Mathematics in Further Education Colleges

Final Report

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Foreword

Mathematics is of central importance to modern society. Our young people therefore need a high quality mathematics education that develops both the *competence* to use appropriate mathematics in a variety of work, learning and life contexts, and the *confidence* with which to do so. Addressing the negative attitudes to learning mathematics that I highlighted in my report to the Treasury in 2017 is key, no more so than for the students in our further education colleges. Improving the quantitative skills of this group, many of whom follow vocational and technical pathways into key employment sectors, is critical for national prosperity and to narrowing the opportunity gaps in our nation.

Many reports have called for improvements in mathematics education and often these centre on learners following academic pathways. This comprehensive study delves into the complex challenges facing managers, teachers and students in England's further education sector. The authors have thoroughly investigated how the various components of the mathematics education system interact in colleges and have made a series of clear recommendations for key stakeholders.

The Inquiry into Post-14 Mathematics Education that I chaired over 15 years ago identified shortcomings in 1) the curriculum and qualifications framework, 2) the supply of teachers and 3) the continuing professional development architecture. Whilst there has been some progress made in these areas for schools, the further education sector has remained something of a black box, until now. As we navigate our way through uncertain times, repositioning our economy post-Brexit and responding to Covid-19, this is a key moment to push for a better mathematics education for these young people.

The authors highlight that much more needs to be done to address the aforementioned three challenges in the FE sector. There is an outstanding need to develop a coherent and sustainable suite of appropriate mathematics pathways to support vocational and technical employment routes. Similarly, teacher supply, initial training and career-long CPD need to be improved and there is a clear need for leadership development. The report suggests that some of this can be achieved by harnessing and coordinating the energy and expertise within the sector, but there is also need for further investment in leadership, recruitment and CPD.

This report offers much needed insight for those with limited experience of our FE sector so that better interventions can be designed to address the seemingly intractable shortcomings in the nation's quantitative skills base. The study takes seriously the complexity of organisational and sectoral change and I hope that the findings and recommendations will both challenge and support those tasked with improving the mathematical competence and confidence of our young people.

Professor Sir Adrian Smith FRS

Director of The Alan Turing Institute

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1 Executive summary

Mathematical skills are key to the future prosperity and wellbeing of individuals and society. Yet concerns about adult numeracy raised at the end of the last century in the Moser Report[1] have not abated[2] and international comparisons continue to highlight England's weak quantitative skills base[3]. In the last decade, the Wolf Report[4], Sainsbury Review[5] and UK Industrial Strategy[6] have all reinforced the need to improve the nation's mathematical competence. Achieving such improvement, however, is a *wicked problem*.

Smith's (2017) review of post-16 mathematics[7] expressed "the need to recognise more explicitly…the fundamental importance of Further Education in the post-16 landscape". The current Centres for Excellence in Mathematics programme is one aspect of the government's strategic response to that report and the forthcoming Further Education (FE) White Paper will hopefully bring renewed attention to mathematical learning as a necessary element of reforms to vocational and technical education.

The new Condition of Funding, first introduced in 2014, required many more post-16 students without a GCSE grade C/4 to continue their study of mathematics. For those previously awarded a grade D/3, retaking GCSE is now the only option although those with lower grades may take a Functional Skills qualification as a 'stepping stone' to GCSE. This policy produced an initial increase in mathematics participation and progress, which national published data suggest has stalled thereafter. The Condition of Funding also precipitated considerable changes to the mathematics teacher workforce and to the management and organisation of mathematics in General Further Education Colleges (GFECs)[8].

Students with low GCSE attainment in mathematics (and English) have been termed 'the forgotten third'[9] and the majority of them proceed to vocational programmes in FE post-16. Analysis of retake students' mathematics progress in 2015/16 highlighted relatively poor progress for those in FE colleges[10]. Less than a quarter of students without a GCSE grade 4 in mathematics at age 16 achieve this by age 18.

Continued investment is therefore needed to improve mathematics outcomes for these students and this report proposes a number of priority areas for action. A long-term strategy for the development and continual improvement of appropriate qualifications and learning experiences is required. This is in contrast to the regular changes in

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[1] Moser, S. C. (1999). *Improving literacy and numeracy: a fresh start*. London: DfEE Publications.
[2] National Numeracy (2019) Building a numerate nation: confidence, belief and skills. NN: London
[3] OECD (2016), Skills Matter: Further Results from the Survey of Adult Skills, OECD Skills Studies, OECD Publishing, Paris
[4] Wolf, A. (2011). Review of vocational education. London, Department for Education.
[5] Sainsbury, D. (2016). Report of the Independent Panel on Technical Education. DfE/BIS. London.
[6] BEIS (2017). Industrial Strategy: building a Britain fit for the future. Department for Business. London, HMSO
[7] Smith, A. (2017). "Report of Professor Sir Adrian Smith's review of post-16 mathematics." London: DfE.
[8] The project centres on General Further Education Colleges (GFECs) since these are the main providers of further education in England with 174 GFECs out of a total of 257 FE colleges (February 2019). For simplicity, we sometimes omit 'general' and refer to these as FE colleges in the report
[9] ASCL (2019). The Forgotten Third: final report of the commission of inquiry. Oxford, Association of School and College Leaders.
[10] Rodeiro, C. V. (2018). "Which students benefit from retaking Mathematics and English GCSEs post-16?" Research Matters (25): 20-28.

