.9	100.5	+0.32	-	-	-	-	-	-
KS2 Scaled Maths**	-	-	-	-	-	-	-	-	-	104.6	104.8	-0.06	105.8	105.4	+0.14
%Female	48.9	49.3	-0.14	49.2	49.2	+0.02	49.7	50.4	-0.09	49.2	49.4	-0.03	46.0	49.0	-0.37
%FSM (6 years)	23.4	21.1	+0.03	22.1	21.2	+0.05	26.8	24.9	+0.10	27.8	25.6	+0.11	29.0	25.7	+0.18
Mean School size	402	348	+0.34	410	358	+0.31	420	365	+0.31	427	372	+0.31	435	378	+0.31

* - The overall KS2 Average Points Score (APS) attainment measure changed scales in 2016.

**** KS1 to KS2 maths value added score was available for 2013 to 2015.

*** KS2 scaled maths score was available for 2016 and 2017

Table 77: KS1 Pupil level descriptive analyses 2013 to 2017 [re-matched sample]

KS1 Average Points Score (Overall and KS1 Maths)

	2013			2014			2015			2016			2017		
	MTE	Match	*d*[1]	MTE	Match	*d*	MTE	Match	*d*	MTE	Match		MTE	Match	
KS1 APS[3]	16.5	16.2	*+0.08*	16.3	16.4	*-0.02*	16.6	16.5	*+0.02*	-	-	-	-	-	-
KS1 Maths APS[4]	16.8	16.5	*+0.08*	16.7	16.8	*-0.03*	16.9	16.9	*-0.01*	-	-	-	-	-	-

KS1 Maths Attainment Thresholds[5]

	2013			2014			2015			2016			2017		
	MTE	Match	*OR*[2]	MTE	Match	*OR*	MTE	Match	*OR*	MTE	Match	*OR*	MTE	Match	*OR*
Expected+	95.2%	93.7%	*1.33*	92.5%	94.8%	*0.68*	94.1%	95.2%	*0.80*	77.5%	77.6%	*0.99*	79.2%	79.9%	*0.96*
Exceeded+	29.8%	26.8%	*1.16*	31.1%	29.1%	*1.10*	31.3%	29.8%	*1.07*	22.9%	21.5%	*1.08*	26.1%	26.0%	*1.01*

KS1 Pupil demographics

	2013		2014		2015		2016		2017	
	MTE	Match	MTE	Match	MTE	Match	MTE	Match	MTE	Match
% Female	46.9%	48.7%	47.5%	48.9%	49.6%	48.4%	50.4%	48.9%	49.6%	48.0%
% FSM (6)	26.0%	21.0%	24.0%	20.0%	21.0%	20.0%	20.0%	19.0%	19.0%	16.0%

1 - d = Cohens d effect size; **2 -** OR = Odds-Ratios; **3 -** Overall KS1 Average Points Score (APS) available 2013 to 2015; **4 -** KS1 Maths Average Points Score (APS) available 2013 to 2015; **5 -** Thresholds of KS1 maths attainment can be viewed across all five years. These identify when a pupil has reached a standard that is expected at KS2 or not (expected+) and whether a pupil reached a standard that surpassed expectations in KS2 maths (exceeded+). Prior to 2015, a pupil was identified as reaching the expected standard when their KS2 maths attainment was at level 2 or higher (which linked to a KS1 maths APS of 13 points or higher). Similarly, prior to 2015, a pupil was identified as exceeding the expected standard when their KS2 maths attainment was at level 3 or higher (which linked to a KS1 maths APS of 21 points or higher). From 2016 KS1 maths tests became purely categorical (no scale measure available) and the change in methodology is seen to be reflected by the sudden change in statistics observed from 2016. From 2016, pupils who were categorised as 'Working at expected standard' or 'Working at greater depth than expected standard' are classed as expected+ whilst pupils who are categorised as 'Working at greater depth than expected standard' are classed as exceeded+.

