Education Endowment Foundation

Secondary Maths

Practice review

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Contents

About the evaluator

The Sheffield Institute of Education, Sheffield Hallam University, is recognised for excellence and innovation in research, teaching, and learning. It has been developing and delivering educational innovations and evaluations locally, nationally, and internationally for over 25 years as one of the country's leading providers of initial teacher education in one of the U.K.'s largest universities.

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Executive summary

The project

The aim of the Secondary Maths Practice Review was to address the question, 'What are the capacity challenges, priorities, and practices for maths teaching in English state-funded secondary schools?' The purpose was to primarily inform EEF commissioning but also for the benefit of other stakeholders.

The review focused on four areas: teacher skills and expertise, targeted interventions and support, impactful practices, and programme engagement. Within each of these areas, specific sub-themes were researched and these are shown in Table 1 as 'review themes'. The selection of sub-themes was informed by considering prior research on potentially effective practices and possible areas of current interest to practitioners. However, the inclusion of these sub-themes or any reference in the practice review to previous research on practice effectiveness does not imply that such practices are necessarily impactful. During 2024, an evidence review is being conducted which will support school and trust subject leaders to make judgements about which current practices make a difference to pupil outcomes. This practice review in combination with the evidence review may offer insights into issues of implementation.

Methods were desk review of relevant evidence, a survey of maths subject leads, focus group workshops with maths subject leads, and contributions from advisors with insight into the review areas. The review, including fieldwork, took place between November 2023 and February 2024. The focus of the review was broad ranging and against the background of variable quality and availability of existing evidence about practice and the requirement to generate evidence in a short timescale.

Key limitations of the review are that the desk work did not include an extensive review of all relevant sources and the limited size of—and potential bias in—the survey and workshop samples. Thus, findings of this review should be considered indicative. As previously stated, the focus of this review is practice rather than effectiveness or impact.

Table 1: Summary of the practice review findings

Review themes	Finding
Teacher skills and expertise 1a. Challenges in supporting pedagogical knowledge and skills with a focus on non-specialist teachers. 1b. Availability and use of PD. 1c. Priorities for subject and subject pedagogical knowledge development, particularly to support disadvantaged pupils.	Previous research indicates that: • many schools deploy highly qualified teachers to high-stakes classes, sometimes leaving younger pupils and low attainers without specialist teachers; • there is a variety of maths teacher professional development (PD) available; • the National Centre for Teaching Excellence (NCETM)—and the Maths Hubs it coordinates—plays an important role as does department-led professional development; and • some teachers are dissatisfied about the place of maths professional development in trust, school, and early career provision. Surveys and workshops identified that: • PD on teaching techniques and problem-solving was the highest specific general priority while the use of representations was the highest priority for teaching lower attaining students likely to enter Foundation GCSE; and • collaborative forms of professional development with departmental collaboration is a priority.
Targeted interventions and support 2a. Pupils' needs and provision of further support and selection of programmes.	Survey and workshop data indicates that high quality teaching is the main cohort-level intervention used for students in KS3 and KS4. Targeted interventions on specific groups or individuals such as individual tutoring are less common. Outside of school, interventions like homework and online platforms are used for practice and consolidation. Decision-making about targeted support is typically at the school leadership level, with some schools offering 'study support' related to exam preparation.

2b. Programmes used to support intervention, including tutoring. 2c. Challenges to access for disadvantaged pupils.	Teachers require support to teach certain topics differently as the same approaches may not be effective for all students. Review of previous evidence suggests that attendance has worsened in some schools since the Covid-19 pandemic and this, and developments in practice including in use of technology, mean that evidence of how interventions are used is at risk of becoming outdated.
Impactful practices 3a. Topics and skills teachers find it challenging to teach. 3b. Topic and skills priorities to address to impact learning, particularly for disadvantaged pupils. 3c. Consolidation practices that are prevalent including the use of homework. 3d. KS2 to KS3 transition. 3e. KS3 to KS4 transition.	Survey data indicates that problem solving is a core aspect of maths and teachers are more likely to integrate problem solving into all or most topics and teach specific problem-solving techniques, rather than using extended problem-solving tasks or dedicating whole lessons to problem solving. Mathematical talk is widely promoted through a variety of practices. There appears to be greater use of, and interest in, using representations and manipulatives than previously. From review of prior evidence and from workshops, a possible explanation for this may be the widespread use of bar modelling being widely promoted through various curriculum and professional development initiatives and within the mastery approach. Survey data indicates that homework is often used to consolidate learning. Workshop respondents reflected that it is unclear what specific practices are most appropriate. There are challenges of equity for students from disadvantaged backgrounds to fully access homework Participants agreed that the KS2 to KS3 transition is important. The survey provided data on the wide variety of practices in schools. Survey and workshop data indicated that addressing topics associated with greater opportunity to learn during KS3 appears challenging in some schools. There are differences in KS3 curriculum content strategies by schools, with some evidence of more variability between high and low attaining schools. The study also found that schools may make different decisions about curriculum content with lower quintile schools more likely to be selective about the curriculum content taught than higher quintile schools. In the GCSE curriculum, similar variation was found in the strategies schools adopt in selecting the approach to covering curriculum content with both Foundation and Higher tier entry pupils with lower quintile schools being more likely to be selective. However, some lower attaining schools aimed to cover the whole curriculum and some higher attaining schools adopted more selective strategies.
Programme engagement 4a. Influences on leaders' selection of maths programmes. 4b. Barriers and facilitators to engagement and implementation.	From review of previous evaluation reports, initial and continued engagement in EEF programmes is primarily driven by factors such as meeting a need or priority, aligning with existing developments, individual staff interest, departmental interest, access to professional development for non-specialists, previous relationship with the programme team, and recommendation from a trust, school, or subject leader. Considering prior reports, workshop participant contributions and experience of programme providers suggest that barriers to engagement before or during programmes include difficulty in releasing teachers to engage in external professional development, challenges in achieving fidelity of attendance at CPD for secondary teachers, difficulties in using specific curriculum materials, trial compliance issues, and the prevalence of interest in generic rather than subject specific professional development by some school and trust leaders. Collaborative cultures are important, and support implementation. Barriers to scaling programmes by developers include the importance of manualisable programmes, the potential for establishing structures and processes, the quality assurance of training and implementation, and replicability.

Implications

The practice review aimed to inform EEF commissioning, considering implications for efficacy or effectiveness trials, future programme development, and other potential EEF activity. Contextual influences vary considerably in different

schools. These affect how decisions are made on curriculum, pedagogy, interventions (including support for specific groups of learners), and professional development. The implications of this are that:

- EEF-commissioned programmes requiring substantial teacher professional development (PD) may be more implementable if they are based on whole department models for PD rather than those focused on individual teachers;
- programmes or PD premised on the use of specific curriculum materials may be less appealing than those focused on pedagogical principles or technical professional development;
- programmes aimed at pedagogical or curriculum change are more likely to be acceptable if they are whole-department based; and
- programmes focused more directly on pupil learning and motivation may be more implementable if they focused on individual pupils, for example, tutoring, or those that can supplement or be used in conjunction with a broad range of curriculum and pedagogical approaches such as programmes using software and platforms to support consolidation of learning: specifically, interventions that involve different forms of homework to support disadvantaged students to consolidate their learning may be worthy of further exploration.

The review considered some potentially impactful practices, including enhancing the quality of mathematical communication. Given the range of reported current practices, it may be difficult for programmes to be sufficiently different to existing practices to significantly influence outcomes.

The review found differences in schools' strategies around the inclusion of more challenging topics in Key Stage 3. The EEF might consider possible early stage development programmes around specific curriculum content. The review also highlighted that schools make different curriculum choices in both Key Stage 3 and Key Stage 4. There is a lack of evidence about the impact of curriculum choices, particularly in Key Stage 4. This suggests the possibility of 'school choice' research in this area, which aims to produce causal evidence about the impact of different school-level approaches and policies on outcomes of interest, with particular attention to impact on pupils from socioeconomically disadvantaged backgrounds.

There is also need for further research in other specific areas such as widespread variation in KS2 to KS3 transition practice or consolidation practices. Further in-depth review of practice could support guidance for schools, potentially in collaboration with external organisations supporting maths in schools such as the NCETM and MEI.

School and trust subject leaders can use the practice review findings as points for reflection about their own practice.

Background and purpose

The importance of secondary maths

Maths in secondary schools is important to pupils, to the school, and in policy. For pupils, success in a maths GCSE is an important gateway to training, to Level 3 study, and is an entry requirement for studying a number of professional qualifications. Failure to achieve a pass leads to requirements to achieve Level 2 maths post-16. For schools, attainment in maths is central to a number of performance measures including headline GCSE pass rates, Progress 8, and the English Baccalaureate. Since 2013, the overall proportion of pupils gaining grade four in maths has steadily increased.[1] Maths is now the most popular A level.[2]

Secondary maths and disadvantaged pupils

Many children leave primary school without achieving the expected level in maths. This is especially true for children from disadvantaged backgrounds and the Covid-19 pandemic has exacerbated this situation. In 2023, only 59% of pupils from disadvantaged backgrounds reached the expected level at the end of Key Stage 2 compared to 79% of pupils from non-disadvantaged backgrounds. This is a decline—an increased gap from 2019 (pre-COVID) when the respective percentages were 67% and 84%.[3]

While early intervention to improve maths attainment is necessary, it is unlikely to be sufficient on its own. Pupils from disadvantaged backgrounds may struggle to access the secondary maths curriculum. Almost half of disadvantaged pupils did not reach age-related expectations in primary school and even those who do can go on to struggle: research by the Education Policy Institute shows that the attainment gap worsens during secondary school (Hutchison et al., 2016).

This even affects disadvantaged pupils who achieve the expected level when leaving primary school. A recent report on high-attaining maths students found that only 52% of high performing students from IDACI quintile 1 (the poorest) at the end of Key Stage 2 progress to grades 7 to 9 at GCSE compared to 74% of those in quintile 5 (the richest). FFT Education Datalab analysis of 2022 GCSE results found that the average grade in maths for disadvantaged students is 3.6, compared to 5.1 for other students (Benyon and Kenyon 2022). This means disadvantaged pupils are, on average, not likely to achieve the standard pass of grade 4, equivalent to the old grade C. Pupils from disadvantaged areas are underrepresented in the group that progresses to A level maths even when KS2 performance is controlled for (Noyes et al., 2023).

GCSE reforms—which include the change from the old C pass threshold to the grade 4 pass and grade 5 ‘good pass’ threshold—do not appear to have reduced the attainment gap. During the period of the reforms the gap has increased by just over a quarter of a grade across nine subjects including maths, considering all grades. However, the gap in achieving a pass at GCSE has remained nearly the same: in 2018, 48.8% of disadvantaged pupils did not achieve a pass in maths compared to 30.5% of all pupils (Burgess and Thomson, 2019).

This affects life chances as an adult: DfE analysis, based on longitudinal and administrative data, suggests that the financial return for individuals from an extra GCSE grade in maths gained in the period 2001 to 2005 was higher than for any other subject and particularly high around the important grade boundaries at that time, for example, D to C (Hodge et al., 2021).

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[1] https://analytics.ofqual.gov.uk/apps/GCSE/Outcomes_Link1/

[2] https://www.gov.uk/government/statistics/provisional-entries-for-gcse-as-and-a-level-summer-2023-exam-series/provisional-entries-for-gcse-as-and-a-level-summer-2023-exam-series

[3] https://explore-education-statistics.service.gov.uk/find-statistics/key-stage-2-attainment

Improving maths education and addressing disadvantage

In policy, maths has been of ongoing interest, spanning the National Numeracy Strategy. It has resulted in, twenty-five years ago, the founding of the National Centre for Excellence in the Teaching of Maths, the reform of maths GCSEs, the current investment in Teaching for Mastery through the Maths Hub network and in post-16 maths through the Advanced Maths Support Programme, and the current policy ambition for all to study maths to 18.

The EEF has previously commissioned a number of programmes to improve secondary maths. Its current commissioning approach is to focus each funding round on particular topic foci. The EEF aims to support and evaluate programmes with the potential to improve secondary maths outcomes for pupils aged 11 to16 (Key Stages 3 and 4) in England, particularly for pupils eligible for free school meals (FSM) and high-attaining pupils from socioeconomically disadvantaged backgrounds.

The review

Aims and scope

The review of secondary maths practice was a scoping review to inform EEF commissioning, other stakeholders such as the DfE, and identify priorities for further research.

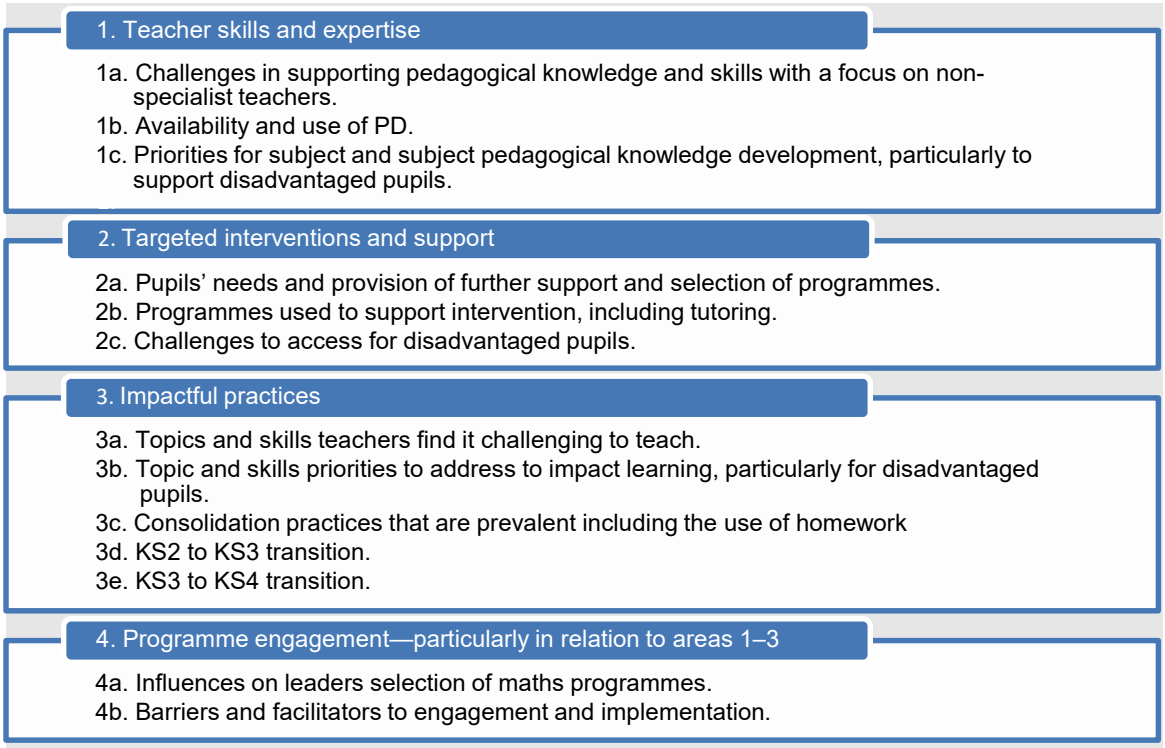
The aim of the review was to address the question:

What are the capacity challenges, priorities, and practices for maths teaching in English state-funded secondary schools?

We characterise this as a 'scoping review' because it was concerned with a wide range of areas of interest to the EEF and others, each of which could potentially be a specific focus for a practice review. There has been relatively little recent research focused specifically on the core aim of the review and the existing evidence on current practice in secondary maths has considerable gaps. The review was undertaken over a relatively short period of time (November 2023 to February 2024) and so was limited in terms of the depth of research possible in any single area.

To address the overarching question, four sets of interconnected question groups were explored (Figure 1). In addition, detailed research questions addressing each of the subgroups (1a, 1b, etc.) were developed to guide data collection and analysis. The detailed research questions are in Appendix 1.

Figure 1: Review question groups and subgroups



Several of these areas for review focus on the relative importance of maths topics, skills for teaching, professional development, or the adoption of programmes. In keeping with the EEF's aim for the review to inform the commissioning of programmes and to identify the sub-themes we considered:

- areas of practice commonly considered as effective, often informed by prior evidence reviews or the EEF toolkit; and
- possible areas of current interest to practitioners and perceptions of potentially worthwhile practices.

Although the review sought to focus on potentially effective practices, the inclusion of these sub-themes or any reference in the practice review to previous research on practice effectiveness does not imply that such practices are necessarily impactful. The label for the third group, 'impactful practices', was proposed by the EEF in its invitation to conduct the practice review as a means of referring to practices that might be impactful. There may be practices not considered in the practice review that might also be impactful. During 2024, an evidence review is being conducted which will support school and trust subject leads to make judgements about which current practices make a difference to pupil outcomes.

This practice review in combination with the evidence review may offer insights into issues of implementation. The findings may also be relevant to those making decisions about potential practice changes or improvements outside of formal programmes. We also considered how far changes in practice might be sufficiently different to current practice so as to potentially lead to positive change for pupils.

Thematic areas

We identified thematic areas to inform both data collection and analysis, and to guide purposeful data collection from different participants and types of research activities. The sources that informed initial identification of thematic areas and subsequently the review findings are provided in Appendix 2.

Our two thematic areas, with sub-areas, were:

- mathematical content and teaching practices:
    - content and lesson activity; and
    - teaching practices and issues; and
- departmental, school, or trust level practices and policies relating to:
    - learners; and
    - staff.

Review questions

The first three question groups identified by the EEF were teacher skills and expertise, targeted interventions and support, and impactful practices. For these, we broadly address the following general questions:

- What is the available evidence?
- What are current practices?
- What are priorities and possibilities for change?

For the fourth question group, programme engagement, we considered influences on the selection of programmes and, more broadly, innovation in curriculum and pedagogy and engagement with professional development. Centrally, we considered barriers and facilitators to engagement and implementation.

Summary of methods

Details of the methods used are provided in Appendix 1; Table 2 provides a summary of the methods.

Table 2: Summary of methods

Method	Detail
Desk review	A review of 54 sources relevant to the practice review foci.
Survey	A survey of secondary heads of department, Key Stage leads, and multi-academy trust subject leads in state schools in England. The survey was in sections with opt-in and opt-out of individual sections. A total of 335 respondents provided data for one or more substantive sections, could be matched to school census data, and reported for at least one survey question.
Workshops	There were nine focus group workshops involving 27 participants who were heads of department, MAT subject leads, or had otherwise worked with multiple schools to support maths teacher professional development or subject improvement.
Advisor input	Input came from a range of advisors, notably the National Centre for Excellence in Teaching Maths (NCETM) and Maths Education and Industry (MEI). The NCETM's School and Professional Development Team provided a collective view on barriers to engagement and on other review foci. Either individual or collective input was gained from 18 advisors in total. Advisors contributed verbally or in writing.

Survey data was analysed descriptively. We undertook comparative analysis of differences in responses for a selection of questions based on retrieved data of schools' attainment (grade 5 to 9 English and maths) and free school meals (Ever 6 FSM) as a proxy for the socioeconomic profile of pupils. We did not undertake significance testing as this is inappropriate for a non-random sample and, in any case, with a large number of statistics can lead to falsely identifying significance due to chance (Gorard, 2016).

The focus group workshops involved a limited number of participants recruited both by general invitation and partially as a convenience sample through existing networks of the EEF, NCETM, and MEI. Therefore, while the qualitative data collected helps to illustrate and explain findings from the desk review and survey, the number of participants and the recruitment methods mean that inferences are tentative and indicative.

Survey data and workshop data are potentially limited by sample bias particularly given an important means of recruitment was through the above existing networks. The schools in the survey sample had a slightly better mean attainment (56.7%) than the population average (50%) and slightly lower proportion of FSM children (23.6% compared with 27.6%). This should be considered when interpreting findings from the survey data. The survey was aimed at subject leads and so does not represent the views of all teachers, and this is particularly important when considering the responses on professional development priorities. It does not, for example, include the views of non-specialist teachers of maths.

Similarly, the workshop participants were self-selected groups who responded to invitations to participate in workshops on pre-determined themes at specific times, thus there is an element of convenience sampling in the recruitment process, but combined with some purposeful sampling as there were workshops targeted at leaders with specific roles. The desk review activity was conducted rapidly with only a few sources identified for each sub-theme. The findings should be taken as indicative although some of the sources were based on more secure review methods. Additionally, some sub-themes were not fully addressed or included in all of the review activities (desk review, survey, and workshops).

The review was supported by advice and information on practice in relation to areas of interest from the National Centre for Excellence in Teaching Maths and Maths Education and Industry. The NCETM manages the Maths Hub programme for the Department for Education (DfE); Maths Education and Industry is part of the NCETM consortium and also separately leads the Advanced Maths Support Programme for the DfE that has elements that extend into the secondary phase. As leading providers of maths teacher professional development, both organisations had insight into many of the research issues.

Ethics, consent, and GDPR

The design of the research was ethically reviewed at Sheffield Hallam University and was approved as 'EEF Secondary Maths Practice Review ER60752993 on 20/11/2023. All participants gave consent for participation and legal requirements for data processing were followed. The basis for the use of data was public task. Further details about these matters are provided in Appendix 1.

