The Royal Society Mathematical Futures Programme

Landscaping Mathematics Education Policy: Landscaping national mathematics education policy

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Executive summary

1. This report examines the shaping of mathematics education in England by education policy since the 1980s. It consists of:

   (i) a chronological mapping of mathematics education policy interventions in England

   (ii) a trend analysis and interpretation of policy, trajectories and system changes relating to mathematics

   (iii) the implications of this analysis for influencing mathematics education policy and practice.

   It is based on documentary analysis and expert views gathered through virtual interviews and workshops.

2. The review focuses on mathematics education policy and draws on broader education policy where this is relevant and/or impacts on mathematics education. Criteria for inclusion and exclusion of evidence focus on the education of 4-19-year-olds in England. Given that, in England, the statutory framework for mathematics education for 4-year-olds is the Early Years Foundation Stage (EYFS) (DfE, 2014), the review includes EYFS policy literature but focuses on Foundation Stage 2 (Reception classes). Educational phase is used to inform and organise the review using customary systemic phases of

- EYFS
- Primary education (KS1 and KS2)
- Secondary education (KS3 and KS4)
- Post-16

We undertook a chronological mapping covering the following time-periods (with indicative initiatives for England):

- 1980-1989 (Cockcroft to Education Reform Act),
- 1990-1998 (GCSE and the introduction of the national curriculum),
- 1999-2010 (National Strategies, NCETM, Smith Report),
- 2011-2021 (new national curriculum, Mastery programme).

Mathematics education as a field may be categorised in different ways. The following analytical categories – aspects of mathematics education - were identified in dialogue with the Royal Society:

- Curriculum and pedagogy
- Qualifications and assessment
- Resources and technologies
- Teaching workforce & professional learning (ITE, teacher supply)
- Systems including incentives, implementation, influences including context[1]; we also extend ‘systems’ to refer to systemic issues that are found across the other aspects of mathematics education
- Philosophy, values, purpose, priorities, perspectives.

[1] Note that in the ITT, proposal, and at the inception meeting, this appeared as "Systems including incentives and drivers (incl. context)" however, the term 'drivers' here has a potentially ambiguous meaning from drivers as a 'push' factor in implementation rather than 'driver' in policy analysis models that is an aim or goal of the policy.

3. An orientation to the overall chronology, policy environment and educational landscape provides an overview of selected milestones in mathematics education.
   This is further developed by identifying ten political, economic, and cultural forces influencing mathematics education policy:
   - Marketisation
   - Citizen as consumer
   - Smaller state
   - New public management
   - Globalisation/glocalisation
   - Human capital
   - Social reproduction
   - Moral panics
   - Technological changes
   - Discourses of meritocracy

Seven broad changes in the education landscape that also influence mathematics education are described:

- System complexity
- Accountability measures
- Ofsted and inspection frameworks
- Teaching workforce supply and retention
- Changing teacher professional conditions
- Evidence and practice
- Transnational influences

4. The chronology of mathematics education in England is extended by consideration of educational phases: EYFS, Primary, Secondary, and Post-16.

For each phase, outcomes of the research are presented as:

- A visual timeline of the phase chronology by years
- A summary of policy features, drivers, warrants and levers by time periods
- Factors, developments and consequences, and current influences on mathematics education

5. Policy drivers (goals and aims) in mathematics education are reviewed and how these have changed across time and by phase. Patterns in drivers are identified grouped as
   - Economic drivers
   - Individual outcomes and opportunity
   - The quality of mathematics teaching

Educational ideologies and core beliefs underpinning drivers are identified.

6. Eight policy trends are identified with two each illustrating trends in four aspects of mathematics.
   i. Reduced curriculum content and increased prescription (curriculum and pedagogy)
   ii. Increased policy direction of pedagogy (curriculum and pedagogy)
   iii. Narrowing of assessment methods and forms (qualifications and assessment)
   iv. High-stakes testing (qualifications and assessment)

v. Changing patterns in depth and intensity of funded subject specialist professional development (workforce and professional learning)
vi. 'School led' innovation and professional development trending recently towards more centralisation of direction (workforce and professional learning)
vii. Changing availability of curriculum resources and material (resources and technologies)
viii. Decreased use of ICT in mathematics – including computing and programming (resources and technologies)

7. Seven case studies illustrate key developments in mathematics education. The featured cases are:
   - Problem solving in recent curriculum and pedagogy
   - Data handling and statistics
   - Core Maths
   - Teacher subject knowledge
   - Digital technologies in mathematics education
   - The 'forgotten third'
   - National Centre for Excellence in Teaching Mathematics (NCETM)

8. The increased politicisation of policy development in mathematics education is identified with the following noted:
   - more direct influence of ministers on curriculum and implementation of policy
   - a changed role and nature of special political advisors with educational expertise apparently less important
   - increased number and type of policy influencers and actors.

   A chronology of reports and the changing role of reports as warrants for policy development are described.

9. Four policy development cases are presented, comprising an overview of the significance of the case, a brief introduction of the policy, followed by an analysis of policy development:
   - Using and applying mathematics in the national curriculum
   - The National Numeracy Strategy
   - The Further Mathematics Support Programme
   - The Mastery programme

10. The four policy development cases are analysed in relation to models of policy development:
    - Multiple streams
    - Advocacy Coalition Framework
    - Policy cycle

11. Drawing on the case studies and other policy analysis models, the four cases are also analysed in using proposed models of a) successful policy development and b) an implementation strategy model.

12. Considering the landscaping of mathematics education policy, the following key features are noted:

i. Educational policy in England is not particularly shaped by a careful consideration of evidence
ii. There is an increasing divergence from high-performing systems which are reshaping their education policies including in mathematics education in response to economic and social changes

iii. Political, cultural, and economic forces, and education landscape features are important barriers to policy change and successful implementation in mathematics education.

13. To take forward the Mathematical Futures Programme, the following issues need considering:
- Feasibility - assessing the feasibility of a particular programme, initiative, or action at a particular time in relation to relevant forces and features and the general capacity for change
- Moderating the expression of forces and features in change programmes
- Seeking opportunities for forces and features to be 'flipped' and drive change

In analysing, policy development processes we identified changes in the process of policy development with a more ideologically driven approach to policy development.

Previous drivers and concerns may no longer be relevant or as powerful in particular:

- Concerns of employers and industry and HEI may be less important than populist concerns
- The power of evidence to persuade
- Changes in the importance of transnational influences with potentially more concern for national distinctive approaches

Appeal to previous concerns and drivers may need to be nuanced and careful consideration given to audience and their interests. There is a need to map and engage with current and future policy influencers.

15. A change process model of initiation, implementation, and continuation would support Mathematical Futures activities. This model is applied to the identified Mathematical Futures Phase 2 themes.

An initiation phase focused on the four themes has the potential to develop foundations for future more systemic change across the whole of mathematics education. Two feasibility issues are considered to inform future planning:

- The overall 'fit' between the theme and current curriculum in each phase and the relationship of these to core beliefs
- What aspects of a theme may be appropriate in a phase.

Suggestions are proposed for developing and testing programmes related to the Phase 2 themes, informed by Theory of Change models and for the development of coalitions to influence the climate for change. Such coalitions would need to include both traditional stakeholders and partners of the Royal Society.

Approaches to support policy engagement are identified:

- Expanding policy networks
- Campaigning
- Costed policy design

16. Five additional recommendations, for more immediate action, are made

i. Engaging with stakeholders as Mathematical Futures begins Phase 2
ii. Identify or develop models of effective policy development and implementation
iii. Establishing an ACME policy contact group.
iv. Engagement with current policy governance networks

v. Develop pilot programmes

PART ONE Introduction

Part One introduces the study and report and situates it in relation to the remit of the Mathematical Futures Programme, including the parallel study - the Horizon Scanning of International policy Initiatives. It goes on to describes the research aims, questions and scope and methods.

1. Introduction

The Royal Society's Mathematical Futures Programme aims to:

a) Understand the mathematical competences that will be needed by students leaving compulsory education and training in the future
b) Consider the implications of reshaping mathematics education for 4–19-year-olds
c) Recognise the skills required for teachers who would teach these curricula.

This report is the second of two reports. The first report "Landscaping Mathematics Education Policy: Horizon scanning of international policy initiatives" was based on a horizon scan of policy and change in international jurisdictions. It provided an overview of recent developments in mathematical, statistical, and computational thinking, and data literacy informed by views of international mathematics education experts. This second report contributes to the Mathematical Futures Programme aims by synthesising evidence and mapping national mathematics education policy since the 1980s. The research for this report was conducted between July 2021 and February 2022.

The review, including focal areas and choices of case studies, is informed by:

- previous Royal Society visions for mathematics (Royal Society, 2014)
- the analysis of the Mathematical Futures Programme 'Call for views' (Golding & Smart, 2021)
- the horizon scan of international policy initiatives (Adams & Boylan, 2023) and discussion of the findings of that study with the Mathematics Futures Programme Board
- and emerging priorities identified by the Mathematical Futures Programme Board as themes for Mathematical Futures phase 2 -
    1. Inequalities in mathematics education and the challenge of engaging pupils and students
    2. The intersections between mathematics, statistics, data science and computing
    3. The role of technology in mathematics education
    4. The implications of the above three themes for the teaching workforce.

Thus, this landscaping of mathematics education policy is informed by:

- The importance of broad and balanced education and addressing priority areas of mathematical and quantitative skills, science, and computing education.
- The importance of mathematical thinking (as well as scientific thinking).
- The need to develop a scientifically and mathematically informed society and the implications of this for the relationship between STEM education and citizenship.
- Recognising that individual and societal mathematical needs are unmet and changing; policy change is needed focused across mathematics education as whole: curriculum, pedagogy, qualifications and assessment, the mathematics education workforce, the use of technology and across all educational phases.
- Particularly urgent needs and opportunities for change in relation to a coherent and cross phase approach to the use of digital technology in mathematics, opportunities for enhancing coding and computational thinking in mathematics, and the integration of data science into the mathematics curriculum.

Policy changes to address these challenges requires considerable collaboration and coherent re-envisioning. These concerns informed evidence gathering and selection of examples for analysis and presentation in the report, in the context of a broader, more comprehensive mapping. The study comprised identification, chronological mapping and synthesis of key policy texts and interventions influencing mathematics education in England, with expert views validating interpretations. Methods and methodology are described in section 4.

The report structure

The report has nine parts as shown in the figure below.

Figure 1: Parts of the report

Parts	Details
Part One: Introduction	Introduction to the study' research aims, questions and scope; methodology and methods
Part Two: Overview	An orientating overview of forty years of mathematics education policy across four periods including a chronology of legislation and government policy; system level drivers; and general education policy influences on mathematics education.
Part Three: Phases	Phase chronologies and analysis of policy features, warrants, levers, and drivers by phase; identification of current influences
Part Four: Purpose, values, and system levers	Purpose and values in mathematics education; system warrants and levers
Part Five: Trends	Mathematics education trends
Part Six: Illustrative cases	Cases illustrating influences, drivers, warrants, levers, and trends
Part Seven: Policy development and implementation	Policy development and implementation including policy development cases
Part Eight: Mathematical Futures	Implications, recommendations, and conclusion
Part Nine: Supporting materials	Supporting materials: acknowledgements, references, appendices

Two different types of cases are included: illustrative cases and policy development cases. In Part Six there are seven cases that illustrate policies and their effects related to phases and aspects of mathematics. The case studies illustrate key developments, with the aim of providing a richer study for aspects of mathematics education and a narrative that spans policy background, development, and implementation. The selection of the cases was informed by previous Royal Society publications, earlier reports for the Mathematical Futures Programme - including the horizon scan of international policy initiatives (Adams & Boylan, 2023) - and discussion with the Mathematics Futures board. Each case begins with a short section where their relationship to phases and different aspects of mathematics education are noted.

Figure 2: Illustrative Case studies

Case study
Problem solving in recent curriculum and pedagogy
Data handling and statistics
Core Maths
Teacher subject knowledge
Digital technologies in mathematics education
The 'forgotten third'
The National Centre for Excellence in Teaching Mathematics

In Part Seven, four case studies focused on policy development processes, one from each of the four phases, are examined.

In the introduction to this report, we identified the positionality of our review and approach to reporting in relation to previously stated positions of the Royal Society and early outcomes of the Mathematical Futures programme. This has informed the selection of the four policy developments analysed in Part Seven. Each one led to changes aligned with at least some aspects of these positions (although not necessarily fully aligning with them). The four examples and aspects or elements that relate to the Mathematical Futures project are in the table below, which also has examples drawn from each of the four periods. The dates given relate to the main period in which policies developed and/or activity influenced policy, rather than dates in which the policy was implemented and/or applied.

Table 1: Featured policy development

Policy development	Dates	Relevant features
Using and applying mathematics in the national curriculum	1988-1991	Applications of mathematics, problem solving, alternative forms of assessment
The National Numeracy Strategy	1994-1999	National CPD policies applicable in all schools, subject knowledge and subject pedagogical knowledge, coherent approach to curriculum, pedagogy, assessment, and systems
The Further Mathematics Support Programme	2005-2022	Tuition and resources to support advanced Mathematics and Further Mathematics, subject knowledge and subject pedagogical knowledge teacher professional development, support networks
Mastery	2014-2018	Subject knowledge and subject pedagogical knowledge, teaching for understanding, focus on all learners

The four examples are by no means unique in having relevant features. However, they were selected because they also share the following common features:

- implementation at system-wide scale
- influence on policy by external bodies or coalitions –all to an extent arose from a convincing campaign for policy change being made
- research and evidence as a warrant for change

2. Research aims, questions and scope

Aim

Informed by documentary analysis and expert views based on virtual interviews and workshops the study aim was to draw implications for and from mathematics education policy and practice through:

a) Chronological mapping of mathematics education policy interventions in England[2].

b) A trend analysis and interpretation of policy, trajectories and system changes relating to mathematics education to extrapolate from historical policy trajectories to inform the future.

2.2 Research questions

Main research question

How has mathematics education (in England) been shaped by education policy and educational change more generally since the late 1980s?

Contributing questions

a) What policy interventions, both direct and indirect, have influenced mathematics education in 2021?
b) What were/are the motivations and intentions for these policy initiatives?
c) How effectively were the policy intentions realised and communicated?
d) How can understanding of past policy and change trends inform thinking about future possibilities?

With regard to the fourth contributing question, we focused on considering future possibilities for the work of the Mathematical Futures programme and how the Royal Society and ACME might influence policy change.

2.3 Conceptual framework

Educational phases

The review focuses on mathematics education policy and draws on broader education policy where this is relevant and/or impacts on mathematics education. Criteria for inclusion and exclusion of evidence focus on the education of 4-19-year-olds in England. The review includes EYFS policy literature but focuses on Foundation Stage 2 (Reception classes). This is because, in England, the statutory framework for mathematics education for 4-year-olds is the Early Years Foundation Stage (EYFS) (DfE, 2014),

We use educational phase to inform and organise the review using customary systemic phases of

- EYFS
- Primary education (KS1 and KS2)
- Secondary education (KS3 and KS4)
- Post-16

[2] Note that the primary focus of the Mathematical Futures Programme is on England, with a wider interest in the UK policy developments and changes.

Notwithstanding that, generally, educational phases are relatively separate in terms of mathematics education specific policy, there are notable examples of cross-phase policies. For example:

- Primary school mathematics influencing or impacting on EYFS
- National Strategies crossing KS2 and KS3
- Policies such as GCSE that are relevant across 14-19.

Time periods

We undertook a chronological mapping covering the following time-periods (with indicative initiatives for England):

- 1980-1989 (Cockcroft to Education Reform Act),
- 1990-1998 (GCSE and the introduction of the national curriculum),
- 1999-2010 (National Strategies, the NCETM, the Smith Report),
- 2011-2021 (the revised national curriculum, the Mastery programme).

Given resource available, timescales for research and reporting, and a focus on current influences on policy and practice, the amount of desk work undertaken in relation to each period was skewed towards more recent developments.

Policy categories: aspects of mathematics education

As noted above there is increasing divergence across UK systems. The focus of the evidence synthesis in this report is England. This is supplemented by a focus on recent key policy developments in other Nations of the UK most relevant to the research aims, guided by the aim of supporting discussion and recommendations on opportunities and challenges for future change.

Mathematics education as a field may be categorised in different ways. The following analytical categories were developed in dialogue with the Royal Society during the project inception period:

- Curriculum and pedagogy
- Qualifications and assessment
- Resources and technologies
- Teaching workforce & professional learning (ITE, teacher supply).

These categories – referred to as **aspects of mathematics education** - were used as an identification and selection tool to: 1) identify policy initiatives to analyse - by, for example identifying changes in the national curriculum and 2) to ensure examples of policy changes had been identified across the different fields.

In addition, again in dialogue with the Royal Society we also considered two cross-cutting related categories:

- Systems including incentives, implementation, influences including context[3]; we also extend 'systems' to refer to systemic issues that are found across the other aspects of mathematics education
- Philosophy, values, purpose, priorities, perspectives.

[3] Note that in the ITT, proposal, and at the inception meeting this appeared as "Systems including incentives and drivers (incl. context)" however, the term 'drivers' here has a potentially ambiguous meaning from drivers as a 'push' factor in implementation rather than 'driver' in policy analysis models that is an aim or goal of the policy.

Direct and indirect influences on mathematics education

The mapping review focused on mathematics education policy. However, this changed along with, and has been influenced by, other education policy changes. These other policy changes also influence how policy is enacted in practice. Examples of this are a more complex and marketised education landscape (Boylan & Adams, 2023) and the move to linear GCSEs. Important indirect forces and influences are described in Sections 4.3 and 4.4 below.

3. Methods and methodology

3.1 Analytical constructs models

To report on policy interventions over the past 40 years, in keeping with the study requirements we identified:

- Policy **development** including description of background context
- Policy **drivers**: intended broad aims or goals articulated through policy documents (e.g., White papers), ministerial statements and speeches, press releases and legislation
- Policy **warrants**: justifications for the policies
- Policy **levers** (delivery strategies): including through government targets, funding, national initiatives, inspection
- The **role of stakeholders** in policy development, implementation and change as evidenced in policy documents.

These features are described further in Appendix 1. However, the analytical frame used is based on a relatively linear view of policy development. Thus, the above analytical constructs should be treated as offering metaphorically two-dimensional images of multi-dimensional phenomena. Alternative models point to the complexity of policy development and implementation (for example, Baker & McGuirk, 2017; Clarke, Bainton, Lendavi, & Stubbs, 2015; Ball, 2016).

One way, we have sought to address this complexity is by using three models of policy development. (see, Cairney, 2012):

- Multiple streams analysis
- The Advocacy Coalition Framework
- The policy cycle model

These three models are not necessarily mutually exclusive as they focus on different aspects of policy development (see, Adams & Boylan, 2023).

3.2 Review

Although the evidence synthesis is a policy review, it differs from customary approaches to such reviews in that the aim is to develop an overall synthesis considering many policy developments over an extended period (see, section 2.3 *Framework*). It was beyond the scope of the evidence synthesis to undertake comprehensive and in-depth review of all the policies over the time period studied. Considering, as an example, mathematics qualification reforms in the period 2000 to 2014 illustrates why a comprehensive review for each policy or policy area was not possible. The number of relevant policy texts extends into the thousands. Thus, selection and filtering were important to the review and synthesis.

Our approach was shaped by timescale, resource, and specific purpose of the synthesis in relation to the wider Mathematical Futures project in identifying systemic policy patterns whilst being inclusive, rigorous, accessible, and transparent in our approach. We gathered for analysis the following three principal sources of textual evidence - using standard search approaches to gather evidence.

1. White Papers, Green Papers, reports, and reviews commissioned by central government and changes to legislation and government departmental remits and evaluations of key initiatives published between 1980-2021.

2. Independent policy orientated literature. This category includes policy briefs, reports and contributions produced by a variety of 'stakeholders' in mathematics education. An important source were documents, and contributions to consultations by ACME itself, as well as the Joint Mathematics Council (particularly in the period before ACME was constituted). Grey literature was retrieved from organisations websites.
3. Academic peer reviewed literature. Here given the timescale and resource the focus was on texts that are policy reviews or analysis of policy development, together with implementation of key policies, for example the introduction of the National Numeracy Strategy.

3.3 Engagement with experts

Stakeholders were identified in consultation with the Royal Society's programme team and include national experts in curriculum, assessment, pedagogy, technology, and the teaching workforce across educational phases, with representatives from the four nations of the UK. These experts were invited to participate in one of nine focused 'roundtable' events. The roundtable topics were EYFS, primary, secondary, post-16, curriculum and pedagogy, qualifications and assessment, teaching workforce, technology, textbooks and curriculum materials.

Approximately 80 experts were invited, with 39 participating. Each roundtable had 3-6 experts contributing and lasted 75-90 minutes.

Discussions were structured around key issues arising from the evidence synthesis. Draft visualisations and mappings of the mathematics education landscape were used to stimulate discussion and test approaches. Thus, the drafts of the mapping were validated by external expert opinion.

3.4 Case studies

The purpose of the case studies is to:

- illustrate key developments in relation to aspects of mathematics education and cross-cutting categories of a) systems (including incentives, implementation influences and context) and b) philosophy, values, purpose, priorities, and perspectives
- examine how different themes across policy components interacted
- consider how themes and trends manifest (or not) across different educational phases

3.5 Developing the chronology

From the review, we developed a chronology of mathematics education policies and policy enactments since 1980. This was further refined by expert review in the roundtables. We have aimed for a comprehensive chronology of key milestones. However, it is by no means fully complete. Since 1979, there have been 80 government acts wholly or partly about education (EdPol 2020); not all of these are included in the chronology. In just a two-year period (2011–2013), 50 reports were published related to mathematics education[4].

Further, for many of the key events, each could be broken down into multiple events and, rather than taking place at one time point, occurring over a period of time. For example, Rushton (2013) provides a descriptive analysis of changes in qualifications for 16-year-old and post-16 students,

[4] https://mathsreports.wordpress.com/

which identifies 13 changes in mathematics qualifications, comprising 36 episodes, and references over 50 policy documents. As a second example, Dalby and Noyes' (2020) policy review of Functional Skills (post-16 Level 2 qualifications) charts multiple events over a policy developed and enacted over the last 15 years. Considering the overall time span of 40 years, all educational phases, and all areas of mathematics education, the number of relevant mathematics policies or general education policies with significant impacts on mathematics education that could be considered is in the hundreds. To add to the complexity, some events are specific to a particular educational phase or aspect of mathematics education (such as the educational workforce). Others are relevant to more than one phase or aspect of mathematics education.

Necessarily, for a system level policy analysis spanning 40 years of policy, we have had to select which events to include. We have selected approximately 120 events and presented these as timelines in Parts Two, Three, and Seven. We made some pragmatic choices about the amount of information to present. So, for example, the introduction of Maths Hubs in 2014, is impactful across all phases, but in the chronologies below, it is included in the primary phase because it was highlighted in the primary roundtable as being of particular importance and has been central to the mastery policy in primary.

PART TWO: Overview

Part Two begins with an orientation to the overall chronology, policy environment, and educational landscape, together with an overview of selected milestones in mathematics education. This is further developed by considering political, economic, and cultural forces and changes in the education landscape influencing mathematics education.

4. Forty years of mathematics education policy in England

4.1 An overview of the four periods

Table 2, below, presents an overview of the four periods considered with important features of the educational policy environment and selected milestones in mathematics education; some of these are more general educational policies.

Despite the quantity of policy related activity in education and mathematics education, prior to 2010, there was considerable consensus in educational policy visions that were stable across changes in government. The election of the coalition government in 2010 led to a more significant change in direction, particularly in the wider educational system but also in the curriculum, with a shift towards greater direction by ministers in the detail of the curriculum.

During this period, devolution across the UK has led to increased divergence in educational systems across UK nations.

Table 2: Periods, the educational policy environment and selected mathematics education events

Periods, the educational policy environment, and selected mathematics education events

Time period	**Educational policy environment**	**Selected milestones in mathematics education**
1980-1989	Conservative government. Groundwork for policy direction in education. Growth of policy concern and debates and a new consensus that education needed improving and changes such as comprehensive movement had 'gone too far'. Introduction of markets, school choice, league tables, assisted places scheme.	Cockcroft; Ofsted Mathematics 5 to 16; Education Reform Act
1990-1998	Conservative government then New Labour. Increased government direction over school curriculum, teacher education, development of school accountability and performativity measures, start of marketisation	Introduction of GCSE and the introduction of the national curriculum Using and applying in first NC; NC assessment KS1-KS3; National Numeracy Strategy
1999-2010	New Labour government. Central direction over teaching and pedagogy as well as curriculum, introduction of academies, personalisation, and technology agendas; new ITT routes – greater school involvement	National Strategies; national curriculum reforms; ACME founded; Smith Report (2004); Launch of NCETM
2011-2021	Conservative government. Greater direction over teaching and pedagogy, curriculum reform, academies, free schools, multi-academy trusts, Teaching School Alliances; marketisation and centralisation of control, emphasis on knowledge rather than skills, in school led ITT; 'bonfire of quangos' – ending of variety of government funded bodies (QCA, BECTA, NCSL, TDA etc); change in school accountability indicators e.g., EBACC; Progress 8; Pupil premium funding. Increase in discourse of evidence informed teaching – establishment and influence of the Education Endowment Foundation.	New national curriculum 2014 and end of NC levels; Maths Hubs; Mastery programme; GCSE and A level reforms

4.2 Legislation, government policies, statutory changes

Figure 3, below, presents a timeline of legislation, policies, and statutory changes.

Figure 3: Legislation, government policies, statutory changes from 1980 to 2021

1980

- Education act (1980) parental choice, publication of school results to parents
- Education Act (1981) SEND and implementation of the Warnock Report
- Council for the Accreditation of Teacher Education (CATE) established (1984)

1985

- Education Act no 2, (1986)
- Education Reform Act (1988)

1990

- The Education (Schools) Act established Ofsted; School performance tables introduced (1992)
- Education Act 1994 – founding of TTA

1995

- Qualifications and Curriculum Authority (QCA) established (1997)
- School standards and framework act – ltd primary class size; GTC established (1998)
- National Numeracy strategy including the numeracy hour (1999)
- Revised NC - greater emphasis on core subjects - Maths, English, Science (2000)

2000

- Education Act 2002 – introduces sponsored and high-performing academies (2002)
- Children's Act (2004) based on the 2003 green paper Every Child Matters

2005

- Education Act 2005 – TDA becomes TTA; strengthens role of Ofsted
- Childcare Act established the Early Years Foundation Stage (2006)
- Ofsted became 'The Office for Standards in Education, Children's Services and Skills' (2007)
- Ofqual tasked over functions of QCA (2008)

2010

- 15 hours free childcare 3- & 4-year-olds and 2-year-olds disadvantaged families; Teaching schools established (2010)
- DfE Teachers' Standards changes; Education bill – GTC and TDA abolished; EBacc measure introduced; pupil premium funding (2011)
- DfE Statutory Framework for the EYFS; Teaching Agency as part of DfE gives more direct control to ministers (2012);
- Move from Early Years Professional Status to Early Years Teacher (2013)
- Revised NC and EYFS framework; GCSE, A level reforms, GCSE resits required for 16+ (2014)

2015

- Change in school accountability measures – e.g., Progress 8
- Early years national funding formula and 30 hours offer (2017)
- ITT core content framework (2019)

2020

- Non statutory guidance for maths teaching, EY framework; T levels introduced (2020)
- Teaching school hubs established; Early Career Framework (2021)

5. Political, economic, and cultural forces

In Part 3, we analyse specific drivers that have shaped mathematics education policies, such as improving pupil outcomes. These mathematics education policy drivers were variously shaped by or expressions of broader political, economic, and cultural forces in education over the forty-year period. It is beyond the scope of the report to explore this fully. However, some key forces over the time period are described here, with examples and some details, and these would potentially influence or moderate any future policy developments.

Table 3: Political, economic and cultural forces

Forces	Details and/or examples in education
Marketisation	Competition as the best way of delivering public services and market as a moral good
Citizen as consumer	1980s school choice and accountability policies position school places as a market
Smaller state	An ideological driver in the 1980s amplified for financial reasons, from 2010 in general political climate of austerity
New public management	Alongside marketisation and competition, growth in the role of state as regulator and performance manager
Globalisation/glocalisation	Transnational governance – OECD, world trade in education, transnational education policy mobilities; trade considerations in the Shanghai exchange
Human capital	Economic needs of industry and employers, ‘UK PLC’ - long standing concerns amplified by globalisation
Social reproduction	Reproduction of cultural values, ‘British Values’, rich knowledge, cultural capital
Moral panics	Fear of young people’s activity, ASBOs, school behaviour policies, fear of teacher indoctrination of pupils (e.g., the 1986 Education Act). ‘British Values’
Technological changes	New technologies such as computers, digital tools, internet, and new educational actors – the growth of a ‘knowledge economy’
Discourses of meritocracy	Growth in meritocracy and social mobility as the accepted approach to social justice – discourse of ‘closing the gap’ and levelling up, alongside downplaying, or ignoring structural inequality

6. Changes in education landscape influencing mathematics education

Government policy and legislation, detailed in the above timeline, influence both the educational environment and mathematics education in multiple ways. Such influences have had varying effects over time. Here, we focus on those we consider most relevant to the current policy environment and the possibilities for and barriers to policy innovation in mathematics education. There are other changes not included or other lenses that could be used to describe emergent effects, and the relationship between changes is largely ignored—for example, how accountability and a particular interpretation of evidence in teaching lead to pressures on teacher agency and autonomy.

Here, we identify six changes. For each of these, we briefly discuss how these issues influence mathematics education in general, and, where appropriate, consider curriculum and pedagogy, qualification and assessment, resources and technology, and the teacher workforce (if the general influence does not in any case pertain to one of those). Following this, for the first four of these, we summarise the influences of each aspect in relation to each educational phase. Here, we describe mediators and 'influences'. A mediator refers to paths and routes for the abstract influence to act upon mathematics education. For the last three of these areas of change, describing them by differences across phases is not appropriate, as differences across phases are fuzzier or not applicable to all phases.

1. System complexity

Over the last forty years, the complexity of the education system has increased. One aspect of this that is particularly relevant to understanding mathematics education is **how education provision is organised.** During the nineties and noughties, the role of Local Education Authorities (LEA) diminished, described as the removal of the 'middle tier' (Crawford, Maxwell, Coldron & Simkins, 2020). The legacy relationships of LEAs vary geographically. Governance, law, and finances of schools, colleges and early years settings have changed. Most markedly, in the school sector, the process of academisation and growth in multi-academy trusts has led to greater complexity. These changes have been experienced differently across phases, with the growth in academies progressing more quickly in secondary than primary.

In the post-16 sector, over the forty-year period, there has been a growth in Further Education Colleges and, more recently, the sixth form college sector (though these are coming under recent funding pressure). At a national level, until 2017, FE college funding and policy oversight were the responsibility of the ministry focused on business and industry rather than the Department for Education (or its predecessors). These changes in system complexity, mean a more heterogeneous system across phases and regionally, with more types of schools and colleges and more varied relationships with other schools and colleges both in their locality and across the nation.

In relation to how mathematics education is enacted, there is greater scope for variability; academies are not required to follow the national curriculum. However, in some multi-academy trusts (MATs) there can be more restricted and constrained approaches to teaching that can act as a barrier to innovation (Boylan, Adams, Coldwell & Willis, 2018). The related issue of increased variability in how the education workforce is trained is considered below in relation to teaching workforce supply and retention.

This partly follows from the increased system complexity, particularly the growth of MATs. Leaders from some MATs are positioned as important advisors to the government on various Department for Education review groups. One aspect of this complexity has been described as a 'shadow state' with various organisations funded by the government both enacting policy and also helping to shape it

(Ellis, Mansell, & Steadman, 2021). The outsourcing of state functions means that publicly funded teacher professional development, including in mathematics education, is undertaken, or led by a variety of actors in the market with state direction of form and content (Boylan & Adams, 2023).

Table 4 summarises a selection of the mediators and influence of system complexity across phases and how specific instances or effects of complexity influence mathematics education.