(mathematics) qualifications since the Moser Report that evidence an academic drift through core skills, key skills and functional skills to GCSE[11].

In this context of complexity and change, the Mathematics in Further Education Colleges project set out an ambitious research agenda designed to understand the mathematics education landscape in FE; the processes of policy enactment in colleges; the challenge of recruiting, developing and organising the workforce; and colleges' operational strategies and students' experiences. The focus was on the student cohort retaking GCSE Mathematics and vocational students in particular, since these comprise the largest part of mathematics provision in colleges.

The MiFEC project (2017-20) aimed to bridge from the national scale through college provision to classroom experience. The multiscale research design assumed that more effective change and implementation planning is contingent upon systems thinking and coordinated action. The project comprised four work packages:

Work Package 1: Review of literatures and twenty year policy analysis

Work Package 2: Analysis of national administrative datasets

Work Package 3: Case studies of General Further Education Colleges

Work Package 4: National survey of the FE mathematics teacher workforce

The case studies engaged around one sixth of England's GFECs at the time the project commenced[12]. In total the field work involved 44 site visits, including 238 interviews with staff and 62 focus groups involving 388 students. There were 480 survey respondents from the sample colleges, a response rate of over 60%.

A series of Interim Reports[13] and academic papers have been published from the project to date. This Final Report synthesises the findings from the four work packages into six themes. Our recommendation are made with four groups in mind (national policymakers, senior leaders in colleges, mathematics curriculum leaders and other stakeholders) but we refrain from linking any particular recommendation to a group.

Appreciating context and ensuring equality of opportunity

A college's local context and its general curriculum offer influence both the size and the motivations of the mathematics student cohort. Mathematics performance models would be fairer if such contextual factors were taken into account. Colleges' prioritisation of learner needs and/or different progress measures influence strategic decisions about students' mathematics pathways. Similar students in different colleges do not therefore get the same opportunities. Changes to measures of progress may lead to greater consistency between colleges and more equitable learning experiences for students.

> **Recommendation 1:** Consideration should be given to adding contextual factors into models of mathematics progress to more fairly reflect the achievements of students and colleges.

[11] Dalby, D. & Noyes A. (2020). Mathematics curriculum waves within vocational education, Submitted for review to Oxford Review of Education

[12] Other FE colleges (e.g. Sixth Form Colleges, specialist colleges) may identify with some of the issues raised but the size of provision and organisational complexity of large GFECs means this has been the main focus of this study. Where we use FE Colleges, it refers to GFECs

[13]MiFEC reports are available at www.nottingham.ac.uk/research/groups/crme/projects/mifec/index.aspx

Recommendation 2: The learning goals and preferred qualifications pathways for students entering FE with GCSE grades 1 and 2 should be agreed, with performance measures being revised to support these objectives.

Understanding and developing leaders, systems and processes

Cross-college leadership and management is challenging due to the dispersion of students across sites and the shared responsibilities with vocational staff. Bespoke training is needed to enable cross-college managers to make well-informed decisions on strategic and operational approaches. Colleges benefit from mathematics being an institutional priority, with well-defined sharing of responsibility and good collaboration between those with leadership responsibilities for mathematics at different levels. Operational challenges are complex in large colleges. Approaches to timetabling, induction, staffing and attendance monitoring that are sensitive to the particular needs of these mathematics students helps to produce classroom experiences that are more conducive to learning.

Recommendation 3: A new national programme of leadership training should be developed appropriate for those in cross-college mathematics leadership positions to include strands on 1) curriculum leadership, 2) organisational strategy, 3) systems management, and 4) reflective and evaluative change leadership.

Recommendation 4: A mathematics self-evaluation toolkit and support package should be designed to aid college managers in reviewing their organisational strategies and developing improvement plans appropriate to their local context.

Recommendation 5: Operational planning (e.g. timetabling, attendance) in some colleges needs to take better account of the GCSE retake students' characteristics in order to provide the best possible environment for learning.

Establishing a distinctive FE mathematics teacher workforce

Mathematics teachers[14] in colleges come from a range of backgrounds with different subject and teaching qualifications. The workforce had to expand due to the increased numbers of students retaking mathematics following the Condition of Funding, albeit amidst ongoing national teacher shortages. The deregulation in the FE sector has allowed colleges to make independent judgements about appropriate qualifications and training for their staff. Entrepreneurial approaches to teacher recruitment have been developed by colleges but more support is needed nationally to boost recruitment and to provide appropriate training for those entering FE mathematics teaching through a variety of routes.

Recommendation 6: A national recruitment campaign to attract career-changers from diverse backgrounds should be designed and launched with some urgency.

Recommendation 7: Initial training requirements for teaching mathematics in FE should be reviewed and a national training strategy developed that distinguishes between the needs of teachers who are undergoing 1) a significant *career* change, 2) a change of *curriculum* focus, and 3) a change of educational *context* (e.g. from school to FE)**.**

[14] In this study we refer to mathematics teachers as those teaching courses that lead to a mathematics qualification. Mathematics is also taught by other teachers (e.g. vocational teachers) in embedded and modular forms within other courses.