Table 78: KS2 Pupil level descriptive analyses 2013 to 2017 [re-matched sample]

KS2 Attainment (Overall and KS1 Maths)

	2013			2014			2015			2016			2017		
	MTE	Match		MTE	Match		MTE	Match		MTE	Match		MTE	Match	
KS2 Maths FPS[1]	5.04	5.06	-0.02	5.06	5.13	-0.08	5.09	5.06	+0.02	-	-	-	-	-	-
KS2 Maths SMS[2]	-	-	-	-	-	-	-	-	-	104.8	104.6	+0.02	105.6	105.4	+0.02
KS2 Maths Raw Test Scores[3]:															
Total Score	75.5	76.1	-0.03	75.5	77.4	-0.11	76.5	75.9	+0.03	79.6	79.4	+0.01	79.0	78.8	+0.01
Mental Arithmetic	15.4	15.6	-0.04	15.7	16.2	-0.13	14.9	15.1	-0.05	31.7	31.8	-0.02	32.2	32.1	+0.01
Paper A	29.6	30.0	-0.04	30.3	31.1	-0.11	30.0	29.6	+0.05	24.5	24.3	+0.01	24.7	24.8	-0.01
Paper B	30.4	30.5	-0.01	29.4	30.0	-0.08	31.6	31.1	+0.07	23.4	23.2	+0.02	22.0	21.9	+0.01
KS2 APS[4]	29.6	29.8	-0.03	29.9	30.3	-0.09	30.1	30.1	0.00	-	-	-	-	-	-
mean KS2 score[5]	-	-	-	-	-	-	-	-	-	105.3	105.3	0.00	104.8	104.6	+0.03
KS1 APS (KS2 cohort)[6]	15.6	16.0	-0.12	15.4	16.0	-0.17	15.7	16.0	-0.07	16.1	16.3	-0.08	16.6	16.4	+0.05
KS1 Maths APS (KS2 cohort)[7]	16.0	16.4	-0.13	15.8	16.4	-0.19	16.1	16.3	-0.07	16.3	16.6	-0.08	16.8	16.6	+0.04

KS2 Pupil demographics

	2013		2014		2015		2016		2017	
% Female	49.0%	49.0%	49.2%	49.4%	48.8%	50.0%	48.4%	48.5%	46.3%	48.6%
%FSM (6)	30.0%	23.0%	27.0%	23.0%	29.0%	23.0%	29.0%	24.0%	28.0%	24.0%

1 - KS2 Maths Fine Points Score (FPS) available 2013 to 2015;
2 - KS2 Scaled Maths Score (SMS) available 2016 & 2017;
3 - The KS2 maths raw test scores are available for all five years (2013 to 2017) but there was a change in methodology in 2016 (and this is seen with the sharp change statistics in 2016 and 2017 compared with 2013 to 2015). The greatest change is observed with the mean Mental Arithmetic score which reflects how marks on this paper doubled from 20 points in 2015 to 40 points from 2016. Between 2013 and 2015, there were two written KS2 maths papers (Paper A and Paper B) which were renamed in 2016 to Reasoning 1 and 2 respectively. The marks attributed to these written papers reduced from 40 points in 2015 to 35 points from 2016. The result of the changes increased the total KS2 raw test marks available from 100 in 2015 to 110 from 2016. Prior to 2016, the 100 points were weighted 20 / 40 / 40 for arithmetic / paper A / paper B and from 2016 the 110 points were weighted 40 / 35 / 35 for arithmetic / reasoning 1 / reasoning 2.
4 - Overall KS2 Average Points Score (APS) available 2013 to 2015.
5 - Mean KS2 Score - derived from mean score of all (scaled) KS2 test scores - available 2016 & 2017.
6 - Overall KS1 Average Points Score (APS) for KS2 pupil cohort (i.e. for the 2013 KS2 cohort, the KS1 data stems from 2009 when this cohort sat their KS1 tests) - available for all years 2013 to 2017.
7 - KS1 Maths Points Score (APS) for KS2 pupil cohort - available for all years 2013 to 2017.

9. Strand four: cohort 2 evaluation data collection and analysis

9.1 Strand four data collection

In autumn 2017, interviews were undertaken with the exchange teacher (where possible) in 27 MTE cohort 2 schools. Details of the 140 teachers who took part in the PMTMSP in 2015/16 had been obtained. Of this group, teachers from 70 schools (two per Maths Hub) took part in an exchange visit to Shanghai, and 35 of these also hosted a Shanghai teacher in their schools. These 35 Maths Hubs were sampled to identify a set of teachers for interviews according to the following procedure.