Table 4: System complexity - mediators and influences across phases

Phase	Mediators	Influences
Early Years	Reduced Local Authority support for EY settings CPD and guidance	Less maths specific CPD with training on phonics and children's personal development more common Gap opening in maths specific EY support with Maths Hub network focused on school provision increasing the tendency towards schoolification
Primary	Reduced Local Authority role and funding	Available free CPD focused on Mastery through Maths Hubs Primary schools buying into schemes – leading to overlapping curriculum and CPD ecosystems
Secondary	Growth of multi-academy trusts (MATs)	MAT mathematics education policies and processes Reduced local networks of department leaders
Post-16	Reduced Local Authority role and funding	Contributed to a loss of cohesion in local and regional networks

2. *Accountability measures*

Initiated in the eighties, with policies to promote 'parental choice' and school competition, since the early nineties, school accountability measures have been a central feature of the education system and a political lever to influence the system. These have included various measures for comparison of early years settings, schools, and colleges. The type of measures and how this data has been presented and accessed have changed considerably over time and been subject to critique (see, for example, Wiliam, 2010; Prior, Jerrim, Thomson, & Leckie, 2021).

For primary and secondary schools (including 11–18), these measures have more direct effects in terms of published outcomes. For early years, FE, and sixth-form colleges, the measures may work in more indirect ways. For example, outcomes measures influence Ofsted inspection frameworks and outcomes. Across all phases, accountability measures can lead to a narrowing of the curriculum and teaching to the test. Across different measures and continuing across time, mathematics is positioned as central to the curriculum.

Table 5 summarises a selection of the mediators and the influence of accountability measures across phases (where applicable)—that is, how specific instances or effects of accountability measures influence mathematics education. Accountability measures are not applied in the same way to post-16 settings. For 11–18 schools, A level results are reported. However, the influence on A level teaching appears relatively weak.

Table 5: Accountability – mediators and influences across the phases on mathematics education

Phase	Mediators	Influences
Early Years	Reception as part of EYFS and KS1 outcomes Phonics progress check	School settings – schoolification of Reception and school run/based nurseries Emphasis on phonics and so lower priority for Early Mathematics. Non-school settings tending to be insulated from accountability measures
Primary	KS1 and KS2 testing	Skew curriculum and teaching particularly in Y6 – teach to the test
	NC levels and sub-levels and their legacy and league tables including changing demographic targets of measures	'Flight path' view of mathematical learning Increase in setting and in class grouping (though more recently possibly reversed)
Secondary	Focus on GCSE and early entry and three-year KS4	Focus in KS3 on preparation for KS4 Pressure to focus on exam preparation and content
Post-16	*Not applicable*	*Not applicable*

3. *Ofsted and inspection frameworks*[5]

Since 1992 and the founding of Ofsted as a reform of the school inspection service, Ofsted has had considerable influence over education in England. The main way this occurs is through the inspection of schools and the importance of grading school quality (there is considerable literature about Ofsted's influence; for example, see McVeigh 2020 for review). Ofsted also influences schools through their evidence reviews; this is considered below in Section 6 on research and evidence-informed practice.

Table 6 summarises a selection of the mediators and influence of Ofsted across phases—that is, how specific instances or effects of Ofsted and inspection frameworks influence mathematics education. Across all phases, as a general influence, the general effects of performativity on teachers' practice are well documented (e.g., Ball, 2003). Further Education inspection was conducted by several bodies, from HMI to the Further Education Funding Council (FEFC) (1993-2001) and subject to inspection by two bodies, the Adult Learning Inspectorate and Ofsted (2001 – 2007) until the move to a single inspectorate, Ofsted, in 2007[6].

[5] The influence of Ofsted through reports is considered in Section 23 Warrants in policy development trends.

[6] https://www.aoc.co.uk/sites/default/files/Inspection%20and%20FE%20Colleges%20FINAL.pdf

Table 6: Ofsted - mediators and influences across the phases

Phase	Mediators	Influence
Early Years	Ofsted frameworks for EY inspection as descendants of school frameworks Inspection and grading	Schoolification
Primary	Inspection and grading	Lead to inertia to innovation, performative approach to teaching Focus on mathematics and English measures maintains priority for those subjects in terms of curriculum time and CPD focus
Secondary	Inspection and grading	Continue to drive pedagogy and practice. Innovations more likely to be accepted by senior leaders if they will impact positively on Ofsted inspections and examination results.
Post-16	Inspection and grading	Drives local performative practices of observation of teaching and learning

4. *Teaching workforce supply and retention*

We consider here generic issues of teacher workforce supply and retention, and whole system policies in initial teacher education, training, and qualification. Trends in mathematics education teacher professional development are discussed in the specific mathematics education teacher workforce section and case study ‘Teacher Subject Knowledge’.

England has longstanding issues with teacher supply and retention (see, for example, Worth & Van den Brande, 2019; Long & Denachi, 2021). The value of teachers’ pay adjusted for inflation has dropped for a decade, with teachers’ annual pay increases frozen for 2 years and then capped at 1% (Pyper et al., 2018). Teachers in England continue to report very high levels of workload, and the trend continues to be upward, indicating ongoing work intensification. This is linked to challenges with retention, with one third of teachers who start teaching after qualifying leaving within the first five years (Long & Denachi, 2021).

The last forty years have seen continual change in initial teacher education, spanning the establishment of the Council for the Accreditation of Teacher Education in the 1980s through the most recent ITT Market Review in 2021. This is an area of much policy research and review in which details of these changes have been described and analysed (e.g., Furlong et al., 2000; Sorensen et al., 2019).

Key changes over this period have been:

- The move from a teacher **education** model to a teach **training** model
- A reduced role and influence of Universities in ITE/ITT
- An increase in the number of training routes, limited subject specialist focus and uneven quality in some programmes
- An increase in the amount of time spent in school with an emphasis on practice contrasted with theory
- Increased central direction of content - e.g., the ITT Core Content Framework (DfE, 2019a) and the Early Career Framework (DfE, 2019b).

In Early Years there has been a counter tendency in Foundation Stage 1 (Nursery settings) to greater professionalisation and University involvement in courses.

Table 7 summarises a selection of the mediators and influences on teacher workforce supply and retention issues across phases—that is, how specific instances or effects of workforce issues influence mathematics education.

Table 7: Teaching workforce – mediators and influences across the phases

Phase	Mediators	Influences
Early Years	In Nursery settings professionalisation In school settings similar developments and consequences (Reception/Foundation Stage 2)	In Nursery settings professionals who may engage in CPD In school settings similar influences as in primary
Primary	Lack of time for mathematics specialist subject or subject pedagogical knowledge, also for preparation and CPD	Variable mathematics knowledge on entry to profession Lack of entrants with strong primary mathematics teacher identity. Ad hoc approach to use of curriculum materials
Secondary	Shortage of mathematics teachers, particularly in disadvantaged areas	Lower attaining groups often taught by non-specialists, impacting pedagogy and attainment. Places additional burden on in-school development and support including mentoring
	Increase in number of providers including smaller SCITTs	Can lead to 'lone mathematics trainees' with limited opportunity to learn from and with peers
	Changing and bursaries and financial incentives	Impact on recruitment patterns, retention, preparedness, early career progression
Post-16	FE initial teacher education – no subject knowledge component, lack of recruitment strategy,	Insufficient mathematics specialists. This strengthens the case for continued support from FMSP/AMSP Support has benefits wider than on post-16 teacher development/tuition.

5. Changing teacher professional conditions

The effects of accountability measures, such as the emphasis on league tables and Ofsted, combined with changes in school governance and greater prescription of curriculum and pedagogy, have an impact on teachers' professional conditions. There are long term changes to teachers working lives (Day et al., 2000; 2007; Galton & MacBeath, 2008). This has led to a general increase in teacher workload (Long & Denachi, 2021).

This has impacted teacher agency and autonomy. For example, in the primary and secondary phases, the National Strategy (see Part Seven) is an example of 'informed prescription' (Barber in Stobart & Stoll, 2005, p. 228).

6. Evidence and practice

Over the last twenty years and increasing in the last decade, there has been an increase in advocacy for 'evidence-based' or evidence-informed teaching (Coldwell et al., 2017). This is notwithstanding an arguable decrease in the use of evidence as the basis for policy (see Part Seven) or the extent to which what is claimed as evidence-based is when subject to critical scrutiny of what a focus on 'evidence' can mean in the education system (Biesta, 2010; Coldwell & Burnett, 2020). Notwithstanding this, discourses of evidence are important to influencing practice.

Four mutually influencing and interacting factors are:

1. the establishment of the Education Endowment Foundation as a 'What Works' centre, and its subsequent activity, including its guidance documents and Research Schools Network
2. The ResearchEd movement promoting a 'science of learning' approach to education
3. Various other actors responding to this by seeking evidence warrants for their educational views (for example Ofsted and its 2021 research review series: mathematics (Ofsted, 2021))
4. The legacy of the 'self-improving school system' in which Teaching School funding was predicated on engaging with research as part of core activity.

These four factors are applicable across practice as a whole and to varying extents. We do not identify specific mediators and influences with specific phases as we did for the previous four changes considered in this section.

One reason for this is the complex interplay between the extent to which evidence-informed practice represents either the application of evidence to practice or the rhetoric of evidence about practice. An example of this is the Ofsted Mathematics Research Review (Ofsted, 2021), where the extent to which it is based on a consideration of evidence is contested (see, for example, this analysis of the citations used in the Ofsted review – AMET, 2021). A similar rhetoric is found in the reference to 'best evidence' in the Initial Teacher Training Core Content Framework (ITT CCF) (DfE, 2019a) and Early Career Teacher Frameworks (DfE, 2019b). This 'best evidence' focuses on the application of cognitive science to education, popularised by the networks connected to ResearchEd.

Given the importance of the ITT CCF to the inspection of initial teacher training provision, what is proposed as evidence-based influences practises, including those of future teachers. However, the extent to which this leads to teachers engaging with evidence is more questionable. So, in the case of this aspect of change, the mediators and influences on practice are more diffuse.

These influences are also more variable and appear to be stronger in the primary and secondary phases than in EYFS and post-16. For example, the Education Endowment Foundation (EEF) has funded 10 programmes in the post-16 phase compared to nearly 100 in the secondary phase. In the early years, the professional conditions of the workforce (see Part 3) act as barriers to engagement with evidence.

7. Transnational influences

Compared to the previous six changes, the growth of transnational influences has been less significant in the education system. However, there have been both indirect and more direct influences on mathematics education. Important influences are listed below.

Transnational influences on system complexity and teacher workforce supply

In part, the changes in system complexity and on initial teacher education were influenced by policies in other education systems. Early development of academies was referenced to Charter Schools in the USA, and the Free School programme to Swedish free schools (Eyles, Hupkau, & Machin, 2016).

International comparisons as drivers and warrants

International comparative test outcomes have acted as both drivers (aiming to increase outcomes) and warrants (for system change). This is particularly true of the OECD's Programme for International Student Assessment (PISA) and its use as a justification for curriculum and system change after 2010. However, international comparisons were also important in the development and case for the National Numeracy Strategy (see Section 25). International comparisons on post-16 and advanced mathematics study were important in shaping support for A level study and incentives and penalties to encourage study post-16, for example, the Nuffield funded study by Hodgen et al. (2010). The 2014 national curriculum was designed to 'benchmark' against curricula in high-performing jurisdictions with a study undertaken of curricula in other jurisdictions (DfE, 2011) (see Section 24.3). Both the National Numeracy Strategy (see Section 24) and the Mastery Programme (see Section 26) were informed by mathematics teaching in other education systems.

PART THREE: Phases

In Part Three, the chronology of mathematics education in England is extended by consideration of educational phases:

- EYFS
- Primary
- Secondary
- Post-16

For post-16, in the noughties there was move in policy towards constructing policy in relation to 14-19. However, for simplicity such instances are discussed in both secondary and post-16.

For each phase, outcomes of the research are presented as:

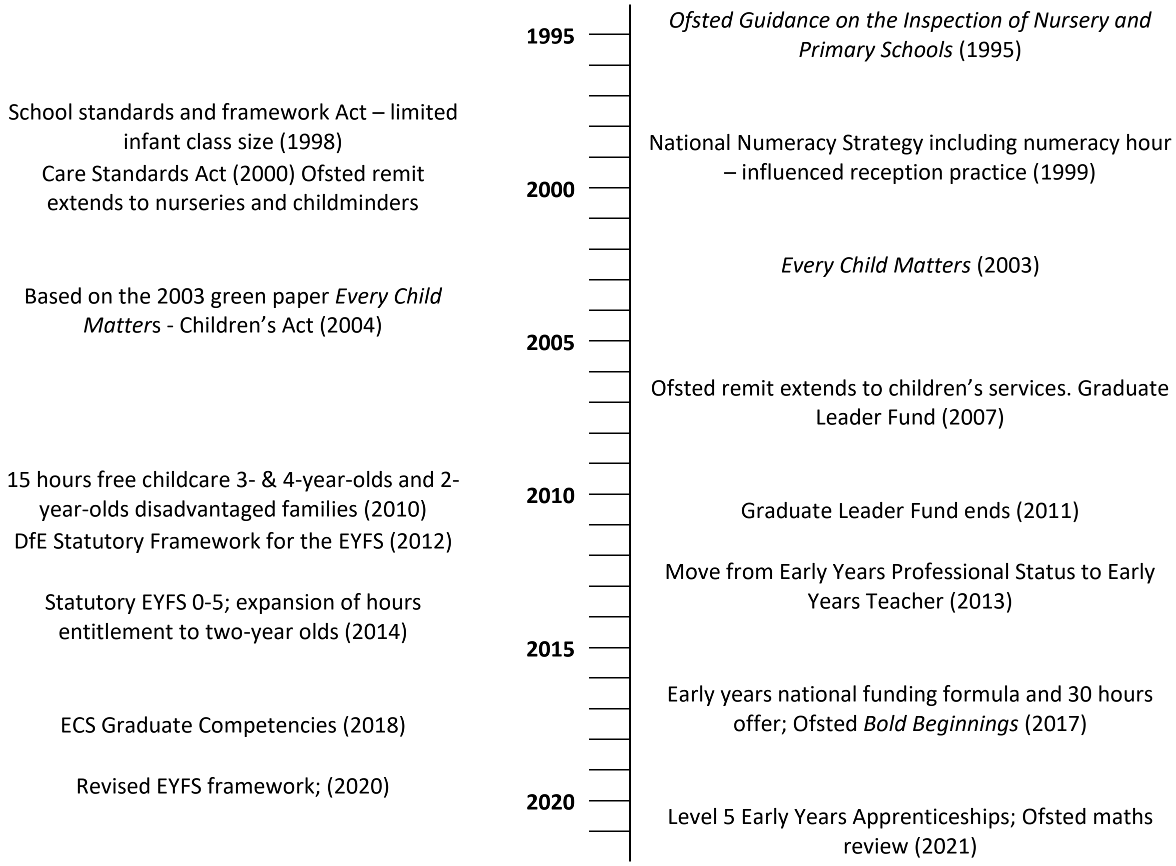
1. A visual timeline of the phase chronology by years
2. A summary of policy features, drivers, warrants and levers by time periods
3. Factors, developments and consequences, and current influences on mathematics education

7. Early Years

7.1 Early Years timeline of selected events

The Early Years Foundation stage was established on a statutory basis by the 2006 Childcare Act. The chronology for the EYFS, presented in Figure 4, includes events before this which influenced pre-school provision and early mathematical experience. The timeline starts from 1995 rather than 1980 as for other phases, this being the date when explicit guidance on inspection of Nursery schools was introduced as part of the establishment of Ofsted. The early years mathematics curriculum is described in the early learning goals (ELG).

Figure 4: Early Years from 1995 to 2021



7.2 Early Years Policy features and warrants, and drivers and levers across periods

Early Years: 1999-2010

Key features

- Early years increased as a policy priority but there was no national education framework equivalent to the national curriculum.
- In the nineties Ofsted's remit extended to nursery schools, but private provision, including childminders was originally outside the framework. In such provision the emphasis historically was on care rather than education, particularly in childminding (Brooker, 2016). The current remit of Ofsted was established in 2007.
- As the educational aspects of early years provision began to be emphasised a process of professionalisation of early years practitioners began which has continued in various ways

since (Bonetti, 2020; Campbell-Barr, Bonetti, Bunting, & Gulliver 2020). An important initiative was the Graduate Leaders Fund.

Drivers

- Importance of early years for future educational outcomes, for example, underpinning the Sure Start Centres development.

Warrants

- Every Child Matters 2003 – following the high-profile Victoria Climbié case.

Levers

- Children Act 2004
- Ofsted
- Funding for provision
- Funding for training and professional development (Graduate Leaders Fund).

Early Years: 2011-2021

Key features

- The introduction of the EYFS and an extension of funding for childcare
- A change in the balance of care and education within policy documents moved towards greater emphasis on education
- Similarly, within educational aspects, a shift from a focus on child development to concepts such as school readiness, so increased schoolification
- Mathematics in the Early Learning Goals has narrowed in the most recent version to a focus on number and number pattern.

Drivers

- Addressing attainment gaps and differences in home learning environments
- Workforce availability particularly of women
- School 'readiness'.

Warrants

- National frameworks.

Levers

- National frameworks and guidance
- Ofsted
- Free childcare hours for parents
- A minimum GCSE workforce requirement (but there is evidence this was counterproductive – Bonetti, 2020).

7.3 EYFS: Factors, developments and consequences, and influences on mathematics education

The chronology and narrative of features, drivers, warrants, and levers do not give a full picture of change in the sector. In addition to the statutory policies, Table 8 below summarises influences on EYFS practice, that have directly or indirectly influenced EY mathematics education. Many of these are interconnected and mutually reinforcing. All these influences, in different ways, have a tendency towards ‘schoolification’ (Bradbury, 2019) of EY mathematics, which may be counterproductive to later mathematics attainment (Williams, 2018).

Current changes and policies are likely to continue the influences and trends identified above, along with additional factors, such as baseline assessment, contradictions or tensions between Ofsted and DfE policy, and other influences on practice, such as the NCETM. Examples of possible unintended consequences continue. For example, the primary textbook subsidy and a focus on textbooks led to publishers extending textbook-based schemes into reception and using the same or similar pedagogical forms such as slide presentations and worksheets.

Table 8: Factors currently influencing Early Years mathematics education

Factor	Consequences	Influence on mathematics education[7]
Funding	Creation of more school-based nursery provision	'Schoolification' with NC content influential and tendency to early formalisation of teaching and learning, and greater intervention on provision by school senior leaders who may not have maths expertise
Funding	Pressure on salaries in the sector	Qualifications and skills of professionals – including mathematics qualifications and confidence, tending to perpetuate a tendency to practitioners having had negative maths experiences
Funding	Time-pressure on EYFS practitioner/teachers; limited resource for 'extra'	Lack of CPD in general and particularly in maths
'30 hours' offer	Tendency towards alignment of Foundation Stage 1 and Foundation stage 2 (reception)	Changes in organisation of the day tended towards schoolification
National curriculum assessment approaches	Sub-levels and flight paths in schools supported a 'tick box' approach to Early Learning Goal assessment	Lack of holistic approach to mathematics related ELGs; tendency against inclusion of all learners – emphasis on exceeding; tendency towards acceleration of learning
Ofsted govt phonics and early reading policy	Focus on phonics in language and number in maths	Mathematics related ELG less important as a focus in practice compared with phonics Number orientated practice
Curriculum trends since EYFS introduction in 2012	Increased emphasis on number, and in that memorisation, and less on shape, space, and pattern – not present in the current EYFS ELGs.	Narrowing of the curriculum and less emphasis on experiential learning and mathematical play Move away from evidence-based practice
Misunderstanding of Early Maths	Lack of knowledge of EYFS and mathematics in DfE and policy makers/influencers	Policies/guidance from DFE EY and Ofsted teams lacking depth of knowledge of mathematics
Misunderstanding of Early Maths	Lack of understanding amongst practitioners of EY maths combined with desire to resist schoolification	Mathematics associated with formal teaching, lack of understanding of what early mathematics means, anti-schoolification resistance can slip into negative views of side-lining of mathematics

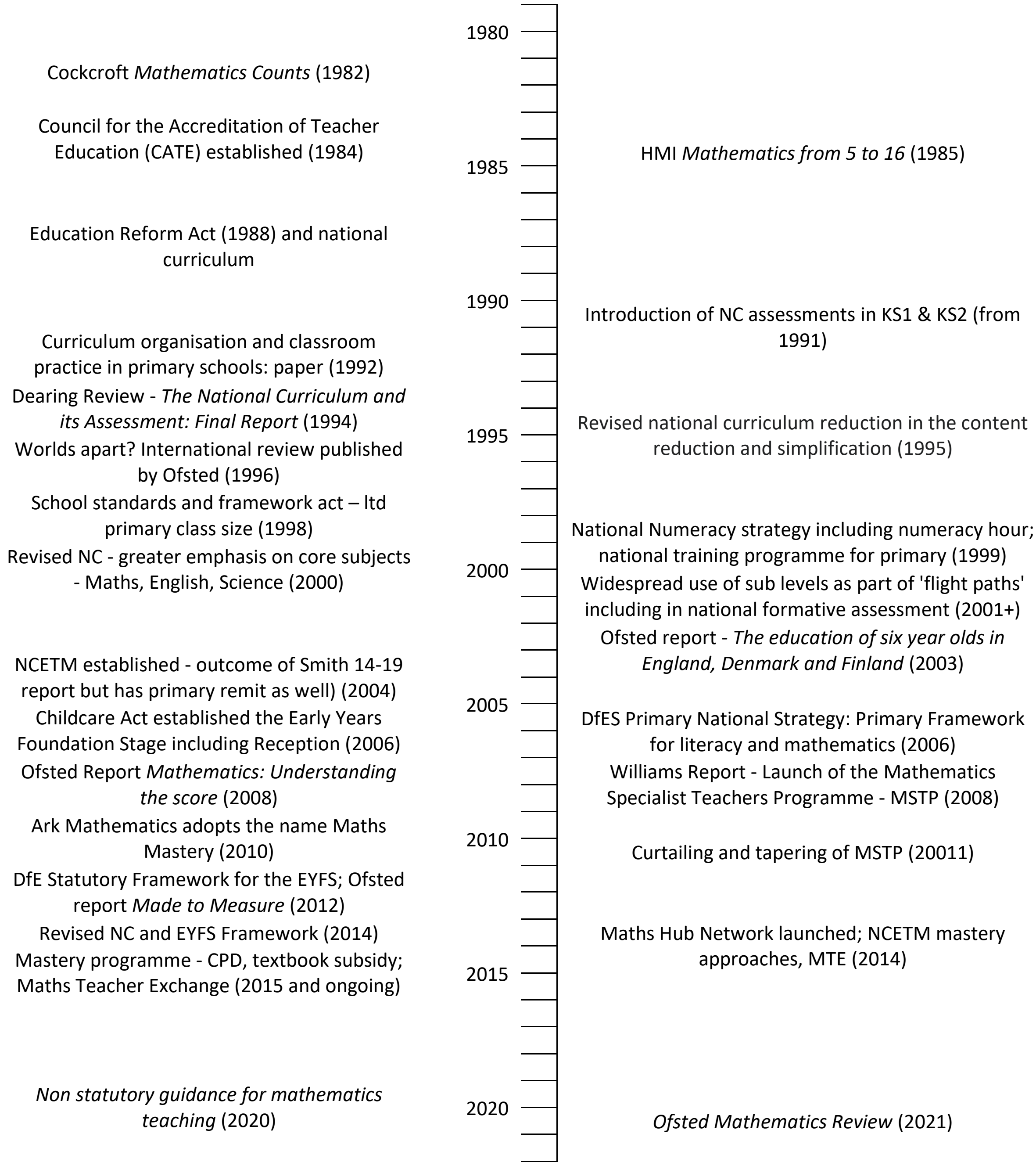
[7] Note that these influences and consequences would be more or less apparent across settings

8. Primary education

8.1 Primary chronology

Figure 5, below, details key events and relevant milestones to primary from 1980 to 2021.

Figure 5: Primary events and milestones from 1980 to 2021



8.2 Primary Policy features and warrants, and drivers and levers across periods

Children in England generally start school at age four and must start full-time education from compulsory school age following their fifth birthday[8]. The national curriculum is organised into Key

[8] https://www.gov.uk/schools-admissions/school-starting-age

Stages, with primary education encompassing reception (ages 4-5), Key Stage 1 (5-7) and Key Stage 2 (7-11). The above timeline includes curricula and workforce milestones impacting mathematics education. From 2012, the initial year in school for 4–5-year-olds - 'Reception' - was part of the EYFS.

Primary: 1980-1989

Key features

- The focus in primary during this period was on curriculum development, with the Cockcroft Report being influential. The government funded the Primary Initiatives in Mathematics Education project, 1985-89 (Shuard et al., 1990).
- In some geographical areas, in the absence of a national curriculum, there was local government curriculum and pedagogy policy. Various Local Authority and regional schemes and initiatives such as the LAMP and RAMP project (West Sussex Institute, 1987 cited in Millett, 1996), Kent Maths Project and South Notts Project.

Drivers

- Improve mathematics teaching
- Employers and higher education concerns

Warrants

- *The Cockcroft Report*
- HMI Mathematics from 5 to 16
- Government support for Primary Initiatives in Mathematics through the School Curriculum Development Committee and completed under the auspices of the National Curriculum Council.
- Evidence such as Concepts in Secondary Mathematics and Science (CSMS) study - origins of the idea of a seven-year difference (Brown, 2014)

Levers

- Curriculum development projects

Primary: 1990-1998

Key features

- Implementation of the national curriculum, including 'Using and Applying' mathematics
- National assessment and testing including mental arithmetic assessment
- The curriculum recognised the importance of calculator use and did not recommend particular pedagogies – focusing on the what rather than the how of mathematics education
- The initial curriculum structure and assessment was reformed and simplified

Drivers

- Arithmetic skills
- Establish the national curriculum
- Establish national assessment and testing
- Address workload concerns

Warrants

- The National Curriculum
- *Curriculum organisation and classroom practice in primary schools* report (1992)
- *Worlds apart? Ofsted Reviews of Research* (1996)

Levers

- The National Curriculum
- Statutory assessment and testing including informing Ofsted judgements
- Publication of KS1 and KS2 outcomes

Primary: 1999-2010

Key features

- The National Numeracy Strategy reformulates primary mathematics as numeracy
- National Curriculum revisions to align with/informed by the National strategies.
- National Curriculum levels and sub-levels and 'flight paths' for pupils with expected outcomes
- Teaching and pedagogy focused on whole class interactive teaching and a focus on mental arithmetic.
- The Mathematics Specialist Teachers (MaST) programme (following the Williams Report)

Drivers

- Economic competitiveness
- Focus on numeracy and numerical competence – 'basic skills'
- Address inequality and differences in school performance
- Primary teachers' mathematics subject knowledge

Warrants

- Worlds Apart – international comparisons
- Ofsted reports *'The education of six-year-olds in England, Denmark and Finland*' (2003) and '*Understanding the score*' (2008)
- The Williams Report (2008)

L**evers**

- Ofsted
- Local Authority school improvement
- National strategies infrastructure, training and guidance documents, Strategies consultants, school-based Numeracy Coordinators
- NCETM
- Primary Mathematics Specialists trained by collaborations of HEIs and Local Authorities.

Primary: 2011-2021

Key features

- In the first half of this period, in the context of austerity, there was reduction in funding for mathematics professional development as promoted in the Williams report. This led to the curtailment of the new Mathematics Specialist Teachers (MaST) programme
- Increased politicisation of policy: government discourse positioned both local authority consultants and university-based mathematics educators as part of the 'blob' (Gillard, 2015). The policy rhetoric focused on 'traditional' curriculum
- The 2014 curriculum reform saw the end of national curriculum levels and the flight path system of sub-levels
- The 2014 curriculum gave greater emphasis on number and arithmetic with a reduction in content at primary level in other areas of mathematics
- Emphasis on knowledge and content as important to understanding and application in primary
- Central to policy developments in the second half of the period was 'Teaching for Mastery' (see the illustrative case in Part Seven) and the development of Maths Hubs, and a changed role for the NCETM (see NCETM case study, Part Six)
- Both the mastery policy and the statement in the 2014 curriculum supported arguments to increase all attainment teaching in mathematics in primary schools (see Boylan et al., 2019).

Drivers

- Improve mathematical attainment
- Improve mathematics teaching
- Increase whole class teaching
- Emphasise knowledge in the curriculum
- Learn from high-performing systems
- Reduce the influence of higher education

Warrants

- Vorderman (2011) 'A world class mathematics education for all our young people' report
- National Curriculum Review. The Framework for the National Curriculum (December): report of the advisory panel chaired by Tim Oates
- Wolf "Review of vocational education" and DfE funded Report on subject breadth in international jurisdictions (NFER)
- DfE study visits to Shanghai that were a precursor to the Mathematics Teacher Exchange (see Boylan et al., 2019)

Levers

- The new national curriculum
- NCETM and Maths Hubs
- The Mastery programme – Mathematics Teacher Exchange, Primary Mastery specialists, NCETM support and materials including concepts/frameworks, materials, resources, CPD
- Textbook subsidy
- Ofsted

8.3 Primary: Factors, consequences, and influences on mathematics education

Table 9, below, summarises legacy influences on primary mathematics education practice. By 'legacy influence' we mean the effects of policies that are no longer in effect but continue to influence primary mathematics education today.

Table 9: Factors influencing primary mathematics education: Legacy influences

Factor	Consequence	Influence on primary mathematics education
National Numeracy strategy	Three-part lesson History of manipulatives, concrete models	Three-part lesson as an obstacle to a mastery lesson structure. Warrant for whole class teaching Manipulatives – warrant for Concrete Pictorial Abstract heuristic
National curriculum assessment levels, sub levels and flight paths	Strong beliefs and practices around pupil progress Legacy of levels/sublevels despite removal	Re-interpretation of 'greater depth' as equivalent to old 'high ability' School and MAT level systems for tracking pupil progress
Primary Mathematics specialist programme	PMST alumni roles as SLT, in Maths Hubs, and as early adopters of mastery	Champions of mastery in primary school SLT A cadre of primary mathematics specialists who took professional development leadership roles
Primary Mathematics specialist programme	Masters study in primary mathematics	Some MaST programmes continue as PG Cert programmes e.g., Brighton, Edge Hill, Northampton

Table 10, below, summarises influences on primary mathematics education in 2021.