Developing the existing FE mathematics teaching profession

Few mathematics teachers in FE undertake full-time training prior to entering the workforce so professional development is particularly important. There are wide variations in the amount, type and quality of mathematics-specific CPD accessed by teachers. Colleges would benefit from clearer guidance on what 'professionalism' in FE mathematics teaching means and a framework of professional standards to guide teacher development. Diverse entry routes and teacher backgrounds add to the complexity of providing appropriate professional development for all. Training needs analysis tools, longer-term professional development planning and better understanding of effective CPD are needed so that colleges can make good use of effective models, including college-based opportunities to develop professional learning communities and practitioner research.

> **Recommendation 8**: Designated funding should be ring-fenced for the professional development of mathematics teachers in FE colleges.
>
> **Recommendation 9**: An individual entitlement to high-quality, mathematics-specific continuing professional development should be defined and adopted nationally.
>
> **Recommendation 10**: Sector agreement on appropriate professional standards for mathematics teachers in the FE sector needs to be established as a framework for professional development.
>
> **Recommendation 11**: Tools for conducting training needs analysis should be developed to support long-term professional development planning for mathematics teachers and teaching teams.
>
> **Recommendation 12**: Guidance on effective CPD models, such as the development of professional learning communities and practitioner research, should be provided in order to build capacity in the workforce for sustainable self-improvement.
>
> **Recommendation 13**: The initial and ongoing training of vocational teachers[15] should include better opportunities to develop personal confidence with mathematics.

Understanding and developing pedagogy in context

Teachers' choices of classroom approaches are contingent upon a range of contextual, organisational and educational factors. Teachers and students are largely in agreement about the teaching and learning approaches that work best in the FE context. Most students view their learning experiences more positively than those in school, although they would like even greater use of student-centred approaches[16]. Teachers identified the need to counter low levels of student motivation and engagement and to adapt teaching in multiple ways to meet students' needs. This contingent teaching requires a rich toolkit of strategies and resources, and this in turn demands a sustained programme of teacher professional development. There are variations in the provision and uptake of out-of-class learning opportunities for students, and in the embedding of mathematics into vocational

[15] Vocational teachers are considered here to be those who teach solely on vocational study programmes and do not teach mathematics qualifications.
[16] A categorisation of student-centred and teacher-centred approaches was used based on that developed by Malcolm Swan (2006).

learning which require further research to ensure colleges can supplement and support classroom teaching in the most effective ways.

Recommendation 14: Teaching and learning approaches that address the specific contexts, constraints and affective issues in FE need to be researched, developed and widely disseminated across the sector.

Recommendation 15: Mathematics teachers in FE need ongoing support and professional development to develop rich pedagogical toolkits that enable them to adapt teaching and learning to meet diverse students' needs.

Recommendation 16: More effective strategies for out-of-class mathematics learning for FE students needs to be developed, evaluated and disseminated.

Recommendation 17: Research on approaches to the 'embedding' of mathematics into vocational learning and the impact of different practices needs to be commissioned[17].

Objectives, pathways and sustainable improvement

Analysis of FE mathematics policy over the last 20 years shows how repeated attempts to develop alternatives to GCSE mathematics (i.e. core, key and functional skills) have failed to produce a sustainable and trusted qualification that addresses the skills needs of vocational learners. Now is an opportune time for a renewed attempt to establish post-16 mathematics pathways for different academic, vocational and technical tracks and to map the full mathematics learning opportunities across programmes. Future policy design and implementation needs 1) greater involvement from the FE sector, 2) more realistic timescales, and 3) careful consideration of unintended consequences. The design of sustainable, trusted qualifications for vocational learners that can stand the test of time (c.f. GCSE) is needed.

Recommendation 18: The long-term policy objectives for post-16 mathematics education need clear articulation. This might include:

- renewed effort to establish a pathways model for 14-18 mathematics that complements different academic, vocational and technical routes[18];
- identification of recommended qualification pathways for students with particular prior attainment and mathematical learning needs;
- a mapping of post-16 mathematics learning opportunities both in stand-alone qualifications and embedded within courses and programmes.

Recommendation 19: Future developments in post-16 FE mathematics require:

- a long-term commitment to design, development, piloting and improvement in order to build trusted qualifications and break the pattern of qualification devaluation;

[17] The General Mathematical Competencies framework designed by the RS/ACME and adopted into the T-level framework offer one line of approach that might have wider applicability for vocational programmes.
[18] For commentary on the metaphor of 'stepping stone' qualifications see Dalby, D. & Noyes, A. (2020). The waxing and waning of Functional Skills mathematics. Journal of Vocational Education and Training. https://doi.org/10.1080/13636820.2020.1772856

- a realistic timescale and planning process[19] including consideration of staffing, training and CPD, qualification and resource development;
- consideration of potential unintended consequences;
- closer collaboration with the sector during development and implementation phases.

Recommendation 20: A broader set of performance indicators should be considered for post-16 mathematics education, for example confidence and self-efficacy, in order to stimulate policy and practice that better addresses the national challenge of improving quantitative skills.

[19] The Royal Society/Advisory Committee on Mathematics Education's ongoing work to develop a Qualifications Assessment Framework could inform such design processes.

2 Introduction

2.1 Context

Improving the mathematical skills of adults in England is a national priority as seen in the Industrial Strategy[20], Sainsbury Report[21] and Post-16 Skills Plan[22]. The economic benefits for individuals and society are well evidenced, both nationally[23] and internationally[24] but there is also recognition of the wider value of mathematical skills for full and meaningful engagement in society[25].