Project team

The following personnel were involved in this project.

Sheffield Hallam University

Professor Mark Boylan, Co-Head of Research and Innovation and Professor of Education: Principal Investigator.

Hongjuan Zhu, Mixed-methods researcher: Project manager and survey research assistant.

Dr Gill Adams, Reader in Education: Senior advisor.

Anna Stevens, Research Fellow : Quantitative Lead.

Amy Birkhead, Senior Lecturer in Maths Education: Researcher.

Dr Emma Rempe-Gillen, Senior Lecturer in Maths Education: Researcher.

Professor Emily Perry, Head of Sheffield Institute of Education's Research and Knowledge Exchange Centre, and Co-Head of Research and Innovation for Sheffield Institute of Education: Senior research on system issues.

SMaR+ PD Limited

Dr Laurie Jacques, Independent consultant and part-time researcher at UCL: Qualitative data collection lead.

The report

Following the introductory sections, the report continues with findings organised into sections on

- teacher skills and practice;
- targeted interventions and support;
- impactful practices; and
- barriers to programme engagement and related issues.

Each of these sections are further divided by considering the sub-themes identified in Figure 1.

The conclusion of the report summarises the findings and discusses implications for programme development, innovation, and commissioning. The main report is supported by two Appendices. The first provides more detail on methods and methodology. The second is tabulated data from the survey analysis.

Findings—teacher skills and practice

Section content and summary of findings	
Supporting pedagogical knowledge and skills of teachers	Previous research indicates that some schools deploy highly qualified teachers to high-stakes classes leaving younger pupils and low attainers without specialist teachers. Workshops confirmed previous research that to mitigate these issues, leaders provide less-experienced maths teams with plans and resources developed by others.
Availability and use of professional development	Previous evidence was triangulated by workshops confirming that a variety of maths teacher professional development (PD) is available. Workshops and survey data indicate there are notable absences, such as the use of subject-specific coaching models and a lack of PD focused on metacognition in the context of maths. The NCETM, and the Maths Hubs it coordinates, plays an important role in supporting subject knowledge and sharing expertise across schools. Department-led PD supports teachers' understanding of effective teaching of specific parts of the maths curriculum. There is dissatisfaction among teachers about the place of maths professional development in trust and school provision.
Priorities for the development of subject knowledge and its associated pedagogy	Maths specialist teachers and subject leads are survey respondents' highest priority for professional development. PD on problem-solving is a specific general priority while the use of representations was the highest priority for teaching lower attaining students likely to enter Foundation GCSE. The survey and workshops identified that collaborative forms of professional development with departmental collaboration are priorities. This suggests that whole department models for professional development may be more implementable than those focused on individual teachers.

Supporting pedagogical knowledge and skills of teachers

Concerns about the subject knowledge of maths teachers are longstanding in England. Secondary maths teachers are less likely to have a degree in maths than teachers holding relevant qualifications to teach non-shortage subjects (Allen and Sims, 2018). The situation is exacerbated by a recruitment and retention crisis in teaching (Long and Denachi, 2021) resulting in a less experienced workforce that has been teaching maths for fewer years. Almost half of all 2016 maths teaching (43%) was by those with six or fewer years of experience (Allen and Sims, 2018). This is of concern given that teacher subject knowledge, including pedagogic content knowledge, is a key factor in high quality teaching and raising attainment of students (Barra and Boccia, 2022; Hodgen et al., 2018).

To address these challenges, many schools choose to deploy more highly qualified teachers to classes where external stakes are high, such as GCSE, GCSE retake, and A level classes. This means that Key Stage 3 classes, low attaining sets, and schools in disadvantaged areas are less likely to be taught by an experienced maths teacher with advanced qualifications (Allen and Sims, 2018). Year 7 and low attaining sets are also more likely to be taught by more than one teacher so that no classes are taught entirely by non-specialist teachers (Ofsted, 2023b). While leaders' choices about where to deploy staff aim to minimise the impact of teacher shortages on Key Stages 4 and 5, there may be long term effects of leaving younger pupils and low attainers without a specialist maths teacher.

Leaders also mitigate recruitment and retention challenges by providing their less-experienced maths teams, including non-specialists, with plans and resources developed by others (Ofsted, 2023b). These include resources from commercial schemes, multi-academy subject teams, or more experienced members of the department. The aim is to provide some quality assurance so that students with teachers lacking appropriate subject knowledge can make progress, but resources can lack suitable detail about pedagogical choices and are unlikely in themselves to develop teachers' pedagogic content knowledge. In the survey undertaken for this review, we found that a wide variety of materials and resources were used for consolidation of learning (Table 15) and similarly, from focus groups with MAT leaders and heads of department, the use of multiple sources of curriculum materials was reported. This echoes findings of research on the use of resources in primary maths (Marks et al., 2023).

Professional development is recognised as the key to raising the quality of teaching and therefore those teaching maths should have the opportunity to engage with opportunities to build on their subject knowledge throughout their career (ACME, 2016). ACME suggested that with no national guidance on what this entails, teachers and senior leaders find it difficult to identify professional learning opportunities that enable highly effective maths teaching (op cit.). However, this was not raised in focus group workshops and so may no longer be as relevant; this may reflect the activity of the Maths Hubs. Reviews have recommended that professional learning should be subject-specific, personalised, collaborative, and prolonged (ACME, 2016; Cordingley et al., 2018). Professional development which is focused on generic pedagogy was found to be insufficient to support subject pedagogical content knowledge, particularly in maths.

A recent review and analysis of effective professional development identified 14 underpinning mechanisms that are described in generic terms (Sims et al., 2021). These are grouped around four purposes of PD: helping teachers gain new insights, pursuing new goal-directed behaviours, acquiring new skills or techniques, and embedding these changes in their practice Three forms of professional development identified as involving some of these mechanisms and that are found to have positive effect sizes on attainment from meta-analysis are instructional coaching, teacher learning communities, and lesson study.

Availability and use of professional development

Much current maths professional development incorporates effective features of professional learning, including the national professional development programme available through the NCETM and the NCETM-coordinated Maths Hubs. The latter have played an increasing role in supporting and developing subject knowledge and sharing expertise across schools. This includes training Primary Mastery Specialists. By 2019, Maths Hubs had worked with around half of the primary schools in England (Maths Hubs and NCETM, 2023).

Although Maths Hubs are a prominent feature of maths teacher PD they exist in complex markets in professional development provision (Boylan and Adams, 2023) and complex and varied local landscapes in which national, local, and multi academy trust provisions interact (Greany et al., 2023). This influences access to PD for secondary teachers. The capacity to engage in professional development that is part of innovative external programmes varies according to schools' institutional capital related to status, demographics, and attainment profile (Boylan et al., 2018). Schools with a high number of non-specialist teachers and more staffing pressure generally may find it more challenging to release teachers. Senior leaders at schools with more successful Ofsted outcomes may feel more scope to innovate.

Nevertheless, support offered by the Maths Hubs and information produced by the NCETM about high quality teaching have been identified as key drivers of improvement in maths education, although more evident in the primary phase (Ofsted, 2023b). At best, the support available means that teachers can show strong subject knowledge in the classroom, adopt new and improved ways of modelling concepts, and adopt evidence-based approaches (op cit.). However, there is a lack of evidence as to the impact of current PD provision in maths on pupil outcomes. This absence of evidence should not be seen as evidence of absence of impact on pupils but rather a result that there has yet been no independent impact evaluation of the Maths Hub programme or elements of it.

In secondary schools with historically stronger provision, department time is allocated to improving the quality of maths teaching. Department-led professional development in these schools supports teachers' understanding of effective teaching of specific parts of the maths curriculum. In contrast, teachers in schools with historically weaker provision often received PD at a whole-school level on generic themes and were then given time as a department to consider how this might improve maths provision (Ofsted, 2023a).

Decisions about professional development are often made by senior leaders in schools and trusts and do not necessarily prioritise subject-specific learning or learning appropriate to the stage of the teachers' career (ACME, 2016). This assessment from 2016 appears to still be the case or has even become a more prominent barrier to subject-specific PD. MAT leaders in focus groups conducted for the review reported the challenges of providing subject-specific PD given other priorities and organisational issues.

> *'It's hard to get time for maths people to get together on whole MAT CPD days as not all subjects have cross MAT leads.'*

There appears to be widespread dissatisfaction from teachers about professional development opportunities they experience. A recent Ofsted (2023a) review of teacher professional learning in general found that only around two fifths of teachers thought that their training was relevant, sufficient, and of high quality. Some teachers noted the difficulty in engaging with courses where the materials were focused on generic content rather than being specific to the subject, phase, or school context in which they taught. The potential consequence of this is that teachers may be reluctant to engage in PD opportunities they deem to be irrelevant to their own professional learning priorities.

A lack of subject-specific PD has also been identified as an issue with the Early Career Framework (ECF). The ECF offers professional development for Early Career Teachers (ECTs), including training and self-study materials and an in-school mentor. Schools have the option to provide these themselves, but most choose to use an external DfE-accredited provider for these materials. However, evidence shows that the current materials offered are largely generic and not well matched to the subject or phase in which the ECT teaches. A survey of mentors and ECTs found that only 4% of ECTs said that their self-study materials were subject-specific (Ford, Allen and Wespieser, 2023); 60% of mentors surveyed said that the ECF is not subject-specific enough and over half of the ECTs said that further specialisation of their self-study material should be a priority. Concerns with the lack of subject-specific content and materials are against a more general background of challenges of the ECF on new teachers and on mentors (op cit.).

In response to concerns raised in the 2023 review of the ECF, from September 2025 the ECF will be replaced with the initial teacher training and early career framework (ITTECF).[4] This combines the ECF with the initial teacher training core content framework and aims to reduce mentor workload and provide more subject-specific training. This will be done via the Oak National Academy that will work with support providers to enhance their existing provision with more subject-specific content. In relation to addressing subject-specific content, the Ambition Institute began to pilot a maths-specific ECF programme with a cohort starting in Sept 2022.[5] Maths Hubs have also developed 'work groups' specifically for ECTs,[6] such groups being a core mode for collaborative professional development offered by Maths Hubs.[7]

To address the professional development needs of non-specialist teachers, a series of policy-supported programmes have been implemented, however, opportunities for such teachers have repeatedly shrunk in terms of length, scope, and budget. Over time these have reduced in duration and overall time spent studying. Fifteen years ago, the Mathematics Development Programme for Teachers was a funded programme over the course of a year with day release for teachers. Non-specialist teachers in 2009 could engage in part-time, funded courses over four terms, including 30 taught days and ten school-based development days. In its place, the Maths Hubs now deliver the Teacher Subject Specialism Training and the Subject Knowledge for Teaching Maths courses over six days (Boylan, Adams and Birkhead, 2022). Some subject leaders in schools and MATS recognised NCETM support for non-specialist teachers as a good option; the use of twilights is appreciated as it overcomes barriers to releasing teachers during the school day.

> *'The NCETM twilights are easier for people to be involved in. Even if we could get cover agreed for daytime courses, we just can't source supply teachers we would be ok with having them do the cover.'*

Although there is a considerable variety of maths teacher PD available, there are some notable absences. Two examples, related to either impactful PD or impactful teacher practice are:

- The use of subject-specific coaching models—for example, using external coaches. This showed promise in science (Hobson, 2012) and, as noted, the EEF PD review identifies coaching as often involving effective mechanisms (Sims et al., 2020) reflecting meta-analysis of coaching interventions (for example, Kraft et al., 2018).

[4] https://www.gov.uk/government/publications/initial-teacher-training-and-early-career-framework

[5] https://www.ambition.org.uk/news/ambition-institute-launches-maths-pilot-early-career-teachers/

[6] https://www.ncetm.org.uk/maths-hubs-projects/specialist-knowledge-for-teaching-mathematics-secondary-early-career-teachers/

[7] https://www.ncetm.org.uk/maths-hubs/what-maths-hubs-are-doing/what-is-a-work-group/

- There is a lack of PD focused on metacognition in the context of maths: this is in spite of a history of addressing issues of metacognition in maths, particularly through problem-solving pedagogy and teaching forms of mathematical thinking. Metacognitive aspects are apparent as being present in other PD—for example the NCETM mastery programme—however, sustained PD programmes with metacognition as the main focus do not appear common. Quigley, et al. (2018) offer guidance that could inform such PD.

The lack of availability of the above forms of professional development may reflect perception of need. When survey respondents were asked about PD priorities (Tables 3 and 4) few were coded as related to metacognition and so gathering participants for such PD may be challenging.

Priorities for the development of subject knowledge and its associated pedagogy

In our survey, participants were given a list of potential recipients of professional development and asked to place these in order of importance (Table 3 and Appendix 2: Tables 1 to 7). In considering these findings, it is important to note that the survey respondents were subject leaders and this may not reflect the views of other teachers and in particular non-specialist teachers. Maths specialist teachers were placed as the highest priority followed by maths subject leads. In focus groups, subject leads agreed that they should be a priority for professional development. They felt well-placed to engage with PD, which they could then cascade to their colleagues during team meetings, and in changes to the department's scheme of work and associated teaching strategies.

While they acknowledged that professional development that increases their knowledge and understanding of strategies for teaching maths is important, there was agreement that PD specifically focused on how to cascade this learning and develop staff would also be valuable. They noted the limited opportunities to receive PD related to their role as subject leads when they had been in the role for a longer period.

Table 3: Professional development priorities—potential recipients

	1	2	3	4	5	Mean	Total n
Maths specialist teachers	63%	25%	9%	2%	1%	1.53	240
Heads of departments and other maths leaders in schools	16%	37%	26%	18%	4%	2.56	240
Non-specialist teachers trained in other subjects	15%	15%	25%	26%	20%	3.20	240
Teaching assistants	3%	17%	31%	33%	17%	3.43	240
Subject leaders supporting teachers in multiple schools	3%	7%	10%	22%	59%	4.29	240

'1' is the highest priority, '5' the lowest.

In our survey, participants were asked to identify three priorities for professional development and three further priorities for teaching lower attaining students—those who were likely to enter Foundation GCSE. Responses were coded and analysed to identify the percentage of respondents that identified this priority in at least one of their three choices in each of the two questions. Notably, approximately half the priorities identified were categorised as generic professional development and half as subject specific. The highest-rated generic pedagogical priority as teaching technique and the highest subject pedagogical priority for professional development was problem-solving (see Table 6). Teacher views from the focus group workshops more generally about problem-solving in the curriculum are discussed later.

Table 4: PD priorities—areas

	#1	#2	#3	Total	Percentage
Pedagogy	101	95	66	262	52%

Professional development (nonspecific)	30	13	12	55	11%
Meeting learners needs	11	18	14	43	9%
Curriculum	15	14	9	38	8%
Assessment	11	13	10	34	7%
Examinations	15	12	8	35	7%
Technology	2	6	5	13	3%
Behaviour	0	2	6	8	2%
Metacognition, attitudes, affect	1	5	1	7	1%
SEND	2	1	3	6	1%
			Total	501	

‘Percentage’ here is the percentage of respondents who identified the area as one of their three priorities.

Table 5: PD priorities for teaching low attainers

	#1	#2	#3	Total	Percentage
Pedagogy	107	97	67	271	54%
Meeting learners needs	20	18	5	43	9%
Curriculum	14	8	9	31	6%
Metacognition, attitudes, affect	9	13	4	26	5%
Assessment	5	4	8	17	3%
Professional development (nonspecific)	6	5	4	15	3%
Examination	1	1	8	10	2%
SEND	4	3	5	12	2%
Technology	0	2	2	4	1%
Behaviour	2	2	3	7	1%
			Total	436	

‘Percentage’ here is the percentage of respondents who identified the area as one of their three priorities.

Data for subject-specific priorities was further analysed by considering categories identified by respondents in each of their responses. This is shown in Table 6, with highest priorities chosen indicated by shading.

Table 6: Specific professional priorities: percentage of respondents that identified this as a priority in one of their responses

	General (%)	Low attainers (%)

Assessment - Afl	14%	9%
Assessment - other	3%	1%
Behaviour for learning	4%	4%
Behaviour - other	1%	0%
Curriculum - specific subject area	3%	1%
Curriculum - other	15%	12%
Exam - A level	8%	0%
Exam - Core Maths	1%	0%
Exam - GCSE	3%	2%
Examination - other	4%	13%
Metacognition and affect other	4%	13%
Pedagogy - representations	20%	44%
Pedagogy - problem solving	27%	18%
Pedagogy - practise	12%	21%
Pedagogy - teaching techniques	30%	30%
Pedagogy - Mastery	14%	9%
Pedagogy - communication	15%	17%
Pedagogy - other	17%	13%
Professional development nonspecific	25%	9%
SEND	3%	7%
Meeting learners needs Specific groups of learners	5%	7%
Meeting learners needs Attainment range	10%	13%
Meeting learners needs other	4%	5%
Technology	7%	3%
Other	1%	1%

Number of respondents: general priorities, n = 183; low attainer priorities, n = 163.

Data reported in Table 6 indicates that a further subject pedagogical priority was the use of representations—the highest priority in relation to teaching lower attaining students—and professional development on problem-solving a general priority.

In our subject leader workshop, participants expressed a desire for PD focused on supporting low attainers upon entry to secondary school as, although based on limited data, there was an agreement that far more pupils than ever before are unable to access the curriculum, especially in disadvantaged areas. Some schools previously provided bespoke support for such pupils on entry to secondary school, but with increased numbers of low attaining pupils they no longer felt that this was adequate and that there is a need for teacher PD that addresses the challenges they face.

Those teachers who are trained in secondary maths often find it difficult to support particularly low attaining pupils and feel that they require a better understanding of what happens in primary maths (KS1 and KS2) in response to the needs of these cohorts. While they note that the Maths Hubs offer professional development in this area, this is quickly booked by primary teachers and there is nothing aimed at secondary teachers supporting very low attaining Key Stage 3 pupils.

It was also identified in the workshop that setting and streaming practices gave heads of department challenges when supporting staff. There was some use of mixed-attainment teaching (particularly in Key Stage 3) and in one school pupils' attainment in English, maths, and science was used to make an overall judgement of whether they were placed into a higher or lower 'band'. This often resulted in teachers feeling unable to meet learners' needs given the wide range of attainment levels in their classes, including those with particularly low attainment on entry, and heads of department feeling unable to offer guidance.

> *'We've got students that are coming in, working at maybe Key Stage 1 levels. In the past, maybe we would have had one or two and we would be able to put something bespoke together for them. We're now getting maybe seven or eight in our intake and we're feeling as teachers like we're secondary trained, we're not really sure how to change our teaching styles, the strategies, the manipulatives, and things that we would need to be able to, you know, try to accelerate these students from their starting point to be able to access any of the secondary level maths' (head of department).*

While more experienced teachers may be able to adapt their teaching in the moment, early career teachers would not have the skills or confidence to do this. It was felt that more PD to support teachers with these challenges is needed, which would be best delivered to heads of department to cascade.

In summary, key findings from the survey, supported by workshops, are:

- subject pedagogical professional development areas identified as priorities are problem-solving and the use of representations;
- there is a lack of appetite for professional development focused on classroom use of technology;
- professional development for subject leaders is considered as more important than for non-specialist teachers (maths teachers in general are the highest priority); and
- from workshops and, to an extent, the survey, there is evidence of interest in PD focused on supporting low attainers on entry to school.

In the survey, respondents were asked about the *content* of professional development, however, some respondents chose, as priorities, *forms* of professional development. These forms emphasised collaboration with opportunities for departments to work together.

As noted, releasing subject teachers to attend external professional development is increasingly challenging for schools. One MAT subject leader reported that it was not a matter of cost as much as locating supply teachers for cover. Issues of equity for pupils created challenges in individual teachers adopting new practices separate from departmental-wide change as this would mean pupils would experience different teaching. Similarly, organisational issues might occur if there were additions to content that would then affect internal assessment. This suggests that whole-department models for professional development may be more implementable than those focused on individual teachers. These findings echo those from evaluation evidence (Boylan et al., 2015; Culliney, et al., 2022).

Findings—targeted interventions and support

Section content and summary of findings	
Pupils' needs and provision of further support and selection of programmes	Interventions can be used for cohorts, such as grouping students based on their prior attainment, or individuals, such as individual or small group tutoring and peer tutoring. Survey respondents view high quality teaching as the main cohort-level intervention for students in KS3 and KS4, countering the 'falling behind' culture in schools.
Programmes used to support intervention, including tutoring and challenges for disadvantaged students	Individual tutoring and peer tutoring have been shown to have a positive impact on students' learning, however, the type and focus of these interventions are important. Interventions can be used outside of school—such as homework and online platforms for practice and consolidation of learning—however, this results in a blurring of the distinction between interventions targeting specific groups of students and programmes intended for all students and, as a result, how these are viewed and included in schools' practice. Some online platforms target diagnostic assessment and feedback, while others provide individual and small group interventions.
Challenges to access for disadvantaged pupils	Decision-making processes about targeted support are generally made at school leadership level, with some schools offering 'study support' related to exam preparation. There are challenges for pupils in benefiting from interventions that rely on high fidelity to the intervention developer's principles. Teachers require support to teach certain topics differently, as the same approaches may not be effective for all students. Poor attendance has worsened in some schools since the Covid-19 pandemic. Evidence of effectiveness for some interventions is at risk of becoming outdated and schools will need to adapt their interventions to address specific student groups.