Table 10: Factors influencing primary mathematics education in 2021

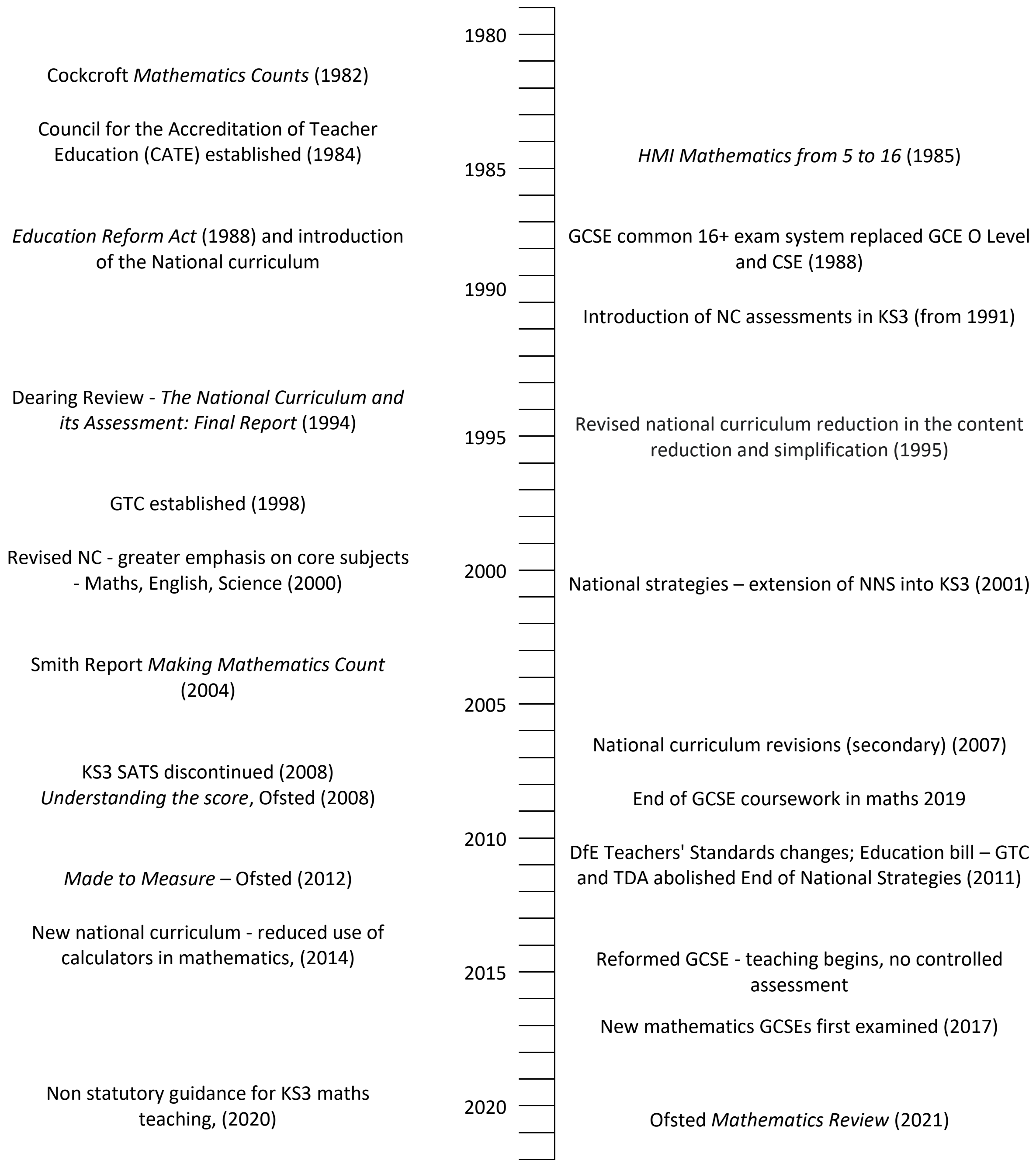
Factor	Developments and consequence	Influence or potential influence on primary mathematics education
Mastery policy (1)	Mastery pedagogy – (NCETM big ideas, models and representations more broadly, step by step approach)	Influencing shift from ability grouping to discourses and practices focussed on attainment
Mastery policy (2)	Mathematics Teacher Exchange (MTE)	Introduction/adaptation of Shanghai practices. Offered insight into alternative policies and practices that may encourage innovation
Mastery policy (3)	Mastery Specialist professional development	Cadre of mastery specialists contributing to developing practice through local and regional Maths Hub networks
Mastery policy (4)	Textbook subsidy – since first MTE, use varies	May support teacher development and the use of mathematically coherent approaches but research evidence is limited
NCETM Maths Hubs	Support for school/college led improvement of mathematics education	Collaborative curriculum, pedagogy and professional development activities instigated by teachers, together with projects coordinated centrally, many focussed on Mastery. Free mathematics professional development available
Marketisation of Professional development	Multiplicity of mathematics resources and CPD. Resources often available online without associated CPD	Variable quality and considerable variety of curriculum materials in school
Policy concern with basics	Introduction of Year 4 times table check	Skews learning of mathematical facts towards multiplication facts, emphasis on speed
Curriculum 2014 (1)	Reduced curriculum content. Aims of fluency, reasoning, problem solving	Warrant for mastery approaches
Curriculum 2014 (2)	Commitment to move through curriculum together	Support trends towards all-attainment teaching in primary schools

9. Secondary education

9.1 Secondary chronology

Figure 6, below, details key events and milestones relevant to secondary mathematics from 1980 to 2021.

Figure 6: Secondary phase milestones from 1980 to 2021



9.2 Secondary: Policy features and warrants and drivers and levers across four time periods

Secondary: 1980-1989

Key Features

- Curriculum development and teacher professional learning were linked through teachers' active roles in school curriculum policy development.
- The influence of the Schools Council was evident in the continuation of local and national initiatives from the 1960s and 1970s, including the School Mathematics Project (SMP) and SMILE mathematics.
- The introduction of GCSE as a single combined examination at the end of the period led to coursework as part of assessment for pupils across the attainment range.

Drivers

- Cockcroft Report argues that mathematical learning is needed for engaging in further and higher education, employment and adult life.
- Few central drivers, but a general commitment to curricula enhancement at a local policy level, such as a commitment to equity (e.g., ILEA support for SMILE mathematics with a focus on all attainment teaching) and improving practice.
- Technological changes with calculators more widely available and the introduction of computers.
- Opposition to progressive initiatives evidenced in Thatcher's 1987 speech to the Conservative Party conference where anti-racist mathematics is set against basic mathematical skills in the argument for traditional subjects.
-

Warrants

- Reports – Cockcroft, HMI Mathematics 11-16.

Levers

- Funding models supporting local initiatives.
- High levels of teacher agency and professional autonomy to support curriculum development.
- Cockcroft Report proposes the introduction of financial incentives and flexible routes for teacher education and some introduction of these e.g., two-year PGCE mathematics routes, two-year BSc.
- Tracking of mathematics teacher qualifications to improve teacher quality.

Secondary: 1990-1998

Key features

- In this period, curriculum was again in focus, but now through the centrally mandated national curriculum.
- Assessment and testing were aligned to the new NC and to the newly introduced GCSE, with some opportunities for teachers to design and manage assessment methods and forms e.g., coursework.
- Assessment of mental arithmetic in KS3 tests.

- The introduction of league tables and Ofsted began to impact on school practice.
- Reduced teacher autonomy, increase in control and accountability.

Drivers

- "Standards" – including mental arithmetic
- Transnational comparisons
- Address workload concerns with simplification of the curriculum

Warrants

- The national curriculum

Levers

- The national curriculum,
- Assessment and testing
- League tables
- Ofsted
- Local levers – LA school improvement staff

Secondary: 1999-2010

Key features

- The focus shifted to teaching with the introduction of the National Strategies.
- Greater emphasis on arithmetic in the curriculum, although the secondary subject continued as mathematics rather than numeracy.
- The use of ICT and particularly calculators continued to be embedded in the curriculum. Rapid changes in employment patterns and practices in ICT use not matched in education.
- The Key Stage 3 Strategy including the mathematics framework, briefly piloted in mathematics in 2000 and introduced the following year built on the Primary Numeracy Strategy.
- Subsequent revisions to the national curriculum (2014) emphasised fluency, mathematical reasoning and problem solving. In policy, basic skills were emphasised at secondary level with the setting of minimum performance levels.
- There was an increase in school-based ITT and various approaches to addressing professional development needs of non-specialist teachers of mathematics and to increase the supply of teachers with mathematics teaching qualifications.

Drivers

- Raising "standards"
- Choice and diversity - 'personalised' learning agenda
- Address inequality and variation in school performance
- Skills agenda
- Scientific and industrial research and development, the 'knowledge economy' including finance and ICT industries, employment opportunities (see Smith, 2004)
- Ensuring qualifications meet the needs of employers and HE

- Shortage of specialist mathematics teachers

Warrants

- Smith (2004)
- Ofsted – indirectly through frameworks (See Section 6) and directly through reports, e.g., *Understanding the score* (2008), this was influential in a shift towards teaching for understanding, together with a subsequent report (Ofsted, 2012).
- Rapid implementation of the National Strategies in secondary was justified by evidence of a dip in students' performance in the early secondary years (Stobart & Stoll, 2005), the perceived success of the NNS in primary schools, where substantial increases were reported in the numbers of students achieving the expected standard analysis.

Levers

- Local Authority inspection and advisory service
- Professional development (Key Stage 3, Secondary National Strategies, NCETM, Local authority)
- National curriculum revisions
- National curriculum levels and sub levels and related 'flight paths'

Secondary: 2011-2021

Key features

- The focus on Key Stage 3 in the previous period through the National Strategies waned and the end of KS3 SATS in 2008 and accountability pressures led a widespread move to 3-year KS4 with start of GCSE courses in Year 9 (56% of schools in a 2019 survey)[9].
- Early entry to mathematics GCSE, a trend resulting from the inclusion of mathematics as one of the five GCSEs in performance tables, caused concern, reducing progression to A level. This prompted a change in policy that meant that only the first sitting of the GCSE counted in a school's performance tables[10].
- In the second half of the period, discourses of knowledge rich curriculum and cultural capital influenced the Ofsted inspection framework and general educational discourse, though this was less apparent in mathematics education.
- Also, in the second half of the decade, issues with the transition from primary to secondary remained, and together with concerns that progress stalled in Key Stage 3 led to a renewed focus on this period.

Drivers

- Increased participation in higher level mathematics
- International competition in mathematics outcomes
- Mathematics outcomes linked to national economic performance

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

[10] https://www.gov.uk/government/news/changes-to-early-entry-at-gcse

- Pupil premium, social mobility and 'catch up' - "ensure more children from poorer backgrounds catch up with their peers"[11]

Warrants

- DfE (2011) research report 'Early entry to GCSE examinations'[12]
- PISA 2012 results[13]
- Ofsted (2015) 'Key Stage 3: the wasted years'[14]

Levers

- Reformed GCSE and end of early entry to GCSE
- Ofsted frameworks focus on curriculum
- mastery programme in secondary
- Maths Hubs
- NCETM
- Changes in accountability measures such as EBacc and Progress 8

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[11] https://www.gov.uk/government/speeches/2012-oecd-pisa-results

[12] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/184109/DFE-RR208.pdf

[13] https://www.gov.uk/government/speeches/2012-oecd-pisa-results Note that apparent 'drop' in mathematics is unreliable as previous results in England were withdrawn by OECD due to sampling concerns.

[14] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/459830/Key_Stage_3_the_wasted_years.pdf

9.3 Secondary: Factors, consequences and influences on mathematics education

Table 11, below, shows factors and influences on secondary mathematics education.

Table 11: Factors currently influencing secondary mathematics education

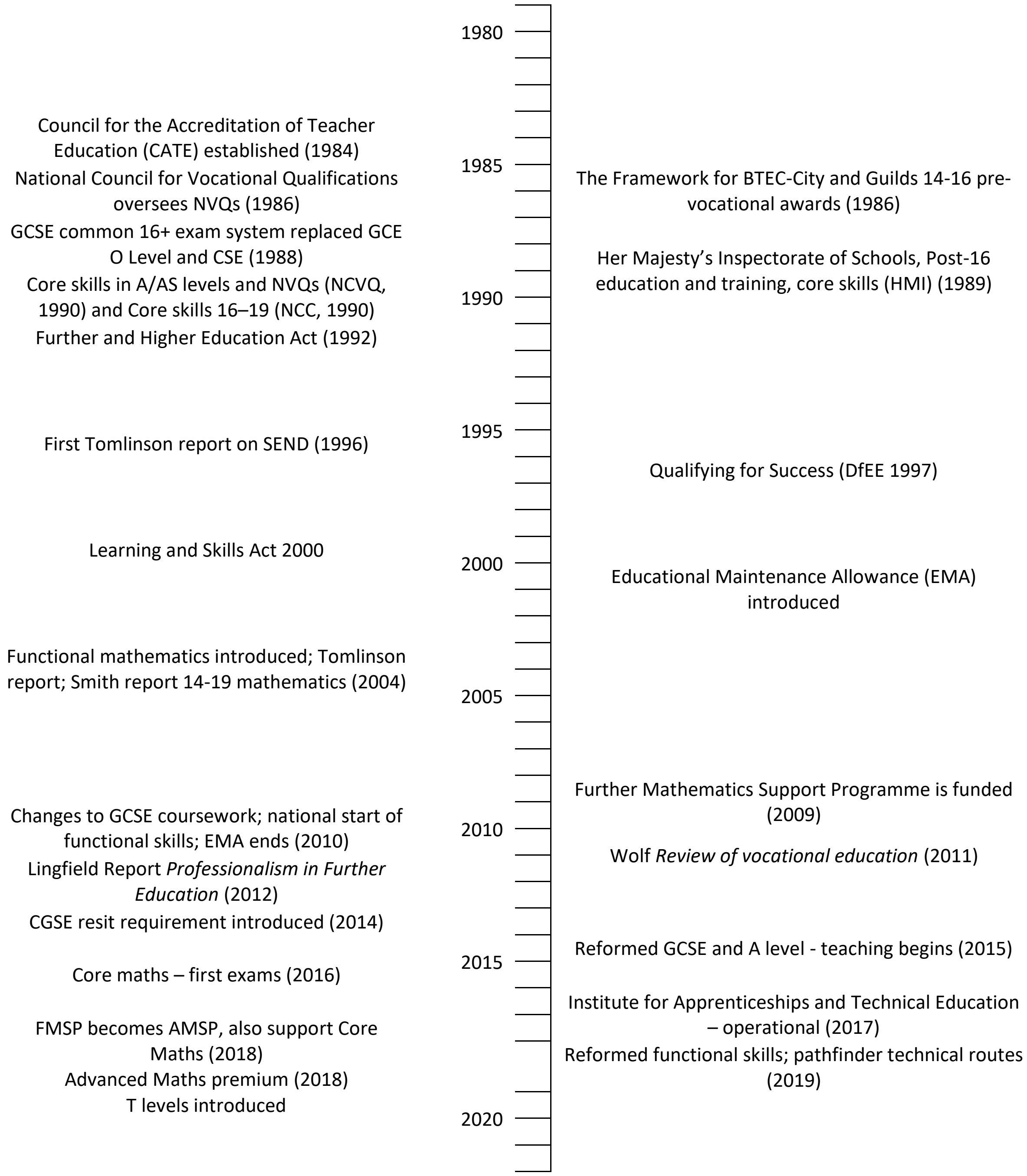
Factor	Consequences	Influence on mathematics education
Qualifications & league tables	GCSE – changes to assessment including growth of then ending early entry, coursework, inclusion of mathematics in league tables, move to linear courses with terminal assessment	Raised the profile and stakes for mathematics GCSE and equivalent qualifications
Funding	Pupil premium, core maths, advanced maths premium	Funding impacts on senior leaders, helps to prioritise mathematics. Money used to develop bespoke responses to school needs. Changes at post-16 influence school leaders to focus on level 2 students, aiming to increase participation at level 3
National curriculum & assessment (1)	Key Stage 3 – ending of SATs	Combined with league table pressure leading to early entry and early start to GCSE courses – effectively a three-year KS4
National curriculum & assessment (2)	Removal of national curriculum levels from 2014 Key Stage 2 change in emphasis including focus on times tables, mastery	Adaptation of schemes of work in secondary to meet changing student skills, knowledge and need and year-based curriculum
Teacher professional development (1)	Academy/free school policy reduced opportunities for teachers in these schools to engage in external collaborative professional development	Some Academies/MATS prescribe restrictive teaching and development approaches
Teacher professional development (2)	Centres for Excellence, Maths Hubs, NCETM	Collaboration between centres to support schools/colleges
Teacher professional development (3)	Signs of a shift back to subject specific professional development from more generic	Potential to support teachers in departments to collaborate (e.g., on development and planning) and to facilitate networking and collaboration across institutions

10. Post-16 education

10.1 Post-16 chronology

Figure 7, below, details key events and milestones relevant to post-16 mathematics from 1980 to 2021.

Figure 7: Post -16 phase milestones from 1980 to 2021



10.2 Post-16: Policy features, drivers warrants and levers across four time periods

There is no statutory curriculum, so and what is taught is determined by examination syllabi. Post-16 mathematics can be categorised by the learning level of courses and qualification:

- Level 3 (A level and equivalent)
- Level 2 (GCSE equivalent but also comprising other qualifications with mathematical study)
- Level 1 and/or other mathematics and numeracy skills (often as part of other qualifications)

Another way of categorising courses and qualifications is as either

- Academic (general study of mathematics not linked to specific professions or employment)
- Or vocational (study of mathematics in contexts of professionals and employment)

While there is a relationship between these two categories, there is not a direct correspondence. This creates a complex post-16 picture. A (and A/S) level mathematics as the principal and most common level 3 academic mathematics qualifications have been subject to reform as part of Curriculum 2000 and, more recently, a rolling back of these reforms. However, even when reformed, A levels had similar mathematical content and generally, in mathematics, had the acceptance and support of a wide range of stakeholders. In contrast, vocational and technical mathematics—of whatever qualification level—have been subject to repeated reports, initiatives, and reforms, with an overall picture of instability in policy and also enactment given the complexity of the post-16 environment (Dalby & Noyes, 2018).

Because of the different categories of mathematical qualifications and study in post-16, the description of features, drivers, warrants, and levers is more extended than for other phases. There are two particularly relevant case studies: Core Maths and the Further Mathematics Support Programme, Post-16: 1980-1989.

Key features

- The establishment of the National Council for Vocational Qualifications to oversee National Vocational Qualifications (NVQs) in 1986, and, in the same year the development of the BTEC (Business and Technology Education Council) qualifications framework were important in determining the mathematics experience of the majority of students who were not taking A levels.
- Overall, there was increased participation in post-16 education (Young & Spours, 1998).

Drivers

- Increase the proportion of young people engaged in post-16 study.
- Employers' concerns

Warrants

- Economic and employment needs

Levers

- National council for voluntary qualifications
- BTEC framework
- Funding for Technical and Vocational Education Initiative (TVEI) for 14–18-year-olds was launched in 1982

Post-16: 1990-1998

Key features

- The increase in participation in post-16 education seen in the eighties continued in the early nineties, beginning to plateau in the mid-1990s (Young & Spours, 1998).
- As growth in participation slowed and concerns were raised about attainment declining, the Dearing review of 16–19 qualifications was established (Dearing, 1996). This review examines these issues and considers how best to prepare young people for work and higher education. The remit included a focus on maintaining the rigour of A levels and a review of the General National Vocational Qualifications (GNVQs) and National Vocational Qualifications (NVQs).
- When the Labour government came to power, Qualifying for Success (DfEE, 1997) was published, notably broadening the curriculum and leading to the Curriculum 2000 reforms. In addition to breadth, Curriculum 2000 was underpinned by principles of progression, flexibility, key skills, and status, with the latter aiming to raise the status of vocational qualifications. It introduced AS levels, new A level specifications, and Key Skills. Concerns raised about the reforms, notably those focused on implementation, support, and the burden of assessment, prompted changes.
- Free Standing Mathematics Qualifications (FSMQs) were developed and piloted in 1998–2000. They were designed to meet the needs of those who hadn't achieved a GCSE pass, were on vocational courses, or needed some mathematics to support their A level choices.

Drivers

- Desire to continue to expand participation for workforce reasons and general desire to improve qualifications of young people
- Concerns about attainment outcomes

Warrants

- Dearing review of 16-19 qualifications established (Dearing, 1996), responding to concern over declining participation and attainment, demands of employers and higher education.
- Qualifying for Success (DfEE, 1997)

Levers

- The establishment of the Further Education Funding Council (FEFC) in 1992 was used to 'to drive down unit costs and expand learner numbers in FE' (Steer et al. ,2007, p.179).
- Changes to qualifications and to their assessment and to funding, notably broadening the curriculum and leading to Curriculum 2000 reforms.
- Social welfare levers use to encourage increased post-16 participation.

Post-16: 1999-2010

Key features

- Curriculum 2000 GCE A levels were modular and in two parts, with AS taken at the end of one year of study, and A2 at the end of a second year. The aim was that students would study more subjects in the first year of study post-16 before focussing on a smaller number of A levels.
- Following the introduction of Curriculum 2000, issues with the mathematics qualifications at A/AS level rapidly became apparent. Difficulties with AS mathematics were raised in 2000/1, notably a low pass rate compared with other subjects and a decline in entries. Revised specifications were drawn up, first taught from 2004, to counter declining entries in AS, A

level mathematics and A level further mathematics. Changes included removing A2 core content from AS mathematics and reducing the number of applied units (statistics, mechanics, or discrete mathematics) from 3 to 2 in any mathematics A level.

- The Smith Inquiry, commissioned in 2002, reflected continuing concerns about participation and attainment in mathematics, emphasised by comparisons with other countries.
- Running parallel to the Smith Inquiry was a working group on 14–19 curriculum and qualifications reform in England, chaired by Mike Tomlinson. This proposed a diploma framework for 14–19 qualifications; however, this was not taken up in policy.
- Free Standing Mathematics Qualifications (FSMQs) were developed and piloted in 1998–2000 and introduced for the first time in 2001 with 11 titles (3 at level 1, 5 at level 2, and 3 at level 3). At the time of the Smith report (2004), the number of entries was growing, and although FSMQs were viewed as an appropriate offer, funding, small classes, and a limited profile were clear obstacles to their adoption.
- There were widespread concerns about the number of students retaking GCSEs without improving their grades. A feature of the three-tier GCSE structure was that grade C was not accessible to all and was not aligned with the two-tier curriculum structure. The Inquiry recommended that GCSE maths be redesignated a double award, with modifications as necessary (Smith, 2004) (see case study: The 'forgotten third').

Drivers

- The needs of employers and higher education: existing qualifications were seen as not meeting the needs of the workforce or HE ('the rise of information technology has increased the range of mathematics needed to perform competently in the workplace' (Smith, 2004, p. 91).
- Aiming to raise the status and quality of vocational qualifications informed by principles of progression, flexibility, key skills, breadth, and status.
- Evidence of the low participation in mathematics post-16.
- A need for mathematics specific CPD (Smith, 2004).

Warrants

- Smith Report (2004)
- Tomlinson report (2004).

Levers

- Qualifications and assessment changes
- Funding changes

Post-16: 2011-2021

Key features

- Smith's review of mathematics education post-16: The report recommended a review of 16–19 funding to eliminate disincentives to mathematics. It proposed increasing incentives for AS and A level Further Mathematics and providing incentives for Core Mathematics. Incentives were subsequently increased in 2019.
- Qualifications were reformed with changes in funding that led to a decrease in the number of students taking AS Mathematics.

- The Advanced Maths Premium (Education and Skills Funding Agency 2018), introduced in 2018, provided funding for each additional student taking mathematics (above a baseline).
- Technical education continues to be relatively neglected in this period, despite some agreement that the needs are greater (Hodgen, Wake & Dalby 2017; Report of the Independent Panel on Technical Education, 2016[15]).
- The Wolf report in 2011 was very influential. It marked a clear break with approaches to developing 14–19 pathways, including in vocational education.
- The Wolf report also influenced, from 2014, a new policy intended to support progression to further study and employment that required 16–19-year-olds without grade C to continue study of mathematics, with those with grade D (now grade 3) required to retake GCSE (a condition of funding[16]).
- The DfE FE workforce development programme, launched in April 2013 to address FE workforce challenges arising from policy changes, including those relating to maths, English, and supporting learners with SEND, aimed to create an additional 2,500 maths teachers and 2,600 English teachers with the skills to deliver GCSEs by the end of the 2015/16 academic year (Zaidi, Howat & Rose, 2018).
- The shortage of specialist mathematics teachers continued. Smith (2017) called for the DfE to collect further data, specifically on the qualifications of the workforce teaching mathematics and numeracy in FE.
- Teachers have difficulty attending subject-specific CPD e.g., schools and colleges face challenges in releasing teachers to attend AMSP courses (Walker et al., 2020).
- There is some indication of positive developments resulting from the COVID-19 pandemic, with teachers increasing engagement with online professional development and providers, notably AMSP, NCETM, and NRICH, all seeing increases.

Drivers

- Continued demand from employers and HE for increased mathematical understanding and applications numbers leaving education at 18 with no Level 2 Maths qualification, e.g., 'the increasing importance of mathematical and quantitative skills to the future workforce' (Smith, 2004, p.2).
- Professional development needs of the FE mathematics teaching workforce, e.g. 45% of respondents to a large-scale survey did not hold a mathematics or numeracy qualification. (Noyes, Dalby & Lavis, 2018).
- Access to University, e.g., Mathematics and Further Mathematics as Facilitating A Levels.

Warrants

- Wolf Report (2011)
- Smith Report (2017)

Levers

- Funding (condition of funding, Advanced Maths premium)

15 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/536046/Report_of_the_Independent_Panel_on_Technical_Education.pdf

16 https://www.gov.uk/guidance/16-to-19-funding-maths-and-english-condition-of-funding#summary

- Ofqual, established in 2010, regulated qualifications, examinations and assessments in England and led A level reform
- Education and Training Foundation activity.

10.3 Post-16: Factors, consequences, and influences on mathematics education

Table 12, below, shows factors and influences on Post-16 mathematics education.

Table 12 Factors currently influencing secondary mathematics education

Factor	Consequences	Influences on mathematics education
Continued academic/vocational divide	Inequality in funding and provision	Level 2 courses and below may be seen as not requiring mathematics specialist Prioritisation of level 3 qualifications and support
Assessment and qualifications (1)	A level reform and A/S level structure	impacted negatively on mathematics up take
Assessment and qualifications (2)	Several unsuccessful initiatives in technical and vocational education	Low engagement and attainment remain issues
Funding (1)	Requirement for those without GCSE grade C to continue to study mathematics, with low repeat examination success rate	Increase demand for specialist mathematics teachers. Prioritisation of mathematics in schools/colleges
Funding (2)	Advanced maths incentives	Support continued activity and offers
Funding (3)	Funding in FE generally viewed as inadequate	Barriers to teacher engagement in professional development

PART FOUR: Purpose, values, and systems

Part Four reviews policy drivers in mathematics education and how these have changed across time and by phase. Drivers are considered in relation to educational ideologies.

11. Purpose and values

11.1 Drivers: patterns across time by phase

In this section we summarise the drivers from each phase across each time period. The first two periods do not have the EYFS drivers.

Period 1: 1980-89

The table below summarises mathematics education policy drivers for the period 1980-1989

Table 13: Mathematics education drivers for 1980-1989

Phase	Drivers
Primary	Improve mathematics teaching Employers' and higher education concerns
Secondary	Cockcroft Report mathematical learning needed for engaging in "further and higher education, employment and adult life" (p. iv). Few central drivers, but a general commitment to curricula enhancement at a local policy level, such as a commitment to equity (e.g., ILEA support for SMILE mathematics with a focus on all attainment teaching) and improving practice. Technological changes with calculators more widely available and the introduction of computers. Opposition by governing politicians to progressive initiatives
Post-16	Increase the proportion of young people engaged in post-16 study. Employers' and Higher Education concerns

Period 2: 1990-1998

Table 14, below, summarises mathematics education policy drivers for the period 1990-1998.

Table 14: Mathematics education drivers for 1990-1998

Phase	Drivers
Primary	Establish the national curriculum
	Establish national assessment and testing
	Address workload concerns
Secondary	"Standards"
	Transnational comparisons
	Address workload concerns with simplification of the curriculum
Post-16	Desire to continue to expand participation for workforce reasons and general desire to improve qualifications of young people
	Concerns about attainment outcomes

Period 3: 1999-2010

Table 15, below, summarises mathematics education policy drivers for the period 1999-2010

Table 15: Mathematics education drivers for 1999-2010

Phase	Drivers
Early Years	Importance of early years for future educational outcomes
Primary	Economic competitiveness. Focus on numeracy and numerical competence – 'basic skills' Address inequality and differences in school performance Primary teachers' mathematics subject knowledge
Secondary	Raising "standards" Choice and diversity - 'personalised' learning agenda Address inequality and variation in school performance and school leaver access to employment opportunities Skills agenda Scientific and industrial research and development, the 'knowledge economy' including finance and ICT industries Ensuring qualifications meet the needs of employers and HE Shortage of specialist mathematics teachers
Post-16	The needs of employers and higher education - existing qualifications not meeting needs of workforce/HE, including in information technology Aiming to raise the status and quality of vocational qualifications informed by principles of progression, flexibility, key skills, breadth, and status Evidence of the low participation in mathematics post-16. Identified need for mathematics specific CPD

Period 4: 2011-2021

Table 16, below, summarises mathematics education policy drivers for the period 2011 - 2021

Table 16: Mathematics education drivers for 2011-2021

Phase	Drivers
Early Years	Addressing attainment gaps and differences in home learning environments Workforce availability particularly of women School 'readiness'
Primary	Improve mathematical attainment Improve the quality of mathematics teaching Increase whole class teaching Learn from high-performing systems Reduce the influence of higher education on teacher professional development
Secondary	Increased participation in higher level mathematics International competition in mathematics outcomes Mathematics outcomes linked to national economic performance Pupil premium, social mobility and 'catch up' - "ensure more children from poorer backgrounds catch up with their peers"[17]
Post-16	Continued demand from employers and HE for increased mathematical understanding and applications Numbers leaving education at 18 with no Level 2 Mathematics qualification Professional development needs of the FE mathematics teaching workforce Access to University e.g., Mathematics and further mathematics as facilitating A levels

11.2 Patterns in drivers

Looking across phases and across time periods, drivers cluster into three broad areas, though with different emphases in different phases and at different times.

Economic drivers

There is a consistent concern with the needs of employers and the importance of mathematics to them. As might be expected, this is more apparent for the secondary and post-16 phases, given the relationship between qualifications at 16 and 18 and further study. Over time, the emphasis in these drivers shifts from a concern with the needs of specific employers to a framing in terms of the overall national competitiveness.

Individual outcomes and opportunity

In the 1980s, addressing issues of inequity was an important motivation for teachers and curriculum developers but not particularly a policy concern in the introduction of the national curriculum. From

[17] https://www.gov.uk/government/speeches/2012-oecd-pisa-results

the late 1990s on, these issues became more important drivers. Although the coalition government adopted the language of social justice[18], this was framed in relation to social mobility rather than equity per se (for example, a 'wasted talent' discourse). Previous concern with girls' outcomes in mathematics lessened over the four periods, at the policy level at least; part of the justification for ending coursework was that final examinations might address the perceived underachievement of boys.

The quality of mathematics teaching

Improving the quality of mathematics teaching was an ongoing driver in the primary and post-16 phases (particularly in FE and in relation to Level 2 mathematics). This was less of a concern in secondary teaching overall, with the focus not on teaching but on teachers who did not have Level 3 or degree-level mathematics qualifications.

11.3 Educational ideologies

Policy drivers are relatively explicit statements of positions. Although, as we noted in the introduction, the idea of driver is misleading, if understood as a policy aim formulated on the basis of a linear and primarily rational approach to policy development and implementation. An important influence on policy drivers and policy design and implementation more generally are educational ideologies.

There are different formulations of educational ideologies prevalent in England and elsewhere, and these are linked to wider political ideologies. Paterson (2003) proposes a model of educational ideologies in the British Labour Party connected to wider political positions:

- New Labourism with similar educational views as the conservative New Right
- Developmentalism – focused on economic competitiveness
- New social democracy – with public management to reduce negative effects of the market and discourses of social responsibility as exchange for rights

A typology of mathematics education ideologies was first proposed by Ernest (1991, 1992) and was an application of a more generic model of educational ideologies in England (Williams, 1961) and has been taken up since in mathematics education policy analysis (e.g., Boylan, 2000; Hodgen et al., 2021; Noyes, Wake & Drake, 2011). Important ideologies in mathematics education policy development identified since the inception of the national curriculum are shown in Table 17 below.

In Ernest's 1998 account, his typology also included two other ideologies. The first is 'progressive educator'. However, as this ideology has been less influential in policy, it is not included here, notwithstanding that aspects of this view of mathematics education align with those of many EYFS practitioners or have potentially influenced curriculum reform in the past (Noyes, Wake & Drake, 2011). The second, 'the public educator,' with a concern for social change and education for citizenship, has not been a central influence on mathematics educational policy.