Professor Sir Adrian Smith's wide-ranging review of post-16 mathematics education[26] noted that aspects of Further Education (FE) provision, critical to realising this skills agenda, are poorly understood. There remains limited knowledge of how FE college strategies, managers, teachers and pedagogies mediate policy or how a raft of policy changes over recent years have impacted upon students' experiences and outcomes.

The FE sector has experienced long-standing policy churn, as highlighted by the Institute for Government[27]: "In further education alone, since the 1980s there have been 28 Acts and 48 Secretaries of State covering some part of it, while no organisation has lasted more than a decade". Since *incorporation* in 1992, responsibility for Further Education has transferred between government departments several times. Such a level of flux is not conducive to sustained improvement. Changing priorities in policy and qualifications have influenced the mathematics offer to students and successive mathematics qualifications for vocational education (core, key and functional skills) have been devalued.

The latest major development for mathematics education in FE was the introduction of a new Condition of Funding (CoF) in August 2014. The Condition of Funding has since been amended twice:

- From August 2015 it became compulsory for students achieving a GCSE Grade D/3 at 16 to retake GCSE rather than any alternative mathematics qualification;
- From September 2019 was it no longer obligatory for students who achieve Level 2 Functional Skills mathematics to progress to GCSE.

This CoF intervention followed from the 2011 Wolf Report[28] on vocational education, as a means of tackling low attainment and increasing the number of students achieving a GCSE Mathematics grade C/4. Performance measures have supported the Condition of Funding

[20] www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future
[21] assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/536046/Report_of_the_Independent_Panel_on_Technical_Education.pdf
[22] www.gov.uk/government/publications/post-16-skills-plan-and-independent-report-on-technical-education
[23] Cerqua, A. & Urwin, P. (2016). Returns to Maths and English Learning (at level 2 and below) in Further Education. London: BEIS.
[24] Hanushek, E. A., Schwerdt, G., Wiederhold, S. & Woessmann, L. (2015). Returns to skills around the world: Evidence from PIAAC, European Economic Review, 73(C), 103–130
[25] Bredberg, J. (2020). The role of mathematics and thinking for democracy in the digital society. Policy Futures in Education, 18(4) 517–530
[26] Smith, A. (2017). Report of Professor Sir Adrian Smith's review of post-16 mathematics. London: Department for Education. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/630488/AS_review_report.pdf
[27] www.instituteforgovernment.org.uk/sites/default/files/publications/IfG_All_change_report_FINAL.pdf
[28] www.gov.uk/government/publications/review-of-vocational-education-the-wolf-report

developments, the most pertinent being the high-grade achievement rate[29] and the maths progress measure[30]. Progress for 16-18 year olds in FE colleges, however, remains slow with just over a third (36.5%) making measurable progress in 2019 and 18.2% achieving a GCSE grade 4.

Other significant curriculum changes, such as revisions to GCSE and Functional Skills mathematics qualifications, have also taken place and FE Area Reviews[31] have led to a number of college mergers.

2.2 The Mathematics in Further Education Colleges Project

The Mathematics in Further Education Colleges (MiFEC) project is a national, mixed-methods research study funded by the Nuffield Foundation from 2017-2020. It set out to provide evidence-based advice for policymakers, college managers, curriculum leaders and practitioners on how to improve mathematics education in England's FE colleges.

The project centres on General Further Education Colleges (GFECs[32]) since these are the main providers of further education in England with 174 GFECs out of a total of 257 FE colleges[33] (February 2019). For simplicity, we sometimes omit 'general' and refer to these as FE colleges in the report.

These FE colleges are generally large, complex organisations with a wide curriculum offer. A typical college focuses on vocational education and training but may also offer academic programmes and courses for adults. Apprenticeships, specialist provision, supported learning and HE provision are also provided by many FE colleges.

The MiFEC project was organised in four work packages that set out to answer the following questions:

1. How has FE mathematics policy and practice been shaped since 2000 and what lessons can be learnt to improve the design of policy in the future?
2. *Who attains what mathematics qualifications in FE and how has this changed over time?*[34]
3. How do FE colleges mediate government policy on post-16 mathematics education?
    - What different strategies have been employed?
    - How has/is funding shaping college policy and classroom experience?
    - What are the workforce strengths and limitations?
    - How is curriculum and assessment changing?

[29] High-grade achievement is the percentage of students gaining GCSE grades 1-4 out of the total enrolled at the start of the course.
[30] See here for the full guidance.
[31] https://www.gov.uk/government/collections/post-16-education-and-training-area-reviews
[32] GFECs form the major part of the Further Education (FE) sector. Other FE colleges (e.g. Sixth Form Colleges, specialist colleges) may identify with some of the issues raised but the size of provision and organisational complexity of large GFECs means this has been the main focus of this study. Where we use FE Colleges it refers to GFECs
[33] Association of Colleges (2019). *College Key Facts 2018-19*. Retrieved from: https://www.aoc.co.uk/sites/default/files/College%20Key%20Facts%202018-19.pdf
[34] Due to a series of delays in accessing government datasets brought on by new legislation, legal complication in linking government datasets for non-departmental use, and a ramping up of technical requirements for remote access, a no-cost extension was granted from late 2019 to the end of October 2020. Unfortunately, further delays have since resulted from the global Covid-19 pandemic. Work on WP2 is ongoing although some analysis on multiple sets of annual summary data have been undertaken and are referenced in this report.