Interventions and support—existing evidence and context

For this review, we take the term 'intervention' to represent a specific practice or approach schools adopt in order to ensure that students achieve their potential. Interventions might be used for:

- cohorts—how students are organised for learning maths or through curriculum design; or
- individuals—specific programmes schools use to support individuals, sometimes as part of small groups of students.

Cohort interventions

An important potential cohort intervention is to change the approach to grouping pupils in relation to their prior attainment. For example, a school may increase the homogeneity of pupils' prior attainment in classes by 'setting' (grouping by attainment for maths) or streaming (grouping by attainment for multiple subjects: see Taylor et al., 2020, for a discussion of types of grouping practices). Conversely, a school could choose to intervene in a cohort by reducing the amount of setting. As noted in the above section on professional development, changes in grouping arrangements can lead to challenges for teachers and so to professional development needs.

There is long-known evidence pointing to negative benefits of setting for low attaining students (for example, Slavin, 1990; Kutnick, 2005; EEF, 2021a). However, a study reported by MacLeod et al. (2015) indicated that 34% of secondary schools in England had chosen setting or streaming as a means to address the needs of disadvantaged pupils. MacLeod et al. (ibid.) does not report for which subjects schools chose this arrangement. However, setting remains the predominant approach to grouping students for maths in secondary schools to meet cohort needs. Even where schools begin by grouping students in mixed attainment classes in Year 7, by Year 11, students will very likely be grouped in sets (Taylor et al., 2020). Only 0.8% of the secondary teachers surveyed by MacLeod et al. reported setting or streaming as having been an effective approach to raising outcomes for disadvantaged pupils. However, the teachers did report

one to one tutoring and paired or small group additional teaching to be most effective for this purpose and supported by evidence (EEF, 2021b).

There is limited evidence about the practices associated with curriculum design as a cohort-level intervention. However, Ofsted (2023) reported that students who learn maths more slowly than their peers in secondary school frequently receive a curriculum that does not meet their needs because it is narrowed by a focus on facts and procedures without experiencing how they can be used to solve problems. Furthermore, students who are expected to sit the foundation tier GCSE papers experience a curriculum content that enables them to be successful in exams but without securing the mathematical knowledge they need to be successful later. These students also repeat all, or most, of what they have learned at Key Stage 3. Data collected during our practice review related to these issues is reported in a later section on KS3 to KS4 transition.

Individual

Individual or small group tutoring and peer tutoring has been shown to have a positive impact on students' learning generally (EEF, 2021c; EEF, 2021d) and specifically for maths (Hodgen et al. 2018) and is a cost-effective approach to improving attainment. However, not all programmes are effective: Y7 'catch up' programmes, for example, did not later impact GCSE attainment (Cook et al., 2020). This indicates that the type and focus of programmes is important.

The National Tutoring Programme (NTP), introduced in the academic year 2020/2021, has been an important part of the government's Covid-19 recovery response—supporting schools to respond to the disruption to education caused by the pandemic and subsequent school closures—offering targeted tuition to support disadvantaged students who have been hit hardest by this disruption. One of the aims of the NTP is to stimulate a well-functioning and sustainable tutoring market. According to the evaluation of the second year of the NTP (DfE, 2022) those surveyed or interviewed perceived the NTP to have had a positive impact on schools in terms of reducing the attainment gap for disadvantaged students. However, availability of high-quality and well-trained tutors was important to ensure the success of the intervention. It is important to note that the evaluation did not specify survey or interview participant perceptions at subject level so it is not possible to determine the specifics in the context of maths. Additionally, only approximately one quarter of survey respondents were drawn from secondary schools. While the NTP makes use of an approach that has been shown to be effective, the content and nature of the bespoke interventions provided by tutors is not well documented or understood.

Schools have limited options for externally developed maths-specific interventions that have shown to improve outcomes for individuals or small groups of students at KS3 and KS4 and which are suitable for the curriculum in England. For instance, a pilot of a school-based intervention, Connecting Maths Concepts, aimed to explore the promise and feasibility for low prior attaining students in KS3 (Hartland et al. 2019). The programme was originally developed in the U.S. making use of the 'direct instruction' model of teaching maths. There is preliminary evidence of positive outcomes on students' confidence in their maths understanding and ability, in particular, confidence in *addition* and *counting* as well as a self-reported positive impact for over half of the pupils on how well they are doing in maths. There is tentative evidence, from a pupil survey and interviews with school staff, that the programme was more beneficial for Year 7 students' maths learning, although the analysis is too limited to draw firm conclusions. Qualitative evidence also revealed low-level behaviour issues related to perceptions of insufficient challenge, too much repetition, and choral responding. The lack of differentiation to meet students' varying needs because of scripted lessons and lack of alignment to the KS3 curriculum content for maths in England was also a concern when supporting students to catch up and return to mainstream maths education. This example indicates how using interventions that are suited to pupils in England has many potential challenges. There is a need for more trials of targeted interventions for students at both KS3 and KS4 that are appropriate for maths education in England.

Interventions can also be used outside of school in the form of homework. Some of these are particularly focused on means to practise maths and review findings related to this are included in a later section on consolidation and practise. More generally, there is also a link between interventions that target specific groups of students and those intended for all students, particularly for students to practise and consolidate their learning. In particular, there is some blurring of distinctions, which may leave schools using certain interventions in different ways from how they were designed. For example, Sparx Maths offers access to aspects of tutoring, if pupils access those features, in the context of a practise programme; conversely, Complete Tutor, an online one to one tutoring platform, can be used as a practise platform.

However, online platforms for use out of school also target similar mechanisms for improving outcomes as other individual interventions, namely, diagnostic assessment and feedback. One such approach is the focus of Eedi[8], which has been subject to an EEF-funded efficacy trial (Boyle et al., 2021). The evaluation was affected by school closures during the 2020/2021 Covid-19 pandemic and the resulting cancellation of GCSE examinations meaning that it was not possible to measure impact on student outcomes. However, the evaluation did gather other evidence including how the intervention was not used by the teachers as was intended by the developer or given to students as frequently as expected. This specific example highlights the challenges for pupils in benefitting from interventions that take a more prescriptive approach and rely on high fidelity to the intervention developer's principles.

An additional form of individual intervention uses enrichment activities of various types. There are many providers of these with the Advanced Maths Support Programme being most notable, providing a suite of events and resources to support teachers to enrich their curriculum.[9]

Interventions and support—current practice

We asked survey respondents to indicate which pupils, according to prior attainment, were prioritised for targeted maths interventions in KS3 and KS4. In KS3, 36% of schools provide high attainers with additional support and 76% provide support for low attainers. In KS4, the corresponding figures are 76% and 91% (data derived from Appendix 2: Table 9). This suggests that intervention priorities at KS3 are focused on lower attaining students, possibly to address gaps on transition from primary school and to enable them to be successful as they progress to KS4. In contrast, it may be that examination preparation focuses interventions at KS4 for both higher and lower attaining students to enable all pupils to be as successful as possible at GCSE.

We also asked survey respondents who provides targeted interventions and in what format. Table 7 (see also Appendix 2: Table 8) indicates that while teachers are responsible for whole-class type interventions, other personnel, such as teaching assistants, tutors, or learning mentors, are more likely to be allocated individual and small group type interventions with 24% of the personnel being drawn from an external programme or organisation (Appendix 2: Table 10).

Table 7: Organisation of additional support

	Teacher	Teaching assistant	Tutor	Other (e.g. mentor)	Does not happen	Not sure	Total n
Individual	30.8%	18.9%	14.0%	11.9%	21.3%	3.1%	286
Small group	40.1%	16.3%	15.9%	12.8%	12.8%	2.1%	289
Class or larger (e.g. revision classes)	84.0%	1.0%	1.0%	2.8%	9.1%	2.1%	287

We gained insight into some decision-making processes about who received targeted support through a focus group workshop. Our interviewees reported using two different approaches to assess students on entry to KS3. They either took account of the students' end of KS2 test results or used a commercial standardised assessment to gain an age standardised score.

The assessments were used to identify a 'baseline' level of attainment on entry. End of KS2 scores were used to avoid the need to assess the students upon entry so that the focus could be on managing the pastoral transition between

[8] https://eedi.com

[9] https://amsp.org.uk/teachers/11-16-maths/inspiring-students/

primary and secondary. On the other hand, the commercial assessment was used because there was a concern about changes to students' attainment over the summer.

Decisions about which interventions to use and who delivers them were generally made at school leadership level, even when schools were part of a multi-academy trust. In some cases, heads of department have strict guidelines to identify the students at risk of not making the required progress. At KS4, schools offer 'study support' related to exam preparation, similar to our survey findings.

Our survey asked respondents to identify ways they support students' mathematical learning who are eligible for Pupil Premium funding. Table 8 provides a summary of their responses.

Table 8: Supporting pupils eligible for Pupil Premium funding

	%
Identified to teachers as being Pupil Premium eligible	88%
Provided with free or subsidised equipment or other materials such as revision guides	84%
Targeted interventions (e.g. in small groups)	72%
Tutoring	57%
In-classroom support by teaching assistants	41%
Other (please provide detail)	14%

74 respondents.

High quality teaching was described as 'knowing your pupils' (including whether they are eligible for Pupil Premium) but also knowing what has not worked for those students previously. Our focus group all agreed that high quality teaching using a clearly planned scheme of learning should be the primary cohort-level intervention for learners in KS3 and KS4 and, in holding this belief, it counters the 'falling behind' culture in schools.

One participant explained how working with a Maths Hub had supported their curriculum planning.

> *'I did a lot of work with the … Maths Hub, … that really starts getting [the students] to think about sort of teaching for depth …, for mastery … looking at topics in detail in Key Stage 3 and getting those core concepts covered before KS4.'*

In the survey (Table 8), 88% of our respondents indicated that knowing which students are eligible for Pupil Premium in each class was a way of supporting disadvantaged students. Focus group participants suggested that teachers require support to teach certain topics in different ways because for students who require further support, experiencing topics the same way as before—when they did not make sense the first time—is likely to lead to the same outcomes. Our survey data also indicated that students eligible for Pupil Premium would be supported with free or subsidised equipment (84%) or provided with small group interventions (72%) or tutoring (57%). As noted above, in general, issues of addressing different groups of pupils' needs across the attainment range was an area of interest for practice and professional development.

Survey data suggests that targeted interventions for disadvantaged students are part of a suite of support provided by schools. One potential barrier to impact was reported in a focus group: that poor attendance had worsened in some

schools since the Covid-19 pandemic.[10] This is most likely a more general matter for schools regarding student progress in normal classes than for those participating in targeted interventions.

Implications for practice

We have shown above that school leaders must make decisions about differing scales of interventions that enable students to achieve their potential. School-level autonomy is an important aspect of such decisions that target the needs of specific cohorts of students, small groups, or individuals. Interventions may need to fit with whole-school or trust approaches (see Findings—Programme Engagement for further discussion). This may cause barriers to interventions such as Connecting Maths or Eedi if they require high fidelity.

The evaluation of the NTP suggested that school leaders reported school-led tutoring programmes as having most impact (DfE, 2022). This approach requires the availability of tutors and training of high enough quality to have the most impactful outcomes. This means that student access to tutors and tutoring is sensitive to the variability and equity of quality depending on geographical location, access to technology, and availability of suitable opportunities for professional development.

While evidence of effectiveness is available to schools for some interventions, this evidence is at risk of rapidly becoming out of date as developers adapt their interventions—for example, Eedi, or technology more generally, moves at pace, for example with the use of AI. Thus, evidence about Computer Aided Instruction is rapidly becoming dated and possibly not applicable to current platforms or potential interventions (Adams and Boylan, 2023).

We found no evidence that pointed to how schools make decisions about which students or which maths-specific programmes will be identified and offered although the EEF's guidance for tutoring provides some generic support in this regard. The following section considers potential developments.

Interventions and support—potential developments

Relatively little is known about any differential practices that are used in mixed-attainment classes or in sets and whether there are differential experiences for certain groups of students according to how schools group them for maths. The EEF-funded Student Grouping Study[11] should provide further insight into this. However, when schools make decisions about which targeted interventions to use with particular groups of students, it might be helpful to contextualise any trials of interventions in terms of existing grouping practices. For instance, an intervention that focuses on metacognitive skills may or may not be as effective with students who are grouped differently.

Most schools are using some form of intervention for both lower and higher attaining students in both KS3 and KS4 (Appendix 2: Table 9). Further research is needed to identify what form these interventions take—whether they are bespoke to individual students or small groups, created 'in-house', subscriptions to online platforms or other commercially available programmes, or whether interventions address particular content such as mathematical topics (for example, quadratic equations) or mathematical skills (such as problem solving). There are current programmes and practices that could be adapted to support teachers working with intervention groups (for example, Eedi) to support formative assessment or redesigning direct instruction approaches.

During the review we did not identify, from desk review or focus groups, specific Professional Development for teachers about working one to one with students or small groups for secondary teachers. However, Maths Hubs offer opportunities for secondary teaching assistants that includes pedagogical knowledge on working with individuals and small groups.[12]

[10] https://epi.org.uk/publications-and-research/examining-post-pandemic-absences-in-england-2/

[11] https://educationendowmentfoundation.org.uk/projects-and-evaluation/projects/student-grouping-study

[12] https://www.yorkshireridingsmathshub.co.uk/work-groups/subject-knowledge-for-secondary-teaching-assistants/

Another apparent absence is subject-specific PD focused specifically on metacognitive and motivational aspects of maths learning, for example, informed by practices such as motivational interviewing or behaviour change models.

Findings—impactful practices[13]

Section content and summary of findings	
Classroom practice priorities	Problem solving is a core aspect of maths and it has been a focus since the introduction of the National Curriculum and the 'using and applying' strands. Teachers are more likely to integrate problem solving into all or most topics and teach specific problem-solving techniques, rather than using extended problem-solving tasks or dedicating whole lessons to problem solving. Survey participants indicated the importance of different ways of promoting mathematical talk, including explicit teaching of vocabulary and sentence stems, providing opportunities for students to make conjectures about mathematical ideas, keeping students' talk in whole-class discussions on-topic, encouraging whole-class discussions, and asking pairs of students to discuss and agree on joint answers. These findings suggest that programmes focused solely on this area may be similar to existing practices. Representations, models, and manipulatives are recommended in the EEF KS2 and KS3 guidance. There appears to be greater use of, and interest in, using representations and manipulatives than previously. This may reflect the widespread use of bar modelling being widely promoted through various curriculum and professional development initiatives and within the mastery approach.
Consolidation practices and how pupils practise mathematical learning	Homework is often used to consolidate learning and there are potentially issues of equity of engagement for students from disadvantaged backgrounds. Interventions that involve different forms of homework to support disadvantaged students to consolidate their learning may be worthy of further exploration.
The KS2 to KS3 transition	KS2 to KS3 transition is regarded as important and schools use a wide variety of practices.
The KS3 to KS4 transition	Addressing the more challenging topics that are associated with greater opportunity to learn during Key Stage 3 appears challenging in some schools. The results showed that there were differences in KS3 curriculum content strategies by schools, with some evidence of more variability between high and low attaining schools. The study also found that schools may make different decisions about curriculum content. Lower quintiles schools are more likely to be selective about the curriculum content taught than higher quintile schools. The strategies some schools adopt vary across Foundation and Higher tiers but not in uniform ways.

Classroom practices

Classroom practice priorities

Survey participants were asked to rank five potential practice priorities. This list of priorities was informed by reviews of impactful practices focused on both causal (Hodge et al., 2018) and broader evidence (Nunes et al., 2009). A mean rank was calculated and is shown in Table 9 in ranked order of priorities based on the calculated mean with '1' being the highest priority.

[13] As noted in the description of the thematic areas, the label 'impactful practices' was proposed by the EEF in its invitation to undertake this practice review: the inclusion of the specific sub-themes in this section of the report, however, does not in itself mean there is evidence they are impactful (see Figure 1 and related commentary).

Table 9: Teacher priorities to promote learning

Potential practice priority	Mean
Promoting mathematical thinking and communication	2.43
Improving explanations, choice of examples, and techniques to promote understanding	2.56
Embedding problem solving	2.91
Using models, manipulatives, and representations in teaching	3.03
Using digital technology including calculators	4.07

266 respondents.

As reported in the section Findings: Teacher Skills and Practice, respondents were also asked to identify three general professional development priorities and three considering teaching low attainers. As reported above, these priorities were coded as either 'general' or 'subject'. Priorities were coded as 'general' if they could apply to different subjects—for example, behaviour—or coded as 'subject' if they were specific to maths, such as problem solving. Considering those categorised as 'subject' provides supporting evidence that the first four of the potential practice priorities identified in Table 9 are of interest to teachers. In addition, the questions on professional development priorities also provide insight into priorities for impacting teaching of lower attaining children with more teachers viewing problem solving as being a general priority (27%) than for teaching low attainers (18%). Conversely, to support teaching of low attainers, *practising* was viewed as a priority by more respondents than as a general concern (12% teaching generally, 21% teaching low attainers) and similarly *representations* was viewed as more relevant to low attainers (20% teaching generally, 44% teaching low attainers).

In the responses to the open questions on professional development priorities and in the ranking question responses summarised in Table 9 the lower interest for the use of digital technology is evident. This may reflect the current situation in which the secondary curriculum guidance does not address the use of digital technology in the teaching of maths and data analysis using technology (JMC, 2023). The current policy and curriculum environment would present challenges for innovations that seek to use technology in the classroom (as distinct from using technology platforms for other purposes such as practising maths discussed below).

Problem solving

Problem solving is a core aspect of maths since the introduction of the National Curriculum and the 'using and applying' strands of maths curriculum (Boylan, Adams and Birkhead, 2022). Problem solving continues as an aim in the current National Curriculum. Since 2015, in the reforms of maths GCSE, the percentage of marks available for questions directly involving problem solving increased from 15% to a minimum of 25% (Jones, 2022). Problem solving also supports mathematical learning generally (Henderson et al., 2022). Different approaches to teaching problem solving are possible, particularly whether this should be done through teaching generic mathematical problem-solving methods or content-specific strategies (see Foster, 2023).

In our subject leader workshop, problem solving was deemed as a priority due to the increase of problem-solving questions in GCSE and A level examinations and the need for this in future careers. In focus group workshops, some participants noted debates and changing views in the research and maths education community about problem solving which left them uncertain about how to integrate it in their own curricula. Some more experienced teachers feel that there is widespread confusion about allocating curriculum time to problem solving, namely, whether problem solving in maths is a one-off lesson, a means by which maths content is taught, or an endpoint when pupils have developed their knowledge of a topic. Although this issue of allocation of curriculum time is distinct from teaching problem solving approaches (Foster, 2023), there are potentially intersections between the two issues.

Survey participants were asked to indicate the importance of different forms of practice in relation to problem solving: the data is reported in Tables 10 and 11 below. This data gives insight into teachers' views of the relative importance of

different approaches to including problem solving in their teaching. To calculate mean values, for Table 10, values of 1 to 5 were used with ‘1’ for ‘not at all important’ and ‘5’ for ‘extremely important’. For Table 11, values of 1 to 5 were also used, with ‘1’ for ‘never’ and ‘5’ for ‘always’.

Table 10: Importance of different problem-solving practices

	Not at all important	Slightly important	Moderately important	Very important	Extremely important	Mean	Total n
Integrating problem solving into all or most topics	0%	2%	9%	42%	47%	4.32	272
Teaching specific problem-solving methods and techniques (for example, tabulate information, pattern spotting, making conjectures)	2%	7%	17%	45%	28%	3.90	271
Specific problem-solving lessons	13%	23%	30%	20%	14%	3.00	271
As extended problem-solving tasks that last for more than one lesson	27%	27%	27%	12%	7%	2.43	266

Table 11: The place of problem solving in sequencing topics

	Never	Sometimes	About half the time	Most of the time	Always	Mean	Total n
At the end of maths topics, for example as extension material or questions	2%	17%	14%	51%	17%	3.64	271
Early in topics to teach new mathematical content through problem solving	18%	46%	19%	13%	4%	2.64	269
Early in topics to engage pupils’ interest	6%	50%	21%	20%	3%	2.39	271

Teachers were more likely to report integrating problem solving into all or most topics as well as teaching specific problem-solving techniques and less likely to report using extended problem-solving tasks or dedicating whole lessons to problem solving. For any innovations on problem solving to supplement existing practices then the latter two approaches could be considered.

Mathematical talk and communication

The quality of talk and communication is central to engaging mathematically. A focus on improving the quality of talk and communication in the classroom is central to a diverse range of programmes and approaches to maths teaching and learning. This includes those that are more focused on dialogical methods such as Realistic Maths Education (Culliney et al., 2022) and those with a more explicit or direct instruction focus (Harland et al., 2019). The quality of communication is central to current policy-supported mastery approaches. Across varied studies, a focus on language is associated with impact on maths attainment (Peng et al., 2020). More generally, improving language and communication skills is viewed as important to supporting students leaving school without passes in English and maths GCSE (ASCL, 2019). Potential foci for improving mathematical talk and communication in the classroom are wide-ranging, from the quality of teacher explanation in worked examples (Barbieri, et al., 2023), student self-explanation (Rittle-Johnson et al., 2017), and peer to peer talk (Hu and Chen, 2023).