[18] https://www.gov.uk/government/speeches/2012-oecd-pisa-results

Table 17: Mathematics education ideologies adapted from Ernest, 1991

Ideology	View of maths and aims of maths teaching	Orientation to learning and teaching and resource	Values and purpose
Industrial trainer	Rules, basics, numeracy, and social training	Transmission, explicit instruction, hard work, effort, practice, anti-calculator	Self-help, authority. Children as empty vessels.
Technological pragmatist	Useful knowledge,	Application, skills acquisition, motivation through relevance, open to ICT	Utilitarian, development, meritocracy, social mobility
Old Humanist	Pass on culturally approved knowledge	Explain, motivate, textbooks, understanding	Hierarchy, paternalism, character building. Cultural reproduction

Although the Conservative Party and Labour Party have different stances on educational policy, these different ideologies can be found across and within both political parties and bodies that influence their policy positions when they have been in and out of government. Similarly, these ideologies are also found in the Liberal Democratic Party, which was part of the 2020-2014 coalition government. Aspects of the 1997 Labour Government's education policy align with 'New Right' (Paterson, 2003), identified as industrial trainers. In the conservative led governments since 2010, Hodgen et al. (2021) identified particular politicians with variously technological pragmatist positions, with a focus on technical and vocational routes (e.g., Wolf, 2011; Truss, 2013), and by those who focused on technical and vocational, an industrial trainer position, with more emphasis on 'traditional' calculations and pencil and paper calculation, with the long division algorithm and the times table recall (Gibb, 2015), and an old humanist position, arguing for transmitting a body knowledge as cultural heritage (Gove, 2011).

This helps to explain why English education policy, including in mathematics education, has characteristics both of change and continuity. Changes in education have often represented developments from previous policies.

Considering policy development, educational ideology has similarities to 'core beliefs' as defined in the Advocacy Coalition Framework model of policy development (Sabatier, 1998).

- 'Deep core beliefs' are fundamental and unlikely to change (like a 'religious conversion') but too broad to guide detailed policy, such as one's views on human nature).
- 'Policy core' are more specific but still unlikely to change, such as the overall view on the role and responsibility of the state
- 'Secondary aspects' relate to the implementation of policy

Secondary aspects are the three types of belief that are most likely to change, as people learn about the effects of, for example, regulations versus economic incentives. The implication of this view is that ideological forces influence any policy development and implementation.

11.4 Drivers and features as expressions of ideology

Informed by Ernest's typology and the construct of 'deep core beliefs', policy drivers can be linked to three ideological beliefs. Here, we use a simplified framework (shown in Table 18) that considers three different beliefs or commitments and, for each, a pair of influential beliefs in policy.

- View of purpose of mathematics education (and general core beliefs about education)
- View of educational process relationship between teacher, curriculum, and learner
- View of social justice

Table 18: Drivers and features in mathematics education

Factors	Focus	Drivers and features
Purpose	Human capital	Economic concerns, employers' needs; numeracy, international competition, and increasing post-16 participation
	Social and cultural reproduction	'Basics' and mathematical knowledge as culturally important GCSE resit policy
Learning and teaching	Instruction	'Basics', whole class teaching, explicit instruction, final examination, knowledge of facts
	Application	Technological change, coursework, problem solving, modular exams and alternative certification, knowledge in practice
Social justice orientation	Social mobility	Individual success, pupil premium, interventions
	Equality	Address gaps in home learning environment and structural inequality, and pupils progress together

12. System levers

In this section, we summarise the levers from each phase by time period and consider trends in system levers across time.

12.1 System levers: patterns across time by phase

Following the analysis of time periods, levers are not identified for the early years in Period 1 and Period 2.

Period 1: 1980-1989

Table 19, below, summarises mathematics education policy levers for the period 1980-1989

Table 19: Mathematics education levers for 1980-1989

Phase	Levers
Primary	Curriculum development projects
Secondary	Funding models supporting local initiatives High levels of teacher agency and professional autonomy to support curriculum development Cockcroft Report proposes the introduction of financial incentives and flexible routes for teacher education and some introduction of these, e.g., two-year PGCE mathematics routes, two-year BSc Tracking of mathematics teacher qualifications to improve teacher quality
Post-16	National Council for Vocational Qualifications BTEC framework Funding for Technical and Vocational Education Initiative (TVEI) for 14–18-year-olds was launched in 1982

Period 2: 1990-1998

Table 20, below, summarises mathematics education policy levers for the period 1990-1998.

Table 20: Mathematics education levers for 1990-1998

Phase	Levers
Primary	The National Curriculum
	Statutory assessment and testing, including informing Ofsted judgements
	Publication of KS1 and KS2 outcomes
Secondary	The National Curriculum
	Assessment and testing
	League tables
	Ofsted
	Local levers – LA school improvement staff
Post-16	The establishment of the Further Education Funding Council (FEFC)
	Changes to qualifications, their assessment and to funding, notably broadening the curriculum and leading to Curriculum 2000 reforms.
	Social welfare levers are used to encourage increased post-16 participation.

Period 3: 1999-2010

Table 21, below, summarises mathematics education policy levers for the period 1999-2010

Table 21: Mathematics education levers for 1999-2010

Phase	Levers
Early Years	*The Children's Act* 2004
	Ofsted
	Funding for provision
	Funding for training and professional development (Graduate Leaders Fund)
Primary	Ofsted
	Local Authorities school improvement
	National strategies infrastructure, training and guidance documents, Strategies consultants, school-based Numeracy Coordinators
	NCETM
	Primary Mathematics Specialists trained by collaborations of HEI and Local Authorities
Secondary	Local Authority inspection and advisory service
	Professional development (Key Stage 3, Secondary National Strategies, NCETM, Local authority)
	National Curriculum revisions
	National Curriculum levels and sublevels and related 'flight paths' of expected graded predicted from previous attainment
Post-16	Qualifications and assessment changes
	Funding changes

Period 4: 2011-2021

Table 22, below, summarises mathematics education policy levers for the period 1999-2010

Table 22: Mathematics education levers for 2011-2021

Phase	Levers
Early Years	National frameworks and guidance
	Ofsted
	Free childcare hours for parents
	Minimum GCSE workforce requirement
Primary	New national curriculum
	NCETM
	The Mastery programme – Mathematics Teacher Exchange, Primary Mastery specialists, NCETM support and materials, including concepts/frameworks, resources, and CPD
	Maths Hubs
	Textbook subsidy
	Ofsted
Secondary	Reformed GCSE and end of early entry to GCSE
	Ofsted frameworks focus on curriculum
	Mastery programme in secondary
	Maths Hubs
	NCETM
	Changes in accountability measures such as EBacc and Progress 8
Post-16	Funding (condition of funding, Advanced Mathematics premium)
	Ofqual, established in 2010 regulated qualifications, examinations and assessments in England and led A level reform
	Education and Training Foundation activity

12.2 System levers across time

Considering system levers across time, the following patterns are found.

1. An increase in the number of system levers used, showing greater and more direct political management of the education system.
2. The importance of Ofsted and qualifications as levers in the system.
3. Direct funding to schools or independent organisations as a lever is not often used, though the Advanced Maths Premium is an exception.

PART FIVE: Trends

Part Five is organised by reference to four aspects of mathematics education introduced earlier.

For each of these, two trends are described. For brevity, we use 'trend' to refer to changes in the same direction over a given period, or where there may be movement in one direction and then movement back.

Curriculum and pedagogy

- Reduced curriculum content and increased prescription
- Increased policy direction of pedagogy

Qualifications and assessment

- Narrowing of assessment methods and forms
- High-stakes testing

Workforce and professional learning

- Changing patterns in depth and intensity of funded subject specialist professional development
- 'School led' innovation and professional development trending now towards more centralisation of direction

Resources and technologies

- Changing availability of curriculum resources and materials
- Decreased use of ICT in mathematics, including computing and programming

13. Curriculum and pedagogy: trends

13.1 Reduced curriculum content and increased prescription

Comparing the first national curriculum introduced in 1990 with the most recent 2014 curriculum, there has been a considerable reduction in content and scope. The first national curriculum in mathematics had 13 attainment targets described over 10 levels with more than one component in some, generating 296 separate descriptors in total (Dowling & Noss, 1990). Even these were a reduction in the content of the original proposal, which had an additional element, the profile components, to model a range of mathematical skills and dispositions (see the case study on the development of Using and Applying Mathematics below).

The 2014 national curriculum is presented not as a single curriculum across the school years but divided into primary and secondary, and within that, Key Stages, and in primary by Year. Areas of content present in 1990 have been reduced—for example, the amount of probability and data handling. Overall, the proportion of the curriculum focused on number, particularly in Key Stage 1 and Key Stage 2, has increased.

Alongside the reduced content, there is greater specificity in detail. Comparing directly is challenged by the different structure into Levels (1989), and Year or Key Stage expectations (2014). However, below are extracts that both refer to learning the 2, 5, and 10 multiplication tables.

1989: AT 3, Level 3

- know and use addition and subtraction number facts to 20 (including zero).
- solve problems involving multiplication or division of whole numbers or money, using a calculator where necessary.
- know and use multiplication facts up to 5 x 5, and all those in the 2, 5, and 10 multiplication tables (DfE, 1989, p. 9).

2014: Year 2

Pupils should be taught to:

- recall and use multiplication and division facts for the 2, 5 and 10 multiplication tables, including recognising odd and even numbers
- calculate mathematical statements for multiplication and division within the multiplication tables and write them using the multiplication (×), division (÷) and equals (=) signs
- show that multiplication of two numbers can be done in any order (commutative) and division of one number by another cannot
- solve problems involving multiplication and division, using materials, arrays, repeated addition, mental methods, and multiplication and division facts, including problems in contexts. (DfE, 2013, p.13).

The increased specificity helps to mask the reduction in content, as the overall 'feel' of the curriculum may make it appear that there is more content in the more detailed description of what, in 1989, solving problems' might involve or what using multiplication facts might mean.

This trend in the curriculum was not sudden, but rather an ongoing process following the 1992 Dearing Review. A possible interruption to this was during the National Numeracy Strategy, when the official national curriculum was supplemented by additional National Numeracy Strategy material. The recent Mastery policy does not have the same effect as the Teaching for Mastery approach, which is centred around approaches to teaching rather than content. However, the NCETM has supported a prioritisation of the primary curriculum, contributing to additional guidance[19].

This general process of reducing content happens at a more granular level, with increased emphasis on a limited range of standard methods. A similar process was noted above in relation to EYFS, where number has been emphasised over other types of mathematics and mathematical activity. Reduction/removal of coursework (see below, Section 14.1) also narrows the curriculum (although see case studies on 'problem solving' and on 'using and applying' in the policy development section).

As shown by comparing the two NC extracts, it is notable that in 1989, the possibility of using a calculator was specifically included. This is not so in 2014, and elsewhere it is made explicit that calculators should not generally be used.

As well as the change in the curriculum content itself, this has reinforced other trends. The lack of reference to ICT, computing, or programming creates a barrier to teachers using those approaches. The narrowing of the meaning of problem solving (see case study) limits the opportunities for cross curricula activity, e.g., along with a reduction in STEM initiatives. These potentially reduce the skills of teachers in making links with other subjects.

One possible counter to this trend can be found in the Core Maths specifications, with a focus on using and applying mathematics and synoptic assessment included to enable candidates to develop awareness of the 'interconnectivity of mathematical ideas' (DfE, 2018 Core Maths technical guidance).

This trend potentially reduces the scope for extending the school mathematics curriculum to include data science and mathematical applications, ICT in general, and specifically, programming.

13.2 The how as well as the what: increased direction of pedagogy

This trend is most notable in primary mathematics education. In secondary mathematics, in contrast, it could be argued that the trend is to increase content through the increased demand of GCSE.

At the time of the first national curriculum, there was no associated direction for how the National Curriculum should be taught. In so far as there was a policy position, this was found in the principles in the Cockcroft Report, which allowed for a high degree of autonomy by teachers. The National Numeracy Strategy was a significant shift in recommending how mathematics should be taught (see the policy development case in Section 24). The NNS promoted whole class interactive teaching and a three-part lesson structure.

In the noughties, there was a shift away from this. The National Centre for Excellence in Teaching of Mathematics (NCETM) explicitly did not promote a preferred or desired pedagogy.

The advent of the Mastery policy (see policy development case study, Section 27) has seen a return to government funded promotion of a way of teaching mathematics. It is outside the scope of this report to compare NCETM's 'teaching for mastery' with the National Numeracy Strategy. However,

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[19] https://www.gov.uk/government/publications/teaching-mathematics-in-primary-schools and https://www.ncetm.org.uk/classroom-resources/cp-curriculum-prioritisation-in-primary-maths/

teaching for mastery is presented as starting from principles and concepts, described as 5 'big ideas[20] rather than, for example, a common lesson structure. Although the focus of the funded Teaching for Mastery Programme is on primary mathematics, mastery concepts appear to have more traction in secondary schools, at least rhetorically. The consequences of this are, arguably, a more consistent advocated pedagogy, but also reduced school and teacher autonomy in accessing available professional development.

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

14. Qualifications and assessment: trends

14.1 Narrowing of assessment methods and forms

Changes to content, structure, assessment, and grading include a move from modular to linear assessment at GCSE and GCE (first assessments 2017), a move to controlled assessment, and the removal of coursework. These changes accompanied an increase in the level of demand as part of the national assessment policy in secondary and post-16.

The recent changes to GCE, including decoupling AS from A level and funding changes, have led to a reduction in curriculum breadth and a dramatic decline in the number of students taking mathematics at AS level[21]. This has reversed a trend of increasing participation in advanced mathematics from 2003/4 following the recommendations in the Smith Report (2004). The regrading of GCSEs from 1-9, with the associated additional demand, has contributed to the decline in entries. Noyes and Adkins (2017) identify GCSE grade as the strongest predictor of likely AS/A level mathematics completion, with a rise in A* and A grades (34% and 56%, respectively, from 2004 to 2010) (p. 17) being the key driver in growth in AS/A level entries.

There are particular implications for using and applying mathematics. Although some progress has been made, for example, with the introduction of the large data set at Level 3, this work is difficult to assess through a timed examination.

A countertrend trend/tendency is found in Core Maths (see Section 17), where assessment regulations permit 20% coursework (although it doesn't appear any Boards offer this). Several Boards provide pre-release materials for Core Maths and A levels (large data sets) to better reflect the context of real-life problem solving.

Core Maths assessment perhaps demonstrates some possibility for adapting assessment to accommodate curricula demands. The increased profile of mathematics as a gatekeeper subject may provide increased leverage for specific mathematics assessment methods.

14.2 High-stakes testing

School performance tables were introduced in 1992, publishing the average attainment of state secondary schools, based on students' GCSE results. Average school performance in Key Stage 2 SATs results have been published for primary schools since 1996.

England joined the Programme for International Student Assessment (PISA) in 2000, an OECD programme that assesses 15-year-olds in reading, mathematics, and science, providing international comparison tables.

In 2006, mathematics and English were included as two of the five GCSEs at grades A*–C reported in school attainment tables. Ofsted uses school performance data to guide school inspections. Another accountability mechanism, performance-related pay, was introduced in 2013. Ofsted inspection reports have focused on English and mathematics, resulting in overemphasis on these subjects and the neglect of core subjects[22]. Leckie and Goldstein (2017) note that whilst the measure of school attainment has remained as the percentage of students achieving five or more good GCSEs, the

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[21] https://meiassets.blob.core.windows.net/amsp-uploads/uploads/files/Level_3_maths_briefing_document_2020-21.pdf

[22] https://publications.parliament.uk/pa/cm201617/cmselect/cmeduc/682/682.pdf pp.15-16

progress measure has shifted from 'value-added' (2002–2005) to 'contextual value-added' (2006–2010) to 'expected progress' (2011–2015) to 'progress 8' (2016–).' (p. 195)

An increase in accountability leads to a narrowing of the curriculum and teaching to the test, which can be detrimental to students' and teachers' wellbeing[23]. It also leads to a reduction in pedagogical risk-taking.

There is evidence that high-stakes testing leads to ability grouping, despite practitioners' reluctance to this practice on moral grounds and in light of research that highlighted problems associated with setting. Bradbury, Braun, and Quick's (2021) study of the impact of SATs in primary schools also found that educational triage and intervention (where groups of children are prioritised over others due to their potential to increase a school's average performance at a key benchmark) were common responses to high-stakes testing, raising concerns of increasing inequalities.

There are some reports of one positive impact on the position of mathematics in secondary schools and colleges, seen in greater priority in resourcing. More recently, changes to assessment during the COVID-19 pandemic may have prompted a reconsideration of assessment practices.

[23] https://publications.parliament.uk/pa/cm201617/cmselect/cmeduc/682/682.pdf

15. Workforce and professional learning: trends

15.1 Changing patterns in depth and intensity of funded subject specialist professional development

Concerns about equity in initial teacher education have been raised with the variety of routes into teaching mathematics, a shift from university to school-led provision, and concerns over the quality of some routes (ACME 2015). Pre-service training: Reduction from a 1-year full-time university-led Mathematics Enhancement Course (MEC) to a short, often online, provision of Subject Knowledge Enhancement (SKE) courses.

Issues of mathematics teacher specialist qualifications and subject knowledge are longstanding (ACME 2015). Efforts to address these through in-service professional development include the National Numeracy Strategy 5-day course for primary teachers from 1999 and the Mathematics Specialist Teacher (MaST) programme introduced in 2010 following Williams Report recommendations (2008). This two-year Masters-level programme began at eight universities and was independently evaluated[24]. Support for funding for MaST was withdrawn after the change in government. Aspects of this funding for sustained CPD for primary mathematics leads have been restored through the Mastery Specialist Leads programme. However, the original Williams model was for one or two teachers to experience two years of training in each school. The current funding in the Mastery Programme would achieve 10–20% of this goal, with other schools experiencing support through a model combining features of collaborative professional development and cascade models.

Funded subject-specific professional development in a variety of formats, including sustained courses, has been provided for teachers of A level mathematics and further mathematics (later also core maths) through government funding for FMSP and AMSP.

These changes are relevant to primary and secondary education in particular. Marketisation has led to the proliferation of providers of Subject Knowledge Enhancement (SKE) courses, offering a range of programmes.

Particular challenges are present in post-16 education, with a lack of subject-specific pedagogy and no national workforce strategy. Around 45% of the FE mathematics teaching workforce does not hold a mathematics or numeracy teaching qualification. The situation is exacerbated by the funding requirement for GCSE resits.

15.2 'School-led' innovation and professional development trending now towards more centralisation of direction

The National Numeracy Strategy and the 2001 Key Stage 3 Strategy marked a shift to centralised professional development. A shift to more school-led approaches was supported by NCETM in the early days (2006–2010), followed by a move to more centralisation through hubs and the Mastery programme.

Shifts were initiated in primary, then moved to secondary and post-16 (e.g., the NCETM Mastery programme expanded into secondary and later into post-16 through the DfE-funded Centres for Excellence in Mathematics (CfEM), shaping the professional development on offer).

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[24] https://www.gov.uk/government/publications/evaluation-of-the-mathematics-specialist-teacher-mast-programme

Academisation supports the trend towards centralisation within MATs, limiting scope for individual teachers and schools to innovate beyond agreed-upon foci.

Consequences of this are an increasing trend towards central guidance over pedagogy and a similar centralising trend in ITT. Schools have varied access to professional development. A challenge from the multiple routes into ITT is the increasingly wide range of subject knowledge starting points beginning teachers have. However, some schools continue to build links with innovations and research that addresses school aims. There is a more varied professional development offer from AMSP, with flexible, on-demand support, particularly focused on A level Mathematics, Further Mathematics, and Core Mathematics but increasing support at KS3 and 4.

16. Resources and technology: trends

16.1 Changing availability of curriculum resources and materials

In Period 1, 1980–1989, prior to the national curriculum, there were many active curriculum development projects (see Section 23). Influential national curriculum programmes were the School Mathematics Project (SMP) and various Nuffield schemes; both were continually developed from the 1960s and achieved widespread take-up (Breakell, 2002). There were also locally-led initiatives involving Local Authorities. The largest of these, SMILE (Adams & Povey, 2018), was supported by the Inner London Education Authority. Other curriculum development projects had relationships with academic publishers, for example, BEAM (Be a Mathematician) with Nelson. Various textbook schemes were also available and widely used in secondary teaching.

During Period 2, this resource ecology continued with the advent of the national curriculum. Where government funding was available, there was autonomy for curriculum developers. For example, in the early nineties, the National Council for Educational Technology (forerunner to BECTA) provided resources for curriculum development for activities that linked ICT with using and applying maths.

Period 3 and the advent of the National Strategies led to the production of exemplar curriculum materials by government-funded agencies aligned with government policy. By the end of Period 3 and during the first half of Period 4, this type of process for producing curriculum and resource materials was less prevalent, with government funding directed to organisations such as FMSP and MEI, the Education and Training Foundation, and projects such as Underground Maths, with materials produced as part of these organisations' activities. During Periods 3 and 4, the development of online resource banks, both by commercial and non-commercial enterprises, substantially increased access to a large number of materials, although with concerns about quality[25]. As part of the Mastery Programme, the government has encouraged textbook use in primary schools through a subsidy and an approval scheme.

16.2 Decreased use of ICT in mathematics – including computing and programming

In Section 19, Digital Technologies in Mathematics, an extended account is given over time. Here, key points are summarised.

Mathematics education was an important site of early exploration of the educational possibilities of digital technology in mathematics. This is evidenced by their being sufficient interest and activity for the Association of Teachers of Mathematics to have for a period a distinct publication focused on this 'MicroMaths'. As noted in Section 14.1, when Using and Applying Mathematics was introduced, one aspect of applying mathematics was using software. In Section 13.1, the 1999 and 2014 national curriculums were quoted. It is notable that, in 1999, calculator use was described as an integral part of primary mathematics but was absent in 2014.

This is representative of an overall decline in the use of digital technologies in mathematics over a 25-year period that has accelerated over the last 10 years. The year 2000 was UNESCO's International Year of Mathematics and promoted in the UK by the Department for Education and Employment as 'Maths Year 2000', and promotional materials included celebrating the power of

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[25] https://www.nuffieldfoundation.org/project/prevalence-use-textbooks-curriculum-resources-primary-maths

using calculators (Oldknow, Taylor & Tetlow, 2010). In its first 5 years, the NCETM had a specific focus on ICT use, holding a themed conference on this in 2008 (op. cit.). Its first pathfinder teacher collaborative research projects had an ICT focus.

As noted in Section 19, there are some exceptions to the decline in the use of digital technology in post-16 Advanced level teaching. However, in the primary and secondary phases, most pupils have very little, if any, experience using digital technology in mathematics. Apart from curriculum changes in mathematics and a focus on 'basics', we suggest other significant factors were:

- In primary, accountability and performance pressures led to a focus on KS1 and KS2 SATs outcomes on the basis that if it is not tested, it is not taught
- In secondary schools the introduction of ICT as distinct subject in the curriculum and reduced access to computer suites
- The switch from ICT to computing as separate subject

Regardless of the reasons, a parallel trend with the decrease in digital technology use in mathematics is that the mathematics teaching workforce, viewed as a whole, has less experience with using digital technology in mathematics teaching than teachers thirty years ago.

PART SIX: Illustrative Cases

Seven case studies illustrate key developments in mathematics education, with the aim of providing a richer study for different aspects of mathematics education. They enable us to surface connections and discontinuities across the different categories. One way this is done is through references to other sections of the report.

The featured cases are:

- Problem solving in recent curriculum and pedagogy
- Data handling and statistics
- Core Maths
- Teacher subject knowledge
- Digital technologies in mathematics education
- The ‘forgotten third’
- National Centre for Excellence in Teaching Mathematics (NCETM)

Each case report comprises:

- Case profile: an overview of the phases and aspects of mathematics education most relevant to the case
- Significance: why this is important in mathematics education in England and/or to the Mathematical Futures programme
- The case: a summary description of the case
- Lessons for mathematics education in the future: key implications

17. Case study: Problem solving in recent curriculum and pedagogy

Case profile

Phases: primary, secondary, post-16

Aspects of mathematics education: curriculum and pedagogy

Significance

Employers highly value the ability to apply knowledge to novel, unfamiliar problems (English & Gainsburg, 2008). This is due to the increase in jobs that require problem-solving skills, many of which are mathematical in nature, and where the ability to solve non-routine problems is necessary. However, concerns have been repeatedly raised about young people's ability to do this. A similar picture can be seen in higher education courses, with many students encountering difficulties drawing on their mathematical skills to solve a problem in new contexts (ACME, 2011).

The case

Building on Cockcroft's 1982 report, the first national curriculum had problem solving embedded across the curriculum and specifically in attainment targets focused on using and applying mathematics. More details are given in Section 23, where 'using and applying' as part of policy development is considered. In later curriculum revisions, using and applying mathematics was no longer identified as a separate strand but integrated into the content of the rest of the curriculum, and KS3 assessment of problem solving as a distinct mathematical activity was discontinued. The lack of emphasis on using and applying mathematics was identified as a persistent weakness in inspections (Ofsted, 2008; Ofsted, 2012). The lack of development in using and applying mathematics was identified as the reason students' understanding of mathematics was inferior to their ability to execute methods and recall facts. By practising one method at a time, mathematics was presented as a collection of rules for memorising, and Ofsted (2008) recommended more guidance for teachers in planning, teaching, and assessing 'using and applying'. This issue has been exacerbated by the nature of external assessments in mathematics, including the removal of GCSE coursework in 2009 and an increasing reliance on short questions that limit the ability to assess reasoning. Ofsted (2008) noted that the pressure teachers feel to prepare students for external examinations has resulted in 'teaching to the test' and is the reason for the lack of development in 'using and applying'.

GCSE reforms from 2014 that have led to firstly the replacement of coursework with timed controlled tasks and later the removal of these (see Section 14) have tended to undermine the importance of using and applying mathematics in the curriculum.

In response to the need to prepare students who will progress to higher education or jobs with a quantitative element, core maths qualifications were introduced in 2014 (see Section 17). These qualifications are aimed at students who have achieved a grade 4 or above in GCSE mathematics but have not chosen to take AS/A level mathematics. They focus on using and applying mathematics in realistic contexts and there have been calls for increased participation to prepare students for their futures (Smith, 2017).

Curriculum

In the primary phase, using and applying mathematics was given more attention in the 2000 national curriculum. Unlike before, where using and applying had been a separate strand of the curriculum, problem solving was now integrated into the programmes of study for curriculum content. A subsequent revision of the framework in 2004 gave further attention to 'using and applying', identifying five themes:

1. Solving problems

2. Representing: analyse, record, do, check, confirm

3. Enquiring: plan, decide, organise, interpret, reason, justify

4. Reasoning: create, deduce, apply, explore, predict, hypothesise, and test

5. Communicating: explain methods and solutions, choices, decisions, and reasoning

Similar developments occurred in the secondary phase, and in 2008, 'using and applying' was reflected in 'key processes, which "should be embedded within the everyday teaching of the strands of number, algebra, geometry, measures, and statistics" (DCFS, 2008).

The integration of mathematical content and using and applying skills has remained a feature of the current national curriculum across all key stages. There is an explicit goal for students to be able to solve a variety of routine and non-routine problems with increasing sophistication. In the secondary curriculum, this forms part of a 'Working Mathematically' strand in which students should be taught to solve problems through the mathematics content. Furthermore, they should "develop their mathematical knowledge, in part through solving problems". English and Gainsburg (2008) note that there is debate as to whether the goal of using problems should be to teach mathematical content, use problem solving as a vehicle, or teach problem solving skills. They do recognise a move towards developing mathematical understanding through problem solving but the lack of research about how to do this indicates problem solving has not been seen as integral to the curriculum.

A further aim of the current curriculum is to ensure that the majority of pupils progress at broadly the same pace. "Pupils who grasp concepts rapidly should be challenged by being offered rich and sophisticated problems before any acceleration through new content" (DfE, 2013, p. 3.

Assessment

Despite the increased emphasis on problem solving in the curriculum, there are concerns that this has not been recognised in similar changes to external assessments of mathematics. In 2009, coursework was abolished in mathematics but retained in other subjects, largely due to concerns raised by teachers regarding the difficulty of knowing if students had completed the work without the assistance of somebody else. For many students, GCSE coursework represented most of their engagement with using and applying mathematics, and when this was removed, many schemes of work gave teachers no guidance on how to teach students to use and apply mathematics (Ofsted, 2012). A response to this concern is the increased use of problem-solving questions in external assessments, such as Assessment Objective 3 (AO3) questions. These questions are defined as those where students "solve problems within mathematics in other contexts" and represent 25%–30% of the total marks. Some have noted that despite this, examination questions are primarily focused on short questions that test rote learning rather than questions assessing sustained reasoning (Brown 2013; Jones 2020). Coursework tasks had provided a means by which to assess problem-solving skills over extended periods of time that were not well suited to examinations. In contrast, Jones notes that when exam questions are worth less than three marks on average, it can be presumed that the average time spent reasoning is less than three minutes. A similar concern is the lack of problem-solving opportunities in recent Key Stage 1 and 2 assessment materials (ACME, 2016).

The nature of questions in external assessments at all stages of education has greatly influenced students' experiences in mathematics classrooms. The pressure to prepare students for external assessments has resulted in teachers relying on 'teaching to the test' to increase marks, resulting in a fragmented curriculum that privileges the memorisation of facts and procedures (Brown, 2013; Ofsted, 2008). Despite an increased emphasis on problem-solving skills across all phases of the curriculum, ACME (2016) noted that the same importance must be attached to the assessment of problem solving to drive improvements in the teaching and learning of problem solving. They recommend:

- assessments involving more problem-solving questions across all phases of mathematics education, ensuring that the curriculum's aims on problem solving are being reflected in assessments at the end of each key stage
- test and examination papers that encourage young people to engage in rich problem-solving activities and to develop mark schemes that reward problem-solving approaches
- developing a range of assessment methods to assess problem solving most effectively
- research to inform decisions about appropriate time allocations for mathematics examinations and tests that include problem solving.

Lessons for mathematics education in the future

It has been argued that the rote learning of the current mathematics curriculum is insufficient to produce the problem solvers required for the future. Adequately preparing students for success in a changing workplace requires a curriculum that enables students to develop a wide range of transferable skills, including problem solving, at a level appropriate for their chosen career. The JMC (2011) recommended that student-led problem solving in the mathematics curriculum should make use of mathematical digital technologies, which are widely used in society and the workplace, because the workplace is significantly impacted by innovations in digital technologies.

18. Case study: Data handling and statistics

Case profile

Phases: secondary, post-16

Aspects of mathematics education: curriculum and pedagogy

Significance

The place of data handling and statistics education in the mathematics curriculum, together with concerns over teachers' knowledge and pedagogical skills to teach them, were issues at the start of the 1980s and remain under discussion today. The Cockcroft Report (1982) noted that the mathematical needs of continuing education and employment included the need to 'interpret data with understanding' (para. 185). In a section on the teaching of statistics (pp. 234–236, paras 774–781), Cockcroft identified the need for 'in-service teacher training courses on the teaching of statistics', both for mathematics teachers and those of other subjects, while emphasising the value of cooperation between teachers of different subjects using statistics. The report highlighted the need to shift the focus from the application of statistical techniques to the discussion of results and drawing inferences. Since Cockcroft reported, rapid developments in technology have shifted and intensified the need for data handling and statistics expertise across a wide range of employment and higher education settings. Smith (2017, p. 16) noted, 'Changes in the labour market are also presenting the need for new skills, in particular in the use and analysis of data'.

The case

Three major concerns highlighted by stakeholder respondents to the Smith Inquiry (Smith, 2004) impacting across the mathematics curriculum have an enduring impact on statistical education today. Stakeholders signalled a crisis in mathematics education due to the following reasons:

- The curriculum and qualifications framework failed to meet the needs of learners, higher education providers and employers and didn't motivate young people to continue to study mathematics beyond 16.
- A shortage of specialist mathematics teachers, adversely impacting on learners' experiences.
- A lack of support for professional development and resources for learning and teaching, including ICT.

In addition to featuring in more general mathematics reports (Cockcroft, 1982; Smith, 2004, 2017), several reports focus on statistics and/or data science. These include reports commissioned by the Royal Statistical Society with support from the Institute and Faculty of Actuaries focused on statistics (Porkess, 2012) and on statistics across A-level subjects (Porkess, 2013), a Royal Society/ACME report also considering statistics across A-level subjects (RSS/ACME, 2015), and one examining data science[26] in the primary and secondary curricula (Pittard, 2018). However, as Davies and Sheldon (2021) report, implementing strategies advanced by such groups is not without challenges.