- What are the possible unintended consequences of policy upon classrooms?

4. Who is teaching post-16 maths in FE? What are the current and future training and development needs?

This report brings together a substantial body of research to answer these questions. Findings on 1, 3 and 4 are already in the public domain in a series of MiFEC Interim Reports and papers (see Section 2.4).

2.3 Research design

The MiFEC project aimed to understand the multi-layered challenges of implementing policy and developing mathematics teaching practices in FE colleges in England. For this reason it combined different scales of analysis with appropriate levels of granularity. Whilst broad patterns and changes over time yield information about the impact of recent developments, such analyses offer little insight into what is currently happening in colleges and the reasons why change may be difficult to achieve. In contrast, a focus only on classrooms results in rich accounts of educational practices but can overlook how institutional and national processes shape such classroom experiences. For these reasons the MiFEC project adopted a mixed-method[35], multi-scale[36] approach that bridged between national patterns, college policies and strategies to teachers' practice and ultimately to students' experiences.

Detailed explanations of the research methods used in the four work packages can be found in the Interim Reports and published papers from different aspects of the project. In brief, the work packages included:

Work Package 1: A review of literatures and twenty year policy trajectory analysis.

Work Package 2: Analysis of national administrative datasets including the National Pupil Database and Individualised Learner Record. The cohort approach aimed to track the mathematics pathways and outcomes of a series of national age-16 cohorts leaving schools.

Work Package 3: Thirty case studies of GFECs to include interviews with a range of managers and teachers (both vocational and mathematics), student focus groups and documentary analysis.

Work Package 4: A national survey of the mathematics teacher workforce.

2.4 Project outputs

The first Interim Report (R1) "A survey of teachers of mathematics in England's FE colleges" was published in December 2018. A clustered sample of around one sixth of England's FE colleges (31) were sampled with 480 teachers of mathematics responding and an estimated response rate of over 60%. Findings inform Sections 3.3 and 3.4 below but the Interim Report (R1) explores the data in greater depth[37].

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[35] Tashakkori, A., & Teddlie, C. (2003). *Handbook of mixed methods in social & behavioural research*. Thousand Oaks, CA: Sage.
[36] Noyes, A. (2013). Scale in education research: towards a multi-scale methodology. *International Journal for Research and Method in Education, 36*(2).
[37] Available at https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/interim-report-1.pdf

The second Interim Report (R2) presented findings from the college case studies conducted from December 2017 to April 2019[38]. This was the largest of the MiFEC project's work packages and surfaced the context-specific nature of the improvement challenge. This work informs all of the sections below but the Interim Report (R2) offers further detail.

A third Interim Report[39] (R3) was published in September 2020 to complement the analysis of the case studies. This report focused in particular on the perspectives of students, a group that are largely invisible in much research on this sector. 388 students from 14 broad vocational areas were involved, the majority of whom were retaking GCSE.

A short report on DfE published annual outcome data for FE has also been produced[40], which acts as a placeholder for the secondary analysis of the NPD-ILR matched data.

The analysis of literatures and policy trends have been the focus of two academic papers[41] [42] and a further paper is currently under review[43]. We draw on these where appropriate.

2.5 The Final Report

This Final Report brings together evidence from the published Interim Reports (R1/R2/R3) and linked research papers under six main subheadings. Each of these themes includes high-level recommendations.

For sustainable change in a complex system, coordinated action is required at different levels of granularity. We therefore have four groups of stakeholders in mind when making recommendations (national policymakers, senior leaders in colleges, mathematics curriculum leaders and other stakeholders) but we refrain from linking particular recommendations to any group.

The aforementioned Interim Reports are regularly referenced in this Final Report but additional details on methods, samples and substantive findings can be found in those documents.

[38] Available at https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/interim-report-2.pdf
[39] Available at https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/interim-report-3.pdf
[40] Available at https://www.nottingham.ac.uk/research/groups/crme/documents/mifec/interim-report-4.pdf
[41] Dalby, D. & Noyes, A. (2018). Mathematics education policy enactment in England's Further Education colleges. *Journal of Vocational Education & Training,* 70(4), 564-580. https://doi.org/10.1080/13636820.2018.1462245
[42] Dalby, D. & Noyes, A. (2020). The waxing and waning of functional skills mathematics. *Journal of Vocational Education & Training. https://doi.org/10.1080/13636820.2020.1772856*
[43] Dalby, D. & Noyes, A. (2020). Mathematics curriculum waves within vocational education, Submitted for review to *Oxford Review of Education*

3 Main findings

The findings reported below offer a high-level synthesis of the MiFEC project's work packages. Some of the six sections draw more heavily on a single work package due to their focus (e.g. the workforce survey is the main source informing the workforce section) but a synthesis of evidence has been presented wherever possible.

The analyses and recommendations commence with (1) high-level trend analysis of student progress and the college contextual factors that affect student trajectories. This is followed by (2) an analysis of college implementation processes, involving leadership and management of mathematics provision and operational systems. The following sections explore (3) the nature of the workforce, (4) the professional development of teachers, and (5) the teaching and learning of mathematics. We conclude with (6) an examination of issues concerning qualifications and policy. *Figure 1* sets out a simplified policy enactment model which offers a high-level overview of how the various sections of the report connect.