Each Maths Hub was assigned a randomly generated number and 27 of the Hubs were then randomly selected. For each of these 27 Maths Hubs, one school (and a second back-up school) was selected using randomly assigned numbers, yielding 27 exchange teachers to approach for interview. Teachers were contacted via email with: a request to take part in an interview, an explanation of the project, and a project information sheet. Repeated attempts were made to contact teachers and, where necessary, a teacher from the second school in the Maths Hub was contacted if the first exchange teacher contacted was unavailable, declined or was unresponsive. An alternative Maths Hub was sampled randomly if neither the first nor second teacher contacted was available. The process continued until interviews with 27 teachers were completed. Details of the numbers of schools sampled and interviews which took place are provided in Table 57 below. Interviewees' job roles in schools are summarised in Table 58. These cohort 2 interviews were recorded (with the exception of one where the teacher asked not to be recorded), fully transcribed and uploaded onto Nvivo 10. Analysis began with higher level coding of all interviews according to the codes created using the initial cohort 2 research questions, plus two additional research questions formulated after the interviews. More fine-grained coding of the material within research questions (to child codes of higher level codes) was then completed by different members of the evaluators' analysis team using the coding structure established for the MTE cohort 1 interviews.

Table 79: MTE cohort 2 schools sampled and interviewed

Total number of MTE cohort 2 schools		70 (35 hosted a Shanghai teacher)
Initial sample of schools to contact		27
Initial sample of schools to contact with back-up school		54
Contacted		48
Interviewed		27
Declined	Left teaching	3
	Moved schools	2
	Lack of time	2
	No reply	13

A small number of teachers who took part in interviews had also recently moved schools, but were still able to answer questions on behalf of their previous school. The 'no reply' column in the table above includes teachers who did initially agree to be interviewed but for logistical reasons the interviews did not take place.

Table 80: MTE cohort 2 interviewee job roles 2017

Assistant head	Maths lead	Head teacher	Specialism curriculum lead	Maths and PD executive
18	7	1	1	1

9.2 MTE cohort 2 further findings

This section reports in more detail the data from the MTE cohort 2 interviews to supplement the information in the main report.

Changes in beliefs and practice resulting from participation in the PMTMSP

Interviewees stated that the training experienced in the PMTMSP was an important foundation for later experiences, helping them to understand subtleties in the Shanghai teachers' practice and ultimately leading to the changes in beliefs reported in outcomes for teachers. However, there was little evidence of changes in beliefs directly attributed to the PMTMSP alone.

Teachers reported that the training gave them a deep understanding of the background to mastery, the 'five big ideas' of coherence, representation and structure, mathematical thinking, fluency, variation, and how they could influence mathematics teaching.

I think the PMTMSP training was the foundation to all of it, it laid the foundations of the five big ideas and just a sense of what we want teaching mastery to look like here in the UK. (MTE cohort 2, school 2A24, interview 2017)

The training course appeared to support teachers in experimentation. Alongside the PMTMSP, teachers were exploring approaches to mastery, trying out different ideas in practice, mainly within their own classrooms, though some were leading wider change in their schools.

When I began on the teaching for mastery, to be a specialist, it was very much initially changing my own practice before then moving on to influence the practice in school. (MTE cohort 2, school 2A1, interview 2017)

The first residential was really just understanding, getting my head around the five big ideas of mastery and how it would look in a classroom. So I was really just experimenting initially and trying things out and trying different planning, putting my steps in for the lesson, so again small steps within a unit, but also small steps within a lesson had to be carefully thought through. (MTE cohort 2, school 2A25, interview 2017)

Another reported working on fluency and on the use of representations:

Well because I'd already been on the training… I had used quite a lot of the big ideas from mastery, so certainly we were … beginning to work on fluency. We were really looking at the representations we'd used, so things like the bar model and the part-part-whole model were becoming much more embedded. (MTE cohort 2, school 2A22, interview 2017)

Several interviewees reported other experiences that supported their learning through the PMTMSP, including previous participation in the MaST training, ongoing study at masters degree level and working in teacher research groups.