Survey participants were prompted to indicate the importance of different ways of promoting mathematical talk, all of which are fine grained practices that potentially promote rich mathematical communication. In Table 12, the practices are listed in order of means based on scoring ‘strongly disagree’ as ‘1’ and ‘strongly agree’ as ‘5’ (see Appendix 2: Table 13 for full data).

Table 12: Relative importance of different practices to promote mathematical talk

	Mean	Total n
I explicitly teach vocabulary and/or sentence stems	4.21	280
I provide opportunities for students to make conjectures about mathematical ideas	4.15	278
I keep students' talk in whole-class discussion on-topic to make sure key teaching points are made	4.14	271
I ask students to think alone and then tell a partner their answer	4.01	281
I encourage whole-class discussions where students question each other and explain their thinking	3.81	280
I ask pairs of students to discuss and agree a joint answer to a question	3.65	279
Students come to the board or visualizer and explain their thinking to the whole class	3.39	279

These findings triangulate responses to a baseline survey of approximately 100 other teachers undertaken in an evaluation of Realistic Maths Education (Culliney et al., 2022). Given the high prevalence of many of these practices, programmes focused only on this area may not be sufficiently different to current practices to generate an impact. However, a limitation of the survey data is that it self-reports importance and not frequency.

Representation, models, and manipulatives

The use of models, manipulatives, and representations is a recommendation of the EEF KS2 and KS3 guidance (Henderson et al., 2022). In the current policy-recommended Teaching for Mastery approach of the NCETM, representation and structure are one of five centrals 'big ideas'.[14] However, when Teaching for Mastery was being introduced in the primary phase, the use of a wide range of manipulatives and representations tended to be seen as more appropriate for younger primary pupils and for low attainers (Boylan et al., 2019). In the trial of Realistic Maths Education, the widespread use of a range of representations and models was limited across both the intervention and control group in the baseline assessment of practice in 2018 (Culliney et al., 2022). There are indications from the practice review survey and from focus group workshops that this is an area of secondary practice that has seen some change recently, with the use of bar modelling being widely promoted through a range of different curriculum and professional development initiatives.

Survey participants were also asked about representations and models used in KS3 (see Appendix 2: Tables 14 to 16), and specifically whether different forms of representations and models were used with higher attaining or low attaining students (defined as students who would be expected to enter for higher tier GCSE or lower tier GCSE respectively). Table 13 reports this data, ordered for high attainers from highest frequency to lowest frequency. Representations and models that are used more with low attainers than high attainers are shown in bold.

Table 13: Use of representation and modes in Key Stage 3

		Frequency %
Equations and functions represented by graphing apps	High attainers	74%
	Low attainers	42%
Bar models	High attainers	72%
	Low attainers	**83%**

[14] https://www.ncetm.org.uk/teaching-for-mastery/mastery-explained/five-big-ideas-in-teaching-for-mastery/

Ratio tables	High attainers	64%
	Low attainers	**67%**
Digital or virtual manipulatives	High attainers	61%
	Low attainers	**68%**
Algebra tiles	High attainers	39%
	Low attainers	**52%**
Double number lines	High attainers	38%
	Low attainers	**52%**
Cuisenaire blocks or other place value objects	High attainers	12%
	Low attainers	**40%**

266 respondents.

In general, all models and representations included in the survey are used more with low attaining pupils, than high attaining pupils, with the exception of equations and functions represented by graphing tools (although ratio tables are reported as used by similar numbers with both high and low attainers). The exception of the use of graphing tools is likely related to the content of the KS3 curriculum and how this is different in many schools for high and low attainers (see KS3 to KS4 transition below).

The survey data suggests that any innovations in the use of representations, models, and manipulatives would need to consider how new practices would be sufficiently different from usual practices. The data also is potentially a useful prompt for reflection about individual school and teacher practices given that some schools are using a wide range of representations and manipulatives across the attainment range.

Consolidation practices

Consolidation practices—existing evidence and context

Specific approaches to *practising* in maths education have become an area of interest in England for teachers, school leaders, and curriculum material developers over the last ten years (Coe, 2019). Important to this is a more general interest in the application of evidence from cognitive science and neuroscience (Perry et al., 2021). Terms such as *retrieval practice* (Karpicke and Roediger III, 2007), *spaced practice* (Emeny et al., 2021), and *interleaving* (Rohrer et al., 2020—also referred to as 'interweaving'—have merged from cognitive science to describe such practices. Each affords students different ways to rehearse prior learning until they are fluent or automaticity is achieved.

In maths, the extensive practice of routine exercises is often associated with *direct instruction* teaching approaches which follow on from detailed teacher explanations and precede application to problems or are included as part of *explicit instruction* where extensive structured practice aimed at achieving mastery follows on from teacher modelling of fixed methods. There is some evidence that these approaches are beneficial for lower prior attaining students (Hodgen et al., 2018).

There is limited prior evidence about how teachers in England provide opportunities for students to practise maths. As part of the TALIS video study, four lessons on the topic of quadratic equations were analysed at country level and compared with similar lessons from other countries (Ingram et al., 2020). One aspect of the analysis was to explore the levels of cognitive demand of maths subject matter. It was found that while teachers occasionally included opportunities for students to experience multiple mathematical methods and provided them with some opportunities to understand the rationale behind the procedures and processes with which they were working, they provided 'a wealth of opportunities' for students to develop fluency with specific mathematical skills through practice or repetition.

More recently, Ofsted (2023) found that in most secondary schools, exercises and activities are used by teachers, but in some schools, students are asked to undertake exercises and activities that are not carefully designed, or some students are moved on without having had sufficient practice to consolidate new learning. Furthermore, students rarely practised solving problems or worked on tasks that required them to explain, prove, justify, or describe relationships.

Consolidation of learning can also be linked to homework processes and practices. There is limited evidence in relation to maths homework practices in secondary schools in England. However, recent studies give indications of practices that may be effective (Brown et al., 2021; Nawaz and Welbourne, 2019). There is currently an interest in—and the use of—software platforms to support effective homework practice, and this reflects the use of platforms in the U.S.A. (for example, the ASSISTments platform: Roschelle, et al., 2016).

A synthesis of research found a generally positive association between the amount of time spent doing homework and attainment in both primary and secondary phases (Cooper et al., 2005). More recently, the OECD (2014), using national comparative data, also identified that the amount of time spent doing homework is positively associated with outcomes. Across all OECD countries, students in schools serving disadvantaged students set less homework (3.6 hours per week across all subjects) than those serving the more advantaged (6.0 hours), and in OECD countries, an advantaged student typically spends 1.6 more hours a week doing homework than a disadvantaged student: 5.7 hours compared to 4.1 (OECD, 2014). In the U.K., low performing students spent less time doing homework than those performing better (OECD, 2016) and get less help (Jerrim, 2017); well-off pupils with same level of achievement get 2.5 hours additional subject homework (across all subjects) than the disadvantaged.

Consolidation practices—current practice

In our survey we asked respondents to consider the ways that they consolidate learning and the extent to which they agree with certain statements (Table 14). Homework was used by over half of respondents for this purpose, but one member of a focus group also noted that they set homework to prepare students for the class topic that would follow. Other schools used homework in Year 11 for rehearsing exam questions.

The survey also revealed widespread use of short quizzes and tests suggesting that formative assessment-type interventions may not distinguish sufficiently from business as usual in trials, as may have been the case in the EEF trial of the programme Increasing Competence and Confidence in Algebra and Multiplicative Structures (ICCAMS) (Pampaka et al., 2022).

A large proportion of teachers also use interleaving and interweaving (80% agree or strongly agree). Focus group participants reported including time for retrieval practice at the beginning of the lesson (several referred to this as a ‘Do Now’) lasting approximately five to seven minutes in each lesson; 83% of respondents agree or strongly agree that their lessons have extended periods for practising techniques with our focus group indicating that their lessons also included time for silent consolidation practice of the maths focus for the lesson. In one case this took between 10 and 15 minutes of the lesson time. The different responses from focus group participants suggest a variety of understandings and priorities when teachers set practice tasks. Our focus group participants reported ways in which they draw from curriculum content previously taught, and one participant mentioned how these retrieval practice parts of their lessons are used to prepare students for a forthcoming teaching unit.

> *‘We ... changed our model with our retrieval practice ... When we’re about to come up to [a new unit], we do retrieval practice starters to try and remember stuff from the year before of the things they’re about to encounter. So, when we’re about to solve equations with variables on both sides, we would do retrieval practice on equations with variables on one and then they would have a ... linked homework to that the following week so that they could then have some independent practice with the aim that hopefully will hit the ground running on the next unit’ (head of department).*

One focus group participant reflected on what ‘quality practice’ meant to her. She felt that repetitive practice of 20 of the same questions adds nothing to students’ learning.

> *‘They’re not thinking, they’re just repeating a process and a month later they’re not gonna remember a single thing. So, I usually just ask myself ... Have they learned it well enough for them to know it next year? Can they apply it in a different situation? That’s gonna ... [be] a gauge of whether I’m teaching them in the right way to some level and linked to that then retrieval space practice, intelligent practice becomes really important’ (head of department).*

For her, quality practice included exercises involving applying skills in different situations. This is an uncommon practice according to Ofsted (2023).

Table 14: Ways that respondents consolidate learning and the extent to which they agree with the statements

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Mean*
I interleave or interweave topics in practice questions by having mixed practice exercises	1%	6%	13%	32%	48%	1.78
Lessons have extended periods for practices techniques	2%	6%	9%	46%	37%	1.91
I regularly use short quizzes and tests	0%	12%	13%	35%	39%	1.98
Learning is mostly consolidated through homework	10%	20%	16%	38%	16%	2.70

* Means were calculated by assigning integer values from 1 to 5 with '1' being 'strongly agree' and '5' 'strongly disagree'.

In the survey, we asked teachers to indicate how often they used certain resources to support students' practising maths and the frequency that they would use them. Findings are shown in Table 15. In considering this data, it is important to note that the specific question was about practising maths and inferences should not be made about resources used for other purposes in teaching or for planning.

Table 15: Frequency of use for the suggested resources to support students to practise maths

	Weekly	Fortnightly	Every half term	Termly	Never or rarely
Department- or teacher-generated exercise	59%	12%	11%	6%	12%
Maths-specific software platforms	51%	18%	11%	8%	12%
Other schemes and sets of resources	48%	11%	6%	6%	30%
White Rose Maths resources	29%	5%	4%	8%	54%
A class textbook	27%	12%	7%	7%	47%
General software platforms	17%	8%	9%	12%	53%
Oak National	1%	1%	2%	5%	91%

The survey findings echo a recent study about the use of primary maths textbooks and curriculum resources (Marks et al., 2023) finding that teachers use a wide variety of sources. The number of department- or teacher-generated examples is relatively high with 59% of respondents suggesting this type of resource was a weekly occurrence. This compares to 27% of teachers frequently using a textbook. There is high use of maths-specific software platforms with at least 88% of respondents using them at least termly and just over half using them on a weekly basis.

Consolidation practices—potential for development

There is a limited evidence base on different approaches to practising maths in secondary school including how these different forms of practising are operationalised (effectively or not) in classrooms. As noted above, recent interest around practising maths is related to a more general interest in the application of cognitive science. However, research evidence from cognitive science is sometimes limited because the findings arise from relatively controlled conditions rather than

in natural settings where transferability of benefits is harder to execute. What appears simple to implement may be sensitive to specific conditions (Perry et al., 2021).

Practise may take many forms but what is also important is *what* students practise. The evidence, although limited, points to students' experience of practising maths as limited to facts and procedures with few opportunities to practise other mathematical skills such as using and applying facts and procedures to solve non-routine problems or practicing more cognitively demanding tasks that involve other forms of mathematical thinking such as conjecturing, generalising, and proving (Ofsted, 2023b; Ingram 2020).

Many schools choose to use homework to consolidate learning but it is not clear how effective this time is in consolidating student learning and may also present challenges of equity for students from disadvantaged backgrounds, particularly when there is the frequent use of online homework platforms in schools. Interventions that involve different forms of homework to support disadvantaged students to consolidate their learning may be worthy of further exploration.

Key Stage 2 to Key Stage 3 transition

KS2 to KS3 transition—background

Maths transition practices from Key Stage 2 to Key Stage 3 are important (Henderson et al., 2018) and there is evidence of maths attainment falling or plateauing following the transition from primary to secondary school (Ofsted, 2015; Cantley et al. 2021). The gap between disadvantaged pupils and their peers widens during the start of secondary school including in relation to attitudes to school and self-confidence.

Currently, the National Centre for Excellence in the Teaching of Maths (NCETM)'s Years 5 to 8 continuity project is a national programme which, in 2021/2022, included 152 'work groups' and 719 schools. The continuity project aimed to strengthen maths transition from KS2 to KS3 through cross-phase teacher collaboration. Stevenson et al. (2023) found the benefits of the collaboration came from a number of factors, including supporting the development of teacher knowledge of the 'other' phase. Teachers observed and engaged with those from the adjacent phase and in doing so they recognised similarities in terms of mathematical expectations, which resulted in a focus on teachers using consistent explanations and terminology in primary and secondary school teaching.

Over 90% of teachers in the study reported changing some aspect of their professional practice and over 61% agreed that their department had changed the approach to transition. However, although the NCETM survey shows evidence of impact on practice, this is from diverse types of activity as it was designed for high variation at school level. Other initiatives operate on a local scale, examples include the Stoke Maths Excellence Partnership and a network of primary and secondary schools working in partnership in Dorset.

Furthermore, Kaur et al. (2022) identified three factors that affected students' experiences of maths transition from KS2 to KS3 in a systematic review of the literature from 1990 to 2020. The first factor identified, student self-regulation, considered students' attitudes, motivation, and identity development as they move from primary schools to secondary school. The second factor related to school and academic practices. This involved curriculum and content, teacher's knowledge, instructional practice, classroom environment, and the school context and climate. A student's social, home, and family environment taken together was the third factor identified, which related to students' relationships outside of the school environment. The research found that a combination of these factors contributed to shaping students' experiences of transition.

Although there is evidence that transition is important there is little evidence related to how specific activities in maths might impact pupils' outcomes (Henderson, et al., 2018). For general interventions for disadvantaged pupils there is evidence that focused 'Year 7 catch up' programmes used previously did not affect GCSE outcomes but that identifying high attaining disadvantaged students as 'gifted and talented' did have positive outcomes (Cook et al., 2020).

KS2 to KS3 transition—current practice

From our survey data, we found many of the respondents were engaged with the Maths Hubs so schools in the Year 5 to Year 8 continuity groups are over-represented in the sample. A number of activities identified that could have plausible impact mechanisms (more sustained or lead to change in practice or learning experience) are:

- curriculum materials from secondary schools (24%);
- collaborative projects (22%); and
- trust or local projects (16%).

Further to the survey, we interviewed an NCETM lead from a work group and a secondary school teacher with responsibility for transition. These yielded in-depth views into the work groups and activities teachers considered impactful. In both cases, they had chosen to focus on multiplicative reasoning as a topic for cross-phase collaborations between one secondary school and its feeder primary schools. Their experiences aligned with those reported by Stevenson et al. (2023) where teachers valued knowledge of the adjacent phase—enabling primary school teachers to view how students would progress and secondary school teachers to view what foundations had already been established. This consideration for the overall student maths journey led to teacher practice changes in terms of using a consistent vocabulary across phases and identifying where there may be potential gaps in topic knowledge from a student perspective. Given that teachers now understood what and how topics were taught in the other phase they could work collaboratively to bridge any gaps.

In both contexts, the schools organised their cross-phase collaborations through meetings which typically happened four to six times per academic year. In these meetings, teachers would work on some maths problems together which were suitable for both Key Stages. Through these problem-solving activities and discussions, teachers see and understand more about the practices of the other phase. Further to this, both contexts encouraged teaching observations of the adjacent phase, which functioned better when senior management were involved and teaching cover could be arranged; in one setting, there was a designated role within the secondary school for maths transition from primary to secondary.

KS2 to KS3 transition—potential for development

The NCETM Year 5 to Year 8 continuity groups develop local initiatives that are varied in focus. There is potential for future evaluation of these to identify potentially promising innovations, however, programmes focused on the KS2 to KS3 transition may be hard to recruit to and activity that has worked in specific contexts may not be replicable with fidelity in others.

Key Stage 3 to Key Stage 4 transition

KS3 to KS4 transition—background

The relationship between the KS3 curriculum and KS4 curriculum is important to pupil progression and outcomes. However, in spite of this importance, research specifically about this relationship is limited as is research on choices schools make to support transition or prepare pupils for KS4. A significant challenge in understanding schools' practices is that although the National Curriculum is organised into a three-year KS3 and two-year KS4, practice varies considerably. Various surveys in the period 2017 to 2019 found that at least a substantial minority of schools—possibly up to a half—were adopting a three-year KS4 curriculum (summarised in Rutt and Poet, 2020). However, the introduction of a revised Ofsted inspection framework with accompanying concerns about the risk of a restrictive curriculum for

disadvantaged pupils (Ofsted and Spielman, 2017) may have changed arrangements. The question of the relationship, if any, on attainment of two or three years of study at KS4 is the subject of a current EEF School Choices study.[15]

OECD analysis on inequality and outcomes in maths indicates that disadvantaged students have less opportunity to learn challenging curriculum content and that this is associated with lower outcomes; that is, for students with similar disadvantage, those with high opportunity to learn do better (OECD, 2016). However, in the United Kingdom, students' and schools' socioeconomic profile is less strongly related to students' access to opportunities to learn maths than on average across OECD countries—5% compared with 9% OECD explanation of differences by socioeconomic variables. This may be explained by lower levels of selective education in the U.K. at a school level. Differences in outcomes do not appear to be directly related to the amount of time spent in lessons in a linear way (op cit.).

Considering curriculum content: by age 15, students in the United Kingdom have heard of algebra concepts—such as exponential functions, quadratic functions, and linear equations—less frequently than the OECD average. They have heard of geometry concepts—such as vector, polygon, congruent figure, and cosine—a few times, similar to the OECD average. For example, 38% of students reported they have never heard the concept of cosine (OECD average: 33%), and 32% reported they know well and understand the concept (OECD average: 34%). Overall familiarity with maths concepts is lower than the OECD average. In the United Kingdom, around 15% of the performance difference between socioeconomically advantaged and disadvantaged students can be attributed to disadvantaged students' relative lack of familiarity with maths concepts (OECD average: 19%; OECD, 2016, p.3).

However, simply increasing content covered in KS3 with the aim of providing a stronger foundation for KS4 may be counterproductive. Ofsted notes the risk of low attaining students being—

> *'rushed through the study of new content, in order to "complete the course", without securely learning what they are studying. This frequently results in pupils repeating content, in key stage 4 that they have already studied, but not learned, in key stage 3 (and 2)' (Ofsted (2023b).*

The risk is that although the content is covered there is little teaching on how to apply knowledge to solve problems mathematically. Thus, the concept of opportunity to learn can be extended from content to learning how to mathematise, problem-solve, and discuss maths and the metacognitive aspects of maths (Watson and De Geest, 2005).

In England, GCSE maths is offered in two tiers, Higher and Foundation. The Higher tier allows entrants to attain grades 4 to 9, and the Foundation grades 1 to 5.[16] Decisions about which tier a pupil will enter do not need to be made until Year 11. However, in practice most secondary schools make that decision in Year 9 (Ofsted, 2023b) and some schools adopt practices that limit access to the full curriculum for particular tiers or otherwise adopt practices that limit preparation for further study of maths, including within post-16 courses that included, but were not focused, on maths (op cit.). Ofsted (2023) further identified that not only can content be rushed in KS3 but also in KS4 if the GCSE curriculum content is completed by the end of Year 10, and Year 11 is used as a revision year.

KS3 to KS4 transition—evidence of opportunity to learn and curriculum strategies

As noted, school organisation of the KS3 and KS4 curriculum is variable. Regardless of school policy, because maths is compulsory for all pupils at GCSE, the concept of a maths KS3 curriculum as distinct from a KS4 curriculum is not a straightforward distinction. Focus group workshops gave insight into a commonly held view that although GCSEs happen in KS4, preparation for GCSE begins in Year 7 and continues throughout KS3 where the foundations for later mathematical learning are laid and therefore transition to KS4 should be smooth and coherent and not a 'big deal'.

[15] https://educationendowmentfoundation.org.uk/projects-and-evaluation/projects/what-works-at-key-stage-4-two-or-three-years-of-study

[16] https://ofqual.blog.gov.uk/2017/02/10/gcse-maths-choosing-the-right-tier/

Although possible survey questions were explored to gather data on current practice in maths, we decided it was not practical to collect meaningful data about potential impact of choices made, particularly given that the review survey covered a wide range of other topics and so the number of items relevant to this particular area of interest would be limited. Consequently, survey data was collected on

- opportunity to learn specific topics in KS3 with the selection of topics informed by OECD research and important topics in GCSE to achieve grade 4 or 5 passes; and
- choices made by schools about strategies for the coverage of curriculum content in the Foundation and Higher GCSE papers.