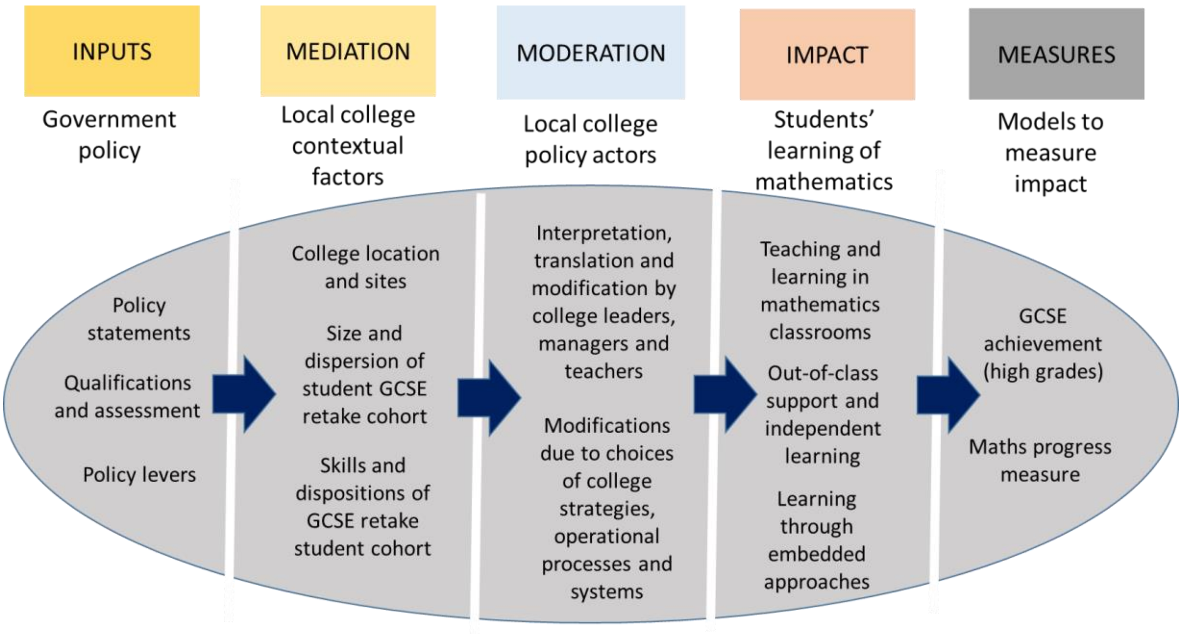

Fig 1: Model of mathematics policy enactment in FE colleges.

3.1 National and college contexts

Analysis of several years of the DfE's annual statistical release highlights national trends in students' mathematical achievement and progress in FE. These national trends hide college-level variations, both in terms of the local contexts and colleges' strategic decisions about students' mathematics progression pathways. Evidence from the case studies shows how local factors affect the challenges faced by colleges and how national performance measures influence colleges' strategic decisions. This can result in variations between colleges in the mathematics education offer available to students with the same prior attainment. There is a need for improved performance models that take account of context and for greater consistency regarding which qualifications are considered most suitable for students entering FE with GCSE grades 1 and 2.

National trends in student achievement

High-level analysis of the DfE annual statistical release on 16-18 student progress in mathematics for those without a grade C/4 at age 16 shows some clear trends in entries and achievement since the introduction of the Condition of Funding in 2014:

- A large reduction in non-entered students[44]
- A large reduction in Functional Skills mathematics entries
- A large increase in GCSE entries and outcomes at all levels

Table 1 summarises the progress made between age 16 and 18 for four consecutive years of completing 16-18 students, with each column referring to the academic year in which a students reached 18. For example, the 15/16 leaver cohort (column 2) is largely comprised of the students leaving school at age 16 in the summer of 2014, the first group subject to the initial iteration of the Condition of Funding.

Mathematics Achievement at age 18	15/16	16/17	17/18	18/19
No entry	31785	25056	21464	18989
Fail	4468	4500	4523	3938
Entry level Functional Skills, Free Standing Mathematics	23208	18460	16817	14805
Grade 1 or G in GCSE Mathematics	2076	2675	3627	5442
F in GCSE	3357	3733	2963	1556
L1 Functional Skills	26655	18215	14610	13739
Grade 2 or E GCSE	10302	12054	15638	17577
Grade 3 or D in GCSE	28787	28323	31387	33270
Grade 4 or C GCSE	18563	23675	26521	24800
Above Grade 4 or C	195	91	466	831
TOTAL	149859	138942	138581	135462

Table 1: Mathematics achievement data for 16-18-year-olds under the Condition of Funding from 2015/16 to 2018/19 [N.B. the left-hand column descriptors are abbreviated. Some small-number alternatives are included but these are the main qualifications]

[44] Note that the Condition of Funding requires enrolment on a programme of mathematical study rather than entry to sit an examination. As a result the no entry column does not mean that all of these students did not study mathematics post-16 but rather that it did not lead to a qualification entry.

The data only shows high-level patterns because a) all students regardless of prior attainment are combined, and b) only final outcomes are reported, not the pathways to get there or the numbers of examination attempts.