Respondents saw the training as an important theoretical foundation for the exchange, noting that they would have found it difficult to understand Shanghai practice without the PMTMSP.

Previously with my mastery specialist training I obviously had the theory; I was trying things out and I was working with the teacher research group in the first pilot teacher research group to have a look at that, but actually going to see it actually happen over two weeks of maths lessons in Shanghai, that's probably had the biggest impact on that particular aspect for me. (MTE cohort 2, school 2A27, interview 2017)

The principles that we learnt about on the training initially we then talked about and analysed and looked for when we went to Shanghai (MTE cohort 2, school 2A18, interview 2017)

The exchange helped to cement and clarify all the theory - having all the conversations outside of lessons, TRGs and seeing it in action. (MTE cohort 2, school 2A21, interview 2017)

As a result of the PMTMSP one teacher said:

When we went to Shanghai I had such a good understanding of the five big ideas … going to Shanghai it really embedded what I already knew. (MTE cohort 2, school 2A5, interview 2017)

For some teachers, the PMTMSP training and the learning from the exchange built on each other, enabling participants to develop an understanding of 'what teaching for mastery looks like in practice and how to make it actually happen in the UK with UK children' (MTE cohort 2, school 2A17, interview 2017).

A small minority of interviewees said that although the training provided a theoretical background, they found it difficult to see how they might put it into practice.

Initially the training we had before we went to Shanghai, it was just getting the basic knowledge. I think the hard bit was how am I going to put that into practice? (MTE cohort 2, school 2A5, interview 2017)

The initial training was as practical as it could have been, but in essence, it was theoretical, it was academic. (MTE cohort 2, school 2A16, interview 2017)

The professional development experiences

In this section, findings are reported on the MTE cohort 2 teachers' professional development experiences. Typically these encompassed teachers' participation in the PMTMSP, a visit to Shanghai, and engagement with the Shanghai teachers when they spent two weeks on reciprocal exchange in a school in England (either the exchange teacher's school or another Maths Hub school). It may also include other professional development related to mastery. Cohort 2 teachers also reported the significance of leading professional development in supporting and enhancing their own understanding and development. Teachers highlighted the importance of trying out ideas in practice, with several commenting that they had also learnt through the experience of leading the teacher research groups.

PMTMSP

Rich material concerning the impact of the PMTMSP on teacher beliefs and practices is reported in the previous section. Below is a short section with additional points raised by interviewees (along with illustrative quotes) about the PMTMSP in the wider context of the professional development experience.

There was broad agreement amongst respondents that the PMTMSP had been an important theoretical foundation for their learning about mastery, one that enabled them to gain more from the visit to Shanghai than they would have without it.

I think that because of the experiences we had before I went to Shanghai, I think that really benefited everyone … because a lot of what you do in China, it's so well-orchestrated and it's very subtle … I think you need to know what you're looking for to get the most out of that. So I would say that sending mastery specialists rather than just choosing perhaps other people to go, I think that would have a greater influence. (MTE cohort 2, school 2A1, interview 2017)

Following the training, teachers had implemented practices in their own classrooms and were beginning to share this with colleagues in their own schools:

I'd finished the training then, I had used quite a lot of the big ideas from mastery, so certainly we were working, beginning to work, on fluency. We were really looking at the representations we'd used, so things like the bar model and the part-part-whole model were becoming much more embedded. Just the whole thing about reasoning and mathematical thinking. And the actual lesson being the kind of ping-pong approach really, so that you're doing a bit of whole class and a bit of… I've done quite a bit of training on that. Certainly we've been doing that in my class. And I've been modelling it for the Year 1 teacher by then, and she'd been starting to do some of it. (MTE cohort 2, school 2A22, interview 2017)

The opportunities the training provided for teachers to discuss mathematics with other specialist teachers was important, as was the course structure which provided training followed by time to try out new ideas in the classroom before coming back to share experiences.

I think the teaching for mastery course, the fact that it was residential was great and you're meeting other people and sharing practice so when we went back we were sharing practice. The work was organised so that you were developing practice in your own class, which was really useful. We're a big school so we plan together, so that impacted on more than just my own teaching. (MTE cohort 2, school 2A2, interview 2017)

Teachers reported that the PMTMSP had impact beyond their own practice through the work they were doing supporting other schools.