'The many reports that have appeared since 2003 have contained scores of recommendations for curriculum development, teaching, learning, and assessment of statistics. Unfortunately, many of the statistics-related recommendations have been ignored'. (Davies & Sheldon, 2021, p. 65)

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[26] See https://royalsociety.org/-/media/policy/projects/dynamics-of-data-science/dynamics-of-data-science-skills-report.pdf for an account of the emergence of 'data science'

Curriculum and assessment

In the secondary phase, changes to assessment have influenced the teaching of statistics. A particular issue is the practical element of statistics, both at GCSE and A level. In an overcrowded Key Stage 4 curriculum, recommendations were made to review the data handling coursework component, particularly to reduce time spent on this (Smith, 2004). In the early 2000s, a quarter of the mathematics GCSE was data handling and statistics. Noting the 'vital importance' of statistics and data handling for other disciplines and for employment, the Smith Inquiry recommended a radical review of the curriculum, stating 'that much of the teaching and learning of Statistics and Data Handling would be better removed from the mathematics timetable and integrated with the teaching and learning of other disciplines (e.g., biology or geography)'. (Smith, 2004, p. 7, para. 0.28).

At A level, the revised criteria for GCE mathematics in the Curriculum 2000 reforms resulted in a reduction in the number of applied units (statistics, mechanics, or discrete mathematics) from 3 to 2 in any mathematics A level. In addition to detailing overarching themes, the GCE subject requirements in the 2017 changes to A level made clear statements about the use of data and technology, in particular a requirement for students to explore statistical concepts and skills through familiarisation with one or more specified large data sets using technology (Ofqual, 2016). One expert contributor to the roundtable noted that the large data set and encouraging students to work with some real data, to work with technology, and to investigate real data is of crucial importance.

A Free-Standing Mathematics Qualification (FSMQ) in using and applying statistics (Level 3) was made available in 2001, with data handling units available at levels 1 and 2. Also at Level 3, the introduction of Core Maths in 2014 was an important development as it embraced mathematical applications and statistics (see Core Maths case study). This qualification aimed to address the mathematical needs of those entering higher education and the workplace, where technological developments have changed the nature of work and the skills required. Smith (2017) noted that these technological changes, particularly the need for skills in analysing and working with 'big data', had implications for mathematics education, recommending the DfE and the Department for Business, Energy, and Industrial Strategy commission a study into the long-term implications of these changes.

Resources

Prior to 1980, a Schools' Council Project on Statistical Education was established to ascertain the situation in statistical education, including teachers' needs, and to develop proposals and teaching materials. This need for resources specifically to support statistical education, including exploring the potential of computers, was noted in the Cockcroft Report. In 1983, the Centre for Statistical Education (CSE), a joint venture between the University of Sheffield and Sheffield Hallam University, ran projects developing material for teaching statistics in schools. Other projects funded in the 1980s and 1990s developed materials to encourage practical work, including for probability and using databases and spreadsheets to teach statistics. When the CSE was closed in 1995, the Royal Statistical Society, in partnership with the Office for National Statistics, a software company, and Nottingham Trent University, opened a National Centre for Statistical Education, which operated until 2014, contributing to statistical education, for example, through the CensusatSchool project (Davies & Sheldon, 2021).

Lessons for mathematics education in the future

A recent report (Royal Society, 2019) recommended the integration of data science knowledge and skills across the curriculum, together with resources and training for teachers and a revised post-16 curriculum to develop the foundational knowledge and skills needed for a ‘healthy data science skills landscape’ (p. 9). They note key roles for the NCETM and the National Centre for Computing Education (NCCE). The NCCE, established in 2018 with DfE funding, offers resources and CPD to state schools through computing hubs. The Computer Science Accelerator professional development programme delivered by NCCE is independently evaluated[27]. The AMSP also addresses data science and they may be best placed to initiate links between the NCETM and the NCCE. In our parallel report on international policy (Adams & Boylan, 2023), we note opportunities to learn from innovation and policy development elsewhere, identifying the integration of data science into the mathematics curriculum as a priority.

[27] https://teachcomputing.org/impact-and-evaluation

17. Case study: Core Maths

Case profile

Phases: secondary, post-16

Aspects of mathematics education: assessment and qualifications, curriculum and pedagogy, teacher workforce and professional development

Significance

Core Maths is a Level 3[28] post-16 qualification specifically designed for students who achieve a grade C or above in mathematics but do not go on to study mathematics at AS or A level. It was introduced in 2013 with the aim of supporting students to develop mathematical understanding and applications in preparation for employment or further study in the increasing range of careers and courses that require mathematical skills.

The case

Difficulties with AS mathematics were raised in 2000/1, notably a low pass rate compared with other subjects and a decline in entries. AS Use of Mathematics was introduced in 2001 for students who had obtained at least a grade C in GCSE mathematics and wanted to continue studying mathematics but without taking A level (Smith, 2004). It focused on understanding, mathematical modelling, reasoning, and communication and had around 500 entries in 2003.

From 2004 to 2010, the Qualifications and Curriculum Authority undertook the Mathematics Pathways Project with the aim of improving participation and attainment in 14–19 mathematics. The Mathematics Pathways project included pilots and work towards GCSE reform as well as post-16 qualifications (Noyes, Wake & Drake, 2013). Core Maths was informed by the Mathematical Pathways Project, with a focus on more mathematical problem solving (see also Section 17) and quantitative literacy.

Core Maths was introduced by the coalition government in 2013 for ‘the 40 percent of students each year who do achieve a grade C or above at GCSE but who do not continue with any form of more advanced maths after age 16—over 200,000 each year in total.’ (DfE, 2013b, p. 3). It followed longstanding concerns about the impact of this lack of engagement with mathematics post-16 on the economy, on an increasingly wide range of careers demanding mathematical skills, and on higher education. The first assessment was in 2016, with around 3,000 entries, and entries rose steadily, approaching 12,000 in 2020 (Homer et al., 2020).

The design of Core Maths was informed by an ACME expert panel in 2013, with policy and technical guidance published for awarding bodies in 2014. The qualifications were around half the size of an A level, drawing on content from the higher tier of GCSE together with more challenging content and focusing on:

- the application of mathematical knowledge to address problems and questions
- representing situations mathematically

[28] Equivalent in difficulty to A level, see https://www.gov.uk/what-different-qualification-levels-mean/list-of-qualification-levels

- the use of mathematical and statistical knowledge to make logical and reasoned arguments in a variety of contexts (DfE 2013c, p. 6).

Core Maths was offered by around 150 early adopters, with applications open to those centres with at least a good Ofsted inspection.

From 2014-July 2017 centres received support from the government funded Core Maths Support Programme (CMSP)[29] to raise the profile of the award. The CMSP also provided professional development for teachers. This support was complemented by regional Maths Hubs run by the NCETM. After almost a year without support, a contract to develop support for Core Maths as part of the Advanced Mathematics Support Programme (AMSP, see below) was won by MEI in 2018, adding Core Maths to their already substantial and well-regarded offer supporting mathematics post-16. Continued support for Core Maths in the form of funding for schools and colleges was provided by the Advanced Maths Premium (2019).

There are currently six core maths qualifications[30], with common content set out by the DfE[31]. A set of case studies of early adopters, together with endorsements from higher education providers and employers were developed by the Education Development Trust[32]. There is a wide range of information and support for students, teachers, leaders, universities, and employers, available through the Core Maths Support Programme[33]. Changes to AS and A levels from 2015, together with funding changes, have created challenges for institutions and their students. Core Maths was intended to be taught over two years alongside three A levels, and this worked well under the models existing at the time of introduction. Changes in funding and accountability measures make this more difficult currently.

The 2020 evaluation of AMSP (Walker et al., 2020) recommended that AMSP continue to work with school and college leaders to promote the benefits of Core Maths and support them in accessing the Advanced Maths Premium. There was also a call to work with universities to increase the recognition of Core Maths and for the DfE to provide long-term resources to fund Core Maths.

The potential of Core Maths has been widely recognised as meeting the mathematical needs of students with only a GCSE in mathematics who go on to study STEM disciplines (Hodgen, McAlinden & Tomei, 2014). Calls for wider recognition and support from universities to emphasise the mathematical requirements of degree courses continue (e.g., Hillman, 2014). In 2017, the Smith report into post-16 mathematics recommended that the DfE support all schools and colleges to offer Core Maths qualifications and that, together with Ofqual, they consider how to increase awareness and take-up of the qualification (Smith, 2017). In January 2022, the British Academy and the Royal Society published a joint statement in support of Core Maths, again highlighting the need for students to study mathematics post-16 and calling on the government to provide additional funding. In addition to their endorsement of Core Maths, they called on universities, employers, and others to encourage take-up.

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[29] https://www.educationdevelopmenttrust.com/our-research-and-insights/case-studies/core-maths-support-programme

[30] https://amsp.org.uk/teachers/core-maths/curriculum

[31] https://www.gov.uk/government/publications/core-maths-qualifications-technical-guidance

[32] Available via STEM Learning https://www.stem.org.uk/resources/collection/416708/core-maths-case-studies

[33] https://amsp.org.uk/teachers/core-maths/resources

Lessons for mathematics education in the future

Core Maths has been positively received by students, teachers, and school and college leaders, providing a post-16 mathematics option focused on using and applying mathematics and bridging the gap between GCSE and employment or further study (Mathieson et al., 2020). This works best when Core Maths is taught over two years alongside three A levels, as was intended when designed. Doing so presents institutions with logistical problems. However, as funding and accountability measures are based on the equivalent of 3 A levels (540 hours of study or 3 180-hour courses per year) (Education and Skills Funding Agency 2017), this is essentially a half course (180 hours in total, equivalent to an AS level). Risk-averse institutions may offer Core Maths rather than A level even to students with high GCSE grades (6 and 7), possibly denying them the opportunity to study A level. Core Maths was seen as an alternative route but not a positive choice, with A level very much the qualification of choice (Mathieson et al., 2020).

Despite broad agreement on the value of Core Mathematics, further support is required to encourage centres to offer it and students to take it. This requires the involvement of a wide range of stakeholders, including the government, universities, and employers, as well as a review of funding and accountability measures to better support the policy intention. The longstanding process of independent evaluations of the work of AMSP and FMSP provide a strong basis for arguing for continued support for centres and for teacher professional development.

18. Case study: Teacher subject knowledge

Case profile

Phases: primary, secondary[34]

Aspects of mathematics education: teacher workforce and professional development, curriculum, and pedagogy

Significance

There is a shortage of appropriately qualified mathematics teachers across all phases of education. Between 2016 and 2019, despite growing pupil numbers in all phases, the number of primary school teachers remained largely unchanged, and the number of secondary school teachers fell by 5% (Education Policy Institute, 2020). This shortage of teachers is particularly acute in mathematics, which has suffered from severe shortages of teachers since 2016 (Nuffield Foundation, 2018), and is evident from the proportion of lessons taught by those without a relevant degree. According to estimates from ACME (2016), 5,500 additional specialist teachers are required in secondary schools alone to teach the mathematics classes currently taught by non-specialists.

There have been concerns about the mathematical subject knowledge of primary teachers for many years. The Cockcroft Report (Cockcroft, 1982) highlighted the need to increase the mathematical expertise of primary teachers and the amount of mathematics-specific training they receive. Such concerns were repeated in subsequent reports such as DfE (1998), Smith (2004), and Williams (2008). Despite this, most current primary teachers have not studied mathematics post-16 and spend much less time on mathematics-specific education during ITE than high-performing jurisdictions (ACME, 2015; ACME, 2016).

There are similar concerns about the mathematical subject knowledge of teachers in secondary and post-secondary education. Secondary mathematics teachers are less likely to have a mathematics degree than teachers holding relevant qualifications to teach non-shortage subjects (Nuffield Foundation, 2018). In post-16 mathematics, only 44% of those teaching A-level mathematics hold a degree in mathematics. Of those teachers without a mathematics degree, 43% of those teaching GCSE and numeracy/functional skills do not hold an A-level or equivalent in maths (Hayward & Homer, 2015). The shortage of qualified mathematics teachers in further education has been exacerbated by the requirement for learners who do not achieve a grade C in GCSE mathematics to continue to study until the age of 18 (ACME, 2016). Since 2004, entries to A-level mathematics have risen by 77%, with mathematics being the most popular A-level (Smith, 2017).

The impact of shortages of appropriately qualified mathematics teachers is greater in the most disadvantaged schools (Education Policy Institute, 2020). There is a consistent pattern in all schools to staff year groups where the external stakes are high, such as Key Stages 4 and 5, with mathematics teachers holding the most relevant qualifications. In actuality, this means that teachers with less advanced mathematical qualifications are more likely to teach Key Stage 3 classes, low-attaining sets, and schools in disadvantaged areas (Nuffield Foundation, 2018).

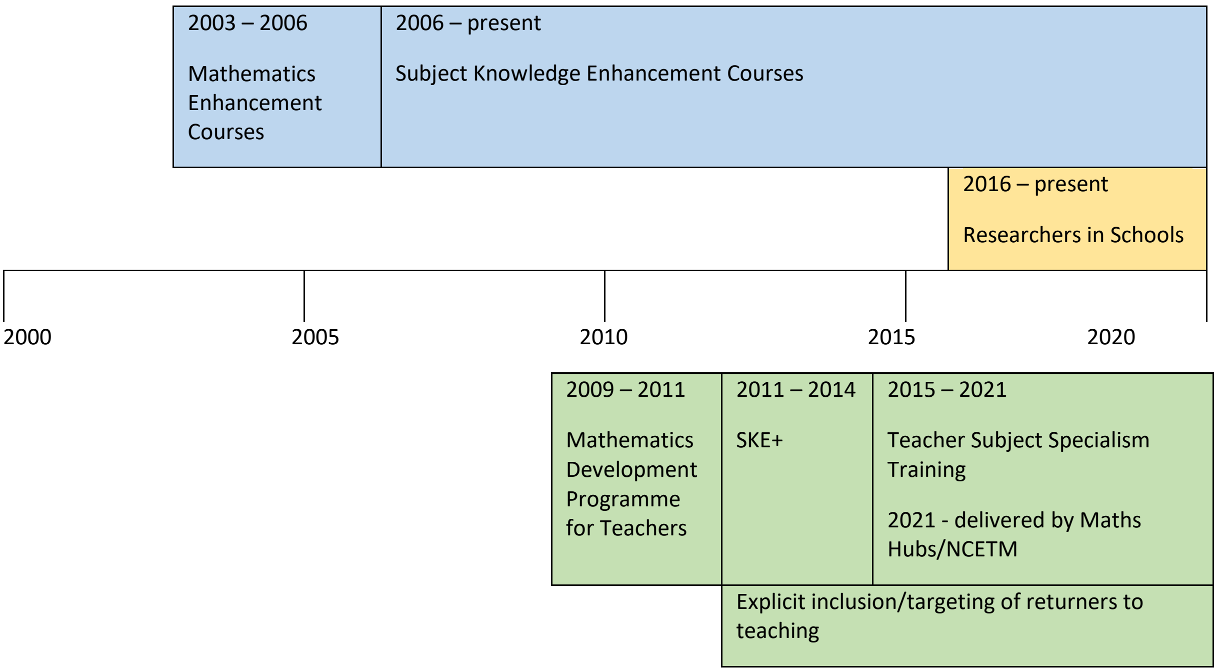
[34] Also an issue in EYFS and post-16 but not a focus here)

The case

Secondary phase

Policy interventions aimed at improving the subject knowledge of secondary mathematics teachers have expanded in two broad ways. Policies that aim to increase the workforce, for example by improving the subject knowledge of non-specialists entering initial teacher education, have developed alongside those that aim to upskill the current workforce, including those non-specialists who are currently teaching mathematics but were initially trained to teach in a different subject. Figure 8 gives an overview of different approaches to addressing teacher subject knowledge related to three aims.

Figure 8 Teacher subject knowledge aims and programmes



(blue)	Aim of increasing supply of qualified teachers. Targeted at improving SK of non-specialists pre-ITT.
(green)	Aim of upskilling current workforce, by improving SK of non-specialists who are teaching/could teach mathematics.
(yellow)	Aim of recruiting applicants with high levels of SK to mathematics teaching.

Subject Knowledge Enhancement (SKE) courses that aim to improve the mathematics subject knowledge of those yet to enter the profession have allowed recruitment of those previously excluded from teacher training routes due to limited subject knowledge. They are widely used, and currently, around a third of mathematics postgraduate students now progress from an SKE course rather than a degree (Stevenson, 2020). Courses differ in length, from 8 to 28 weeks, resulting in some shorter courses only covering GCSE mathematics (AMET, 2015). Funding from the National College of Teaching and Leadership has diversified the number of providers beyond university ITE departments to include teaching schools, academy chains, and online providers (Edwards et al., 2015).

Online courses have notably grown in popularity and "may be perceived to be a convenient tool for access to an ITE course" (p. 37) for those who are completing an SKE while in full-time employment. AMET (2015, p. 1) raises concerns about the changes in SKE delivery, noting that "changes in the funding, provision, and organisation of SKEs in recent years have led to a greater variation in the provision of SKE". They recommend that providers offer opportunities for students to work collaboratively with specialist tutors in a variety of ways, including face-to-face (AMET, 2015; Edwards et al., 2015). Despite recommendations, there is currently no quality assurance for SKE courses (ACME, 2016).

Similar developments can be seen in courses targeting the subject knowledge of those teachers who were not initially trained to teach mathematics but are now teaching the subject. The Mathematics Development Programme for Teachers (MDPT) was launched in 2009 in light of recommendations to enhance professional development programmes for serving mathematics teachers, particularly non-specialists (Smith, 2004). The MDPT was a part-time, funded course for those with no mathematics qualifications at degree level. It included thirty taught days and ten school-based development days over four terms, and providers had the freedom to design their own curriculum (Crisan & Rodd, 2011). In 2011, this was replaced by the SKE+, which, unlike the MDPT, included those teachers who were returning to the profession after an absence of three years or more. With a blend of face-to-face and online learning, Crisan and Rodd (2011) note that this was cheaper to run than its predecessor. In 2014, the SKE+ programme came to an end. In its place, the Maths Hubs are currently delivering the Teacher Subject Specialism Training and the Subject Knowledge for Teaching Mathematics courses. Rani, Sani, and Burghes (2021) conclude that each version of these government retraining initiatives is "progressively becoming more contracted in scope, time, and budget" (p. 21).

Primary phase

Most primary teachers are trained to teach all subjects, and so the mathematics-specific elements of a one-year ITE course are typically equivalent to a few days (ACME, 2015; Carter Review, 2015). The Williams Report (2008) cautioned that it was not safe to assume that mathematics is fully addressed during ITE and recommended a subject specialism with a primary undergraduate or PGCE course to address this. Applications for 2015-16 suggest that out of the 16,500 primary places allocated on ITE courses, only 513 places were allocated to a mathematics specialism.

Examining the need to improve in-service primary teachers' subject knowledge to the level required, the key recommendation of the Williams Report (2008) was that there should be at least one Mathematics Specialist in every primary school within ten years. This specialist would be drawn from the existing teaching force and champion mathematics in the school, acting as a mentor, coach, and outstanding teacher. It was estimated that around 13,000 Mathematics Specialists would be required, leading to the Mathematics Specialist Teacher Programme in 2010. The programme sought to develop the subject knowledge of in-service teachers through partnerships with the local authority and higher education institutes, which would then be shared with colleagues. The programme faced challenges in relation to funding and staffing, which at times impacted the programme (DfE, 2013a). This included a reduction in funding required to enable teachers to work on the programme collaboratively with colleagues and the loss of local authority mathematics consultants to support the programme.

The National Centre for Excellence in Teaching Mathematics (NCETM) and the Maths Hubs have played an increasing role in supporting primary teachers in developing their subject knowledge for teaching, for example through their Specialist Knowledge for Teaching Mathematics course. Since 2015, they have developed the Mastery Specialist Programme. Teachers are trained to be Primary

Mastery Specialists, beginning by establishing mastery in their own school and then working with participant teachers from other schools in subsequent years. By 2019, such specialists will have worked with more than 8,000 other primary schools, or around half of the primary schools in England.

Lessons for mathematics education in the future

ACME have recognised the importance of such cascade models of professional development but note concerns about the lack of a coherent embedded system for addressing subject knowledge (ACME, 2016; ACME, 2015). Since these concerns were identified, the depth and length of subject knowledge enhancement provision has reduced. Increased funding is needed to ensure mathematics teacher subject knowledge is enhanced for all those teaching mathematics.

19. Case study: Digital technologies in mathematics education

Phase: Primary, secondary, post-16

Aspects of mathematics education: resources and technology, curriculum and pedagogy, teacher workforce and professional development, assessment, and qualifications

Significance

The use of digital technologies to support mathematics teaching and learning has been a long-standing focus of attention. The JMC (2011) identified why mathematical digital technologies that are widely used in society should become an integral part of mathematics teaching and learning, noting their potential to:

- support conceptual development
- outsource procedural aspects of problems to enable focus on problem solving and modelling
- enable varied, personalised practice of mathematical skills with feedback
- widen access to mathematics education among poorly represented groups
- prepare students for wider employment and further study
- play a role in constructing mathematics knowledge.

Other reports (Royal Society, 2014) have noted the more personalised approach to learning that can be afforded by digital technologies, meeting the needs of individual learners while allowing them to work collaboratively. Digital technologies also have the potential to build connections between school mathematics and the outside world, "with the ultimate goal that more students reach a broader view of mathematics—one that is so much more than calculation and one that they judge to be personally empowering and fulfilling" (Hoyles, 2018, p. 224).

Despite the possibilities offered by digital technologies, uptake in mathematics classrooms has been slow, and observations of mathematics education have consistently noted that their potential is underexploited (Ofsted, 2004; 2008; 2012).

The case

Inspection evidence a decade ago (Ofsted, 2012) found that most pupils had little to no opportunity to use technology as a tool to solve or explore mathematical problems. This was, in part, attributed to limited access to ICT facilities and a lack of available resources integrated into schemes of work. Despite significant increases in the range and capabilities of digital technologies in the last decade, the use of technology remains predominantly teacher-led, and there is a wide variation in the integration of technology to enhance mathematical learning. There is evidence to suggest that digital mathematical tools are viewed largely as instruments to facilitate presentation or computation (JMC, 2011), requiring a distinction between the needs of mathematical users in search of an answer and mathematical learners engaged in mathematical thinking (Hoyles, 2018).

Several barriers have been identified that have prevented a move towards a more student-centred use of digital technologies, including their omission from the curriculum and high stakes assessment, teachers' beliefs about their importance and place in the curriculum, and their (perceived) ability to integrate these into their practice.

Curriculum and assessment

Digital technologies in mathematics education are not much mentioned in the current National Curriculum (2014). There is a notable lack of guidance and statements are generally focused on the use of calculators – see Table 23.

Table 23: References to digital technologies in the 2014 Mathematics National Curriculum

Key Stage	Reference to digital technologies
1 & 2	Calculators should not be used as a substitute for good written and mental arithmetic. They should therefore only be introduced near the end of key stage 2 to support pupils' conceptual understanding and exploration of more complex number problems, if written and mental arithmetic are secure. In both primary and secondary schools, teachers should use their judgement about when ICT tools should be used.
3 & 4	Calculators should not be used as a substitute for good written and mental arithmetic. In secondary schools, teachers should use their judgement about when ICT tools should be used. Use a calculator and other technologies to calculate results accurately and then interpret them appropriately (KS3 only).
5	The use of technology including mathematical and statistical graphing tools and spreadsheets must permeate the study of AS and A level mathematics. Calculators used must include the following features: - an iterative function - the ability to compute summary statistics and access probabilities from standard statistical distributions

The requirement for calculators to be introduced only near the end of Key Stage 2, when written and mental arithmetic are judged to be secure, has been mirrored in assessment changes. Calculators were banned in mathematics SATs tests for 11-year-olds in 2014, with Education and Childcare Minister Elizabeth Truss warning it was "time to end the dependence on calculators to do basic maths". The criticism that calculator use hinders students' arithmetic skills is unsubstantiated, and the evidence suggests that calculators can be effective for developing arithmetic skills when integrated into the teaching of mental and written calculations (Hodgen et al., 2018). As students move to secondary school, it is recommended that they have more frequent, unrestricted access to calculators. As the Cockcroft Report notes, "the availability of a calculator in no way reduces the need for mathematical understanding on the part of the person who is using it" (Cockcroft, 1982).

Further changes to formal assessments, for example, the removal of the compulsory use of digital technologies within GCSE data handling coursework in 2008, have resulted in little use of digital tools beyond a scientific calculator in formal assessments. One distinction is the requirement, since 2017, to engage with a 'large data set' using technology in mathematics at A level. However, Golding and Lyakhova (2021) note the emerging evidence that this requirement is being widely ignored, with teachers and students ill-equipped to engage with any digital technology other than a scientific calculator. The close relationship between teachers' pedagogical choices and formal assessment arrangements requires a consideration of both curriculum content and assessment of the use of digital technologies. The JMC (2011) has recommended that student-led mathematical modelling and problem solving using digital technologies should be included in the curriculum, and changes made to high stakes assessments to encourage and acknowledge this.

Professional learning

It is recognised that changes to the curriculum and high stakes assessment alone will not be sufficient to develop teachers' use of digital technologies, and that additional measures to upskill teachers will be required (JMC, 2011). Teachers' limited confidence in using digital technologies, including not only their proficiency with using it but also their understanding of how to enable mathematical learning through it, may be accompanied by a limited conviction of the potential of digital technologies for the teaching and learning of mathematics (Golding & Lyakhova, 2021). This has resulted in repeated calls to develop the expertise of teachers and give better guidance on choosing and using digital technologies (Ofsted, 2004; Ofsted, 2012). From 2020, EdTech demonstrator schools have enabled schools and colleges who have shown they can use technology effectively to disseminate effective practice. The Advanced Mathematics Support Programme (AMSP) offers professional learning in integrating digital technologies in the mathematics curriculum, aiming to enrich the curriculum and support understanding.

Lessons for mathematics education in the future

The response to the COVID-19 pandemic highlighted the importance of digital technologies in education, with schools making far greater use of them to support students' learning. In mathematics education, Golding and Lyakhova (2021) note that this increased use has largely consisted of sharing work and accessing pre-prepared digital packages, with less uptake to support students' mathematical exploration and modelling. If teachers are to utilise digital technologies in mathematics to their full potential, there is a repeated call for sustained professional learning that shares effective practice (Royal Society, 2014). The National Centre for Excellence in Teaching Mathematics and the Maths Hub programme have been identified as sources of this professional learning, allowing teachers to share good practice and ways to overcome obstacles (Clark-Wilson & Hoyles, 2017; Hoyles, 2018). This has shown to be beneficial, offering the opportunity for teachers to form supportive communities in which resources are developed and where researchers can provide support as they are implemented in their classrooms (Clark-Wilson et al., 2020).

20. Case study: The 'forgotten third'

Case profile

Phases: primary, secondary, post-16

Aspects of mathematics education: curriculum and pedagogy, assessment, and qualifications.

Significance

Each year, approximately a third of children leave primary school without reaching the expected national standard in English and mathematics. By age 16, a similar proportion of students do not achieve at least a standard pass (grade 4) in English and mathematics. These students have been termed 'the forgotten third', in part because "their chances of progression are diminished in further study, further careers, and, ultimately, in life" (ASCL, 2019, p. 5). Students from disadvantaged backgrounds, ethnic groups, and those with special educational needs and disabilities are persistently overrepresented in the forgotten third. Since 2011, progress in closing the attainment gap between disadvantaged students and their peers has been slow, and Hutchinson et al. warn that "the gap will never close without systemic change" (2020, p. 8).

The case

Discussions of the attainment gap have been longstanding in mathematics education. Cockcroft (1982) drew attention to the difference in attainment which exists between students of any given age, and the extent to which this difference increases as they get older. A 'seven-year difference' which exists amongst 11-year-olds was identified

> *If we relate this to work in the secondary years, it means that the mathematical understanding of some pupils who transfer to secondary school at 11 is likely already to be greater than that of some pupils who have just left school at 16. On the other hand, some of those who arrive at the same time may not, while at school, attain the understanding which some of their fellow 11 year olds already possess.* (para. 436)

Of concern was that if this difference was not recognised in the curriculum, lower attainers would be destined to experience continuing and dispiriting failure. Thirty years after the Cockcroft Report, Ofsted (2012) found that the difference in mathematical achievement between the highest and lowest attainers remained. The attainment gap increased as students progressed through the schooling system and was 'vast' by age 16, with 36% not achieving a pass at GCSE.

Since 2010, there have been significant changes to the mathematics curriculum and qualifications, in part to address these concerns, including the requirement for those who have not passed GCSE mathematics at level 4 or above to continue post-16 mathematics. However, Hodgen et al. (2021) note that despite low attainment in mathematics being an increasing feature of policy discourse over the last sixty years, little progress has been made in finding a solution.

Interventions designed to close the gap

From 1998 to 2011, the National Strategies provided a mix of resources and services across all phases to "secure improvements in standards", largely in literacy and numeracy. An explicit aim was:

> *Narrowing the Gaps (for pupils on free school meals, black and ethnic minority pupils and gifted and talented pupils from deprived backgrounds).* (DfE, 2011)

This was achieved by extensive assessment data tracking through materials known as Assessing Pupils' Progress and early intervention where students did not meet expected standards. Examples of interventions include Numeracy Recovery, Mathematics Recovery, and Catch Up Numeracy, which were often delivered via structured one-to-one interventions. During the period of the National Strategies, the proportion of students leaving primary school with level 4 and above rose from 59% to 77% (Williams, 2008). However, the success did not extend to the lowest attaining students, with the percentage of students attaining level 2 or below remaining stable during the same period. In response, the 'Every Child Counts' intervention was introduced, consisting of intensive intervention aimed at the 5% of lowest-attaining children nationally and less intensive interventions for the next 5 to 10%.

Williams (2008) attributes the rise in attainment for most students to the changes introduced into the pedagogy of mathematics, the training, and the professional development networks that the National Strategies provided. Teachers worked collaboratively on mathematical problems, enabling them to develop their subject knowledge as well as enhance their pedagogical understanding. The report was critical of later moves to more general approaches, recommending that HEIs be closely involved in developing and delivering provision that supported primary teachers' engagement with the 'big ideas' in mathematics.

Since 2010, there has largely been a move away from these individual interventions, and the focus of interest has been the notion of "mathematics mastery", as used in high-performing jurisdictions such as Shanghai. While mastery is conceptualised in different ways, the NCETM highlight:

> *Pupils are taught through whole-class interactive teaching, where the focus is on all pupils working together on the same lesson content at the same time, as happens in Shanghai and several other regions that teach maths successfully. This ensures that all can master concepts before moving to the next part of the curriculum sequence, allowing no pupil to be left behind*[35]*.*

In this way, low attaining students are included with the rest of the cohort, and learners are, to some extent, treated as the same. Hodgen et al. (2022) argue that, despite good intentions, the focus on mastery as a solution to low attainment has led to the particular needs of the lowest attainers being overlooked. By ignoring these needs and treating students the same, it ignores the evidence that low attainers require their needs to be addressed in different ways to learn mathematics.

The National Tutoring Programme (NTP), established in 2020 in response to the widening attainment gap resulting from the COVID-19 pandemic, provided additional, targeted support for those students most affected by the pandemic. Primary and secondary schools were able to access subsidised tutoring provision through an approved list of tutoring providers or trained academic mentors (for example, graduates). Schools with students eligible for pupil premium had the option to recruit their own tutors, although tutoring was not limited to eligible students. This option proved to be the major vehicle for delivering the NTP.