We refer to both these types of decision as 'curriculum content strategies' in this section.

Opportunity to learn in KS3

In the survey, participants were asked about whether certain topics had been introduced to high and low attainers by the end of Y9. These were:

- linear equations;
- simultaneous equations;
- quadratic equations; and
- trigonometry.

For the purposes of this question, participants were asked to consider high attainers as those likely to be entered in Higher GCSE and low attainers as those likely to be entered in Foundation GCSE. Given that schools make different choices about entry, the meanings of these terms will be different for different respondents, nevertheless, responses are indicative of school practices. Table 16 presents data for schools introducing topics to both high and low attaining students (with full data tables presented in Appendix 2 Tables 24 and 25).

Table 16: Teaching of topics by the end of Year 9

Topic	High and low attainers %	High attainers only %	Total n
Linear equations	91	5	298
Pythagoras	77	17	296
Trigonometry	37	35	297
Simultaneous equations	33	39	296
Quadratic equations	28	47	293

Using school attainment and FSM data, we analysed the relationship between these variables and choices about inclusion of content in the KS3 curriculum. Data is presented in Table 17 for attainment (and also found in Appendix 2, Table 26) and data for FSM analysis is presented in Appendix 1 Table 12 and not included here as a similar pattern is found.

Table 17: Analysis by attainment quintile of teaching of topics by the end of Year 9

Attainment quintile 1 = lowest; 5 = highest	Linear equations		Pythagoras		Trigonometry		Simultaneous equations		Quadratic equations	
	High attainers	Low attainers	High attainers	Low attainers	High attainers	Low attainers	High attainers	Low attainers	High attainers	Low attainers

1	92%	90%	92%	76%	71%	31%	72%	26%	76%	28%
2	98%	96%	90%	73%	63%	33%	67%	23%	74%	17%
3	100%	100%	100%	77%	71%	35%	71%	19%	77%	23%
4	98%	98%	100%	83%	80%	42%	71%	31%	72%	30%
5	96%	86%	95%	80%	79%	44%	85%	56%	77%	41%
Difference between q5 and q1	4%	-4%	3%	4%	8%	13%	13%	30%	1%	13%

From the data presented in Table 17, difference for each topic area between reported strategies between high and low attainers was calculated and presented in Table 18.

Table 18: Quintile analysis of Year 9 curriculum content—difference between high and low attainers

Attainment quintile 1=lowest; 5 = highest	Linear equations	Pythagoras	Trigonometry	Simultaneous equations	Quadratic equations
1	2%	16%	40%	46%	48%
2	2%	17%	30%	34%	57%
3	0%	23%	36%	52%	44%
4	0%	17%	38%	40%	42%
5	10%	15%	35%	30%	35%

Important to interpretating the analysis by quintile are potentially different meanings as to who are considered ‘high’ and ‘low’ attainers by the respondents. The survey question asked respondents to consider students who would be likely to be entered for either the GCSE Higher (‘high attainers’) and Foundation (‘low attainers’). However, the general issue of this meaning being dependent on school-level practices is accentuated when quintiles are considered as schools may make different decisions about entry. Data reported in the next section about GCSE curriculum strategies implies that schools are making different decisions and variability in practices is reported by Ofsted (2023) and affirmed by focus group participants in the practice review (see Tables 19 and 20).

The survey responses indicate:

- there are differences in KS3 curriculum content strategies by schools; and
- there is some evidence that for some curriculum content (trigonometry, simultaneous equations, and quadratic equations) there is more variability between high attaining schools and low attaining schools than other content.

GCSE curriculum strategies

To explore issues identified by Ofsted (2023) about different GCSE curriculum content strategies, participants were asked about choices on curriculum coverage in GCSE higher and foundation groups. Detailed tables of overall responses are available in Appendix 2 (Appendix 2, Tables 28–31).

Overall, approximately half of respondents reported that their school aimed to teach all the content of the relevant tier and, conversely, about half reported their school adopted different strategies to select material based on an overall target of grade 4 or 5, or an individual pupil’s target grade. This triangulated Ofsted’s observation.

This data was further analysed to consider school characteristics based on quintiles of attainment (maths and English grade 9 to 5) and free school meals (Ever 6 FSM). Table 19 and Table 20 present the analysis for the Higher and Foundation tiers, respectively, by attainment quintiles. The FSM data follows a similar pattern. Note that respondents could choose more than one option and so responses do not sum to 100%. In the focus group workshops, participants explained apparent contradictions: for example, someone might select the option that pupils are taught the full GCSE syllabus but also that selections are made about the content taught. The former response might refer to overall curriculum planning and the latter that once the whole curriculum had been taught there might be finer grained selection, particularly in the period before exams when revising.

Table 19: Higher tier curriculum content strategies

Attainment quintile (1 = lowest, 5 = highest)	**1**	**2**	**3**	**4**	**5**
All students entered for Higher GCSE are taught the full Higher GCSE syllabus	47%	51%	57%	28%	66%
For some students, we select content that gives the best chance of their individual or classes target grades	63%	58%	55%	80%	36%
For some students, we select content that gives the best chance of getting a grade 5	20%	24%	19%	16%	11%
For some students, we select content that gives the best chance of getting a grade 4	10%	13%	13%	6%	2%
Other (please explain)	4%	9%	6%	8%	9%

Table 20: Foundation tier curriculum content strategies

Attainment quintile (1 = lowest, 5 = highest)	**1**	**2**	**3**	**4**	**5**
All students entered for Foundation GCSE are taught the full Foundation GCSE syllabus	47%	49%	57%	43%	53%
For some students, we select content that gives the best chance of their individual or classes target grades	55%	56%	53%	57%	21%
For some students, we select content that gives the best chance of getting a grade 4	33%	20%	30%	18%	8%
For some students, we select content that gives the best chance of getting a grade 5	31%	20%	26%	14%	11%
Other (please explain)	4%	7%	9%	4%	25%

Total n range: 45–53.

Given the correlation between attainment and free school meals, unsurprisingly a similar pattern was found for FSM.

Tables 19 and 20 indicate that:

- lower attainment quintiles schools are more likely to be selective about the curriculum content taught than higher quintile schools; and
- the strategies some schools adopt vary across Foundation and Higher tiers but not in uniform ways.

Combining this with the general observation that schools make different choices about selection of content suggest that different schools make different choices about curriculum content strategies. This underlines that whatever strategy is adopted it can be implemented in all types of schools.

However, there is a lack of evidence about the effect of different strategies on GCSE both in terms of the immediate impact on GCSE or longer-term impacts such as the issues Ofsted (2023) highlight about preparation for further study or the potential effect on those retaking GCSE.

KS3 to KS4 transition—potential for development

The practice review has identified that schools adopt different curriculum strategies in both KS3 and KS4. However, there is no evidence of the impact of these strategies on outcomes, for example, in relation to progress against measured prior attainment in KS2. In focus group workshops, one participant highlighted that the same lack of evidence extends to more detailed choices schools make around preparation for GCSE such as revision strategies. Further research would be needed to identify which strategies schools adopt are more beneficial for outcomes.

Findings—programme engagement

Section content and summary of findings	
Influences on leaders' selection of maths programmes	The review of EEF trial reports on secondary maths reveals that initial engagement in these programmes is primarily driven by factors such as meeting a need or priority, aligning with existing developments, individual staff interest, departmental interest, access to professional development for non-specialists, previous relationship with the programme team, and recommendation from a trust, school, or subject leader. These factors also facilitate continued engagement, particularly if engagement requires release from teaching.
Barriers and facilitators to engagement and implementation	Barriers to engagement before or during programmes include difficulty in releasing teachers to engage in external professional development, challenges in achieving fidelity of attendance at CPD for secondary teachers, difficulties in using specific curriculum materials, trial compliance issues, and the prevalence of interest in generic rather than subject-specific professional development by some school and trust leaders. Barriers to scaling programmes include the importance of manualisable programmes, potential for establishing structures and processes, quality assurance of training and implementation, and replicability. Variation in practices and priorities is also a concern, with local decision-making by heads of department and departments being important for deciding on curriculum and pedagogy. Collaborative cultures are important and programmes aimed at pedagogical or curriculum change are more likely to be acceptable if they are whole-department based. For a significant minority of schools, the trust is important in deciding on curriculum and pedagogy, though to a lesser extent for pedagogy. However, some trust leads may use limited time available for subject PD to engage schools across the trust in common professional development experiences or focus, which presents an opportunity for scaling innovations but may be a potential barrier to recruitment to trials if the focus does not align with trust generic or subject PD priorities. Programmes or PD premised on use of specific curriculum materials may be less appealing than those focused on pedagogical principles or technical professional development.

This section is focused principally on (1) considering insights from EEF trial reports reviewed and (2) input from workshop participants and insights from the NCETM and MEI. The NCETM secondary and professional development team compiled a summary of barriers and facilitators to engagement, and this is included in this section.

Selection of programmes

From reviewing reports of EEF trials specifically focused on secondary maths (Boyle et al., 2021; Culliney et al., 2022; Harland et al., 2019; Pampaka et al., 2022), the following reasons for initial engagement in one or more of these programmes was identified:

- meets a need or priority;
- aligned with existing developments;
- individual staff interest or champion to be involved;
- departmental interest;
- a means to access professional development for non-specialists;
- previous relationship with the programme team or the programme team's reputation; and
- a trust, school, or subject leader recommends or asks staff to engage.

These factors also facilitate continued engagement, with senior leader support also being key, particularly if engagement in professional development requires release from teaching. These factors appear to be similar to engagement in EEF trials generally (Demack et al., 2021).

Beyond EEF programmes, insights from the NCETM secondary and professional development teams point to additional factors that influence school leaders' decision making (Table 21).

Table 21: Influences on selection of programmes identified by the NCETM

Professional development	Exam boards, Ofsted, cost, beliefs of SLT, what is available locally, MAT philosophy. Distance to travel, online versus face to face. What the MAT offers.
Curriculum and teaching	What the MAT's scheme of work is. Exam boards, supports use of the 'bought scheme of work'. Does the programme curriculum match the schools' needs?
Interventions and focused support	Exam boards, cost, evidence of outcomes/impact, KS2 results, SEND profile, how many TAs/HLTAs the school has.

Below, we summarise barriers to engagement before or during programmes drawing on sources from across the review.

Table 22: Barriers to engagement in EEF programmes

Issue	Details
Participating in professional development	Release of teachers to engage in external PD is increasingly challenging. Survey and workshop findings reflect indications from other sources that there are barriers to subject-specific PD because of the priority given to generic PD by schools and trusts. Releasing teachers (and so challenges of achieving fidelity of attendance at CPD for secondary teachers).
Using specific curriculum materials	Challenges of being able to use new or different curriculum materials at individual class level.
Trial compliance	Lots of pupil movement between classes (and teacher churn/change) mitigating against programmes that last for more than a year; tension then with practicality of length of PD that is likely to make a difference, and feasibility in a single year.

In general, subject professional development faces barriers to engagement given 40% to 45% of survey respondents' PD priorities were generic rather than subject-specific. There are some respondents who identified all or nearly all generic foci for professional development.

Barriers to engagement identified from trial reports, combined with participants' views on professional development in the practice review activities, suggest that department- rather than teacher-level programmes may have more take-up.

Barriers and facilitators to engagement in professional development programmes and innovations

To support the review, the NCETM secondary and professional development teams undertook a review of barriers and facilitators to engagement. Their summary is reproduced in Table 23.

Table 23: NCETM view on barriers and facilitators to engagement in PD and other programmes

	Barriers	**Facilitators**
School level (e.g., primary) or department (e.g., secondary)	Lack of time. Lack of money. Competition overshadows collaboration. Does it make trust leads feel uncomfortable that they require external help?	Other schools in the trust involved. Evidence that the programme will improve GCSE grades. Ofsted mentioning that it's a priority.
Teachers	Lack of time. Lack of money. Perceived benefit. Teacher turnover. 'Structure of department': lots of non-specialists.	Meet identified need from development plan. Evidence that the programme will improve GCSE grades. Ofsted mentioning that it's a priority.
Teaching assistants	Lack of time. Lack of money. Frequency of school to implement 'new ideas'. Schools are reluctant to allow teachers out of school, even if there is cover—they want them in front of their classes. Shortage of teachers.	Meet identified need from performance management. Teaching a different Key Stage to normal, teaching a new syllabus for the first time.
Pupils	Lack of time. Lack of money. Lack of confidence in own mathematical prowess.	Working alongside teacher. PD opportunities within schools. Confidence in specialist knowledge.
School or department	Will the programme mean that pupils have non-specialists or supply?	Question-level analysis highlights a particular area of the curriculum that pupils struggled with in GCSE examinations. Pupil voice, and low retention of pupils to post-16 courses.

As well as these generic barriers to engagement, potentially impactful practices may have specific barriers and facilitators to engagement. A summary of these is provided in Table 24. This is informed by input from the NCETM, desk review, and focus group workshops.

Table 24: Barriers and facilitators to engagement in specific areas with impact potential

Practice area	**Barriers**	**Facilitators**
Using digital technology including calculators	Marginalised in the curriculum and exams. Money and time needed for investment. School-level barriers for access. PD need versus likely benefits.	Promotion by bodies with influence. Investment and resourcing. Teacher champions. Demonstrable benefits.
Representations, manipulatives, and models	Seen as for low attainers. Lack of knowledge of how learning happens, scaffolding and process to abstraction, linked to seeing representations as methods rather than a means to understand. Teachers may overuse some representations they are familiar with.	Teacher knowledge and familiarity. Department-level resourcing. Department-level collaborative practice to support curriculum coherence. Proven impact for example showing less time is needed for repeat teaching if connections and conceptual understanding are made. Teacher champions.

	Investment of time needed to develop proficiency.	
Problem solving	Not well understood. Multiple definitions. Relies on teacher knowledge, harder for non-specialists or early career teachers. Perception of behavioural challenges and lack of confidence to manage different ways of learning. Link to examinations not transparent.	A coherent curriculum across KS3 and KS4 rather than a focus on problem solving for GCSE. Accessing professional development and curriculum resources. Teacher champions.
Mathematical talk and communication	Varied set of practices. Distinguishing from usual practice; may require subtle distinctions. Level of teacher knowledge and skill to orchestrate rich mathematical talk.	Whole-school language and oracy policies. The use of structures such as sentence stems to scaffold learner (and teacher) activity. Explicit teaching of mathematical communication practices. Access to professional development and curriculum resources that support improving mathematical talk and communication.

Notably, across the different forms of practice the importance of individual teachers or department leaders championing innovation is a common theme.

Barriers to scaling

In awarding grants, the EEF considers the possibility of scaling programmes. Some issues previously identified in relation to EEF programmes are the importance of:

- manualisable programmes or the potential for clear choice guidance (school or teacher choices) (Straw and Boylan, 2023);
- potential to establish structures and processes to ensure quality assurance of training and implementation and access to in-depth expertise on the intervention and how it should be implemented (Maxwell et al., 2021); and
- replicability—for example the potential for high quality reproducible CPD that can lead to ‘train the trainers’ (Maxwell et al., 2021).

Variation in practices and priorities

In the survey, participants were asked about who makes decisions about curriculum and separately about pedagogy (see Appendix 2: Tables 32–34). The question was intended to give insight into where decisions were made that might influence recruitment to programmes and, related to this, the agency of different actors to engage in innovation.

Survey data suggests that local decision-making by heads of department and departments are important for deciding on curriculum and pedagogy. Collaborative cultures are important and from workshop data, programmes that are aimed at pedagogical or curriculum change are more likely to be acceptable if they are whole-department rather than change of individual teacher practice.

For a significant minority of schools, the trust is important in deciding on curriculum and pedagogy—though to a lesser extent for pedagogy. Even where this is not the case, and there is more local autonomy, some trust leads want to use the limited time available for subject PD to engage schools across the trust in common professional development experiences or focus. This presents an opportunity for scaling innovations across trusts but is a potential barrier to recruitment to trials if the focus of the programme does not align with the generic or subject CPD priorities of the trust. Programmes or PD premised on the use of specific curriculum material— curriculum professional development (Boylan

and Demack, 2018)—may be less appealing than programmes or PD focused on pedagogical principles or more tightly focused technical professional development. In considering potential variation in engagement, data from quintile analysis in relation to existing current practice may also be potentially relevant for some programmes.

Conclusion

Summary of findings

Teacher skills and expertise

1a. Challenges in supporting pedagogical knowledge and skills with a focus on non-specialist teachers

Maths teachers in England face challenges in subject knowledge and pedagogical skills due to a recruitment and retention crisis. Many schools deploy highly qualified teachers to high-stakes classes, leaving younger pupils and low attainers without specialist teachers. To mitigate these issues, leaders provide less-experienced maths teams with plans and resources developed by others. Subject-specific professional development is crucial for raising the quality of teaching but lacks national guidance on the balance of subject-specific professional development as distinct from generic professional development.

1b. Availability and use of professional development

The National Centre of Excellence for Teaching Maths and the Maths Hubs that it coordinates play an important role in supporting subject knowledge and sharing expertise across schools. Department-led professional development in schools with historically stronger provision supports teachers' understanding of effective teaching of specific parts of the maths curriculum.

Senior leaders in schools and trusts often prioritise generic learning over other priorities, leading to widespread dissatisfaction among teachers, including dissatisfaction about the place of maths in early career development. A variety of maths teacher PD is available but there are notable absences, such as the use of subject-specific coaching models and a lack of PD focused on metacognition in the context of maths.

1c. Priorities for subject and subject pedagogical knowledge development, particularly to support disadvantaged pupils

The practice review survey revealed that maths specialist teachers and subject leads are respondents' highest priority for professional development. The survey also identified three priorities for professional development. The highest priority was problem-solving, while the use of representations was the highest priority for teaching lower attaining students likely to enter GCSE. There is a lack of appetite for professional development focused on classroom use of technology. The survey and workshops identified that collaborative forms of professional development with departmental collaboration are priorities. This suggests that whole-department models for professional development may be more implementable than those focused on individual teachers.

Targeted interventions and support

2a. Pupils' needs and provision of further support and selection of programmes

This review considered interventions in schools aimed at ensuring students achieve their potential in maths. Interventions can be used for cohorts, such as grouping students based on their prior attainment, or individual, such as individual or small group tutoring and peer tutoring. Survey respondents view high quality teaching as the main cohort-level intervention for students in KS3 and KS4, countering the 'falling behind' culture in schools.

2b. Programmes used to support intervention, including tutoring

Individual tutoring and peer tutoring have been shown to have a positive impact on students' learning. However, the type and focus of these interventions are important. The National Tutoring Programme has been an important part of the government's Covid-19 recovery response, offering targeted tuition support to disadvantaged students. Other interventions, such as Connecting Maths Concepts, have shown preliminary evidence of positive outcomes for low prior attaining students in KS3. However, low-level behaviour issues and lack of differentiation to meet students' varying needs remain concerns.

Interventions can be used outside of school, such as homework and online platforms for practice and consolidation of learning. However, these result in a blurring of the distinction between interventions targeting specific groups of students and those intended for all students and, therefore, on how these are viewed and included in schools' practice. Some online platforms target diagnostic assessment and feedback while others provide individual and small group interventions. Survey respondents indicate that intervention priorities at KS3 are focused on lower attaining students, possibly to address transition gaps.

2c. Challenges to access for disadvantaged pupils

Decision-making processes about targeted support are generally made at school leadership level, with some schools offering 'study support' related to exam preparation. There are challenges for pupils in benefiting from interventions that rely on high fidelity to the intervention developer's principles.

Teachers require support to teach certain topics differently as the same outcomes may not be effective for all students. Poor attendance has worsened in some schools since the Covid-19 pandemic. Evidence of effectiveness for some interventions is at risk of becoming outdated, and schools will need to adapt their interventions to address specific student groups.

Impactful practices[17]

3a. Topics and skills teachers find it challenging to teach

Addressing more challenging topics associated with greater opportunity to learn during Key Stage three appears challenging in some schools. There is some evidence of difference between schools related to their overall levels of attainment outcomes. Teaching low attaining pupils at the start of Key Stage 3 to bridge methods from primary schools is an area of concern for some.

3b. Topic and skill priorities to address to impact learning, particularly for disadvantaged pupils

The survey indicates that teachers prioritise promoting mathematical thinking and communication, improving explanations, offering a choice of examples, embedding problem solving, and using models, manipulatives, and representations in teaching. Representations are viewed as more relevant for low attainers. A lower interest in digital technology is evident, possibly due to the current secondary curriculum guidance not addressing the use of digital technology in teaching maths and data analysis using technology. Problem solving is a core aspect of maths and has been a focus since the introduction of the National Curriculum and the 'using and applying' strands. Teachers are more likely to integrate problem solving into all or most topics and teach specific problem-solving techniques, rather than using extended problem-solving tasks or dedicating whole lessons to problem solving.