Figure 2 presents data only for those entering FE[45] with a Grade D/3 and includes baseline data from the two cohorts prior to the introduction of the Condition of Funding (CoF). It shows the progress made from age 16 to 18:

- The Condition of Funding (CoF) produced an initial fall in non-entered students as intended. This decline continued in subsequent years, albeit at a slower rate;
- The proportion 'passing' GCSE (i.e. moving from Grade D/3 to C/4) has stabilized. The initial move from 27% to 36% can be attributed to the Condition of Funding requirement to retake GCSE rather than other mathematics qualifications (in 2015);
- Some of 2015/16 cohort would have passed Functional Skills mathematics at level 2. The DfE maths progress measure does not equate this level 2 pass with a GCSE level 2 (i.e. grade 4 or above) so the *improvement* in 2016/17 is, in part, a product of how qualifications are valued in the progress measure;
- It is questionable whether the redistribution of students from 'no entry' or 'lower than KS4' to 'same as KS4' is a successful outcome for the CoF policy;
- The 'lower than KS4' proportion has recovered to levels similar to those pre-CoF following a spike in the 2015/16 cohort.

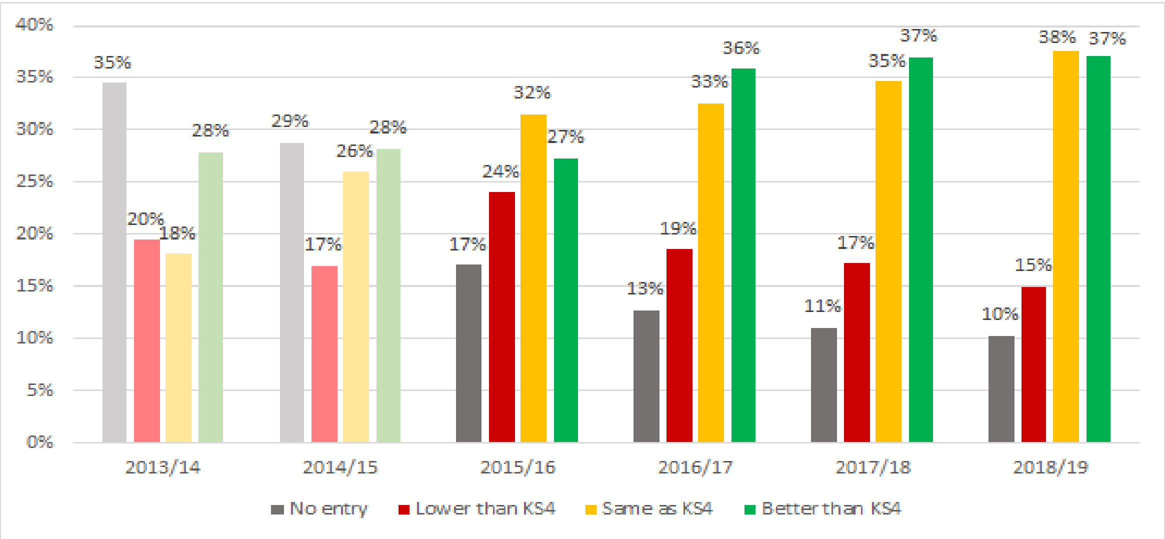

Figure 2: *Progress of students aged 18 who achieved a Grade 3 or D at KS4*

[45] Although the DfE's data includes students on all study pathways and in all types of institutions, the vast majority of them are in further education (FE), and more specifically in FE colleges. For example, the 2018 data release included 145,448 students who needed to undertake post-16 mathematical study; 95% were in further education and 92% of those were in FE colleges (i.e. not sixth form centres). So although the figure includes 16-18 students from all institutional types the trends apply to FE colleges. The DfE's analysis shows, however, that these mathematics learners tend to progress less well in FE colleges than in other settings so the patterns in progress probably overestimate progress for these settings.

Variations in college contexts

National data indicate that GFECs usually have 2000-8000 students aged 16-18, distributed across a wide range of vocational, and sometimes academic, study programmes and apprenticeships. Data from the MiFEC case study colleges show that mathematics provision is typically dispersed across multiple sites – as many as nine – and these are often several miles apart, with inter-site travel times of 30 minutes or more.

The mathematics offer in FE colleges ranges from Entry level to level 3, though most providers without A-level provision do not offer level 3 mathematics qualifications. Mathematics includes stand-alone qualifications (e.g. GCSE, A level, Core maths), modules within vocational qualifications (e.g. Engineering, Applied Science, Business) and embedded mathematics within vocational learning. Core maths is offered by some colleges but usually to very small numbers of students[46]. Stand-alone qualifications, in particular GCSE, dominate mathematics provision and are therefore the main focus of this research. The number of mathematics examination entries in MiFEC colleges ranged from 300-2500 per year for GCSE and 500-3000 with Functional Skills added. The number of mathematics teachers in a college ranged from 8 to nearly 40, including full-time and part-time in different proportions.

The mathematics curriculum offer in colleges is shaped by three main factors:

- The range of vocational programmes on offer;
- The balance between vocational and academic programmes;
- The proportion of study programmes at level 3.

These factors influence the characteristics of the student cohort and the size and nature of a college's mathematics provision. For example, motivation to study mathematics is usually connected to the future exchange value of a qualification to the individual and is therefore strongest for students on level 3 study programmes who are intending to progress to university (see R3). Motivation is lower in vocational areas where the main progression route is directly into employment and a mathematics qualification is not required. Study skills are also often better developed in students on level 3 programmes (R2). For students on certain vocational courses (and levels), less time is therefore devoted to addressing poor student attendance and engagement, both inside and outside the classroom.