Qualifications for students who do not achieve a grade 4 at GCSE

A significant focus of policy since 2012 has been how to support lower attaining students post-16. The Wolf review (2011) of vocational education proposed that post-16 mathematics should be a required component of all study programmes for those without a 'good' pass in the subject at GCSE. Adopted in 2014, a condition of funding has meant that nearly all students who did not achieve a

[35] https://www.ncetm.org.uk/media/uhjhtxy1/the-essence-of-maths-teaching-for-mastery-june-2016.pdf

grade 4 in mathematics were required to continue studying mathematics until age 18. Students who achieve a grade 3 or below in GCSE mathematics have the option to study for an alternative non-GCSE qualification. The most common of these are Functional Skills Qualifications (FSQs), which are equivalent to grades 4 and above at GCSE. The purpose of such qualifications is to support students' ability to apply mathematics in different contexts and prepare them for the workplace. Assessment must:

- provide realistic contexts, scenarios, and problems
- specify tasks that are relevant to the context
- require the application of knowledge, skills, and understanding for a purpose
- require problem solving.

From 2019, the FSQs were reformed to include a greater focus on using times tables and working with and without a calculator, with the aim of using mathematics more confidently in the workplace.

An additional condition of funding in 2015 meant that FSQs were not an option for some students who did not achieve a grade 4 at GCSE. Any student who achieved a grade 3 at GCSE would be required to continue to study GCSE mathematics post-16, rather than an alternative mathematics qualification. At the same time, the nature of GCSE examinations changed; more emphasis was placed on final examinations rather than modular content, exams lasted longer, and students were required to memorise formulae.

For those students resitting their GCSE, it has been argued that the policy has not achieved the intended outcomes, and too many students are no nearer to a grade 4 at the end of their further study than they were at the start (ASCL, 2019). Smith's (2017) review of post-16 mathematics notes that this may be due to a lack of motivation and confidence after already experiencing failure, compounded by the number of teachers of GCSE mathematics in further education without appropriate experience and training. He recommends a review of the 16–18 resit policy and the consideration of appropriate curricula and qualifications for these students. One suggestion, proposed by ASCL (2019), is for a Passport in Maths, which would be taken at any stage between ages 15 and 19 and built upon over time, removing the need for students to continue to re-sit their GCSEs during further education.

Lessons for mathematics education in the future

There are indications of a renewed focus on low attainment in mathematics. Hodgen et al.'s (2021) policy review identifies a shift from ability discourses to a focus on attainment with a broadly inclusive agenda, although this often fails to address the particular needs of low attaining students. They identified a need for further research into strategies to address low attainment in mathematics, noting that this was not simply a problem for mathematics but one located in an inequitable society and education system, requiring policy responses founded on strong research evidence and that would survive changes in government.

Reports continue to raise issues with teacher preparedness, supply, and professional development, with students in disadvantaged areas and/or low attaining students less likely to have access to mathematics specialists. Experts consulted for our review echoed these concerns. The Education and Training Foundation (ETF) currently offer training to support those teaching mathematics functional skills and GCSE mathematics.

21. Case study: National Centre for Excellence in the Teaching of Mathematics

Case profile

Phases: Primary, secondary

Aspects of mathematics education: Workforce and professional learning, curriculum and pedagogy

Significance

The National Centre for Excellence in the Teaching of Mathematics has had a central role in mathematics teacher professional development for twenty years. Currently, any future policy developments involving teacher professional learning for schoolteachers would benefit from the involvement of the NCETM. The changing role of the NCETM over time reflects changes in the policy environment and educational system.

The case

We consider the NCETM's activity across three periods: 2006-2010, 2010-2012 and 2013-2021.

The NCETM 2006-2010

In 2002, the government tasked the Smith Inquiry (Smith, 2014) with making recommendations on how to implement its decision to establish a new National Centre for Excellence in the Teaching of Mathematics (NCETM). This followed the House of Lords Science and Technology Select Committee (2000) report in 2000 on the need for subject specific CPD for science teachers. The NCETM was launched in 2006. Celia Hoyles became Director in 2007, with the centre managed by Tribal Education Ltd.

When established, the key objectives of the NCETM were:

- To stimulate demand for mathematics specific CPD contributing to strengthening the mathematical knowledge of teachers and improving school and college performance in mathematics
- To lead and improve the coordination, accessibility, and availability of mathematics specific CPD
- To enable all teachers of mathematics to identify and access high quality CPD that will best meet their needs and aspirations (Hoyles, 2010, p.44).

An online portal was central to achieving these aims. The portal provided resources and tools to support mathematics teacher professional development. In addition, the NCETM supported face-to-face national and regional events and funded projects and networks. By 2010, the NCETM had 40,000 registered users (Coldwell, Boylan, Shipton & Simkins, 2010). Examples of support directly for teacher professional development include the 'Personal Learning Space'. Registered users could access a Self-Evaluation Tool (SET) focused on subject and subject pedagogical knowledge.

The NCETM had a small central Directorate that managed the NCETM provision and a team of Regional Coordinators, which at that time was equivalent to a specialist staff of 17. The permanent staff of the NCETM was also supported by a pool of approximately 120 Associates, skilled and experienced mathematics teachers and educators contracted by the NCETM to support specific activities. The portal also hosted various online forums and communities, although this was not a particularly well-used feature compared to the number of registered users (ibid.). The portal is the publication site for four monthly e-magazines. In addition to the portal, the NCETM also provides small awards to support school- or college-based or inter-school or college-based professional development projects. Different types of grants were offered: for Teacher Enquiry Projects, for Mathematics Knowledge Networks and for Regional Projects. Enquiry projects supported teacher-led learning and professional development at the school or college level. Mathematics Knowledge Networks (MKNs) brought together teachers from different schools and colleges to share and develop knowledge about teaching mathematics.

Instead of supporting a specific type of professional development, the NCETM placed an emphasis on its "commitment to placing teachers' needs and goals at the core of its work by putting in place structures through which teachers are able to develop ownership of its provision" (Hoyles, 2010, p. 45). NCETM funded both a study of current effective practice (Back et al., 2009) and a parallel review of research on effective CPD for teachers of mathematics (Joubert & Sutherland, 2008).

In keeping with the period, partnership with HEIs was an important aspect of the NCETM’s work, as also found in the Mathematics Specialist Teacher Programme (see Section 18) and outside of mathematics education, in the Science Learning Centres, as exemplified in contributions to online resources and in encouragement for grant recipients to engage with researchers and university-based teacher educators.

In an independent evaluation of the NCETM’s work in 2010 (Coldwell, Boylan, Shipton & Simkins, 2010), its role as champion and coordinator of mathematics professional development was affirmed. Additionally, an emerging role was identified as a broker between different sections of the mathematics education community and different views on mathematics curriculum and pedagogy.

The NCETM 2010-2014

Between 2010 and 2014, the NCETM continued to develop its work and refine its activities. There was a change in the consortium leading the NCETM, with Mathematics Education and Industry (MEI) taking a leading role in the NCETM programme direction, with the Chief Executive of MEI becoming the NCETM Director and Tribal continuing to lead business activities.

The election of the coalition government in 2010 changed direction in education policy, including a ‘bonfire of the quangos[36]’. The latter term refers to the reduction or removal of funding and the ending or reorganisation of various government bodies, including in education. Reduced funding meant a change in regional provision and a reduction in the scope and size of activities. Government support for the NCETM continued, but on more precarious terms, including a series of temporary contract extensions. Towards the end of this period, the NCETM commissioned an external evaluation, including a Return-on-Investment cost-benefit analysis (Coldwell et al., 2015), indicating some pressure on the NCETM to justify its funding.

During this period, the NCETM developed a prototype for what would become the Maths Hubs. There were three ‘MESH’ schools (Mathematics Education School Hubs) identified to provide regional support for the implementation of a DfE funded Multiplicative Reasoning Programme. NCETM staff were involved in DfE study visits to Shanghai in 2013. By 2014, the NCETM was advocating mastery approaches (NCETM, 2014), and soon after, the term 'Teaching for Mastery' was adopted. The start of the Mathematics Teacher Exchange (Boylan et al., 2019) happened at the same time as the launch of the Maths Hub Programme.

[36] https://www.instituteforgovernment.org.uk/news/latest/bonfire-quangos

The NCETM 2015-2021

Since 2015, NCETM funding has been more secure, with the programme centred on Teaching for Mastery (TfM) and managing the Maths Hub network. The Teaching for Mastery programme consists of a professional development programme to train mastery specialist teachers, support for the specialists to work with groups of teachers from local schools, a subsidy to support purchasing textbooks, and further exchanges with Shanghai teachers. A fuller account is provided as policy development case study in Section 26. The main aim is for over half of English primary schools to engage with the TfM programme in some way by 2023.

The NCETM manages a national network of 'Maths Hubs' to promote and organise professional development opportunities. Maths Hubs are led by schools chosen by their capacity to lead a school network.

Although the NCETM leads the government's mastery programme, due to increased system complexity, there are many other bodies that are also engaged in promoting mastery or employing this term to refer to their professional development offers. These include textbook publishers, curriculum schemes, and professional development providers (see Boylan & Adams, 2023, and the Mastery case study). Thus, the NCETM now has a complex role as a shaper of government policy, an implementer of the policy it has shaped, and a competitor in an educational market for mathematics professional development (Boylan et al., 2019; Boylan & Adams, 2023).

The changing role of the NCETM

Table 24, below, contrasts the roles of the NCETM in its early days and more recently. For simplicity, the middle period is not included, as at that time the NCETM's role was in the process of transition. The comparison shows that the role of the NCETM has changed significantly from a broker and supporter of mathematics professional development to an implementer of government policy. However, aspects of this previous brokering and facilitative role are important to local Maths Hubs.

Table 24: The changing role of the NCETM

	NCETM 2006-2010	NCETM 2015-2021
View on PD	Explicit/policy – no preference Implicit – teacher agency	Professional development programme
Curriculum and PD materials	Gateway, hosting, multiplicity	NCETM produces materials
Other resources	Resource banks, practice cases, individual assessment tool	NCETM additional resources linked to NCETM materials and Teaching for Mastery
View on mathematics teaching	Non preferential	Teaching for Mastery
View on professional development	Teacher autonomy and collaboration	Teacher Work Groups – experts supporting collaborative implementation
Relationship to other actors	Broker and aspirant leader	Leading role but competing in marketplace
Reach	Registered users – considerable reach – but those engaged with groups/grants smaller – cadre of the committed/believers Geographically variable	National reach in primary through the Mastery Programme More geographical consistency through the Maths Hubs
Policy work	External engagement in policy formation through ACME, JMC other partners	External influence through mathematics policy bodies supplemented by more direct shaping of policy through negotiation with DfE policy in contracting and funding

Lessons for mathematics education in the future

The NCETM's role has changed. It has a more powerful role in terms of implementing policy. Through the Maths Hub network and the cadre of teachers who have undertaken its professional development programmes, it has pathways to influencing practice. The NCETM and the Maths Hub network are likely to be important to successful future change in mathematics education.

PART SEVEN: Policy development and implementation

Part Seven comprises four broad subsections, the first providing an overview of policy development focused on key reports influencing mathematics education, with a chronology of these reports, together with key patterns in report development (section 22). The second part is made up of four case studies of policy development (Sections 23–26). The third part (sections 27 and 28) draws on models of policy development, analysing features evident in the four cases and identifying features of successful policy development. The final part (Sections 29 and 30) focuses on policy implementation, evaluation, and impact. Section 29 is an analysis of implementation, drawing on the case studies and other examples.

Details for the choice of policy development cases were provided in the Introduction. In summary, they are:

- Using and Applying mathematics in the National Curriculum
- The National Numeracy Strategy
- The Further Mathematics Support Programme
- The Mastery Programme

Each case includes an overview of the case's significance, a succinct explanation of the policy, and an analysis of the policy's development.

22. Policy development trends

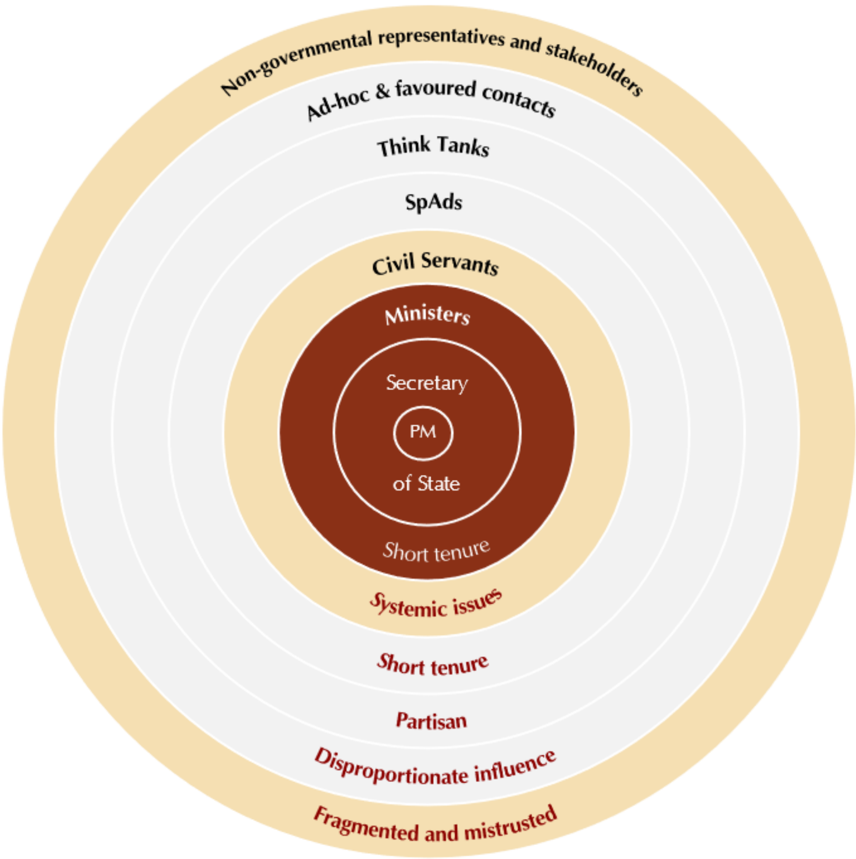
22.1 Increased politicisation

As noted in Part Two, there was relative consensus in the first two periods studied in this policy review, with broad agreement about the introduction of GCSEs and the National Curriculum. However, over the forty-year period there has been an increase in politicisation of education policy detail. Since 2010, there has been a marked increase in political decision making over detail of policy. There are three features to highlight:

1. more direct influence of ministers on curriculum and implementation of policy
2. a changed role and nature of special political advisors, with educational expertise apparently less important
3. an increased number and type of policy influencers and actors.

Figure 9, below, reproduced from EdPol, provides a visual representation of circles of influence on education policy decision making.

Figure 9 Circles of influence on educational policy



https://www.edpol.net/

22.1 Warrants and reports in policy development trends

Across the four periods and across the four educational phases (see Sections 7–10), the importance of reports in providing warrants for policy is notable. However, the role of reports has changed over time. Mathematics education-focused reports are shown in Figure 10.

We note three overarching patterns in the types of reports and how they have influenced mathematics education.

Changes in the commissioning of reports by government and the composition of groups contributing to them

In the first three periods focused on in this study—from 1982 to 2010—generally government-commissioned reports and reviews draw on a range of different views and perspectives that reflect those of stakeholders. This is reflected in the composition of the Mathematics Curriculum Working Group of the national curriculum through contributors to the Smith review in 2004 and Williams in 2008. Since 2010, there has been a change to the commissioning of reports and reviews where the alignment of the authors is more likely to be known and is broadly representative of the government's agenda.

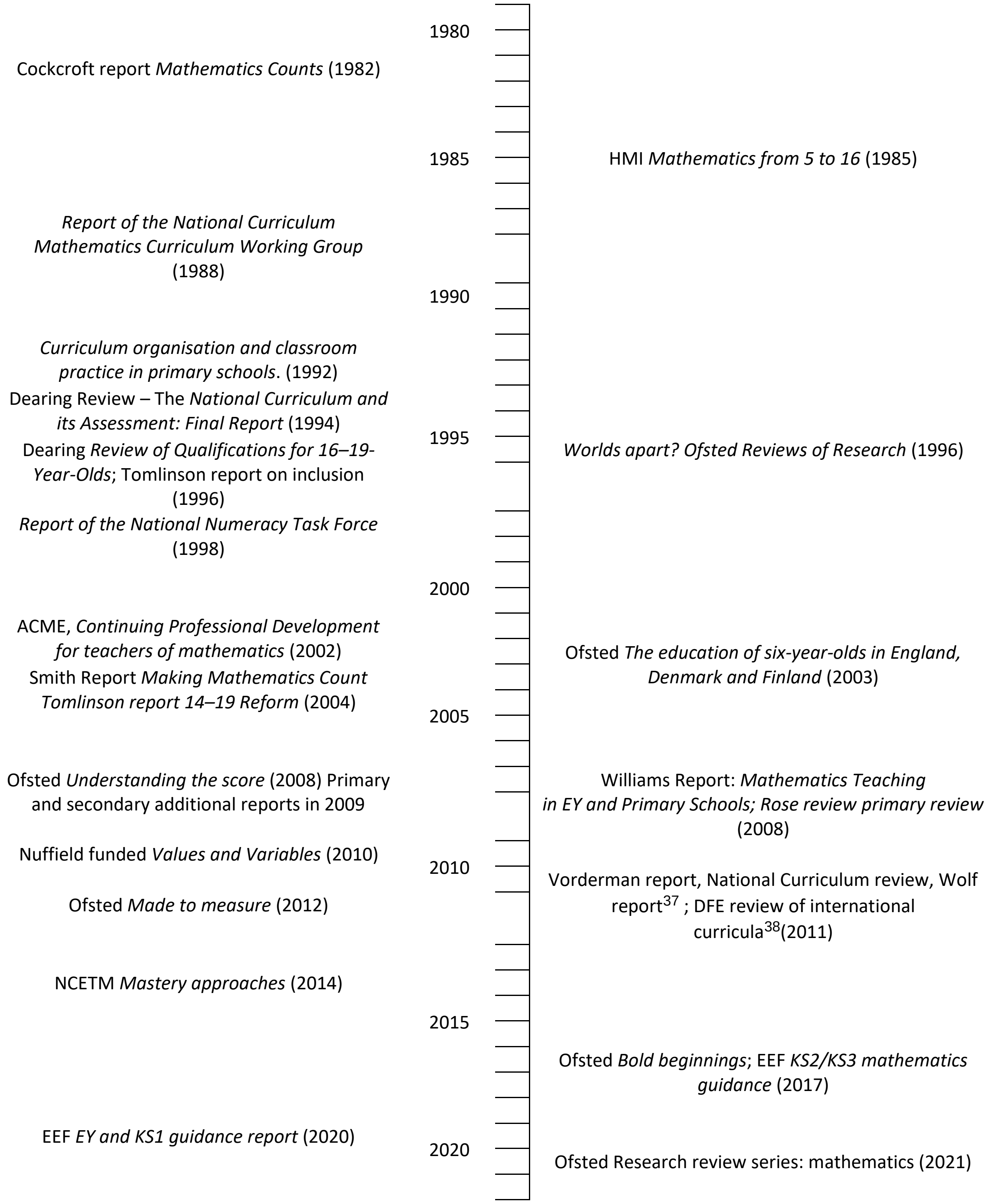
Pattern in influential Ofsted reports

- 1980s reflecting broad consensus of 'good practice'
- 1990s attempting to set the agenda in a particular direction
- 2000s reflecting broad consensus of 'good practice'
- 2020s attempting to set the agenda in a particular direction

Change in relationship to evidence

Increasingly evidence of what is claimed to work is presented as policy justification, with those ideologically aligned to government position given enhanced status in contributing to policy development (Helgetun & Menter, 2022, p.98).

Figure 10: Policy reports influencing mathematics education from 1980 to 2021



[37] This year saw the publication of four influential reports: Vorderman, 'A world class mathematics education for all our young people'; *'National Curriculum Review. The Framework for the National Curriculum (December): report of the advisory panel chaired by Tim Oates'*; the Wolf *'Review of vocational education'*; and a DfE funded Report on subject breadth in international jurisdictions https://www.nfer.ac.uk/publications/91040/91040.pdf

23. Using and applying mathematics in the first mathematics national curriculum

23.1 Using and applying mathematics: The significance of the case

The inclusion of 'using and applying mathematics' in the national curriculum represented a general consensus on the importance of mathematics as an applied body of knowledge and agreement that mathematical processes were important.

23.2 Using and applying mathematics as policy

When the national curriculum in mathematics was introduced in 1990, it had 14 'Attainment Targets' (AT)—strands or areas of mathematics. Of these 14, AT 1 and 9 were different from the other 12, which described progression in knowledge, skills, and understanding' (DES/WO, 1989, p.D1, cited in Millett, 1996). AT1 and AT9 referred to 'using and applying knowledge, skills, and understanding' [emphasis added]. These two attainment targets were intended to permeate the other 12 attainment targets. Set tasks were provided that could be used to demonstrate attainment and support teachers' understanding of what was required.

These attainment targets were assessed as part of the initial national assessment arrangements through tasks designed for this purpose, e.g., investigations in KS3. After the 1994 Dearing review that led to simplification of the national curriculum and assessment, the two attainment targets were consolidated as MA1—one of four areas of study—with the importance of mathematical communication and reasoning as integral to using and applying mathematics retained as part of investigative work and problem solving.

Subsequent versions of the national curriculum revised the using and applying strand and removed it as a separate strand, with the intention for it to be integrated across all strands. At the time of the introduction of the national curriculum, support for professional development occurred through Local Authorities.

23.3 Using and applying: policy development

The Cockcroft Report (1982) stressed the importance of problem solving, referred to as 'the heart of mathematics'. In addition, the report emphasised the application of mathematics, including to everyday situations, as a feature of mathematics teaching at all levels. By developing problem-solving techniques and communicating results, the aim was that students would be better equipped to make use of mathematics in their futures. This was developed in the HMI report 'Mathematics from 5 to 16' (HMI, 1987), which identified strategies to support application and problem solving such as the use of trial-and-error methods, simplification of complex tasks, pattern spotting, reasoning, understanding of proof, and the ability to estimate and approximate. The HMI report also identified qualities such as the development of good work habits and a positive attitude towards mathematics.

Through the eighties, the Cockcroft Report provided a warrant and framework for the integration of the application of mathematics and problem solving into various curriculum and professional development programmes. Examples of these included:

- Teacher led or HEI-teacher collaborations like SMP mathematics, Nuffield
- HEI curriculum design e.g., Nottingham Shell Centre Blue and Red boxes

- Local Authority and regional schemes such as SMILE, by initiatives such as the LAMP and RAMP) project (West Sussex Institute, 1987 cited in Millett, 1996) and the Kent Maths Project
- In primary the Primary Initiatives in Mathematics Education project, 1985-89, (Shuard et al., 1990) had government backing through School Curriculum Development Committee and completed under the auspices of the National Curriculum Council)

These approaches were important in materials produced by both the Mathematics Association and the Association of Teachers of Mathematics, the two mathematics subject associations.

The inclusion of coursework in the new GCSE allowed the development of the ATM 100% coursework GCSE (Ollerton & Watson, 2007), though “the retention of fairly traditional content examination papers led to investigations being regarded as something of a separate entity, a ‘bolt-on’ addition to the curriculum rather than something ‘built-in’ to the learning of content” (Millet, 1996).

Millet (1996) gives a detailed and relatively contemporaneous account of the development of using and applying the national curriculum, which is drawn on here. Although there were a variety of developments aligned with Cockcroft principles, these had not produced much change in classroom practice, particularly in primary schools. The draft national curriculum developed by the Mathematics Curriculum Working Group included attainment targets called ‘practical applications’ that consisted of ‘using mathematics’, ‘communication skills, and ‘personal qualities’. After challenges in writing statements of attainment across the 10 levels (required in the national structure), the resulting Ats were called ‘using and applying mathematics in number, algebra, and measures’ (AT1) and ‘using and applying mathematics in shape and space, and handling data’ (AT9). Notable in this development is that the Mathematics Curriculum Working Group had a significant degree of independence.

24. The National Numeracy Strategy

24.1 The National Numeracy strategy: The significance of the case

The National Numeracy Strategy represented a whole scale attempt for system wide change in teaching methods in primary schools. It represented an extension of policy direction over curriculum to include pedagogy.

24.2 The National Numeracy strategy as policy

The National Numeracy Strategy (NNS) for primary schools was developed as policy in 1997-1998 and implemented from 1998.

The NNS consisted of

- NNS framework which provided curriculum sequence and pedagogical/teaching approach, supported later by a revised national curriculum with revisions aimed at alignment with the NNS
- Key features of the NNS teaching approach were whole class interactive teaching and a three-part lesson (starter, main activity, plenary)
- Teaching and professional development and training materials and resources, including video as well as text-based materials
- A cascade model of different NNS leads – national, regional, LA, school level; the Numeracy coordinator in school as a key role (see Corbin, McNamara, & Williams, 2003; McNamara & Corbin, 2001).

An important aspect of the teaching approach, exemplified in training materials, was the use of number props to support mental arithmetic and number work.

The NNS – with its parallel initiative the National Literacy Strategy – expanded into the National Strategies and extended into KS3, from 2001, before discontinuation in 2011.

24.3 NNS: policy development process

The background context for policy development had three aspects (Brown, Millet, Bibby & Johnson 2000):

- discourses around economic competitiveness, emphasising the importance of mathematics
- a trajectory of policy direction over the curriculum then extending into not what was taught but how it was taught, as exemplified and furthered by the Alexander, Rose and Woodhead (1992) report into primary curriculum and teaching
- Ideological contestation continued from the national curriculum introduction with a re-emphasis on mental calculation, showing the influence of the industrial trainers' ideology

The NNS development process spanned the change of government from Conservative to New Labour, representing consensus across both parties about mathematics education. An important warrant and influence on the introduction and design of the NNS was the 'Worlds Apart' report (Reynolds & Farrell, 1996) commissioned by Woodhead, the head of the then-new inspection service Ofsted.

In parallel with these developments was a mathematics project funded by the LA (Barking and Dagenham), which involved exchange with Swiss teachers and methods (Ochs, 2006; Prais, 1996).

Barking and Dagenham is also an example of wider comparative and transnational projects – notably in relation to Hungary and the development of the Mathematics Enhancement Programme[39]. The extent to which the Barking and Dagenham project influenced the NNS is disputed, with Brown et al. positioning it as incidental and Ochs (2006) and Prais (1996) emphasising its importance, with the latter pointing to the visit of the education minister as evidence.

A National Numeracy Project (NNP) was established in 1996, funded by and within the Department for Education under the Conservative government.

The NNP was introduced into 12 inner-city LEAs, with a focus on low-performing schools (Brown et al., 2000). The initial approach followed the Barking and Dagenham model of whole-class teaching with no differentiation. The NNP under Straker's leadership adapted this to an outline lesson template and sets of objectives, with a focus on sequencing the curriculum. This was implemented in 200 schools, thus demonstrating potential at some scale. The NNP was then taken up by the Labour government, and the Numeracy Task Force was established to rapidly report and develop policy. The decision to adopt the NNP by the Labour Party happened before the general election.

Important in the take-up by the Conservative government and then in the New Labour formulation were commitments to 'traditional teaching methods'. Brown et al. (2000) describe this as a nostalgia-based policy. The approach was also shaped by increased centralisation (the New Labour version of new public management) and prescription.

Funding was important to the success of the National Numeracy Strategy, with £55 million—approximately £100 million today adjusted for inflation—in the initial period. As well as new funding for the NNS, the policy leveraged existing school improvement funding and activity in local authorities.

Communication and engagement with teachers and with society more generally happened through multiple pathways. Before the introduction of the Strategy, campaigners for change had been successful in generating enough media interest for a Panaroma programme[40] focused on mathematics teaching to be produced. Blair, the new Prime Minister, was featured at the start of the first numeracy strategy training video and training materials. Care was taken to produce materials in a consistent style with news media materials:

> *The device of extracting key points and representing them printed in bold in highlighted and bullet-pointed boxes is translated in the transparencies or PowerPoint screens specified centrally for training sessions run in LEAs and schools. The prescriptive and certain voice also dominates press releases, which are often translated verbatim into the media (Brown et al., 2000, p. 462).*

Evaluation of the NNS pointed to importance of:

> *systematic and detailed planning on the part of an increasingly centralized system had resulted in a good fit among other government policies, priorities, and guidelines of related agencies… Such alignment meant that there was a degree of policy coherence (at least in theory) than is usual." (Earl, Watson & Torrance, 2002, p. 37).*

[39] https://www.cimt.org.uk/projects/mep/index.htm

[40] Panorama was the BBC's flagship current affairs programme at the time

25. The Further Mathematics Support Programme

25.1 The Further Mathematics Support Programme: the significance of the case

The Smith report (2002) provided an overview of existing mathematical pathways post-14 and made recommendations for the future. The report noted with concern that very few students progressed to level 3 mathematics qualifications post-16 (6.5% of the cohort in 2002) and stated that 'the present qualifications framework is in need of a radical overhaul' (2004, p. 81).

25.2 The Further Mathematics Support Programme as policy

The Further Mathematics Network (FMN) (2005-2008) and subsequently the Further Mathematics Support Programme (FMSP) (2009-2018) were both established to support all state educated students to access advanced level mathematics post-16. The FMSP aimed to:

- increase participation in Mathematics and Further Mathematics at AS/A level, particularly amongst under-represented groups
- increase demand from students for these courses
- increase the capacity of schools and colleges to provide high quality mathematics teaching,
- and support improvements in Level 3 mathematics teaching[41].

From 2019, the work of the FMSP was expanded to include provision to support Core Maths and known as the Advanced Mathematics Support Programme (AMSP).

25.3 The Further Mathematics Support Programme: policy development

Mathematics in Education and Industry's (MEI) Gatsby-funded pilot project, 'Enabling Access to Further Mathematics', from 2000 to 2005, aimed to provide distance learning to enable all sixth-form students to study further mathematics. The motivation for the project was a decline in the number of students pursuing Further Mathematics A level, which fell from about 15,000 in the early 1980s to less than 3,500 in 1995. There were concerns that this decline would continue after the implementation of Curriculum 2000 and the encouragement it provided for students to pursue a wider range of subjects (Stripp, 2001). For those going on to study mathematics and related subjects at university, A level Mathematics was insufficient. AS and A level Further Mathematics was difficult to run in individual centres due to the very small numbers of students taking it, and issues with mathematics teacher supply and expertise added to the challenges. A second MEI-led initiative (with the University of Warwick), again with funding from Gatsby, 'Upgrading Mathematics Teachers', was aimed at supporting non-specialist teachers to teach mathematics at AS and A levels.

A key driver for increasing Further Mathematics take-up came from industry (STEM) and universities. In 2004, entries to Further Mathematics were low, at 0.8% as a total of entries (A level maths, 6.8% as a total number of entries). The initial intention to increase participation in FM was later expanded to include Core Maths as part of a more general policy for mathematics to be compulsory post-16. Transnational influences and comparisons were used to make a case for the programme (see Smith, 2004) and may have supported its continued funding (e.g., Hodgen et al., 2010).

[41] https://amsp.org.uk/resource/students-fmsp-legacy-resources-archive

The Smith Inquiry identified several voluntary initiatives supporting a mathematics education infrastructure, including the MEI/Gatsby pilots, and recommended that the proposed national and regional centres include a responsibility for funding such initiatives (Smith, 2004, p. 138).

An evaluation of the MEI/Gatsby pilot programme 'Enabling Access' found that the programme made it possible for students to access Further Mathematics, was positively received by students and tutors, and had a number of wider benefits, including encouraging independent study habits (Barmby & Coe, 2004). From 2005, in response to the Smith Report, the government funded MEI to run the Further Mathematics Network (2005–2008), furthering the aims of these earlier projects and aiming to increase the numbers studying AS/A level Mathematics and Further Mathematics (FM).

26. The Mastery programme

26.1 The Mastery Programme: The significance of the case

The Mastery programme is a sustained national attempt to change mathematics teaching in England, particularly in primary schools. It is led by the NCETM and the Maths Hub network, key actors in mathematics teacher professional development. It is also an ongoing policy and so any proposals for mathematics education in the future would need to be shaped to take account of the mastery initiative and current school, teacher, and policy discourses.