The quality of mathematical talk and communication is crucial for engaging students in maths. Improving this aspect is central to various programmes and approaches to teaching and learning. Survey participants indicated the importance of different ways of promoting mathematical talk, including explicit teaching of vocabulary and sentence stems, providing opportunities for students to make conjectures about mathematical ideas, keeping students' talk in whole-class discussions on-topic, encouraging whole-class discussions, and asking pairs of students to discuss and agree on joint answers. These findings suggest that programmes focused solely on this area may not generate additional improvements in outcomes greater than already being achieved by existing practices.

Representations, models, and manipulatives are recommended in the EEF KS2 and KS3 guidance. There appears to be greater use of—and interest in using—representations and manipulatives than previously. This may reflect the

[17] See earlier notes about limitations in the use of the term 'impactful practices' (page11).

widespread use of bar modelling being widely promoted through various curriculum and professional development initiatives and within the mastery approach.

In general, all models and representations used in the survey were more with low attaining pupils than high attaining pupils except for equations and functions represented by graphing tools. The exception of the use of graphing tools is likely related to the content of the KS3 curriculum and how it differs in many schools for high and low attainers. Innovations in the use of representations, models, and manipulatives would need to consider how they would be sufficiently different from usual practices.

3c. Consolidation practices that are prevalent, including the use of homework

Over the past decade in England, there has been a growing interest in cognitive and neuroscience evidence in relation to teaching. This has informed practices such as retrieval practice, spaced practice, and interleaving, which allow students to rehearse prior learning until they become fluent or automatic. Homework processes and practices also play a role in consolidating learning. Research has shown a positive association between the amount of time spent on homework and attainment in both primary and secondary phases. However, there is limited evidence about how teachers in England provide opportunities for students to practise maths. A survey revealed that over half of respondents used homework to consolidate learning, with a third pointing to other uses of homework. A large proportion of teachers also use interleaving and interweaving, including time for retrieval practice and extended periods for practising techniques. Quality practice includes exercises involving applying skills in different situations, which appears less common.

The review survey of teachers in England found that 59% of respondents used department- or teacher-generated exercises and 51% used maths-specific software platforms weekly. However, there is limited evidence on different approaches to practising maths in secondary schools, including how these practices are operationalized in classrooms. Students' experience of practising maths can be limited to facts and procedures with few opportunities to practice other mathematical skills. Homework is often used to consolidate learning but it is unclear how effective it is and may present challenges of equity for students from disadvantaged backgrounds. Interventions that involve different forms of homework to support disadvantaged students to consolidate their learning may be worthy of further exploration.

3d. Key Stage 2 to Key Stage 3 transition

Maths transition practices from KS2 to KS3 are crucial for education, with evidence of falling or plateauing in attainment following the transition from primary to secondary school. The 'Years 5 to 8 continuity project' from the National Centre for Excellence in the Teaching of Maths aims to strengthen this transition through cross-phase teacher collaboration. In consequence, over 90% of teachers reported changing aspects of their professional practice and 61% agreed that their department had changed the approach to transition.

Studies have identified three factors that affect students' experiences of maths transition: student self-regulation, school and academic practices, and a student's social, home, and family environment. These factors contribute to shaping students' experiences of transition.

The NCETM Year 5 to Year 8 continuity groups develop local initiatives that are varied in focus, with potential for future evaluation to identify promising innovations. However, programmes focused on the KS2 to KS3 transition may be hard to recruit to and activity that has worked in specific contexts may not be replicable with fidelity to others. KS2 to KS3 transition is important, and schools use a wide variety of practices.

3e. Key Stage 3 to Key Stage 4 transition

The relationship between the KS3 and KS4 curricula is crucial for pupil progression and outcomes. However, research on this relationship is limited due to the varying practices of schools. OECD analysis shows that disadvantaged students have less opportunity to learn challenging curriculum content, leading to lower outcomes. In the U.K., students' socio-economic profile is less strongly related to access to opportunities to learn maths than across OECD countries in general. However, simply increasing content covered in KS3 may be counterproductive as it may lead to low attaining students being rushed through the study of new content without securely learning what they are studying. Focus group participants reported aiming to ensure the transition to KS4 should be smooth and coherent, with KS3 providing

appropriate preparation for GCSE in general and the choice of curriculum content strategies adopted for Foundation and Higher GCSE groups.

In the survey we sought to determine if linear equations, simultaneous equations, quadratic equations, and trigonometry were introduced to high and low attainers by the end of Year 9. The results showed that there were differences in KS3 curriculum content strategies by schools, with some evidence of more variability between high and low attaining schools. The study also found that schools may make different decisions about curriculum content.

- Lower quintile schools are more likely to be selective about the curriculum content taught than higher quintile schools; however, there are schools with both lower and higher quintile attainment that adopt similar strategies.
- The strategies schools adopt vary across Foundation and Higher tiers but not in uniform ways.

This highlights the importance of understanding more about the relationship between variables and content inclusion in the KS3 curriculum in future research.

Surveying GCSE curriculum content strategies revealed that half of respondents aimed to teach all relevant content while half adopted different strategies based on grade 4 or 5 targets or individual pupils' grades. The data was analysed based on attainment quintiles and FSM status (Ever 6 FSM). Lower quintile schools were more selective about curriculum content and strategies varied across Foundation and Higher tiers, however, there is a lack of evidence about the different strategies schools adopt in terms of the immediate impact on GCSEs or longer term impacts such as preparation for further study or retaking GCSEs.

Programme engagement

4a. Influences on leaders' selection of maths programmes

The review of EEF trial reports on secondary maths reveals that initial engagement in these programmes is primarily driven by factors such as meeting a need or priority, aligning with existing developments, individual staff interest, departmental interest, access to professional development for non-specialists, previous relationship with the programme team, and recommendation from a trust, school, or subject leader. These factors also facilitate continued engagement, particularly if engagement requires release from teaching.

4b. Barriers and facilitators to engagement and implementation

Barriers to engagement before or during programmes include difficulty in releasing teachers to engage in external professional development, challenges in achieving fidelity of attendance at CPD for secondary teachers, difficulties in using specific curriculum materials, and trial compliance issues. In general, subject professional development faces barriers to engagement including the prevalence of interest in generic rather than subject-specific professional development.

Barriers to scaling programmes include the importance of manualisable programmes, potential for establishing structures and processes, quality assurance of training and implementation, and replicability. Variation in practices and priorities is also a concern, with local decision-making by heads of department and departments being important for deciding on curriculum and pedagogy. Collaborative cultures are important and programmes aimed at pedagogical or curriculum change are more likely to be acceptable if they are whole-department based.

For a significant minority of schools, the trust is important in deciding on curriculum and pedagogy, though to a lesser extent for pedagogy. However, some trust leads may use limited time available for subject PD to engage schools across the trust in common professional development experiences or focus, which presents an opportunity for scaling innovations but may be a potential barrier to recruitment to trials if the focus does not align with trust's generic or subject CPD priorities. Programmes or PD premised on the use of specific curriculum materials may be less appealing than those focused on pedagogical principles or technical professional development.

Limitations

As noted in the introduction to the report, as a scoping study, the methods were limited due to:

- the short timescale for the review leading to identification of limited sources for desk review;
- sample bias in the survey; and
- the need to balance data collection across a large number of themes and issues against minimising participants time so as to encourage engagement restricting the length of the survey and of the workshops.

There are some themes for which there was limited data available on current practice from previous research or where data collection in this review was limited. In addition, as noted, the inclusion of the practices in this review does not mean that they are necessarily impactful.

Implications

EEF commissioning

The main aim of the practice review was to inform EEF commissioning. We consider implications for commissioning of EEF programmes for (1) efficacy or effectiveness trials, (2) future possible programme development, and (3) other potential EEF activity.

1. EEF efficacy and effectiveness trials

Potential EEF-commissioned programmes may be of three types that are considered in turn.

a. Programmes involving substantial teacher professional development

In programmes involving substantial teacher professional development, the causal chain to pupil impact is longer as both the professional development and change practice need to be successful (Boylan and Demack, 2018). There is a substantial existing provision for maths teacher PD both external to schools and inside larger trusts. There are barriers to individual teachers accessing PD and then changing curriculum or pedagogy for individual classes. Programmes that involve department-wide change may be more acceptable and practicable than those requiring individual teacher release due to processes by which decisions are made in some MATs and schools. An exception to this might be support for subject-specific instructional coaching models. This may be particularly relevant for supporting non-specialist teachers.

In terms of content, there appears to be an appetite for professional development on models and representations, particularly for teaching low attainers and to support transition in Year 7 and in general on problem solving. Programmes that provide greater opportunity to learn for low attainers in Key Stage 3 may address differences between school practices, notwithstanding that there is a lack of evidence about which strategies schools adopt lead to better outcomes.

b. Programmes focused on tutoring and similar means to supporting individual pupils

There is considerable variability across schools. This means that schools are able to implement programmes of various types and so EEF-funded programmes are likely to be implementable. There are also indications from these variations that there are potential gaps in provision for some schools and more flexibility to engage.

c. Programmes using software and platforms to support consolidation of learning

This is an area of considerable change in practice and also considerable variability in platforms schools use. Building evidence in this area has potential for the future scaling of innovations.

2. EEF programme development

The practice review found differences in schools' strategies around the inclusion of more challenging topics in Key Stage 3. The EEF might consider possible early stage development programmes around specific curriculum content such as those surveyed in the review.

3. Other EEF activity

The review highlights that schools make different curriculum choices in both Key Stage 3 and Key Stage 4. There are patterns by school attainment and demographic profiles. However, schools with similar profiles make different choices. There is a lack of evidence about the impact of curriculum choices that schools make, particularly in Key Stage 4. The variation in practice does not lend itself to a trial and given that schools already implement a variety of practices, the development of programmes may be inefficient. This suggests the possibility of 'school choice' research in this area. The aim of school choices research is to produce causal evidence about the impact of different school-level approaches and policies on outcomes of interest, with particular attention to impact on pupils from socioeconomically disadvantaged backgrounds (for example, the EEF's 'What works at Key Stage 4, two or three years of study?').[18]

The scoping practice review reported here indicates the need for further research in specific areas, for example, there is widespread variation in KS2 to KS3 transition practice or in consolidation practices. These two areas would benefit from more in-depth review of practice to support guidance for schools, potentially in collaboration with external organisations supporting maths in schools such as the NCETM and MEI.

Programme developers and professional development providers

The practice review identifies areas of potential interest that schools and teachers have that might inform programme developers' future innovation and professional development providers' programmes. There were a number of absences noted in the review that could potentially be addressed such as the role of metacognitive strategies in supporting learners' access to the curriculum and subject-specific instructional coaching models.

School and trust subject leaders

The practice review highlights variation in practice on some key issues across schools and trusts. Leaders can use the practice review findings as points for reflection about their own practice. On key issues such as curriculum content in KS3 and KS4, schools vary considerably in their approaches, and this includes within attainment quintiles. Pending evidence about which approaches, if any, make a difference to pupil outcomes, the variation in practice suggests value in considering whether school or trust current practices are optimal.

[18] https://educationendowmentfoundation.org.uk/projects-and-evaluation/projects/what-works-at-key-stage-4-two-or-three-years-of-study

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Appendix 1: Methodology and methods—further detail

Focus themes and areas of interest

To inform data collection, an initial mapping was undertaken of focus themes and areas of interest. These were also informed by early review of relevant research and other outputs and dialogue with EEF. These sources were then incorporated into the desk review (described below) The descriptions and examples in Appendix 1: Tables 1–4 were used as prompts or explanations in data collection and to organise review activity.

Appendix 1: Table 1. Mathematical content and lesson activity

Theme	Description and/or examples
Using digital technology including calculators	Digital technologies include hardware, software and digital resources which can be used to facilitate and enhance the doing, learning, and teaching of mathematics in a variety of modes (face-to-face, online, hybrid or blended)19.
Use of representations	Representations and models to represent mathematics and aid learning and application, including models that are intrinsic to mathematical content – for example graphical representation of functions - and those that are additional or optional tools such as bar models, double number lines, grid models, and directed number counters; digital representations
Problem solving	Encompasses problem solving as an application of mathematics, intrinsic to mathematics and as a means of learning other mathematics (teaching maths through problem solving); distinguished from the solution of routine or word problems
Mathematical thinking and communication	Mathematical thinking about patterns, structures, relationships, connections, through logic, conjecturing and proof20 Mathematical communication includes teacher modelling of mathematical talk, enquiry and focussing questions, student to student and student to class communication; and teaching and cultivating ways of supporting this - “instruction through language and instruction of language necessary for learning mathematics”21

[19]https://royalsociety.org/-/media/policy/projects/maths-futures/educational-technology-mathematics-education.pdf?la=en-GB&hash=54C4864BEEA8E62119FF7604DBA29F29

[20] https://www.ncetm.org.uk/media/8d85bb9a51fab1a/mathematical_thinking_handout_september_2020.pdf

[21] https://link.springer.com/article/10.1007/s11858-020-01213-2

Appendix 1: Table 2. Teaching practices and issues

Themes	**Description and/or examples**
Motivation, enjoyment of maths and maths anxiety	Intrinsic motivation, promoting student agency, mathematics enrichment, addressing maths anxiety and negativity towards mathematics
Practising mathematics	Practising mathematics for consolidation and as a means to learn in class and at home; resources for practising including digital platforms
Learning how to learn maths, metacognition, and self-regulation	Generic metacognitive skills and knowledge in the context of mathematics; mathematical specific dispositions and knowledge – being mathematical
Teacher knowledge about students' difficulties in mathematics	Pedagogical and pedagogical content knowledge about students' difficulties in learning mathematics, including misconceptions, dyscalculia and causes of low attainment
Teaching low attainers and supporting disadvantaged students in the classroom	Specific practices and resources for supporting low attainers. Disadvantaged students access to the curriculum

Appendix 1: Table 3. Supporting learners and addressing three NC aims: Dept, School, or Trust practice and policy and issues

Theme	Description and/or examples
Curriculum design and assessment	For example, curriculum sequencing, on-going assessment, pupil grouping, timing of decisions about GCSE entry
Structured interventions in KS3	For example, support for pupils who arrive in Y7 working below the expected age level in maths or pupils who have fallen behind with specific skills and knowledge such as number facts or pupils who have identified SEND needs requiring additional support
Structured interventions in KS4	For example, one to one or small group support for individuals at risk of not achieving a GCSE grade; one to one or small group support for individuals at risk of not achieving a GCSE pass or extending students with potential for progression to higher mathematical study
KS2 – KS3 transition	Pedagogical and curriculum continuity particularly from Y6 to Y7 but from KS2 to KS3 in general; professional knowledge of KS2 and KS3 for secondary and primary teachers respectively; use of KS2 attainment data
KS3 – KS4 transition	The organisation of the KS3 and KS4 curricula, grouping arrangements and decisions about GCSE exam level entry, including assessment that informs this

Appendix 1: Table 4. Staffing: Dept school or Trust practice and policy and issues

Theme	Description and/or examples
Teacher and Teaching Assistant deployment and support	Allocation of teachers to classes (e.g., non-specialist teachers); use of Teaching Assistants (Tas) including mathematics specific TAs; support for non-specialists and TAs.
Coordination and leadership	Coordination of different aspects of mathematics teaching and learning: assessment, curriculum, and pedagogy; Key Stage, school, and cross school subject leadership
Subject specific professional development	Mathematics teacher professional development within department, trust, and wider networks; non-specialist teachers of mathematics support and professional development

Detailed research questions

To guide data collection and analysis detailed research questions were developed. The following questions guided review activity. In the time and resource available, some questions were not fully addressed or were included all the review activities (desk review, survey, and workshops).

1. Teacher skills and practice

Areas

1a Challenges in supporting pedagogical knowledge and skills with a focus on non-specialist teachers

1b Availability and use of PD

1c Priorities for subject and subject pedagogical knowledge

Questions

RQ 1.1 What are the prevailing content foci of mathematics teacher professional development and specifically in relation to the identified content and teaching practice themes

RQ 1.2 What forms and sources of professional development do teachers of mathematics (including non-specialists) currently engage with?

RQ1.3 What are the challenges in supporting mathematics teacher professional development and specifically non-specialist teachers of mathematics?

RQ 1.4 What are the priorities for professional development in relation to the 9 content and teaching practice areas (see Appendix 1: Table 1) and other priorities

2. Targeted interventions and support

Areas

2a Pupils' needs and provision of further support and selection of programmes

2b Programmes used to support intervention, including tutoring

2c Challenges to access for disadvantaged pupils

Questions

RQ 2 .1 Which groups of pupils are priorities for schools for additional support and what are their needs?

RQ 2.2 What do schools currently do to support pupils in addition to standard curriculum and teaching, with a specific reference to three learner policy areas:

- Curriculum design and assessment
- Structured interventions for individuals and groups in KS3
- Structured interventions for individuals and groups in KS4

RQ 2.3 How do schools engage with tutoring programmes?

RQ 2.4 What are the challenges for delivering targeted interventions and programmes and what are the challenges for pupils to access them?

RQ 2.5 What are the professional development needs for teachers and teaching assistants so that pupils would benefit from interventions and additional support?

RQ2.6 How does the opportunity to learn vary for disadvantaged and low attaining pupils?

3. Impactful practices

Areas

3a Topics and skills teachers find it challenging to teach

3b Topic and skills priorities to address to impact learning

3c Consolidation practices that are prevalent including the use of homework

3d KS2 to KS3 transition

3e KS3 to KS4 transition

Questions

RQ 3 .1 What are the relative challenges for teachers in teaching or including in their teaching:

- Using digital technology including calculators
- Use of representations

- Problem solving
- Mathematical thinking and communication?

RQ 3.2 What other topics and skills do teachers find it challenging to teach

RQ 3.3 What do teachers and leaders consider is the relative importance of the following for impacting learning

- Using digital technology including calculators
- Use of representations
- Problem solving
- Mathematical thinking and communication
- Motivation, enjoyment of maths and maths anxiety
- Practising mathematics
- Learning how to learn maths, metacognition, and self-regulation

RQ3.4 What other topics, skills and factors do teachers consider as important for impacting learning

RQ3.5 In what ways is mathematical learning consolidated in class and at home?

RQ 3.6 How is transition from KS2 to KS3 transition supported? What are the challenges to supporting transition? What additional support or changes to curriculum and assessment would be helpful to support KS2 to KS3 transition?

RQ 3.7 How is transition from KS3 to KS4 transition supported? What are the challenges to supporting transition? What additional support or changes to curriculum and assessment would be helpful to support KS3 to KS4 transition?

RQ 3.8 What important differences are there in teaching in KS3 and KS4?

4. Barriers to engagement

Areas

4a Influences on leaders selection of maths programmes

4b Barriers and facilitators to engagement and implementation

Questions

RQ 4.1 What influences leaders' selections of maths programmes in relation to:

- Professional development
- Curriculum and teaching
- Interventions and focused support

RQ 4.2 Who makes decisions about engagement in programmes and how is this made?

RQ 4.3 What are the barriers and facilitators to engagement and implementation in programmes for

- Trusts
- Schools/Department
- Teachers
- Teaching assistants

- Pupils (where relevant)

RQ 4.4 For any potentially impactful practices, what is known about implementability (feasibility, acceptance, sustainability)?

RQ 4.5 Are there any barriers and facilitators to engagement and implementation in relation to types of programmes or focus of programmes (e.g., thematic areas in Appendix 1: Table 1)?