The mastery primary specialism has made a massive difference I think not only to my own development but to all the schools that I support as well. I supported six schools last year and I'm supporting seven schools this year. I'm one of eight… 12 teachers that are doing this. So I think that's made a massive impact. (MTE cohort 2, school 2A20, interview 2017)

Visits to Shanghai by mathematics teachers from England

More than half those interviewed found the visit to Shanghai the most valuable element of the professional development opportunities, although many also stressed that they were able to benefit so much from it only because they had taken part in the PMTMSP training and had been trying out mastery approaches in their own schools. Reported professional learning gains from the visits to Shanghai centred on the enhanced understanding of mastery that the mathematics teachers from England gained through opportunities to observe the practice of the Chinese teachers. Although much of this activity focused on the lesson observations, teachers also reported the high value of participation in the teacher learning groups in Shanghai schools. Teachers discussed how the practices they had observed and discussed in Shanghai related to their previous understanding of mastery, sometimes deepening and sometimes challenging this understanding.

And one thing that really, really stood out – one thing that we were trying to do before we went, was variation – the use of variation theory. We knew we had to do it before we went to Shanghai, but then while we were out there, the penny dropped that we weren't doing it very well. (MTE cohort 2, school 2A13, interview 2017)

Teachers noted the level of care and attention to detail that went into planning and there was an acknowledgement that the Shanghai teachers' subject knowledge was superior due to the very different conditions that the teachers in the two countries experience.

Just to see it in action was quite amazing, because their subject knowledge is so incredible. The amount they cover in a lesson, the lessons are just seamless, which for us to do is hard, because our subject knowledge is not as good as theirs. We don't have the time to spend on designing lessons that they do. (MTE cohort 2, school 2A2, interview 2017)

I think probably what I came away with most of all … was the way they think their way through the lesson and the way just how every example they do, the steps they take, has a purpose. They have the end goal in sight, but they know that step-by-step path they're going to take. (MTE cohort 2, school 2A15, interview 2017)

One teacher noted that there was some variation in experience on the visits, with some teachers from England seeing fewer lessons than others, or lessons with less experienced Shanghai teachers.

Shanghai mathematics teachers' visits to England

MTE cohort 2 teachers valued the reciprocal visits in the exchange, describing how the experiences affected their own practice and how important it was also for school leaders, other teachers and teaching assistants who participated at the English host schools. For

the cohort 2 teachers, it helped them to see how they might continue to develop approaches to mastery in their own schools.

The most powerful experience is then bringing those teachers back here so we can see those teachers teach our children and that really supports us in terms of thinking about how can this realistically work in our school in our culture with our curriculum. That's a far more effective way of building up our understanding and our own approach of teaching for mastery. (MTE cohort 2, school 2A16, interview 2017)

It gave us the chance for all of the teachers to see the Shanghai teachers teaching. I think it was clear that they were doing less in a lesson than we were trying to do. I think in some ways the pitch seemed different to what we would do, so it gave us certainly a lot of food for thought in terms of how we do our planning. In terms of teaching I think because we had already made some steps along the journey, I think we were looking at what they were doing and picking out some aspects and also seeing things as you would expect that we'd think maybe we wouldn't choose to do in our school. (MTE cohort 2, school 2A23, interview 2017)

The Shanghai teachers' lessons in English schools had an important impact on others who observed them:

We had lots of heads in our cluster that came in and saw the lessons. Although I could say that this is what we should be doing, having the Chinese teachers there demonstrating what we were talking about, showing the pace of the lessons, and the depth that they go into, and that small step approach, and the use of the language. Heads and all staff really, and TAs, being able to see how successful and how much progress children could make in the lesson, how successful that was, was great. It really highlighted the importance of the approach I think.