26.2 The Mastery Programme as policy

Mastery as mathematics policy consists of a set of direct and indirectly influenced activity. Arguably there are multiple versions of mastery both understood as variously centred on quality of learning (e.g., NCETM 2016), ways of teaching – mastery approaches (Boylan et al., 2019) and, as a policy programme, various government supported or influenced activity. Activity influenced by the programme includes a market in professional development and curriculum materials (Boylan & Adams, 2023). More extensive and detailed descriptions are available (e.g., Boylan et al., 2019). Here a summary is provided.

Focussing on government supported activity, the role of the NCETM is central as is their formulation of teaching for mastery (NCETM, 2016) and five big ideas (NCETM, 2017):

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

Central to the promotion of teaching for mastery are:

- Maths Hubs which organise work groups and coordinate mastery specialists who are funded to work with local schools
- An exchange programme with Shanghai – the Mathematics Teacher Exchange
- A CPD programme to develop Primary Mastery Specialist Teachers
- Professional development and curriculum materials aligned with teaching for mastery
- Subsidy for the purchase of approved textbooks for schools engaged in the mastery programme

As well as the NCETM, there are other actors who use the term mastery to describe their curriculum materials or CPD foci (see Boylan & Adams, 2023).

26.3 The Mastery Programme: policy development process

As noted, the mastery programme has a complex set of interconnected aspects and is connected to other policies that have wider intents and activities (for example, the Maths Hubs). Similarly, the development of the mastery policy is similarly complex, and for a detailed account (up to 2019), see Boylan et al. (2019). Here, the policy is presented in three phases.

2007-2013 Antecedents

In 2007, the Maths No Problem textbook scheme and associated professional development programme were developed based on the translation of a Singaporean textbook series. In a 2009, a multi-academy trust, Ark, also looked to Singapore for ideas, alongside other places viewed as high performers in mathematics. Ark Mathematics was renamed Mathematics Mastery around 2010 with funding from the Education Endowment Foundation for a randomised controlled trial. This was presented as a trial of Singaporean mathematics[42]. However, the influences on the development of the Mathematics Mastery programme were more varied. Interest in East Asian mathematics education led to visits funded by the Department for Education to Shanghai in 2012 and 2013, including with NCETM participants.

2014-2019 Teaching for Mastery and government funding

The NCETM had adopted the word 'mastery' and was writing about mastery approaches (NCETM, 2014). The first teacher exchange with Shanghai in 2014/15 (MTE), involving 48 primary schools. This happened at the same time as the Maths Hub network was established, with a wider remit around mathematics teacher supply, professional learning, and support for subject leadership. The MTE local activity was- and is coordinated through Maths Hubs From this, the Teaching for Mastery (TfM) programme was developed with funding for the CPD programme and support for mastery specialists.

Alongside the MTE, the government funded teacher research into textbook use with these translated or adapted books from East Asian countries. This developed into a funding stream to encourage greater mathematics textbook use in primary schools[43]. A set of criteria was developed for textbooks[44] to be eligible for this scheme, and an expert panel has assessed applications by publishers for inclusion.

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

- Further cohorts of the NCETM-led Primary Mathematics Teaching for Mastery Specialists Programme (PMTMSP), and establishment of a similar training programme for secondary teachers (SMTMSP)
- Providing support through Maths Hubs for PMTMSP and SMTMSP participants and alumni to work with other schools
- Establishing a mastery readiness programme that will be offered to all Opportunity Area primary schools that need it
- Providing funding to support the adoption of high-quality textbooks in primary schools

[42] https://educationendowmentfoundation.org.uk/projects-and-evaluation/projects/mathematics-mastery-primary

[43] http://www.mathshubs.org.uk/what-maths-hubs-are-doing/teaching-for-mastery/textbooks/

[44] http://www.mathshubs.org.uk/media/5559/assessment-criteria-final-09012017.pdf

- Continuing with the MTE exchange programme as part of specialist training. 70 primary teachers will participate annually until 2019/20, with an additional 16 secondary maths teachers in 2018/19 and 35 in 2019/20 (Boylan, et al., 2019).

2019-2021 Embedding mastery and the mastery market

Since the commitment of government funding, the mastery programme has continued, with the committed funding used to support cohorts of teachers on the CPD programme, engage in the MTE, and support schools. Alongside the NCETM and Math Hub-led activity, there has been development of a ‘mastery market’ (Boylan & Adams, 2023), with the following bodies also offering CPD and curriculum materials described as ‘mastery’, as well as other actors in the market who refer to mastery:

- Maths No Problem!
- Mathematics Mastery
- Complete Maths and La Salle Education
- Inspire Maths
- White Rose Maths
- Power Maths

The main focus for the Mastery Programme is primary, but there have been smaller secondary cohorts of Mastery Specialists who have accessed training.

27. Policy models and the four developments

In the parallel report focused on international policy development in mathematics education (Adams & Boylan, 2023), we identified three models drawn from the theories and models of policy development and analysis and used them to identify features of mathematics education policy development internationally.

These three models and features are summarised in Table 25 below[45].

Table 25: Policy development models

Policy model	Features
Multiple streams	Problem/policy/politics streams. Ambiguity, competing problems, haphazard process, often requiring rapid response.
Advocacy Coalition Framework	Policy coalitions variously competing and forming alliances; key role of brokers; variable strengths of relationship between policy subsystem and external events
Policy cycle	Predictable, linear model, moving through agenda setting, policy formulation, legitimation, implementation, evaluation, and maintenance

Tables 26, 27, and 28 below apply these three models to the four policy innovations. Detail aside, and most importantly, in all four cases, aspects of each policy model can be found. The implication of this is that if seeking to develop or influence policy, all three models offer insights into how this might be successful in the context of the policy-making environment in England.

[45] The three models are presented here are in a different order than in Adams and Boylan (2023). In the parallel report, we considered 'multiple stream's and the 'advocacy coalition framework' as alternatives to the more traditional policy cycle model. However, looking forward to future activity to influence mathematical policy, the order we present here reflects a potential sequence of policy action.

Table 26: The four innovations and the multiple streams model

Policy Development	Multiple streams – examples of projects built on in policy development
Using and applying in the national curriculum	Existing initiatives and projects that the Cockcroft Report reflected and encouraged Shell Mathematics – and blue and red boxes ATM 100% coursework GCSE Government supported Primary Mathematics Education project
The National Numeracy Strategy	Barking and Dagenham project, also MEP – as examples Taken up as NNP
The Further Mathematics Support Programme	Existing pilot projects led by MEI that met policy and mathematics education community aims, encouraged by Smith's (2004) recommendations.
The Mastery Programme	Maths Mastery and EEF support and Ark curriculum Legacy of the Primary maths specialist programme The Maths Hub network (Shanghai exchange was first activity)

Table 27: The four innovations and the Advocacy Coalition Framework

Policy Development	Advocacy Coalition Framework
Using and applying in the national curriculum	Coalitions across subject associations, influential Local Authorities, HMI, School Curriculum Development Committee, different teacher led groups
The National Numeracy Strategy	The traditionalist Woodhead as representative of conservative educational philosophy – in Ofsted – aligns with Blunkett's traditionalism School effectiveness movement (represented by Reynolds and Farrell) Mathematics educators/researchers drawing on comparative research – e.g., MEP (1995) Burghes, Andrews International aspects appealing to New Labour technological pragmatists
The Further Mathematics Support Programme	Support from key brokers including Gatsby, MEI, Royal Society/ACME, Smith report, HEIs, Mathematics organisations e.g., JMC, London Maths Soc., engineering employers Broad appeal to range of stakeholders
The Mastery Programme	Oates and textbooks and international comparison NCETM and MEI In government the Department for Business industry and Skills and China-England trade arrangements

Table 28: The four innovations and the Policy Cycle Framework

Policy Development	Policy cycle
Using and applying in the national curriculum	Movement to NC – comes in policy development cycle, building on previous reports particularly the Cockcroft Report
The National Numeracy Strategy	Longer term policy focus on mathematics and numeracy and beyond that educational reform with twin foci on ‘traditional’ and economic goods
The Further Mathematics Support Programme	Alignment with aims for mathematics education infrastructure and teacher support, addressing longstanding goal of increasing participation in mathematics at a time when international comparisons show relatively poor engagement with post-16 mathematics. A level considered ‘gold standard’ qualification, unquestioned. Series of successive positive evaluations demonstrating impact.
The Mastery Programme	Coalition government from 2010– focus on international benchmarking – see GCSE reform Looking elsewhere for policy solution, Shanghai study visits originated in the DfE

28. Features of successful policy development across the four cases

28.1 Model of successful policy development

In the parallel report to this one, reporting on the international horizon scan (Adams & Boylan, 2023), we propose a model of six features of successful policy development and implementation by analysing international examples. Using this model to analyse policy developments in England, we found it broadly applicable. However, in international contexts, we identified 'consensus' as important. However, over time, in England, contestation about educational policy and practice has increased. So, for more recent educational policies rather than consensus, a more appropriate broader category is 'climate' – that there is policy climate receptive to the development.

Noyes and Adkins (2016) analysed how research impacted on A level qualifications reform. As a recent analysis, this reflects policy processes in England. They identified six conditions:

1. The main research findings are simple and/or can be simplified
2. The research is persuasive (this is not an appeal to rigour but more likely that the findings seem to fit with common sense)
3. Key connections are made to key policy networks
4. The research harmonises with policy ideology
5. The implications of the research must be workable: there are available mechanisms or ones that can be adapted
6. The research needs interested champions – interested means that there is some personal or collective gain.

Adapting our model based on international policy developments to the context in England, the model in Table 29 below is proposed. This model is then applied to the four policy development cases. Doing so both illustrates how these features appear in practice as well as demonstrates the usefulness of the model. As to which of these features are necessary, or the number and in what combinations, Noyes and Adkins (2016) note that, even if necessary conditions are met, there may be some serendipity in whether proposed policies are taken up.

Following this, each condition in the model is illustrated in relation to the four policy development cases, with both ways that conditions are and are not evidence in the cases.

Table 29: Model of successful policy development in England

Condition	Features
Purpose	Clear and simple vision of policy purpose
Climate	There is a receptive climate to the policy reform developed through dialogue that involves stakeholders, and particularly around ensuring ideological concerns and core beliefs of policy makers are addressed. This may lead to a consensus
Feasibility	The policy can be enacted using existing or easily adapted mechanisms
Coherence	The policy coheres with mathematics education policies and other educational policies
Systemic alignment	1. curriculum, pedagogy and assessment and teacher professional development and how lack of such alignment can stifle innovation 2. with wider system issues such as teacher professional conditions, accountability measures and marketisation
Piloting and sequencing	Piloting an initiative, depending on scale and governance structures, before wider changes. Professional development taking place in parallel or even prior to changes to curriculum, pedagogy, and qualification and assessment
Sustained attention	Policy processes require attention over time, to develop the case for policy change, as well as detail of implementation
Collaboration and relationships	Dialogue is important between policy makers, mathematics education researchers, teachers, and other stakeholders
Champions	The policy has one or more influential policy champions

Purpose

Clear and simple vision of policy purpose. At a general level, all four policies had an overarching purpose of improving mathematics teaching.

Table 30: Purpose in the four policy development cases

Policy development	Features
Using and applying mathematics	Very clearly articulated in the Cockcroft Report and then developed in the HMI 11-16 report
The National Numeracy Strategy	The NNS was intended to make whole class teaching the norm in mathematics in the context of a daily structured mathematics lesson. So, underpinning the extensive documentation and training materials were a small number of principles
FMSP	Clearly articulated in the pilot project and stable over time
Mastery	For government proponents the purpose of early mastery activity was policy borrowing from East Asia, but mastery itself was negotiated with multiple meanings. More recently, the purpose was articulated by the NCETM

Climate

There is a receptive climate to the policy reform developed through dialogue that involves stakeholders, and particularly around ensuring ideological concerns and core beliefs of policy makers are addressed. This may lead to a consensus.

Table 31: Climate in the four policy development cases

Policy development	Features
Using and applying	Cockcroft inquiry group itself had representation from various stakeholders (Cockcroft was a pure mathematician). There was consensus across HMI and maths associations. The Mathematics Curriculum Working Group had representation from different stakeholder groups. *Using and Applying* was integrated into the curriculum which clearly and explicitly addressed other needs related to basic mathematics. This followed the balanced approach of Cockcroft.
The National Numeracy Strategy	Consensus between DfE, Ofsted leadership, QCA, then putting into place infrastructure. Emphasis on basic maths skills to get wider political support.
FMSP	Pilot project drew on support for example from Engineering Council. Universities, schools, and colleges were partners in the initiative. Smith Inquiry recommended more financial support.
Mastery	Climate generated to an extent by central direction

Feasibility

The policy can be enacted using existing or easily adapted mechanisms.

Table 32: Feasibility in the four policy development cases

Policy development	Features
Using and applying mathematics	This aspect of the NC built on existing practice, increase in practical work following Cockcroft (Brown, 2014)
The National Numeracy Strategy	Aspects of international practice adopted were those most easily translatable, e.g., Taiwan mental starter (idea of a warmup) rather than the more complex and nuanced approaches of Swiss practice found in the Barking and Dagenham project
FMSP	FMN built on successful pilot project, with FMSP extending key features of tuition, wider support, and teacher development
Mastery	Some parts of East Asian practices were adopted but others not. So, for example, early in the Shanghai teacher exchange, the idea of a primary maths specialist had some currency, but this was not taken up in practice by schools. Another example is daily intervention and how that was implemented in some schools

Coherence

The policy coheres with mathematics education policies and other educational policies.

Table 33: Coherence in the four policy development cases

Policy development	Features
Using and applying mathematics	Integrated into the national curriculum
The National Numeracy Strategy	Single national innovation – other things were subsumed into the NNS rather than additional to it, e.g., calculator use, assessment directed to NNS
FMSP	Focussed initially on Further Mathematics participation through the provision of tuition and teacher development. Expanded to include Mathematics at AS/A level and increased support for KS4 and later KS3, also for Core Maths and other Level 3 support. Internal coherence of programme, offering support to students, teachers, senior leaders, and key partners
Mastery	The change in the National Curriculum and removal of levels created an opening around need to address progress of all. Some issues of coherence caused by the development of the mastery market. Led by the NCETM, professional development was centred in the policy.

Systemic alignment

Alignment has two aspects:

- between curriculum, pedagogy and assessment and teacher professional development and how lack of such alignment can stifle innovation
- with wider system issues such as teacher professional conditions, accountability measures and marketisation

Table 34: Systemic alignment in the four policy development cases

Policy development	Features
Using and applying mathematics	National assessment of *Using and Applying* CPD issue not addressed – more ad hoc with Las (possible reasons that Using and Applying could be taken out from the National Curriculum in later revisions, or reframed problem solving as word problems)
The National Numeracy Strategy	Changes in assessment in parallel with the introduction of the NNS Alignment of NNS and NLS. Availability of CPD and NNS linked to existing school improvement infrastructure in Las Accountability measures in league tables linked to NNS goals
FMSP	Strong alignment between curriculum, pedagogy and assessment and teacher professional development with evidence of innovative approaches to pedagogy and teacher development. Alignment with the wider system evident in funding, a variety of sources of funding available in the early days: Excellence in Cities, Widening Participation, Gifted and Talented, Learning Skills Council
Mastery	Wider system issues – marketisation and different competing mastery versions this created

Piloting and sequencing

Piloting an initiative, depending on scale and governance structures, before wider changes. Professional development taking place in parallel or even leading changes to curriculum, pedagogy and qualification and assessment.

Table 35: Piloting and sequencing in the four policy development cases

Policy development	Features
Using and applying mathematics	Various schemes and programmes acted as pilots as did the Primary Initiatives in Mathematics Education project. However, this was no national piloting Access varied and was partially dependent on 'Cockcroft ambassadors' reach or legacies, and local expertise and interest in Local Authorities or mathematics teacher association activity or engaged of HEI based educators
The National Numeracy Strategy	The National Numeracy Programme was effectively a pilot for the NNS– though the pilot was limited. The NNS was a PD-led programme with the changes to curriculum being focused on the framework
FMSP	Developed from an innovation funded by a charity and developed in partnership with a university partner. The programme was piloted for 3 years, and feasibility established. A combination of factors contributed to its success: the involvement of MEI who had experience developing courses, textbooks, and resources, and in the provision of teacher professional development. The distance learning course design was also significant. The offer continues to expand, now incorporating support for 11-16 mathematics and a wide range of mathematics specific teacher professional development
Mastery	The Mathematics Teacher Exchange was created as a pilot, but it moved very quickly to roll out before evaluation. NCETM codified Teaching for Mastery early in the policy development Similarly, the Primary mathematics specialist course was developed before MTE completed. This was less addressed, CPD continued through Las – was not national approach

Sustained attention

Policy processes require attention over time, to develop the case for policy change, as well as detail of implementation.

Table 36: Sustained attention in the four policy development cases

Policy development	**Features**
Using and applying mathematics	The development of the *Using and Applying* strand built on previous work and previous policy texts – the Cockcroft Report and HMI 11-16 report. It was at the centre of activity by both Mathematics Teacher professional bodies, and integrated into influential schemes, as well as in GCSE examination syllabi
The National Numeracy Strategy	The origins NNS can be tracked back to the 1996 Worlds' Apart report and before this previous inquiry into Primary Mathematics (1992). Following the introduction of the policy, funding for the NNS was sustained for more than five years
FMSP	Mathematics in Education and Industry's (MEI) had a long-standing interest in post-16 mathematics and ran a five-year project 'Enabling Access to Further Mathematics', that became a pilot for the Further Mathematics Network
Mastery	From initial study visits to Shanghai in 2013 and funding for the development of Mathematics Mastery, there has been continual government support directly or indirectly for nearly 10 years

Collaboration and relationships

Dialogue is important between policy makers, mathematics education researchers, teachers, and other stakeholders.

Table 37: Collaborations and relationships in the four policy development cases

Policy development	**Features**
Using and applying mathematics	Existing networks and collaborations consolidated in the Mathematics Curriculum Working Group
The National Numeracy Strategy	Important relationships between DfE (the National Numeracy Project) and Ofsted
FMSP	Policy networks mobilised around the importance of A level maths qualifications. MEI drew on existing collaborations.
Mastery	NCETM and MEI both had long standing relationships with DfE.

Champions

The policy has one or more influential policy champions.

Table 38: Champions in the four policy development cases

Policy development	Features
Using and applying mathematics in the national curriculum	An individual champion is less apparent. However, the Cockcroft Report was a powerful reference point, and the network of Cockcroft Ambassadors performed a collective role of champion
The National Numeracy Strategy	Chris Woodhead as first HMI, and then within government Anita Straker appointed as lead of the National Numeracy Project
The Further Mathematics Support Programme	Proponents for A level Mathematics in government – for example Liz Truss
Mastery	Nick Gibb – Minister for Schools – was a proponent of features of the Mastery policy – such as textbooks

28.2 Reflections on the application of the policy development model

We have applied the model developed from the international horizon scan to policy developments in England. This application suggests that this model may be useful in guiding the Royal Society (and others) in developing policy proposals and securing agreement to implement them.

29. Analysis of policy implementation

29.1 An implementation strategy model

Policy development and policy implementation processes are intertwined, particularly where policies are implemented as pilots or initial programmes as part of policy development, for example, the Mathematics Teacher Exchange prior to the development of the range of activities to support teaching for mastery. Thus, to separate policy development from implementation is a simplification and suggests discrete and episodic activity rather than the continual and messy process that is more likely to occur. Further, policy design includes, or should include, implementation planning. In this section, we focus on the four policy development cases and consider issues of implementation. To do this, we use a model focusing on three areas:

- Policy design
- Mechanisms
- Context

This model is informed by 1) analyses of education policy implementation, and 2) more generic implementation models from implementation evaluation.

Analyses of policy implementation

A recent OECD literature review and proposed framework for policy implementation (Viennet & Pont, 2017) define education policy implementation as 'a purposeful and multidirectional change process aiming to put a specific policy into practice and which may affect an education system of several levels' (p. 26).

Viennet and Pont review 18 policy implementation frameworks and models, identifying four key dimensions for an implementation framework to guide policy implementation and analysis:

- Policy design: justification, policy logic (goals, theory of change)
- Stakeholder engagement: stakeholders, beliefs and motivation, capacity, and resources
- Institutional, policy and societal context: institutional variation and constraints, policy contradiction or complementarity, alignment with societal trends
- Implementation strategy: clarity of responsibilities, objectives, tools, communication, resources, monitoring and accountability, timing (p. 28)

They point out that earlier, linear approaches to policy implementation, in which some central authority designed and implemented policy, are controversial. The policy cycle approach discussed earlier is frequently viewed as easier to implement and comprehend by policymakers but ignores the complexity of relationships. Complex models, including the Advocacy Coalition Framework (Pierce et al., 2020, p. 66) and Bell and Stevenson's (2015) implementation framework, inform Viennet and Pont's (2017) framework.

Implementation evaluation models

As well as the implementation of policies, more generic concerns with the implementation of programmes and interventions have led to the production of a large number of framework theories (Birken et al., 2017). Two key concepts in realist models of evaluation informed by complexity theory are mechanisms and context (see Coldwell & Maxwell, 2019).

Implementation strategy model

The implementation strategy model is informed by these frameworks and the analysis of mathematics education policy implementation in England over a forty-year period. Specifically, it summarises features found in two or more of the four policy development case studies. The features identified as important in, for example, Viennet and Pont's (2017) model, such as the importance of assessment of risk and development of contingency plans. The implementation strategy model is presented as a means to analyse previous policy implementation in mathematics education in England rather than a complete model to guide future policy implementation.

Table 39: Dimensions of a coherent implementation strategy

Dimensions	Features
Policy design	Small number of clear, measurable objectives[46] Feasible Realistic timeline Planning and resourcing extends through the whole timeline Embedded evaluation Refinements based on data/feedback
Mechanisms	Stakeholder engagement and communication Clear roles and responsibilities Effective organisations, networks, and processes Capacity building for leadership and policy champions at multiple system levels Adequate resourcing
Context	Accountability measures adapted to context Use existing settings and institutions where possible, or create new ones that fit context Responsive to stakeholder and participant interests Assess risks and develop contingency plans Plan to avoid policy clashes, exploit complementarities, amplifying enablers, reducing barriers

29.2 Applying the model to the four policy development cases

Below, in Tables 40, 41, and 42, we analyse the four policy cases drawing on features of the framework.

[46] Addressed in purpose (table 29) in section 28.1

Policy design

Table 40: Policy design factors influencing implementation in four policy cases

Feature	Using and applying	The NNS	FMSP	Mastery
Small number of clear, measurable objectives	Specific introduction of the U & A attainment target(s)	NNS clearly defined inc. 3-part lesson and whole class teaching	Focus on FM participation and outcomes as core Programme had long-term goals	Key indicators such as the number of schools engaged, mastery specialists etc.
Feasible	Based on/informed by existing activities	Informed by NNP as a pilot	Seeking steady growth in centres offering FM and numbers	Early take up of mastery approaches and textbooks indicated appetite in schools
Realistic timeline	No timeline established	Sequenced programme on a cascade model. Systematic and detailed planning	Realistic 3-year pilot phase – prior to government funding Goals for phases identified in FMSP plans	Planned progressive engagement
Planning and resourcing extends through the whole timeline	No specific resourcing allocated	Significant funding and leveraged existing school improvement funding and activity in Local Authorities.	Funding was medium term, subject to re-application by a tendering process Funding tending to be for 2–3-year phases and affected by electoral cycle	Funding committed for a 5+ year period
Embedded evaluation	No	Yes	Yes	Maths Teacher Exchange evaluated but no external evaluation of the Maths Hubs or Mastery policies as a whole. NCETM internal evaluation

Mechanisms

Table 41: Mechanisms – Stakeholder engagement factors influencing implementation in four policy cases

Feature	Using and applying	The NNS	FMSP	Mastery
Adequate resourcing	Not specifically for U&A	Significant annual resource with costs identified to ensure training and infrastructure was resourced.	Medium term plan in phases with resource committed for a number of years	Lack of alignment with SATs
Clear roles and responsibilities	Not specifically for U&A	Cascade model with National, Local, School level leadership roles	FMSP regional coordinators	NCETM, Maths Hubs, Mastery Specialists, School leads.
Effective organisations, networks, and processes	Not specifically for U&A	National Numeracy Strategy organisation, connected to LA school improvement	A range of stakeholders already involved in FMN, expanded through regional centres	NCETM, Maths Hubs organisation
Capacity building for leadership and policy	Capacity building via 'Cockcroft missionaries'	Cascade professional development including for school leaders	Continued focus on teacher professional development to build capacity	Capacity building through teacher exchange and Primary Mathematics Teaching for Mastery Specialists Programme (PMTMSP)
Stakeholder engagement and communication	Clear messages through curriculum documentation Stakeholders already highly engaged in work to support Using and Applying mathematics through a range of innovations	communication from the DfE and then NNS directly to schools and teachers Use of national media to create a climate for change (e.g., Panorama programme), effective use of video as well as print media	Established web presence, plus support of central, regional, and local networks and core staff	Early engagement of stakeholders including education experts, Ofsted, policy makers in visiting Shanghai
Champions at multiple system levels	HMI support	Included Prime Minister introducing the first NNS video Coalition included Ofsted, DfE secondments	Policy level commitment to A level and FM teaching; university mathematics depts	Policy commitment and funding. Supported via NCETM and Maths Hubs.

Context

Table 42: Context factors influencing implementation in four policy cases

Feature	Using and applying	The NNS	FMSP	Mastery
Draws on relevant local knowledge	Tasks and assessment informed by existing materials and activities	Local Authority role important for tailoring at local level	Programme focussed on a network of support for schools and centres	Informed by NCETM work, previous MaST programmes etc.
Responsive to stakeholder/participant interests	At a policy level through the Dearing Review	Not a feature in the early implementation. The formulation of the NNS did involve balancing different views	Regular evaluations supported a pro-active focus on challenges and future planning	Shaping of mastery policy informed by early adopters e.g., adaptation of same day intervention
Success indicators/measures adapted to context	Not fully included (U&A assessment not reported separately)	Indicators closely tied to existing school performance measures	Indicators focused on programme specifics	Indicators specific to programme implementation and process rather than impact
Use existing settings/institutions where possible or create new ones that fit the context	Support through existing LA structures Integrated into curriculum and professional development	The implementation combined new structures and existing structures – notably Local Authorities, QCA and with Ofsted playing a supportive role.	Built on existing MEI networks, new regional network model created	NCETM and newly created Maths Hubs
Plan to avoid policy clashes, exploit complementarities, amplifying enablers, reducing barriers	Embedded in the National Curriculum	Reformed assessments at the end of KS1 and KS2	Exploited existing structures and networks, extending support to KS3 & 4	Dominant policy focus – although some challenges in alignment with curriculum and assessment

29.3 Reflections on the application of the implementation strategy model

The implementation strategy model was formulated by considering both existing implementation models and a review of the four featured case studies. Thus, it is not surprising that the model fits the four cases. As noted, a feature recommended by Viennet and Pont (2017) is not included. This is why there is an assessment of risk and the development of contingency plans. This was not included because it did not occur in any significant way in any of the four policy developments.

Of the four examples, the one that arguably had the least long-lasting policy success was the introduction of Using and Applying Mathematics. As shown by the case study on problem solving in mathematics [Section 17], the 1989 National Curriculum was the high point for policy adoption of the importance of mathematical application in the school curriculum.

Comparing the features analysed with the model for Using and Applying Mathematics with the other three policy developments, it is notable that there are a number of features that are absent for Using and Applying Mathematics, particularly in the policy design and mechanisms categories. The fact that there is a relationship between the absence of features and implementation being less successful tends to suggest that some of those features are important to success.

30. Evaluation and impact

Policy evaluation is challenging as policy effects can take many years to become evident, and it is difficult to attribute any change to a particular policy. In many cases, mathematics education policy innovations were evaluated only in the short term or not at all. Positive evaluations do not guarantee continued support, as policy shifts are often driven by ideology and introduced at speed for political gain. Of the four policy cases considered above, there have been a series of independent evaluations of the NNS; the NCETM commissioned a series of evaluations, as did the FMSP; but the Maths Hub policy has not yet been evaluated.

A survey of education policy evaluation across OECD countries found increasing emphasis on evaluation while noting a lack of clarity in definitions and concepts (Golding, 2020). Over the period considered in our review, changes in assessment processes, technologies, and methods have contributed to an increased emphasis on evaluation, evident, for example, in policy requirements, funding, and communication. Golding notes that, although there is no standard approach, the following considerations are important:

- Who undertakes an evaluation – examples of evaluators range from internal evaluation units, independent researchers, international organisations, committees, with the latter bringing diverse perspectives to an evaluation
- When to evaluate, with ex-ante evaluation yet little used (that is consideration of alternatives prior to implementation)
- Identifying clear targets and metrics at the outset
- Purposing evaluation to inform learning and future policy refinements.

The National Numeracy Strategy policy was evaluated as successful (Earl, Watson & Torrance, 2000), but it is also important to see that some of its successes were based on changes or directions in practice already happening. For example, Brown et al. (2000) note that from 1976 to 1996, there had been a doubling of interactions in primary schools in a whole-class setting and a reduction of 15% in teachers who had a pedagogy more based on individual interactions (based on Galton's research, see p. 466). An independent evaluation of the NNS noted that:

> *systematic and detailed planning on the part of an increasingly centralized system had resulted in a good fit among other government policies, priorities, and guidelines of related agencies… Such alignment meant that there was a degree of policy coherence (at least in theory) that is unusual in large scale reform efforts (Earl, Watson & Torrance 2002, p. 36).*

The evaluators highlighted the risk to the policy if support was not sustained. A challenge in teacher supply, motivation, and capacity was identified as a possible barrier.

Kyriacou & Goulding (2004) reviewed the daily maths lesson, a key element of the NNS, finding that it had been widely implemented. They reported evidence of an impact on children's confidence and competence in mathematics, although they warned that the gains in the latter may be linked to closer alignment between teaching and assessment (pp. 1–2). They also reported issues, noting that the intended aims of increased interactivity, dialogue, and promotion of mathematical thinking had not been met, possibly undermined by increases in whole-class teaching coupled with an emphasis on 'pace'.

Aspects of the NCETM's work have been independently evaluated. Examples include a longitudinal evaluation of the mathematics teacher exchange (MTE) (Boylan et al., 2019), a mathematical reasoning programme for Year 2 pupils co-developed by NCETM and with training run through Maths Hubs (Anders et al., 2018), and an evaluation of the multiplicative reasoning professional development programme (Boylan et al., 2019). Based on the evaluation of the MTE, Boylan et al. (2018) make further recommendations for implementation and evidence gathering to inform policy refinements.

The Further Mathematics Support Programme (FMSP) has been regularly evaluated (Searle 2012, 2014; Boylan et al., 2015, 2016; Adams et al., 2019). Evaluations considered the success of all aspects of the programme together with external factors, including school capacity and sustainability.

PART EIGHT: Mathematical Futures

In this part, we identify challenges and opportunities for mathematics education policy development in the future.

31. Mathematical policy in the future: challenges and opportunities

31.1 Challenges and opportunities in the education landscape

In Part Two, we identified ten political, economic, and cultural forces:

- Marketisation
- Citizen as consumer
- Smaller state
- New public management
- Globalisation/glocalisation
- Human capital
- Social reproduction
- Moral panics
- Technological changes
- Social mobility

We also identified seven features of the educational landscape relevant to shaping the development and implementation of policy in mathematics education:

- System complexity
- Accountability
- Ofsted and inspection
- Teacher workforce supply and retention
- Changing teacher professionalism
- Evidence and practice
- Transnational influences

Additionally, looking across these forces, change features, and the chronology of events in different phases, underlines the quantity and breadth of change in education in England. As noted in the introductory sections, there have been 80 Government Acts in relation to Education since 1979 (EdPol, 2020). This was prior to the period of the COVID pandemic and the demand for rapid response to changing policy that was required of schools and teachers. Therefore, an important consideration for future initiatives is the capacity within schools and among teachers to engage in further change.