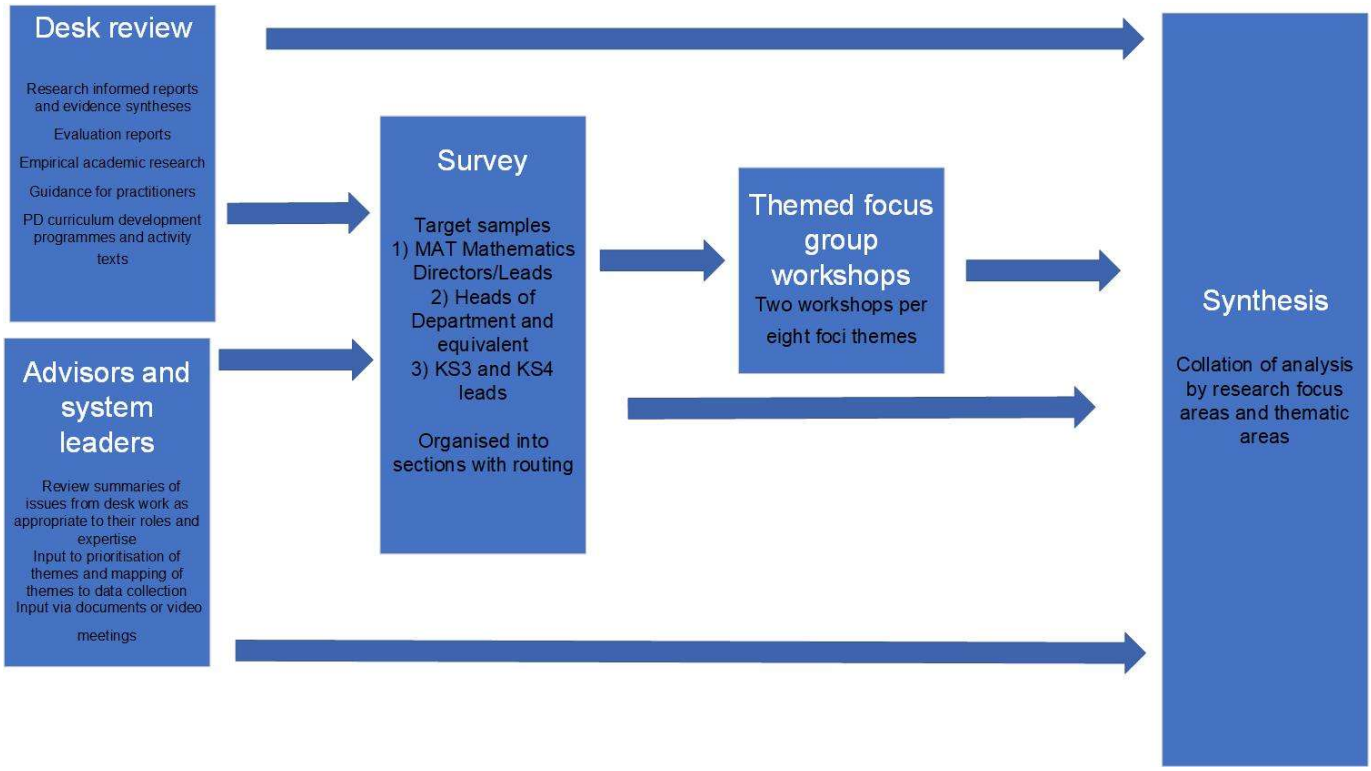
Overview of methods

The practice review methods comprised:

- Desk review of sources relevant to the practice review foci
- Survey of Heads of Departments, Key Stage Leads- and Multi-Academy Trust subject leads.
- Nine focus group workshops with Heads of Departments, MAT subject leads or had otherwise worked with multiple schools to support mathematics teacher professional development or subject improvement
- Input from a range of advisors, notably the National Centre for Excellence in Teaching Mathematics (NCETM) and Mathematics Education and Industry (MEI)

Appendix 1: Figure 1 shows an overview of the methods, The arrows linking components describe the logic of the methodology and how different activities will inform others, leading to an overall synthesis. However, given the short timescale, activity on all components were undertaken in parallel

Appendix 1: Figure 1. Overview of review methods

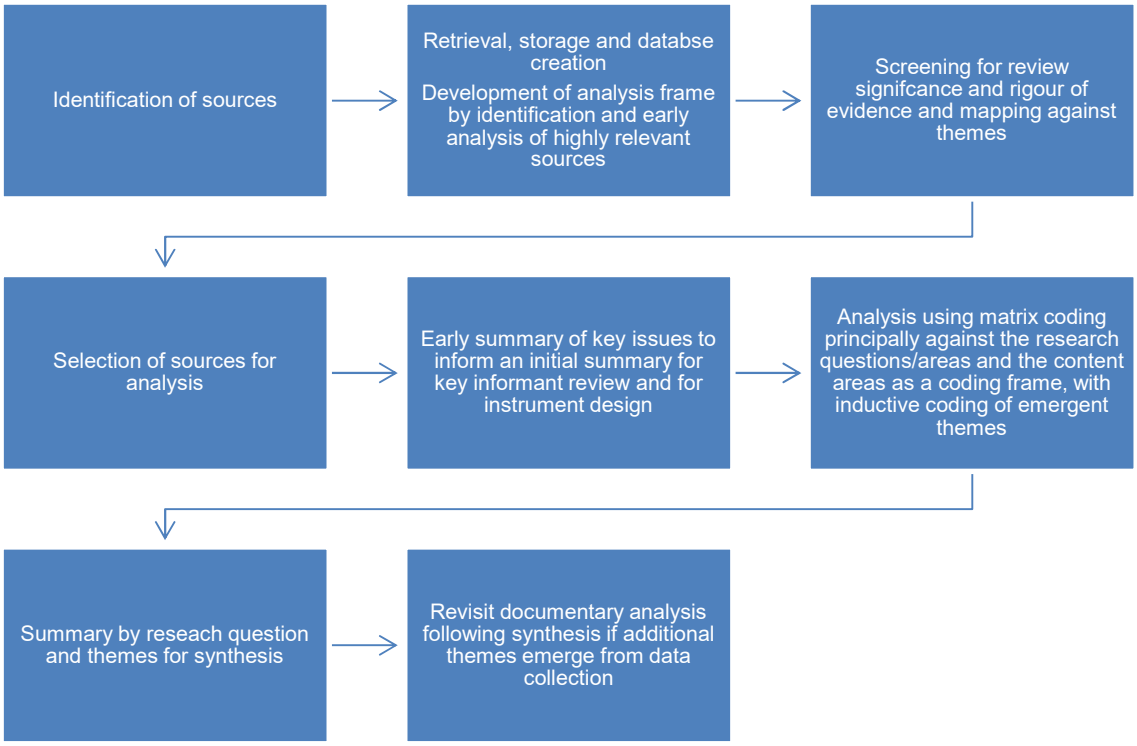


Desk review

Sources were identified through searches of peer reviewed research texts, practice reports and other 'grey literature' relevant to the themes. Necessarily, given resource and the timescale, only a small number of sources relevant to each of the themes of the practice review was identified.

Figure 2, below, provides detail on the desk research process and analysis. Although presented sequentially, sources that are very relevant will be analysed in parallel with the database development.

Appendix 1: Figure 2. Desk review process and analysis



Participants

Appendix 1: Table 5. Research participants

Research participant group	Details
System leaders	Educators with a system level overview and knowledge relevant to the review questions and with a variety of roles, including, Maths PD providers with national reach, curriculum developers, subject associations, academics
MAT Directors of Mathematics	Mathematics subject leaders in Multi-Academy Trusts with an overview across multiple secondary schools
Heads of Department and Key stage leads	School subject leads and secondary mathematics teachers. As well as seeking a national sample, we will target recruitment on the North-east Region.
KS2-KS3 transitions practitioner experts	Recruitment focused on Maths Hub led Maths Hubs facilitate Y5-Y8 continuity work groups network plus open invitation through other channels including to other initiatives e.g., the Stoke Maths Partnership.

Participants will be recruited either by emails that are sent to generic school email addresses, by circulation of invitations to participate through organisations (NCETM, MEI and EEF) or by invitations by social media. No email addresses will be sought from organisations to contact teachers directly. It is possible that school and Trust leaders or teachers may reply to recruitment emails and provide contact details of other potential participants. Such contact details will be considered as personal data and appropriate data management will be followed.

Survey

Survey design

Given the scope of the review the survey was designed to allow respondents to contribute some data. Consequently, the survey had six sections with participants having the option of selecting sections they are able or wish to complete. Four sections contained substantive questions or prompts to gather data for the review and the first and last sections collecting information on the participants and contact details. The sections are shown in Appendix 1 Table 6. The survey was delivered on the Qualtrics platform[22].

Appendix 1: Table 6. Survey design

Section	Details and areas included
About you	Demographic information and participant roles to support routing. This survey will include school name, and postcode and school unique identifier to allow for descriptive statistical analysis of difference by school characteristics.
Curriculum and support for pupils	Decisions about Y7–9 curriculum Opportunity to learn – algebra and geometry Additional support GCSE entry and content
Classroom practice	Decisions about teaching methods Aspects of classroom practice: maths communication talk; representation and models; problem solving Aspects of teaching and improving outcomes Consolidating and practising maths
Professional development	PD priorities: people PD priorities: content (open questions)
KS2 to KS3 transitions	Y7 priority aims Y7 baseline assessment KS2-KS3 transition activities
End of survey	Option to enter the draw or be contacted about the workshops Contact details

Each section was designed to be completed in 6 minute or less. The overall length was approximately-20 minutes if all sections were completed. The survey was mainly closed questions with item responses informed by desk review and system leader input.

The survey was aimed particularly at Heads of Department and Secondary Mathematics Key Stage Leads, although subject leaders of Multi-Academy Trusts will also be invited to participate as well as to snowball the survey link to subject leaders in the schools they work with.

To recruit participants, we emailed all secondary schools and middle schools deemed secondary in England using publicly available email addresses. In addition, we emailed Multi-Academy Trusts for all MATs with two or more secondary schools and asked for the email to be passed on to the Trust mathematics lead. As well as SHU promotion on social media, EEF, MEI and NCETM also promoted the survey through their networks. We used to collector links for the survey with one for Sheffield Hallam mailshots (‘survey 1’) and one for promotion by other organisations (‘survey 2’).

[22] https://www.qualtrics.com/uk/

There was an incentive for completion of the survey, with participants eligible to enter a draw if contact details are provided. Ten participants who opt to enter the draft will be eligible for a draw for a £20 voucher. The survey and recruitment information made clear to potential participants that completion gives the option of entrance to a draw rather than to automatically get a voucher.

Survey analysis

Survey data was analysed descriptively. We undertook comparative analysis of differences in responses for a selection of questions based on retrieved data of schools attainment (grade 5–9 English and Maths) and Free School Meals (Ever 6 FSM) as a proxy for socioeconomic profile of pupils. We did not undertake significance testing as this is inappropriate for a non-random sample and in any case with a large number of statistics can lead to falsely identifying significance due to chance (Gorard, 2016).

Survey responses and profile

Return rate

In total 335 useable responses were achieved, with 105 of these being from the “survey 1” link and 230 responses from the “survey 2 link”

Matching to DfE records

In total there were 12 educational establishments that we were unable to match to DfE held records. All but one of these schools replied from the “survey 2” link. The reasons we were unable to match included the education establishment was based abroad, the respondent indicated that they were involved with several schools, the establishment was a home tuition service/outreach education.

The DfE held variables brought into the dataset for analysis were “*percentage of pupils achieving 9–5 passes in GCSE English and maths in 2022*” and “*percentage of pupils eligible for FSM at any time during the past 6 years*”. It should be noted that not all establishments had records for these variables, for example because they were a sixth form college, or a free school. We were able to match attainment data for 309 cases, and FSM data for 303 cases.

Comparing the achieved sample to the population in terms of these variables, reveals that the schools in the achieved sample have a mean attainment score of 56.7% compared to the population average of 50.0%. Thus, higher attaining schools were slightly overrepresented in the sample.

In terms of FSM, the schools in the achieved sample have a mean value of 23.6% compared a population average of 27.6%. Thus, the schools in the sample have slightly lower proportions of pupils eligible for FSM which should be considered when interpreting findings from the survey data.

Variation in responses

Because respondents could choose which sections to respond to or may have not responded to a specific item, the number of respondents varied for individual sections, questions, or items within questions.

About the survey participants

Current secondary teaching

Survey participants were asked which Key Stage (KS) they were currently teaching mathematics weekly in a secondary, middle school, or another type of school. Data is reported in Appendix 2: Table 7.

Appendix 1: Table 7. Key stages taught by survey participants

	%

KS3 and KS4	42
KS3, KS4 and KS5	40
KS4 and KS5	6
KS4 only	6
KS5 only	2
KS3 only	2
KS3 and KS5	1
Total n	331

Appendix 1: Table 8. Summary of Key Stages taught

		Total n
KS3	84%	335
KS4	94%	335
Other	51%	335

Note - nearly all others are "KS5"; most respondents teach either both KS3 and KS4, or KS3, 4 and 5.

Table 9 below provides data in response to a question whether the respondent was a Head of Department or Key Stage leader. Note that of those answering ‘no’ most had responsibilities across MATs for mathematics

Appendix 1: Table 9. Role in the school

	%
Yes	79
No	21
Total n	335

Appendix 1: Table 10. Regional profile of survey respondents

	n	**%**
Northeast	20	6
Northwest	39	12
North Yorkshire and The Humber	15	5
South and West Yorkshire	21	7
East Midlands	32	10
West Midlands	23	7

East of England	44	14
London	45	14
Southeast	51	16
Southwest	32	10
Total	322	100
Missing	13	
	335	

Appendix 1: Table 11. Quintile analysis of survey respondents

% of pupils achieving 9–5 passes in GCSE English and maths in 2022		
N	Valid	309
	Missing	26
Minimum		0.00
Maximum		1.00
Percentiles	20	0.3800
	40	0.4800
	60	0.5900
	80	0.7200

Appendix 1: Table 12

Percentage of pupils eligible for FSM at any time during the pas		
N	Valid	303
	Missing	32
Minimum		0.00
Maximum		0.75
Percentiles	20	0.1252
	40	0.1850
	60	0.2437
	80	0.3357

Test for bias between survey 1 and survey 2

We undertook a number of comparisons between the two survey collectors – ‘survey 1’ and ‘survey 2’ to see if there were indicators of bias. As noted above, the recruitment strategy for the two collectors was different with survey 1 recruited mainly by direct email to schools and MATs. Appendix 2 Tables 13 and 14 report these analyses for a selection of survey items. Although as might be expected there are small differences in frequency of responses, the survey data is broadly similar indicating that there is not a specific sample bias to the means of recruitment. This is notwithstanding a general limitation of bias in relation to willingness and interest to engage with the practice review survey.

Workshops

Themed focus group workshops were used with the aim of generating rich data on key issues. Participants were recruited from expressions of interest gathered from the survey and directly from social media. We offered a £20 shopping voucher for participation in a workshop to each participant.

Appendix 1: Table 13. Workshop participants and foci

Themes	Number of workshops/interviews	Number of participants
Professional development needs (specialist) and non-specialist) Hard to teach topics Topics that are priorities for student outcomes	1	7
Interventions and supporting students at KS3 KS3 to KS4 transitions and GCSE assessment grouping strategies Supporting students at KS4	1	2
Motivating students Learning how to learn mathematics Practise in mathematics, including homework	1	4
KS2 – KS3 Transition	2	2
Triangulation of system priorities (i.e., share key findings for checking and addition) Engagement with programmes and intervention priorities	4	14

Prior to the workshop or interview, participants were sent a short slide pack focused on the workshop focus issues, based on desk work and, where available and appropriate early findings from the survey.

Analysis of workshop data will be mainly deductive using codes derived from the desk review of likely key issues embedded in the slide pack workshop material. Important emergent codes will also be used if needed.

Ethics and data protection [section draft completed]

The study was reviewed and approved as ‘EEF Secondary Maths Practice Review ER60752993 on 20/11/2023.Our University ethics and integrity processes include Integrity and Researcher Concordats and an Ethics Committee which oversees, and quality assures ethics review, including ensuring consent is obtained appropriately. Institutional policies and practices require researchers to undertake additional Equality, Diversity, and Inclusion training to ensure legally appropriate and socially just practice is followed.

All research was undertaken in compliance with the Data Protection Act 2018 (DPA) and General Data Protection Regulation (GDPR). As a data controller, we have Cyber Essential certification and registered with the Information Commissioner’s Office. The legal basis for data handling was ‘public task’

Using GDPR-compliant privacy notices, we aimed to be clear and open with participants about: who we are; how and why their data is being used; and whether any data will be shared with other organisations/individuals, as well as the value of participating in the study.

Timeline

- Include a timeline of activities related to the evaluation and intervention delivery including recruitment period, data collection and delivery schedule.

Appendix 1: Figure 3. Timeline

Date	Activity
October 2023	Inception
November 2023	Desk review and instrument design
December 2023	Desk review; survey data collection and workshops
January 2024	Survey data collection and workshops
February 2024	Survey and workshop analysis and reporting

Appendix 2: Survey data tables

This appendix contains data tables derived from the participant survey. The data is presented broadly aligned with the content of the sections in the main report. For detail of the survey structure and sequencing see Appendix 1.

Professional development

Professional development priorities: potential recipients

Participants were given a list of potential recipients of professional development and asked “Which of these are the priority for professional development related to mathematics in your school. Please click and drag into order of importance most important first”. A mean was calculated from the ranking scores to support comparison across items. Responses are provided in Appendix 2: Table 1.

Appendix 2: Table 1. Professional development priorities: potential recipients

	1	2	3	4	5	Mean	Total n
Mathematics specialist teachers	63%	25%	9%	2%	1%	1.53	240
Heads of departments and other mathematics leaders in schools	16%	37%	26%	18%	4%	2.56	240
Non-specialist teachers trained in other subjects	15%	15%	25%	26%	20%	3.20	240
Teaching assistants	3%	17%	31%	33%	17%	3.43	240
Subject leaders supporting teachers in multiple schools	3%	7%	10%	22%	59%	4.29	240

Professional development priorities: content

Participants were asked to identify three general priorities for professional development (PD). Responses were recorded as open comments. They were also asked to identify three priorities for professional development for teaching lower attaining students. As elsewhere in the survey, lower attaining students was explained as those who were likely to enter Foundation GCSE.

Responses were then coded (procedures are described in Appendix 1).

Priorities for professional development for teaching mathematics: generic and subject

Priorities were coded as either generic or subject specific. Subject specific were priorities related specifically to mathematics. Examples included problem solving, representations, mathematics examinations. Generic priorities were those where the mathematics specific content was not identified. Examples included behaviour and SEND. However, some of those classified as ‘generic’ may have involved subject related activity when enacted. For example, 11% of the priorities identified were coded as ‘professional development nonspecific’. This was used for types of professional development activity in which the context was not specified, for example, ‘the department working together’. Appendix 2 Table 2 reports the analysis for the question relating to general priorities and Appendix 2 Table 3 priorities for professional development for teaching low attaining students.

Appendix 2: Table 2. Priorities for general professional development: generic and subject

	1	2	3	Total	Percentage
Generic	76	86	80	242	48%
Subject	115	95	56	266	52%
			Total	508	

Appendix 2: Table 3. Priorities for professional development priorities for teaching mathematics to low attaining pupils: generic and subject

	1	2	3	Total	Percentage
Generic	68	80	60	208	47%
Subject	102	73	57	232	53%
			Total	440	

Professional development priorities: areas

Participants' responses were further coded into broad themes. Responses to the prompt for general PD priorities is given in Appendix 2 Table 4, and responses for PD priorities for teaching low attaining pupils in Appendix 2 Table 5.

Appendix 2: Table 4. PD priorities: areas

	#1	#2	#3	Total	Percentage
Assessment	11	13	10	34	7%
Behaviour	0	2	6	8	2%
Curriculum	15	14	9	38	8%
Examination	15	12	8	35	7%
Metacognition, attitudes, affect	1	5	1	7	1%
Pedagogy	101	95	66	262	52%
Professional development (nonspecific)	30	13	12	55	11%
SEND	2	1	3	6	1%
Meeting learners needs	11	18	14	43	9%
Technology	2	6	5	13	3%
			Total	501	

Appendix 2: Table 5. PD Priorities for teaching low attainers

	#1	#2	#3	Total	Percentage
Assessment	5	4	8	17	3%
Behaviour	2	2	3	7	1%
Curriculum	14	8	9	31	6%
Examination	1	1	8	10	2%
Metacognition, attitudes, affect	9	13	4	26	5%
Pedagogy	107	97	67	271	54%
Professional development (nonspecific)	6	5	4	15	3%
SEND	4	3	5	12	2%
Meeting learners needs	20	18	5	43	9%
Technology	0	2	2	4	1%
			Total	436	

Specific professional development priorities

Responses were further coded to consider more specific content priorities for professional development. Data was analysed to identify the percentage of respondents that identified this priority in at least one of their three choices in each of the two questions. Appendix 2 Table 6 reports this data.

Appendix 2: Table 6. Specific professional priorities: percentage of respondents that identified this as a priority in one of their responses

	General (%)	Low attainers (%)
Assessment Afl	14%	9%
Assessment other	3%	1%
Behaviour for learning	4%	4%
Behaviour other	1%	0%
Curriculum Specific subject area	3%	1%
Curriculum other	15%	12%
Exam A level	8%	0%
Exam Core Maths	1%	0%
Exam GCSE	3%	2%
Examination other	4%	13%
Metacognition and affect other	4%	13%
Pedagogy Representations	20%	44%
Pedagogy Problem solving	27%	18%
Pedagogy Practise	12%	21%
Pedagogy Teaching techniques	30%	30%
Pedagogy Mastery	14%	9%
Pedagogy Communication	15%	17%
Pedagogy other	17%	13%
Professional development nonspecific	25%	9%
SEND	3%	7%
Meeting learners needs Specific groups of learners	5%	7%
Meeting learners needs Attainment range	10%	13%
Meeting learners needs other	4%	5%
Technology	7%	3%
Other	1%	1%

Number of respondents: General priorities n=183, Low attainer priorities n=163.

Nonspecific professional development

A total of 70 responses were coded as nonspecific professional development. These were further categorised, and this is shown in Appendix 2 Table 7.

Appendix 2: Table 7. Categories of nonspecific professional development

	Frequency	Percentage

Subject Knowledge	24	34%
Collaboration	15	21%
Specific groups of specialists	7	10%
Subject specific general	4	6%
Non-specialist	4	6%
External provider	3	4%
Pedagogy	2	3%
Teaching assistants	6	9%
Other	5	7%
Total	70	100%

Targeted interventions and support

Organisation of additional support

Participants were asked about additional support for students outside of usual mathematics lessons that is focused on mathematics curriculum content.