If we make sure we address misconceptions in the lesson, we can move the vast majority of children forward. If we have less of a focus on differentiated activities and providing lots of different activities for children to do and be really clear about what it is we're going to teach, we can move children forward in their learning. Because they saw it happening in front of their eyes, it was really, really powerful I think. And suddenly people were going, I get what this is about. I get what we're trying to do here. Yes, it was very successful. (MTE cohort 2, school 2A15, interview 2017)

it was just great for all the other teachers to see it as well. … It's hard to read about it in a book or on the website. Again I think the thing that we all took from it was how clever the lessons were. A lot of people said, 'That was really clever how they thought of that question,' and how they put their questions in to address misconceptions, which I think we're better at now. It really highlighted that they thought about every single question. It wasn't what can we put as a filler? Even the numbers they chose were chosen for a

particular reason to highlight something. Also the way that they did this recorded bit throughout the lesson, I think teachers realised how beneficial that was. (MTE cohort 2, school 2A5, interview 2017)

One teacher questioned the value of observing the Shanghai teachers for those less familiar with mastery approaches, pointing out that this might not be so successful in other schools:

That's what's made the biggest difference to us, is taking part in the teaching for mastery course. The things that my teachers saw the Shanghai teachers doing were things that they were trying to put in place, but they weren't as skilled and they got a lot out of seeing the small steps and the variation done by a master and the way they move their learning on so well. That was incredible to see. I think what's difficult for schools coming, we already had a lot in place so we could build on it, but some schools are out of their comfort zone. I think some schools visiting us to see the teachers, the showcases, that has inspired them to find out more about teaching for mastery, but some I know went away thinking, 'We could never do that here.' (MTE cohort 2, school 2A2, interview 2017)

The overall professional development experience

The majority of teachers interviewed agreed that the various professional development experiences built upon one another, helping to create a shared understanding of mastery. This shared understanding was not simply across the different experiences but enhanced through a collective understanding between participants.

It was really good that [teacher] who's also part of the same hub, and I were together in the same school in Shanghai and having two weeks was amazing, because over those two weeks the understanding developed a lot and by being able to discuss it, and the teachers from the other hubs as well having that discussion constantly allowed me to be clear about it. … I think that watching, being able to reflect and discuss and unpick what's happening in terms of the learning in different lessons, is the most valuable, and I think the opportunity to do that as a group has been fantastic. (MTE cohort 2, school 2A23, interview 2017)

the initial training was as practical as it could have been, but in essence it was theoretical, it was academic. It was effectively lectures and we were sat in a room talking about what it should be like and what we could be doing, but there was no classroom, there were no children – we weren't practising any of the content that we were discussing. The Shanghai experience then really does bring it to life in terms of seeing what a pure mastery approach looks like and how that experience adds flesh to the bones in terms of we've got the theory and we've got the understanding, but now we want to see what it looks like in practice. I think the most powerful experience is then bringing the Shanghai teachers here. (MTE cohort 2, school 2A16, interview 2017)

I think the first mastery specialist programme, with the three residentials, was really good deep understanding of the theory behind how change… Basically what the NCETM had, those five big ideas and how they could really impact mathematical teaching, so that had a great impact straight away because my depth of knowledge was so much greater that I could really show it.…I think going to Shanghai then took that depth of understanding to a completely different level. Suddenly you have a really good idea of why this theory has come about and seeing it in practice, and having time to create your own ideas about how this could work back in your own schools. Then seeing the Shanghai teachers over here – that was really great. (MTE cohort 2, school 2A7, interview 2017)

There is evidence that the cohort 2 teachers' experience of the PMTMSP training and their exploration of mastery approaches in their own teaching enabled an informed observation of the Shanghai teachers, both in Shanghai and in England. One teacher noted how this knowledge and understanding prompted probing conversations with the Shanghai teachers:

It wasn't just the teaching they did, we sat in there and discussed with them and they explained to us how and why they taught things the way they did and took us through the cohesive journey of how they teach certain concepts. We just literally were sponges and we questioned them and questioned them about everything they taught and it helped us with our subject knowledge. (MTE cohort 2, school 2A10, interview 2017)

Evidence of outcomes for teachers

Beliefs about pupil learning and ability

Across all 27 interviews, there was agreement that beliefs about how pupils learn mathematics had changed, with 24 stating that their own beliefs had definitely changed and in some cases those of other teachers had too. The other three felt that beliefs had somewhat changed. The most commonly reported change, cited by two-thirds of interviewees, was a belief that all children could succeed.