In our international horizon scan, 'Landscaping Mathematics Education Policy: Horizon scanning of international policy initiatives', we identified two features of mathematics education policy in England:

1. Educational policy in England is not usually shaped by a careful consideration of evidence.

2. There is an increasing divergence from high-performing systems which are reshaping their education policies in response to economic and social changes, including in mathematics education.

To these two points, we add a third:

3. Political, cultural, and economic forces, and education landscape features are important barriers to policy change and successful implementation in mathematics education.

This is maybe a statement of the obvious, something that is widely understood, but we contend that it is something that needs more consideration from a standpoint of optimistic pragmatism about what can be done to address this issue and where there might be room for bringing about change, even if this is in spite of these forces and features.

While we have pointed to a range of positive developments, we have also identified a trend, particularly since 2010, towards a more ideologically and politically driven approach to education policy. The recent history of mathematics education policy development in England exemplifies the lack of policy take-up of research-based, pragmatic proposals to address societal needs.

This happens at a broad and high level of policy—for example, the challenge for the Royal Society and others to influence the overall direction of STEM education policy in relation to particular content teaching areas. For example, a lack of engagement with digital technology in education outside of a narrowly defined concept of computing. It also happens at a specific programme level—for example, the failure of the Mathematical Pathways project to gain purchase and the lack of support in funding models for Core Maths.

If the Royal Society and ACME aim to influence policy development, then these forces and features need to be considered in three ways.

Feasibility: assessing barriers

The importance of assessing the feasibility of a particular programme, initiative, or action at a particular time in relation to relevant forces and features and the general capacity for change.

Moderating the expression of forces and features in change programmes

Designing programmes so that they are less effected by forces and features that might act as barriers.

Opportunities for forces and features to be 'flipped' and drive change

Drawing on Lewin's force field analysis (see, for example, Swanson & Creed 2014), it is possible to design programmes and policy interventions so that forces and features that appear to inhibit change can be 'flipped', so that they support change.

One example of this could be to identify how a focus on the economic needs of human capital leads to an overall narrowing of educational goals to raise assessment outcomes based on drivers of economic competitiveness. However, the same concern for human capital can be mobilised to support curriculum reform to improve the employment skills of school leavers.

A second example is how increased system complexity makes policy change nationally more challenging but can open room for more local experimentation and, through social movement principles, the diffusion of innovation across the system prior to policy agreement.

A third is changes to initial teacher education and new routes into teaching. On the one hand, this may lead to greater fragmentation; on the other, it opens the potential for routes such as Teach First to reach a group of prospective mathematics teachers who, in the future, may be influential on policy and practice.

31.2 Challenges and opportunities in the policy landscape

In analysing, policy development processes we noted that the process of policy development has changed. We identified a more ideologically driven approach to policy development, since 2010.

There are a number of implications of this.

Previous drivers and concerns may no longer be relevant or as powerful

Three examples of this are:

1. Previous policy changes in mathematics education were informed periodically by concerns of employers, industry, and HEI departments recruiting for undergraduate degrees with mathematics content. This was particularly important in 14–19 mathematics. However, the needs of employers and HEI appear to be less important in these considerations. Or rather, the views of employer organisations and representatives may be disregarded in favour of voices from these sectors within more informal political networks. This is part of a wider change in the political landscape with a shift to populist orientations.
2. The power of evidence to persuade has lessened. As part of a populist orientation, influential politicians promote mistrust of experts. We noted the weak evidence base for the current Ofsted-promoted approach to teaching mathematics education. The response to the quality of the review process being forcefully and systematically challenged (AMET 2021) was to redefine the meaning of research review to state that the document was a position paper.
3. We noted the importance of transnational influences on the National Numeracy Strategy, the 2014 curriculum, and the Mastery policy. However, shifts in the political landscape may mean that drawing attention to how England lags other countries may have currency where political discourse shifts to 'Global Britain'. Similarly, 12 years into the current government's being in power in some form or another, shifting responsibility to others for disappointing PISA outcomes becomes harder to do. Recently, the government withdrew from the OECD TALIS international study, citing value for money. However, continued data showing conditions and working hours for teachers being worse than in other countries may have influenced the decision.

An implication of this is that appeal to previous concerns and drivers may need to be nuanced and careful, with consideration given to audience and their interests.

The need to map and engage with current and future policy influencers

We noted that the policy development landscape has become more complex. There is a wider range of actors who have influenced educational policy. This creates challenges for future policy influence as it requires engagement with more current actors while also considering who may be influential in the future. For example, we have noted the influence of Teach First alumni in the educational policy sphere. This is likely to continue. In previous periods, this would not have been a constituency to consider. Teach First is an example of an organisation that would be important to engage with. Similarly, those Multi Academy Trusts that are represented on DfE policy advisory groups have political influence beyond their size. Against a background of relatively rapid change in both politically appointed and civil servants working on policy in the DfE, such organisations, if committed to change in mathematical education, may help to support sustained policy attention, including in specific areas of policy activity.

32. Mathematical Futures programme: approach to change process

32.1 A change process model

In this section, we consider the implications of landscaping policy for future Mathematical Futures activities. We focus on Mathematical Futures, but success in realising the Mathematical Futures vision will be more likely if there is wider policy work beyond mathematics education to improve the overall policy context. Examples of this wider policy work are improving national policy development processes and addressing forces and features that inhibit change in mathematics education, such as broader qualification reform. Some of that may be a necessary precondition for national-scale policy change in mathematics. However, consideration of these wider issues is beyond the scope of this report.

There are various models of change process in education and beyond. Here, we use a relatively simple model of phases of change, Fullan's (2001) distinction between:

- initiation
- implementation
- continuation
- outcome

Considering the Mathematical Futures programme vision as a whole, the following broad mapping of types of activity is presented in Table 43 in relation to initiation, implementation, and continuation phases.

Table 43: Change process model and the Mathematical Futures vision

	Years	Key features/tasks
Initiation	1-5	Developing networks Generating evidence, and initiating pilot programmes across identified core themes Working towards policy adoption
Implementation	6-15	Scaling and policy development across identified themes towards national implementation Developing foundations for reform of mathematics education as a whole
Continuation	16-30	Embedding change around core themes National implementation Systemic change in curriculum, pedagogy, qualifications and assessment, workforce, resources, and technology

Wider policy reform of curriculum and qualifications across all phases would be supported by the proposed sequenced approach leading to success in thematic programmes and developing wider consensus around a vision for mathematics education as a whole.

32.2 Initiating Phase 2 themes

The Mathematical Futures Board has identified the following Phase 2 themes.

1. Inequalities and diversity in mathematics education and the challenges of engaging students

2. The intersection between mathematics, statistics, data science and computing
3. The role of technology (‘Ed-tech’ or ‘digi-tech’) in mathematical education
4. The implications for the teaching workforce in mathematics and other subjects of themes 1-3

The fourth theme is formulated as being a necessary aspect and condition for success of themes 1-3.

Fostering change in relation to these four themes as an initiation phase has the potential to develop the foundations for future, more systemic change across the whole of mathematics education. However, as noted above, there is considerable change weariness in the education system, particularly given the COVID pandemic. We have identified a range of forces and system features that influence innovation. These are not uniform across phases.

Given this, consideration is needed as to the extent to which initiating programmes and changing the themes across different educational phases is feasible. There are two feasibility issues to consider.

1) It is important to reflect on the overall ‘fit’ between the theme and current curriculum in each phase and the relationship of these to core beliefs. A stronger case may be made for the importance for secondary pupils of the intersection of mathematics, statistics, data science, and computing given the secondary mathematics curriculum, other subjects, and an orientation towards preparing pupils of this age for further study and employment.

2) What aspects of a theme may be appropriate in a phase? For example, given the extent of the NCETM’s Teaching for Mastery programme in primary, it may be hard to generate momentum for a national-scale programme of professional development focused on embedded technology across the full spectrum of primary mathematics education. Such a programme may also not align with the NCETM's current key priorities. However, a more modest programme focused on the use of digital manipulative apps would have more potential as an extension of the current focus in Teaching for Mastery on representation.

As well as considering short-term feasibility in choices for the focus of Mathematical Futures’ activity, it would also be important to consider outcomes of Mathematical Futures Project 2 “Evidence and scenarios for the importance and value of mathematics in the future”.

32.3 Developing and testing programmes

This area of activity draws on the multiple streams model of policy development and the importance of piloting and sequencing innovation. Informed by a theory of change approach (Coldwell & Maxwell 2018), here we use a generic notion of ‘programme’ that includes a range of activities such as the introduction of a new qualification, a small pilot testing out a teaching approach, or the development of curriculum materials.

Programme development activities

Table 44 below identifies three types of activities necessary for programme development. These activities are sequences in that ‘evidence gathering’ and ‘programme innovation’ are necessary before scaling. However, evidence gathering is something that would continue across the sequence.

The suggested approach to programme development is designed to potentially lever or utilise existing infrastructure and funding streams. An example of such an approach to programme development and scaling is found in the Nuffield Early Language Intervention (NELI). The underlying evidence, research and programme development was funded in a variety of ways:

- Nuffield supported early programme development
- The Education Endowment Foundations funded trials
- Subsequently, both the EEF and the DfE have promoted its use in Early Years settings

Table 44: Developing and testing programme activities

Activity	Details
Evidence gathering	Evidence about the design and implementation of relevant programmes (UK and internationally) – with relevance being shaped by Mathematical Futures scenario planning from Project 2 Impact of programmes/curriculum/teaching/learner outcomes – both previous programmes and new programmes
Programme innovation	Development of programmes and evaluation through phases process of - design, pilot and testing of efficacy and effectiveness Integrating programme innovation in curriculum and pedagogy with professional development
Scaling	Implementing programmes and diffusing practices at scale

Across these three areas of activity, consideration is given both to feasibility and to the long-term vision of the Mathematical Futures Programme. In developing the NELI model of support from programme inception to scale, relatively modest funding from a partner or supporter of the Royal Society could support, by competitive application, potential programme developers to be provided with:

- Training in theory of change programme development to consider mechanisms and context
- Seedcorn funding for initial proposals

Promising proposals could be supported for further development with a view to supporting applications to existing funding streams (e.g., Nuffield) as a gateway for programmes with evidence of success to seek EEF funding for further development in large scale trials.

32.4 Social movement coalitions and influencing the climate

Here, we draw on the Advocacy Coalition Framework as a model of policy development and processes identified characteristics, in particular, purpose, climate, collaboration and relationships, sustained attention and champions.

Three areas of activity to consider are shown in Table 45 and discussed below.

Table 45 Coalitions, social movement and climate activities

Aspect	Activity
Creating a social movement	Developing Mathematical Futures as a movement – activists plus supporters (individual and organisational)
Fostering coalitions	Fostering alliances within and beyond mathematics education
Influencing the climate	Influencing societal, cultural organisational beliefs

Mathematical Futures as a potential social movement

The concept of social movement here does not necessarily refer to an organised and bounded group. Social movements may be diffuse; consider, for example, the movement for comprehensive schooling in England. While identifiable organisations were important, proponents of comprehensives could be found across many organisations and in none. Social movement theory can inform how the Royal Society (and partners) could generate system-wide activity and support for change.

Features of successful policy development and implementation in mathematics education accord with the application of social movement theory. Examples include NCETM-funded professional development and system leaders (Boylan, 2018), and more recently, Mastery Specialists (Boylan, Adams, & Maxwell, 2018). Such concepts are applicable to the 1980's with the Cockcroft Ambassadors as well as advocates and champions of various schemes and programmes led by or in collaboration with teachers (Adams & Povey, 2018). In the nineties, those in the National Numeracy Strategy roles acted as brokers and champions for change (Corbin, McNamara & Williams, 2003). Outside of mathematics education, other examples are the Networked Learning Communities programme (Hadfield, 2007), Computing At School Master Teachers (Boylan & Willis, 2015), and the growth and influence of the networks around ResearchEd.

Extending Mathematical Futures out beyond organisational representatives to involve mathematics teachers and educators directly has the potential to support a number of aspects of successful policy development identified earlier: developing and clarifying purpose, developing a receptive climate in educational settings, bringing sustained attention over time that is passed to future teachers, and encouraging teachers to engage in piloting innovations. It also opens up the possibility of fostering collaborations and relationships from teacher to teacher that might be difficult to develop at organisational levels. For example, a priority for engaging in such a movement might be Teach First trainees, given the increasing influence of Teach First alumni in the educational system, including in leadership positions in influential Multi Academy trusts and in policy roles in the Department for Education.

The prospect for developing such a movement or at least a network with shared purpose is shown by the recent 'Maths is More' events, which have gathered hundreds of online attendees. Perhaps more importantly, Maths is More events have attracted support from a wide range of diverse organisations and groups, including White Rose Maths and Ark Mathematics, as well as subject associations and university departments.

Building Coalitions

In an Advocacy Coalition Framework perspective, key to policy development success is the development of coalitions and alignment with existing coalitions. There are three types of potential partners to consider. Some may be ones who would have been part of this type of activity by ACME and the Royal Society previously or were engaged with the Mathematical Futures 'Call for Views' and *Evidence and scenarios for the importance and value of mathematics in the future*. However, there is a need and opportunity to extend alliances and coalitions. We suggest four sets of potential coalition partners.

1. **STEM education stakeholders** such as professional bodies and learned societies, employers and industry including representative bodies, and universities
2. **Thematic interest groups and stakeholders** with interests in focus themes in mathematics education such as: inequalities and diversity; intersections of mathematics, statistics, data science and computing; and the role of technology. For example, alliances might be fostered with groups and organisations that link concerns about student mental health, attendance, and disengagement with the lack of appropriate curriculum pathways

3. **Newer system actors** that have emerged due to increased system complexity. Important here are a) Multi Academy Trusts and in particular cross MAT Leads for Mathematics and other STEM subjects and b) new professional development and curriculum development enterprises
4. **Civil Society groups** such as politicians, lobby groups, parents, trade unions and interested charities

Consideration should also be given to how representatives from other UK and other nations might be included particularly in relation to gathering of evidence and development of programmes.

Influencing the climate

In previous successful policy developments, an important factor in their success was a conducive and receptive climate for the policy. In some cases, this supported consensus across a wide range of stakeholders. In the context of increasingly diffuse and less transparent policy decision-making processes, this may be even more important, as it is hard to know who or what might be influential on a particular policy. Attempts to influence the climate might be across a wider vision for Mathematical Futures or focused on specific themes.

As well as constituencies within education, it is important to consider wider dissemination and public engagement through media and social media. Essentially, the aim of such activity is to develop a widespread consensus that mathematics education needs change.

32.5 Policy engagement and development

The table below identified three types of activity focused on policy engagement and development activity

Table 46: Policy engagement and development activity

Aspect	Activity
Expanding policy networks	Expanding policy networks and engaging across governance networks
Campaigning	Making the case for economic, social, and political Importance of change and improvement - social and economic benefits
Costed policy design	The development of well-designed and costed policies that consider contextual enablers, barriers, and moderators

Expanding policy networks

In Section 6, we identified the complexity of the system and referred to the concept of network governance (Ball 2009). In Section 32.2, we noted that the policy development landscape has become more complex and that traditional approaches to influencing policy may be less productive, and we pointed to the need to map the networks that do or could influence mathematics education policy.

To maximise policy influence, traditional approaches would still be necessary, such as political lobbying, for example, through an all-party parliamentary group. However, it is also important to expand engagement with wider policy networks that may have more informal influence.

Campaigning

Considerable financial investment will be needed for a substantial programme in mathematics education around any one of the Mathematical Futures Phase 2 themes (see below). Given this, campaigning for the economic, social, and political importance of such changes will be essential for policymakers to be convinced that the benefits justify the costs. Here, the outcomes of Project 2 "Evidence and scenarios for the importance and value of mathematics in the future" will be important and may need subsequent follow-up cost-benefit analysis. We noted in the policy development case study on the Further Mathematics Support Programme the importance of the economic argument about the value of the A level mathematics premium (Adkins & Noyes, 2016), notwithstanding oversimplification by policymakers of the robustness of the research (Adkins & Noyes, 2016; Noyes & Adkins, 2016).

Costed policy design

Success in influencing mathematics education policy has been marked by antecedents to those policies that have established both the value of innovations and the costs involved for policies to be successful. Previous programmes provide indications of the likely costs involved. We provide a sketched example here. As a benchmark, a 2-year primary mathematics and computing professional and curriculum development programme, ScratchMaths, cost approximately £2,000 per school (Boylan, Demack et al., 2018). This involved Y5 teacher pairs engaging in two days of professional development, followed by Y6 teachers engaging in two days of professional development. There was additional twilight support. However, the evaluation identified that this time was not adequate for many teachers to both develop programming skills and the capabilities to use materials effectively. A significant barrier to attendance was the issue of supply in schools (one reason for the professional development design to involve only two days of professional development). Considering a programme with four days of professional development for four teachers per primary school with supply cover costs, it might involve costs of £6–8000 per school. Scaled across all primary schools in England, a national project could cost more than £100 million. Other, potentially more cost-effective, models are possible; however, considerable financial investment is needed for the necessary teacher professional development to lead to change.

33. Recommendations

Our recommendations are directed to the Royal Society Mathematical Futures Board. In our discussion of implications, we have made recommendations around challenges and opportunities for policy development, change process models and application of phase 2 themes.

Above we have made the following recommendations. A change process model of initiation, implementation, and continuation would support Mathematical Futures activity.

Applied to the identified Mathematical Futures Phase 2 themes, an initiation phase focused on the four themes has the potential to develop foundations for future more systemic change across the whole of mathematics education.

Suggestions were proposed for developing and testing programmes related to the Phase 2 themes, informed by Theory of Change models and for the development of coalitions to influence the climate for change. Such coalitions would need to include both traditional stakeholders and partners of the Royal Society.

Approaches to support policy engagement are identified:

- Expanding policy networks
- Campaigning
- Costed policy design

Additionally, we make the following five recommendations that would constitute initial steps.

Engaging with stakeholders as Mathematical Futures begins Phase 2

Phase 1 of the Mathematical Futures programme began with Project 1 – a call for views. Both Project 2 and Project 3, were informed by stakeholder views and consultation. Such views were important to landscaping educational policy. As Mathematical Futures enters Phase 2, we recommend that ways are found to continue to engage with stakeholders and potential supporters of the Royal Society's vision for mathematics education. This might include testing key findings and implications, as well as creating opportunities to contribute to future plans.

Such engagement would also support testing whether the type of broad movement around a vision of mathematics in the future could be fostered.

Identify or develop models of effective policy development and implementation

We recommend that the Mathematical Futures Board (and potentially the Royal Society more widely) identify (or develop) models of effective policy development and implementation. As part of this study, we have developed a model for each of these areas, which could be a starting point for further development. We developed these models in order to analyse the policy landscape. However, this was not a commissioned goal of our study, and so these models should be considered work in progress. We have tested the models to an extent by considering both successful and unsuccessful development and implementation. Testing the models we have proposed, or otherwise developing models of policy development and implementation processes would support the work of the Mathematical Futures Board by allowing for assessment of initiatives and, in the future, programmes and policies. One step towards doing this would be to engage with those with experience of policy-making processes from both inside and outside government and test and refine the models.

Establishing an ACME policy contact group.

Currently, ACME is engaged with a wider network of mathematics educators organised thematically. In landscaping mathematics education policy in England and in the previous international horizon scan, in roundtables and workshops, our reviews benefited greatly from the knowledge and reflections of experts with experience of influencing and/or implementing mathematics education policy. The Mathematical Futures Programme might benefit from finding ways to continue to draw on this expertise and that of others who have not yet been involved.

Engagement with current policy governance networks

We have identified ways that policy development processes have changed over time and the importance of engaging with current governance networks. A first step to doing this would be undertaking or commissioning an analysis of current bodies and individuals who do or potentially could influence mathematics education policy. Such an analysis might extend to relationships and the connections between them. We have pointed out the importance of core beliefs in shaping responses to policy. As well as describing policy networks, identifying key drivers and core beliefs of actors in these networks would support engagement with them and the tailoring of messages, which would inform policy design that has the potential to be supported. Given the relatively rapid change in government education ministers and policy teams within the DfE, engaging widely would be important to ensure the long-term development of consensus for change.

Develop pilot programmes

We recommend initiating a sequenced approach to the development of pilot programmes related to Phase 2 themes that have the potential to be scaled nationally in the future. Here, linking to the previous international horizon scan would support the identification of potential areas for development as well as an in-depth study of current and previous programmes implemented in England. Informing programme development with a Theory of Change methodology would support developing effective programmes, generate evidence of impact, and leverage resources from funding sources such as the EEF.

34. Conclusion

We have described and analysed policy and change in mathematics education in England. The chronological mapping of mathematics education policy interventions in England by educational phases demonstrates the extent of change in mathematics education. The analysis of trends, policies, and system changes underlines that the educational policy landscape is challenging to navigate to bring about lasting change.

However, previous initiatives to change policy and practice in mathematics education provide insights for future possibilities. To realise the goals of the Mathematical Futures Programme, it will require a strategic and multifaceted approach to generating policy change.

PART NINE: Supporting materials

This part comprises acknowledgements, references, and appendices.

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37. Appendices

Appendix 1: Methods

Analytical model

In reporting on policy interventions over the past 40 years we identify, as per Royal Society requirements:

- Policy development: description of background context
- Policy drivers: intended broad aims or goals articulated through policy documents (e.g., White papers), ministerial statements & speeches, press releases and legislation
- Policy levers (delivery strategies): including through government targets, funding, national initiatives, inspection
- The role of stakeholders in policy development, implementation and change as evidenced in policy documents.
- Overarching forces and perspectives in mathematics education (e.g., accountability, academisation)

In addition, in considering implementation of policies we attended to influences on implementation including barriers.

Policy levers

Policy levers are understood here as 'the wide array of functional mechanisms through which government and its agencies seek to implement policies' (Steer et al., 2007, p.177).

Ball's 'policy trajectory' approach (1993, 1994 – cited in Steer et al.) encompasses 'interactions over time and at different system levels' (Steer et al., 2007, p.177) – these interactions are conceptualised by Steer et al. in four ways:

1. Different levels of governance system e.g., national, regional, local
2. Interactions at the level of local ecologies or 'cultures' e.g., institutional provision, local labour markets, community, needs, learner trajectories
3. Interactions at institutional levels and within institutions
4. Interactions between policy levers

In this study we are mainly concerned with 1 & 4 given the methodology, scope and aims. These interactions can lead to policy distortions. Some of these interactions can also lead to impediments to policy - for example the change to linear A levels causing a disincentive to Core Mathematics take up (Homer et al. 2020)[47] . Furthermore, Steer at al. note that 'the engineering metaphor of a policy 'lever' does not hold at the level of practice because there is little evidence of practitioners mechanically responding to these levers in simple and predictable ways' (Steer et al., 2007, p.187). Thus, lever as a term is used with reservations.

Warrant

Warrant signifies 'justification, authority, or "reasonable grounds," particularly those that are established for some act, course of action, statement, or belief' (Cochran-Smith & Fries 2011, p.4). In

[47] https://coremathsproject.leeds.ac.uk/wp-content/uploads/sites/32/2020/09/Core-Maths-Final-Report-Sept-2020.pdf

their study of teacher professionalism, Cochran-Smith and Fries identify three warrants: the **evidentiary warrant** (establishment of a position based on evidence), **the political warrant** (justification in terms of public good), and the **accountability warrant** (arguments posed 'to demonstrate that recommended policies are justifiable and justified by the outcomes and results they produce' (p.7). They note that the political and accountability warrant must be considered alongside the evidentiary warrant in considering education reform (here teacher education specifically).

Policy forces

Political-social-economic-policy forces that are shaping policy and governance generally within education or beyond.

These may shape any stage of policy process: development, decision, implementation.

Policy perspectives

Education in general is an arena of contestation over perspectives on purpose, curriculum, pedagogy and how these should be enacted through policy. Arguably, this is particularly true of Mathematics education.

In considering policy perspectives we drew on the advocacy coalition framework (Pierce et al., 2020) model to consider the following types of beliefs

- 'Core': fundamental beliefs that are influence policy but are too broad to guide detailed policy
- 'Policy core' are more specific such as the overall priorities and purposes of education that are unlikely to change.
- 'Secondary Aspects' relate to the implementation of policy. They are the most likely to change

Such beliefs may be about or inform policy in general, education policy or mathematics education policy.

Policy trends and patterns

These were identified by looking across policy analyses and case studies and so were inductive/emergent categories which then informed roundtable discussions.

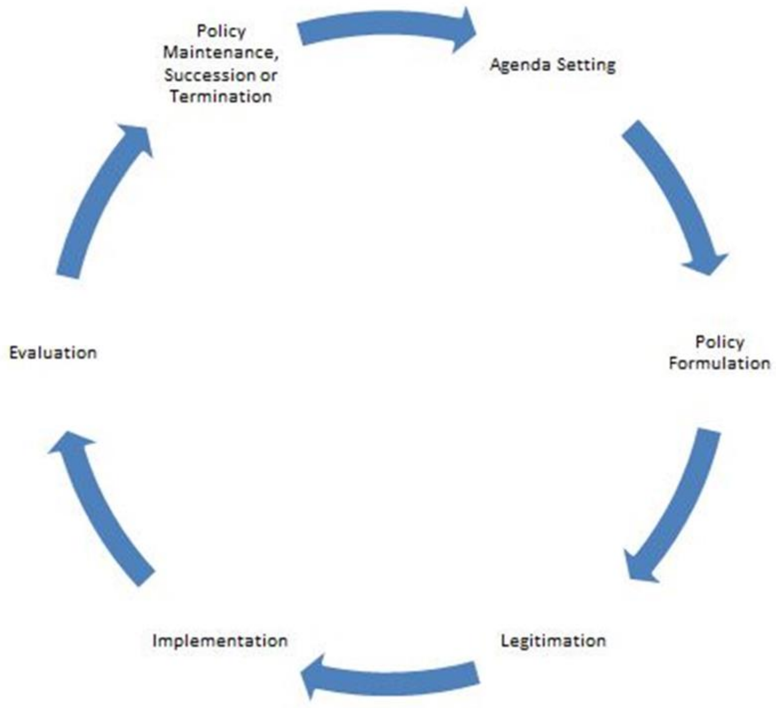
Model

Three models were considered

- Policy cycle model
- the Advocacy Coalition Framework
- multiple streams model

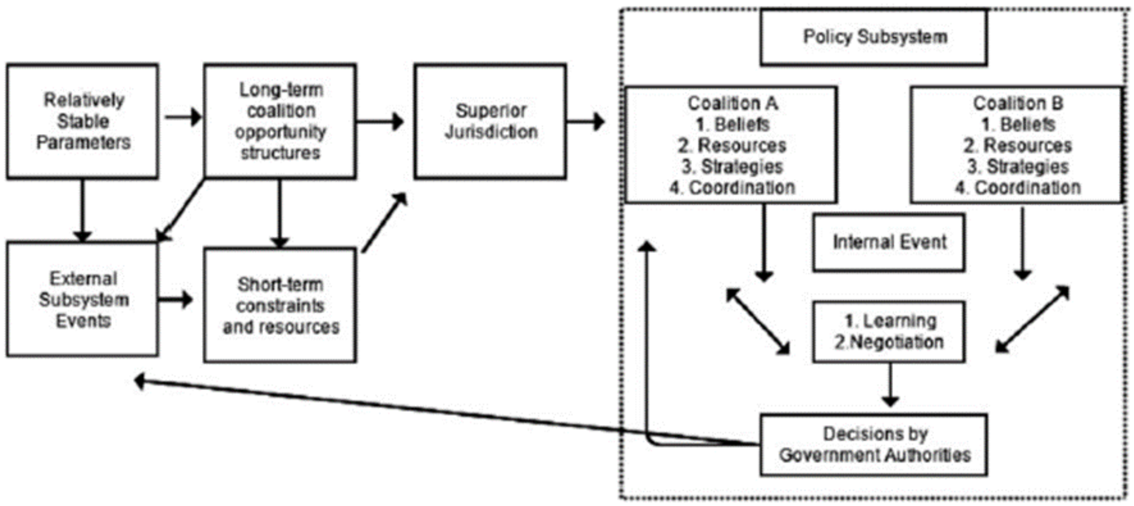
These three models are not necessarily mutually exclusive as they focus on different aspects of policy development. Models are complex not linear.

Policy cycle model



https://paulcairney.wordpress.com/2013/11/11/policy-concepts-in-1000-words-the-policy-cycle-and-its-stages/

Advocacy Coalition Framework



Pierce et al. (2020, p. 66).

Multiple streams analysis

Problem stream –a policy problem emerges is identified or becomes focus of attention

Policy stream - a perceived solution to the problem is available (developed or identified as existing)

Politics stream – policymakers have the motive and opportunity to turn it into policy (Cairney, 2012).

Nature and scope of policy synthesis

As noted in the ITT (537-3), work package 1 is intended as 'an evidence synthesis which aims to bring together information from a range of sources to provide an accurate, concise synthesis of national education policy patterns and approaches' (p.4).

The research undertaken has similarities in its relation to a comprehensive and in-depth policy analysis as a rapid evidence review has to a full systematic review. A rapid evidence review is "a form of knowledge synthesis that accelerates the process of conducting a traditional systematic review through streamlining or omitting a variety of methods to produce evidence in a resource-efficient manner." (Hamel et al., 2021, p.80)[48]. The additional risk of bias in a rapid review (Royal Society, 2018) was countered by engagement with experts. A systematic review is comprehensive and typically is undertaken over a period of 1-2 years.

Selection of texts for review: quality criteria

Above, we noted that even for a single policy area, the volume of publications was beyond the scope of the project. Also, above we used an analogy of a rapid evidence review to describe features of our rapid policy review synthesis. In rapid evidence reviews, one feature that is retained from systematic reviews is a consideration of quality criteria. However, an aspect of quality criteria for selection is the usefulness of the text for addressing the review questions in the timescale required. Taking a similar approach, we filtered texts by initial selection of texts that were themselves wholly or partly a policy review that had:

- reviewed and analysed primary policy texts
- was transparent about methods and analysis (met usual requirements of rigour)
- identified one or more feature in the analytical model i.e., policy driver, feature etc

Gaps in the analysis were filled by going to primary sources where available.

Search, review ,and filtering continued till a record/analysis/frame was complete or pragmatically relevant sources did not appear available or would require a more detailed policy analysis.

The pragmatic choice here was guided by the overall purpose of identifying patterns in the policy features rather than providing a comprehensive analysis of each individual policy if such an analysis had not already been undertaken.

Roundtable structure

Roundtables addressed five questions/topics, broadly following this example from the primary roundtable with some minor variations:

1. What direct policy interventions have influenced primary mathematics education in 2021?

[48] See adapted definitions on p81 Policy analysis texts\Hamel et al 2020 Defining rapid reviews.pdf. And see also Policy analysis texts\cochrane_rr_-_guidance-23mar2020-final.pdf

Participants were provided with tailored list specific to the roundtable of milestones/policy interventions in advance of the roundtable event.

2. What indirect policy interventions have influenced primary mathematics education in 2021?

Participants were provided with tailored list of potential indirect policy interventions as stimulus.

3. What change trends have been important in shaping primary mathematics education in 2021?

A list of change trends was provided in advance as a work in progress. This was grouped in the following themes: curriculum, qualifications and assessment, pedagogy, teacher workforce, resources and technology, system, and purpose and values.

4. What past policy and change trends are important to thinking about future possibilities for primary mathematics education?
5. Considering mathematics education policy in England as a whole, do you have anything to add around the themes of influential policies, change trends and future possibilities?

Appendix 2: Policy development and implementation

The OECD promote a framework of three dimensions to support a coherent implementation strategy, represented in Figure 11 (Viennet & Pont, 2017):

- smart policy design
- inclusive stakeholder engagement
- a conducive institutional, policy and societal context

The figure shows factors that influence, and are influenced by, policy implementation. The process highlights the 'specificity of policy, stakeholders and local context' (Viennet & Pont, 2017, 44). This model, referred to in Adams & Boylan (2022) has the potential to inform future policy development in England.

Figure 11 OECD model of policy development and implementation