Appendix 2: Table 8. Organisation of additional support

	Teacher	Teaching assistant	Tutor	Other (e.g. mentor)	Does not happen	Not sure	Total n
Individual	30.8%	18.9%	14.0%	11.9%	21.3%	3.1%	286
Small group	40.1%	16.3%	15.9%	12.8%	12.8%	2.1%	289
Class or larger (e.g. revision classes)	84.0%	1.0%	1.0%	2.8%	9.1%	2.1%	287

Students who receive additional support

Participants were asked which students in their schools receive this additional support by KS2 and by High and Low attainers. As with other questions low attainers were considered as students who might be entered for Foundation GCSE and high attainers as students who were likely be entered for Higher GCSE.

Appendix 2: Table 9. Students who receive additional support

	High and low attainers	High attainers only	Low attainers only	Neither	Not sure	Total
KS3	33	3	43	15	5	265
KS4	73	4	18	3	2	269

Use of external organisations

Participants were asked if students benefit from additional support from any external programme or organisation, and data is reported in Appendix 2, Table 10.

Appendix 2: Table 10. Schools that use external programmes or organisations to provide additional support

	%
Yes	24%
No	76%
Total n	287

Supporting students eligible for Pupil Premium

The following are additional ways in which some schools supporting students who are eligible for Pupil Premium in mathematics.

Appendix 2: Table 11. Supporting pupils eligible for Pupil Premium

	%	Total n
Identified to teachers as being Pupil Premium eligible	88%	74
Provided with free or subsidised equipment or other materials such as revision guides	84%	74
Targeted interventions (e.g. in small groups)	72%	74
Tutoring	57%	74
In-classroom support by Teaching Assistants	41%	74
Other (Please provide detail)	14%	74

Practice priorities

Aspects of teaching and improving outcomes

Participants were asked to rank, by clicking and dragging five aspects of teaching maths that may help to improve outcomes. A mean rank was calculated for each item.

Appendix 2: Table 12. Aspects of teaching and improving outcomes

	1	2	3	4	5	Mean	Total n
Promoting mathematical thinking and communication	25%	29%	28%	12%	5%	2.43	266
Improving explanations, choice of examples and techniques to promote understanding	29%	27%	17%	15%	13%	2.56	266
Embedding problem solving	18%	19%	26%	27%	10%	2.91	266
Using models, manipulatives, and representations in teaching	23%	17%	17%	22%	22%	3.03	266
Using digital technology including calculators	5%	8%	13%	24%	50%	4.07	266

Mathematical talk

Participants were asked about current practices used that might be impactful and asked for agreement with statements whether these practices happened in their teaching:

Appendix 2: Table 13. Mathematical talk in teachers' practice

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Mean	Total n
I explicitly teach vocabulary and/or sentence stems	2%	6%	9%	36%	47%	4.21	280
I provide opportunities for students to make conjectures about mathematical ideas	2%	5%	7%	49%	37%	4.15	278
I keep students' talk in whole class discussion on topic to make sure key teaching points are made	3%	6%	8%	41%	42%	4.14	271
I ask students to think alone and then tell a partner their answer	3%	10%	6%	45%	36%	4.01	281
I encourage whole class discussions where students question each other and explain their thinking	6%	18%	12%	35%	29%	3.81	280
I ask pairs of students to discuss and agree a joint answer to a question	6%	10%	10%	45%	29%	3.65	279
Students come to the board or visualizer and explain their thinking to the whole class	9%	20%	12%	41%	18%	3.39	279

Strongly disagree = 1, Strongly agree = 5

Representation and models in KS3

Respondents were asked about manipulatives and representations used with higher and lower attaining pupils in KS3.

For the purpose of this question, participants were asked to consider higher attainers as pupils expected to progress to Higher GCSE entry and lower attainers as pupils expected to progress to Foundation GCSE entry.

Appendix 2: Table 14. Use of representations with KS3 high and low attaining pupils

	High and low attainers %	High attainers only %	Low attainers only %	Neither %	Not sure %	Total n
Bar models	67%	2%	12%	15%	3%	278
Double number lines	35%	3%	16%	36%	10%	274
Ratio tables	57%	5%	7%	25%	5%	277
Algebra tiles	34%	3%	16%	43%	4%	276
Cuisenaire blocks or other place value objects	10%	1%	29%	54%	6%	273
Equations and functions represented by graphing apps	40%	32%	1%	20%	7%	275
Digital or virtual manipulatives	56%	3%	10%	22%	9%	273

Appendix 2: Table 15. Use of representations with high and low attainers' frequencies provided separately

		Responses		Percent of Cases
		N	Percent	
High and Low Attainers	Bar models - High attainers	192	9.4%	71.9%
	Low attainers	221	10.8%	82.8%

	Double number lines - High attainers	102	5.0%	38.2%
	Low attainers	140	6.9%	52.4%
	Ratio tables - High attainers	172	8.4%	64.4%
	Low attainers	179	8.8%	67.0%
	Algebra tiles - High attainers	104	5.1%	39.0%
	Low attainers	140	6.9%	52.4%
	Cuisenaire blocks or other place value objects - High attainers	31	1.5%	11.6%
	Low attainers	108	5.3%	40.4%
	Equations and functions represented by graphing apps - High attainers	197	9.6%	73.8%
	Low attainers	113	5.5%	42.3%
	Digital or virtual manipulatives - High attainers	162	7.9%	60.7%
	Low attainers	181	8.9%	67.8%
	Total	2042	100.0%	764.8%

Problem solving

Participants were asked to consider the importance of different approaches to problem solving in mathematics teaching.

Not at all important = 1, Extremely important = 5

Appendix 2: Table 16. Importance of different problem-solving practices

	Not at all important	Slightly important	Moderately important	Very important	Extremely important	Mean	Total n
Integrating problem solving into all or most topics	0%	2%	9%	42%	47%	4.32	272
Teaching specific problem-solving methods and techniques (for example, tabulate information, pattern spotting, making conjectures)	2%	7%	17%	45%	28%	3.90	271
Specific problem-solving lessons	13%	23%	30%	20%	14%	3.00	271
As extended problem solving tasks that last for more than one lesson	27%	27%	27%	12%	7%	2.43	266

Never = 1, Always = 5

Participants were asked about the relationship between problem solving and sequencing of topics.

Appendix 2: Table 17. The place of problem solving in sequencing topics

	Never	Sometimes	About half the time	Most of the time	Always	Mean	Total n
At the end of mathematics topics, for example as extension material or questions	2%	17%	14%	51%	17%	3.64	271
Early in topics to teach new mathematical content through problem solving	18%	46%	19%	13%	4%	2.64	269
Early in topics to engage pupils' interest	6%	50%	21%	20%	3%	2.39	271

Consolidation practices

Participants were asked to consider ways that learning is consolidated.

Appendix 2: Table 18. Consolidation of learning – types of practices

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree	Mean	Total n
I interleave or interweave topics in practice questions by having mixed practice exercises	1%	6%	13%	32%	48%	1.78	273
Lessons have extended periods for practices techniques	2%	6%	9%	46%	37%	1.91	271
I regularly use short quizzes and tests	0%	12%	13%	35%	39%	1.98	271
Learning is mostly consolidated through homework	10%	20%	16%	38%	16%	2.70	273

Participants were asked how often different types of resources were used to practise mathematics.

Appendix 2: Table 19. Frequency of different resources for practising mathematics

	Weekly	Fortnightly	Every half term	Termly	Never or rarely	Total n
Department- or teacher-generated exercise	59%	12%	11%	6%	12%	272
Mathematics-specific software platforms	51%	18%	11%	8%	12%	272
Other schemes and sets of resources	48%	11%	6%	6%	30%	267
White Rose Maths resources	29%	5%	4%	8%	54%	272
A class textbook	27%	12%	7%	7%	47%	273
General software platforms	17%	8%	9%	12%	53%	266
Oak National	1%	1%	2%	5%	91%	270

Impactful practices: KS2 to KS3 transition

Participants were asked if they had particular responsibility for KS2 to KS3 transition, for example being the KS3 lead?

Appendix 2: Table 20. Responsibilities for KS2 to KS3 transition in mathematics

	%
Yes	29
No	71
Total n	197

Types of transition activities: pupils

Participants were asked to select from a list of types of activities that pupils joining their school in Year 7 might experience. More than one response choice could be selected/

Appendix 2: Table 21. Types of pupil transition activities

		Total n
Visits to secondary to experience secondary mathematics lessons	87%	164
Demonstration/sample lessons by secondary mathematics teachers in primary schools	40%	164
Using curriculum materials provided by the secondary school	21%	164
Other (Please provide detail)	10%	164

Respondents were asked to indicate the importance of the following forms of assessment, information, and arrangements for supporting the induction of Year 7 pupils:

Appendix 2: Table 22. Induction activities

	Not at all important	Slightly important	Moderately important	Very important	Extremely important	Not applicable or not sure	Total n
We teach mixed attainment ('ability) classes at the start of Year 7 and set during the year	18%	4%	8%	17%	21%	32%	197
We teach mixed attainment ("ability") throughout Year 7	25%	4%	7%	8%	21%	35%	193
KS2 SATS data	9%	13%	25%	32%	20%	2%	197
School or trust generated tests	14%	12%	21%	29%	12%	12%	195
Written and other information from primary school	11%	25%	32%	17%	12%	4%	197
General aptitude tests that may include mathematics (e.g. CATs)	14%	16%	26%	21%	11%	12%	197
Nationally validated mathematics tests	17%	10%	19%	24%	9%	20%	195

Participants were asked about activities they might engage in to support KS2 to KS3 transition. Respondents could select more than one response

Appendix 2: Table 23. Teacher activities to support transition

		Total n
Other (Please provide detail)	3%	158
Trust or local transition projects	18%	158
Involvement in collaborative projects	25%	158
Lessons in primary schools by secondary mathematics teachers	34%	158
NCETM – Year 5 to Year 8 continuity work groups	34%	158
Visits to secondary schools by primary mathematics teachers to observe teaching	40%	158
Transition curriculum materials or lessons	46%	158
Activities to support teacher understanding of mathematical content in other KS	49%	158
Visits to primary schools by secondary mathematics teachers to observe teaching	56%	158

KS3 to KS4 transition and KS4 opportunity to learn

Year 9 curriculum content – algebra and geometry

Participants were asked who in Year 9 would have been introduced to a selection of topics in mathematics lessons, either in Year 9 or before. 'Introduced' may not mean full coverage of the topic.

Appendix 2: Table 24. Y9 curriculum content algebra and geometry

	High and low attainers %	High attainers only %	Low attainers only %	Neither %	Not sure %	Total n
Linear equations	91	5	2	0	2	298
Simultaneous equations	33	39	1	24	2	296
Quadratic equations	28	47	1	23	2	293
Trigonometry	37	35	2	25	1	297
Pythagoras	77	17	2	3	2	296

Appendix 2: Table 25. Y9 curriculum content – high and low attainers presented as separate frequencies

	frequency	High attainers %	frequency	Low attainers %	Total n
Linear equations	286	98%	277	95%	293
Simultaneous equations	214	73%	102	35%	293
Quadratic equations	219	75%	84	29%	293
Trigonometry	215	73%	115	39%	293
Pythagoras	278	95%	234	80%	293

Further analysis of the data on algebra and geometry curriculum content was undertaken to examine the relationship to attainment quintiles

Appendix 2: Table 26. Algebra and geometry topics by attainment quintiles

Attainment quintile (1=lowest, 5 = highest)	Linear equations		Pythagoras		Trigonometry		Simultaneous equations		Quadratic equations	
	High attainers	Low attainers	High attainers	Low attainers	High attainers	Low attainers	High attainers	Low attainers	High attainers	Low attainers
1	92%	90%	92%	76%	71%	31%	72%	26%	76%	28%
2	98%	96%	90%	73%	63%	33%	67%	23%	74%	17%
3	100%	100%	100%	77%	71%	35%	71%	19%	77%	23%
4	98%	98%	100%	83%	80%	42%	71%	31%	72%	30%
5	96%	86%	95%	80%	79%	44%	85%	56%	77%	41%
Difference between q5 and 1	4%	-4%	3%	4%	8%	13%	13%	30%	1%	13%

Appendix 2: Table 27. Quintile analysis of Y9 curriculum content: difference between high and low attainers

Attainment quintile (1=lowest, 5 = highest)	Linear equations	Pythagoras	Trigonometry	Simultaneous equations	Quadratic equations
1	2%	16%	40%	46%	48%
2	2%	17%	30%	34%	57%
3	0%	23%	36%	52%	44%
4	0%	17%	38%	40%	42%
5	10%	15%	35%	30%	35%

Participants were asked about Higher GCSE entry and curriculum content and what best described their curriculum strategy. Participants could select more than one response

Appendix 2: Table 28. Higher GCSE curriculum strategy

	%	Total n
For some students, we select content that gives the best chance of their individual or classes target grades	56%	287
All students entered for Higher GCSE are taught the full Higher GCSE syllabus	51%	287
For some students, we select content that gives the best chance of getting a grade 5	18%	287
For some students, we select content that gives the best chance of getting a grade 4	8%	287
Other (please explain)	7%	287

The data was analysed by quintiles.

Appendix 2: Table 29. Higher GCSE curriculum strategy by quintiles

Attainment Quintile (1=lowest, 5 = highest)	1	2	3	4	5
All students entered for Higher GCSE are taught the full Higher GCSE syllabus	47%	51%	57%	28%	66%
For some students, we select content that gives the best chance of their individual or classes target grades	63%	58%	55%	80%	36%
For some students, we select content that gives the best chance of getting a grade 5	20%	24%	19%	16%	11%
For some students, we select content that gives the best chance of getting a grade 4	10%	13%	13%	6%	2%
Other (please explain)	4%	9%	6%	8%	9%

Total n range: 45–56

Participants were asked about their Foundation GCSE curriculum strategy

Appendix 2: Table 30. Foundation GCSE curriculum strategy

	%	Total n
All students entered for Foundation GCSE are taught the full Foundation GCSE syllabus	49%	282

For some students, we select content that gives the best chance of their individual or classes target grades	44%	282
For some students, we select content that gives the best chance of getting a grade 4	21%	282
For some students, we select content that gives the best chance of getting a grade 5	20%	282
Other (please explain)	12%	282

Further analysis was undertaken of Foundation GCSE curriculum strategy by attainment quintile.

Appendix 2: Table 31. Foundation GCSE curriculum strategy by quintiles

Attainment Quintile (1=lowest, 5 = highest)	**1**	**2**	**3**	**4**	**5**
All students entered for Foundation GCSE are taught the full Foundation GCSE syllabus	47%	49%	57%	43%	53%
For some students, we select content that gives the best chance of their individual or classes target grades	55%	56%	53%	57%	21%
For some students, we select content that gives the best chance of getting a grade 4	33%	20%	30%	18%	8%
For some students, we select content that gives the best chance of getting a grade 5	31%	20%	26%	14%	11%
Other (please explain)	4%	7%	9%	4%	25%

Total n range: 45–53

Decision-making

Decision-making about the Y7-Y9 curriculum

Participants were asked the importance of different actors or potential actors in decision making decisions about the Y7-Y9 curriculum. Responses are reported in Appendix 2 Table 32.

Appendix 2: Table 32. Decision-making about the Y7-Y9 curriculum all responses

	Not at all important	**Slightly important**	**Moderately important**	**Very important**	**Extremely important**	**Not applicable or not sure**	**Total n**
The Head of Department or equivalent	0%	3%	10%	32%	54%	1%	299
The Key Stage Lead	4%	3%	11%	40%	34%	9%	301
The department deciding together	2%	11%	25%	31%	30%	1%	299
Recommendations in evidence sources like the EEF KS2/KS3 guidance	7%	13%	33%	27%	11%	7%	297
The sequence in the DfE/NCETM National	9%	24%	26%	22%	13%	7%	296

Curriculum guidance							
The classroom teacher	7%	28%	31%	22%	9%	2%	296
An external scheme or programme that we follow	19%	10%	22%	18%	6%	24%	296
The Multi Academy Trust (if part of a Trust)	13%	12%	10%	8%	10%	48%	283

To support comparison of the importance of different factors, percentage responses were recalculated after eliminating 'not applicable or not sure' responses. A mean was calculated by weighting responses on a 1–5 discrete scale, with 1 being not at all important and 5 extremely important. The means are shown in Appendix 2 Table 33. Note that this data is relevant to those schools that are part of a multi-academy trust and may not be applicable to all schools.

Appendix 2: Table 33. Decisions about the curriculum (means)

	Mean	Total n
The Head of Department or equivalent	4.38	295
The Key Stage Lead	4.06	274
The department deciding together	3.78	295
Recommendations in evidence sources like the EEF KS2/KS3 guidance	3.23	275
The sequence in the DfE/NCETM National Curriculum guidance	3.06	276
The classroom teacher	2.99	290
The Multi Academy Trust (if part of a Trust)	2.78	147
An external scheme or programme that we follow	2.74	224

Not at all important = 1, Extremely important = 5

Decisions-making about teaching methods

Participants were also asked "Who or what is important in deciding teaching methods?" Responses are shown in Appendix 2: Table 34.

Appendix 2: Table 34. Deciding teaching methods all responses

	Not at all important	Slightly important	Moderately important	Very important	Extremely important	Not sure	Total n
The classroom teacher	1%	6%	20%	36%	36%	0%	278
The department deciding together	1%	5%	21%	40%	33%	0%	280

The Head of Department or Equivalent	1%	6%	20%	39%	32%	0%	279
The Key Stage Lead	5%	9%	24%	38%	18%	6%	276
External guidance e.g. the NCETM or Maths Hubs	13%	22%	32%	22%	9%	2%	278
The school leadership and school policy	24%	28%	25%	16%	5%	2%	280
The Multi Academy Trust (if part of a Trust)	29%	17%	12%	7%	4%	31%	252
Recommendations from an external scheme or programme that we follow	29%	18%	22%	11%	3%	18%	264

To support comparison of the importance of different factors, percentage responses were recalculated after eliminating 'not applicable or not sure' responses. A mean was calculated by weighting responses on a 1–5 discrete scale, with 1 being not at all important and 5 extremely important. The means are shown in Appendix 2 Table 35. Note that this data is relevant to those schools that are part of a multi-academy trust and may not be applicable to all schools.

Appendix 2: Table 35. Deciding teaching methods (means)

	Mean	**Total n**
The department deciding together	3.99	279
The classroom teacher	3.99	278
The Head of Department or Equivalent	3.95	279
The Key Stage Lead	3.59	260
External guidance e.g. the NCETM or Maths Hubs	2.92	273
The school leadership and school policy	2.47	274
Recommendations from an external scheme or programme that we follow	2.27	216
The Multi Academy Trust (if part of a Trust)	2.11	174

Not at all important = 1, Extremely important = 5

Survey 1 and Survey 2 comparison

A number of questions were analysed to compare survey 1 and survey 2 responses to see if the two approaches to recruitment (email and through NCETM, MEI and EEF networks) led to detectable bias.

This is an example of analysis to consider whether there was any specific sample bias between respondents to survey 1 and 2.

Appendix 2: Table 36. GCSE curriculum strategy for higher tier, comparison survey 1 and 2

		% Yes	Total n
All students entered for Higher GCSE are taught the full Higher GCSE syllabus	survey 1	46%	97
	survey 2	53%	190
For some students, we select content that gives the best chance of their individual or classes target grades	survey 1	60%	97
	survey 2	54%	190
For some students, we select content that gives the best chance of getting a grade 5	survey 1	13%	97
	survey 2	21%	190
For some students, we select content that gives the best chance of getting a grade 4	survey 1	8%	97
	survey 2	8%	190

Appendix 2: Table 37. Comparison of survey 1 and survey 2 Algebra and Geometry in KS2

			Cross-taba										
			Linear equations - High attainers	Linear equations - Low attainers	Simultaneous equations - High attainers	Simultaneous equations - Low attainers	Quadratic equations - High attainers	Quadratic equations - Low attainers	Trigonometry - High attainers	Trigonometry - Low attainers	Pythagoras - High attainers	Pythagoras - Low attainers	Total
ID	Survey 1	Count	99	97	66	34	79	36	74	42	98	81	100
		% within ID	99.0%	97.0%	66.0%	34.0%	79.0%	36.0%	74.0%	42.0%	98.0%	81.0%	
	Survey 2	Count	187	180	148	68	140	48	141	73	180	153	193
		% within ID	96.9%	93.3%	76.7%	35.2%	72.5%	24.9%	73.1%	37.8%	93.3%	79.3%	
Total		Count	286	277	214	102	219	84	215	115	278	234	293

Percentages and totals are based on respondents.

Appendix 2: Table 38

	Survey 1 (n=100)				Survey 2 (n=193)			
	frequency	High attainers %	frequency	Low attainers %	frequency	High attainers %	frequency	Low attainers %
Linear equations	99	99%	97	97%	187	97%	180	93%
Simultaneous equations	66	66%	34	34%	148	77%	68	35%
Quadratic equations	79	79%	36	36%	140	73%	48	25%
Trigonometry	74	74%	42	42%	141	73%	73	38%
Pythagoras	98	98%	81	81%	180	93%	153	79%

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