We change our belief to be that actually, although children might need more scaffolding and support on memorisation, there is this expectation that everyone can learn this concept. (MTE cohort 2, school 2A7, interview 2017)

I think staff have changed a lot of the ways they think about grouping children, because I think what you sometimes find is that if you're grouping them by ability and giving them activities to do, you can be putting a ceiling on what they can achieve. (MTE cohort 2, school 2A14, interview 2017)

Teachers mentioned a change in vocabulary, moving away from using terminology associated with fixed-ability thinking.

Having a growth mind-set and everyone believing that they are mathematicians…one of the Shanghai teachers was teaching my class… [their use of] really carefully planned steps, and really effective use of representation and structure enabled those children who perhaps were less confident to really understand the mathematics. (MTE cohort 2, school 2A24, interview 2017)

Teachers realised that the pedagogy was key, that they could find a way to support all children. Other reported changes to beliefs included greater receptivity to mastery techniques, an acknowledgement of the importance of conceptual understanding and coherence and a need to slow things down.

Knowledge

The MTE leads' understanding and appreciation of the importance of teacher subject knowledge changed through their participation in the exchange, particularly through their visits to Shanghai.

It became very clear that the teachers' subject knowledge was absolutely vital, and very clear teaching for conceptual understanding was very evident. (MTE cohort 2, school 2A10, interview 2017)

It was shocking and disturbing all at the same time, just how proficient they were with every single concept and just how deep their subject knowledge and their love for the subject. (MTE cohort 2, school 2A16, interview 2017)

A range of developments in teachers' knowledge were reported, often related to particular aspects of mastery that teachers had been experimenting with in their own classrooms. These included a better understanding of how children learn mathematics, a better understanding of fluency and of variation, and an appreciation of the value of slowing down and of using conclusions. There was a clear sense that teachers' deeper understanding gave them increased confidence in the way they were leading changes in practice.

The visit of the Shanghai teachers to schools in England typically had a striking impact on exchange teachers, other teachers and school leaders, in the exchange teachers' schools and more widely, giving them a deeper understanding of the rationales of mastery pedagogy and the benefits for pupils:.

They just suddenly got it. They got what we were trying to say. They got that if we focus on the very small steps of learning, one step at a time, we can pull the children with us. (MTE cohort 2, school 2A15, interview 2017)

10. Potential future research

In Section 13 of the main report, possible reasons for the differences in findings in relation to impact at KS1 and KS2 are provided. In this section these intereptations are discussed further and suggestions for additional research are offered. In addition, possible future studies of the Teaching For Mastery Programme more generally are considered.

10.1 Reasons for divergence of KS1 and KS2 findings and possible studies to gather more evidence

1. Reliability of the KS1 measure

As discussed below, there are a number of other plausible explanations for why an impact was found at KS1 and not KS2. However, to gather further evidence pertaining to the reliability of the KS1 measure, a further study could be conducted, using an alternative measure, sampling MTE cohort 1 schools implementing mastery or alternative or supplementary samples of MTE cohort 2 or PMTMSP participating schools. A suitable, independently marked measure for Y2 is advised in a further study to replicate or not the KS1 impact finding, and through comparison with teacher assessment, identify possible bias. A suitable contrast sample would need to be recruited for such a study.

2. Practices of KS1 teachers have changed sufficiently to produce impact, but not those of KS2 teachers

A limitation of the research is that the extent to which MTE mastery pedagogy is enacted by teachers in MTE schools is dependent on the reliability of reports by a single interviewee in the second and third year of the evaluation. Interviewees may have over-reported the extent of change in their schools in order to present a positive picture to the interviewer. However, interviewees were often candid about difficulties in implementation, and made what were apparently honest assessments of the extent to which particular practices were enacted, particularly in relation to KS2. Some interviewees were unapologetic about not implementing certain practices.

Alternatively, interviewees may have reported their beliefs about enactment of mastery accurately, but had an unrealistic view of the extent of change, possibly due to internal performativity pressures in schools, meaning that teachers may be giving an impression of change to senior leaders, but not consistently enacting that change. Given that such pressures are felt more keenly at KS2, this may explain the differences observed between KS1 and KS2.

Moreover, evidence from the early data collection indicates that practices such as allocating different work to groups of pupils in advance of teaching was less common in KS1, and also that more extensive use was already made of representations and models. Thus it may be that KS1 teachers were more receptive to important aspects of MTE mastery pedagogy.

3. The enacted MTE mastery pedagogy at KS2 and related practices do not lead to improvements in pupil attainment, but do so at KS1

This interpretation relies on accepting that MTE mastery pedagogy had been enacted at KS1 and KS2 as intended. A recent review of effective mathematics teaching practice at KS2 and KS3 (EEF, 2017) and in relation to MTE mastery pedagogy (Boylan, et al. 2018) indicates that practices should be effective across the primary phase. However, it is also notable that in the evaluation of Mathematics Mastery (Jerrim and Vignoles, 2016; Vignoles, Jerrim and Cowan, 2015) an effect of one month's additional progress was reported for Y7 pupils (although in a secondary school context) and two months for Year 1 pupils. The difference in outcome between KS1 and KS2 may lie in issues to do with subject knowledge and expertise of KS1 teachers compared with KS2 teachers. Anecdotally, teachers with relatively higher levels of mathematics qualifications are deployed to teach upper KS2. The professional development and new practices may lead to greater gains in KS1.

4. Mastery practices implemented in KS2 are either a) not sufficiently different from the practices implemented in comparison schools or b) not more effective than practices implemented in comparison schools in KS2

The mastery policy is being implemented at the same time as considerable change in curriculum and assessment in primary mathematics in England. This is leading to changes in practices in schools generally. For example, the 2014 mathematics curriculum advises that pupils should progress together with extension by deepening rather than through acceleration. The curriculum content has been made more demanding by age. One example of a practice that appears to have changed more widely is an increased emphasis on factual recall. As noted above, a limitation of the impact study of the current evaluation is that it is not known for certain whether, or to what extent, the comparison schools have engaged with mastery practices. However, whilst data from the mathematics coordinator survey and reports of interviewees indicated that mastery practices are being taken up beyond MTE and PMTMSP, the survey responses do not indicate that as yet this is so widespread as to mean comparison with the contrast sample is not valid.

Although unlikely, if it is assumed that the reason for the evaluation not finding evidence of impact on KS2 attainment is that mastery practices have spread more widely and more quickly than anticipated, including in comparison schools, this still has important policy implications. Put simply, it would suggest that the TfM programme has served its purpose and resources could be redirected elsewhere.

5. There has not been sufficient time for change in practice to impact attainment in KS2

The evaluation of the MTE found that implementation in Y6 was lower than in other years. Three reasons were given for this:

- concern about KS2 SATs
- that Y6 students were accustomed to learning mathematics in other ways
- that there was already a wide gap in attainment between pupils.

The latter two reasons imply that the effect of the practices would be greater if experienced over a longer period of time. Put another way, it may take more than two years of engaging in mastery practices for older children to benefit. Further, there is evidence that in general, teachers' understanding and skills in applying new practices develop over time.

Although it is conceivable that impact may increase over time in KS2, the fact that there has not been any impact evidenced thus far, suggests that the full level of policy ambitions may not be realised, even though more modest improvements could be expected due to improvements in KS1. Further, if no impact is found after two consecutive years of schools engaging directly in a change stimulus, and stating they have implemented mastery for two years with the Y6 cohort, then it suggests that the model for spreading mastery practices more widely may not be successful. This may be due to further dilution of implementation in recipient schools when practices are spread to other schools not directly involved.

Undertaking comparative impact analysis of the MTE cohort 1 schools' KS2 results in 2018 would identify whether impact is found after a further year of implementation. A similar analysis as used in the current evaluation could compare MTE cohort 2 outcomes over time with comparison schools.

10.2 Trials of TfM and PMTMSP

In addition to addressing the divergence of findings between KS1 and KS2, additional evaluation of mastery approaches could be undertaken through trials of TfM, and the PMTMSP. Teaching for mastery is now refined into a set of principles and practices that

has been extensively piloted and then implemented more widely in England. This is also true for the accompanying CPD programme - the PMTMSP. This provides the basis for determining whether this pedagogy and CPD is effective at both KS1 and KS2. Randomised controlled trials would help establish causality. If such an RCT was conducted, an in-depth and rigorous implementation and process evaluation is recommended.

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Department for Education

Reference: DFE-RR903

ISBN: 978-1-78105-992-0

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