MiFEC colleges with a large proportion of level 3 learners typically had fewer students retaking mathematics. The size and dispersion of mathematics provision affects the location and management of mathematics teaching across the college. Colleges with larger mathematics provision, especially when dispersed across multiple sites, face more complex operational challenges.

Current college performance measures for mathematics (maths progress measures[47] and high grade achievement[48]) do not take individual and institutional contextual factors such

[46] Available at https://coremathsproject.leeds.ac.uk/final-project-report/
[47] The maths progress measure compares the highest mathematics qualification achieved by a student in college to their prior attainment. See Appendix 3 for further details.
[48] The GCSE high grade achievement rate is the number of students gaining a grade 4 or above as a percentage of those who were enrolled on a GCSE course.

as these into account. As studies from similar performance measures in schools show[49], this is likely to introduce bias and therefore result in greater criticism of learning progress in institutions serving more disadvantaged students.

> **Recommendation 1:** Consideration should be given to adding contextual factors into models of mathematics progress to more fairly reflect the achievements of students and colleges.

Progression strategies for students

Mathematics education strategies in the MiFEC colleges were focused on improving student performance but were also strongly influenced by performance measures. These were sometimes prioritised over individual students' needs and, as a result, there were variations between colleges in the mathematics learning opportunities offered to students with similar prior achievement and study needs.

Students have little involvement in course enrolment choices, for example between GCSE and Functional Skills courses (R3). For incoming students with a GCSE grade 3 there is little flexibility since the Condition of Funding requires students to retake GCSE. Students with GCSE grade 2 or below may however be enrolled initially on a Functional Skills course or directly on to GCSE. Colleges are free to make this decision and choose students' progression routes.

The main strategies for the initial placement and progression of students without GCSE grade 4 by colleges are summarised in *Table 2*.

Strategy	Description
'Blanket GCSE'	As many students as possible are placed directly onto a GCSE mathematics course, regardless of their prior grade. A small number of students without a prior grade (including those new to the country) or with a very low grade may be placed on a Functional Skills course after initial assessment.
'Skills improvement'	Students are only placed on a GCSE course if they have a grade 3. All other students study Functional Skills and progress to GCSE when they have passed Functional Skills level 2[50].
'Bypassing'	Students with GCSE grade 3 are placed on GCSE. Students with lower grades take Functional Skills until they have passed Level 1 and then progress directly to GCSE[51].

Table 2: Main strategies for initial placement on mathematics courses and progression routes.

The *blanket strategy* has the potential to boost a college's maths progress measure score but is focused on the value of a GCSE grade. It can lead to repeated failure in multiple GCSE resits, which, for many students, results in declining motivation, poor engagement and negative emotional responses (R3). Nevertheless, this has become a popular strategy in colleges.

[49] Leckie, G. & Goldstein, H. (2019). The importance of adjusting for pupil background in school value-added models: A study of Progress 8 and school accountability in England. *British Educational Research Journal*, *45*(3), pp.518-537. https://doi.org/10.1002/berj.3511

[50] Since the latest change to the Condition of Funding progression from Functional Skills level 2 to GCSE is no longer mandatory but was at the time of the research.

[51] This is in keeping with the notion of 'stepping stone' qualifications, an idea that suggests a linear progression in mathematics rather than a range of qualifications with different purposes.

The *skills improvement* strategy allows more time for developing skills and conceptual understanding as well as experiencing examination success before resitting GCSE. The difficulty of the recently reformed level 2 Functional Skills mathematics and its unsuitability as a 'stepping stone' to GCSE adds to the challenge of creating suitable progression pathways.

The general trend since the introduction of the Condition of Funding has been a move away from Functional Skills to GCSE[52]. Current measures of performance push colleges towards teaching to the GCSE examination rather than to broader development of relevant mathematical skills. Whether this is appropriate for all students (R3) and for narrowing England's quantitative skills gap is debatable.

> **Recommendation 2:** The learning goals and preferred qualifications pathways for students entering FE with GCSE grades 1 and 2 should be agreed, with performance measures being revised in support.

3.2 Leadership and management

Good cross-college leadership and management is critical for the effective implementation of mathematics education policy. Leaders and managers take responsibility for the interpretation and implementation of policy but enactment involves complex processes and multiple actors who interpret, moderate and sometimes reconstruct official policy. This section largely draws on data from interviews with college principals, senior leaders, managers (of mathematics and vocational areas) and students. The importance of the cross-college leadership and management role is emphasised along with the need for bespoke training to equip these people with the necessary skills to make well-informed strategic and operational decisions. The benefits of shared responsibility for college-wide prioritisation of mathematics are evidenced, as is how student-focused operational systems can lead to better learning.

Cross-college leadership and management

This important role of cross-college leadership and management differs from that of a typical FE vocational manager or head of mathematics in school, both of whom usually line-manage a single teaching team and set of courses. The complexity arises from:

- the scale of the provision;
- the dispersion of teaching across large, multi-site organisations;
- the sharing of responsibility (i.e. with vocational teams).

The role became more challenging following the Condition of Funding with large increases in student numbers in most colleges and mergers following the Local Area Reviews[53] which increased the size and organisational complexity of many colleges. The challenges of policy implementation for managers are logistical and relational:

[52] Three out of four students arriving into FE with a GCSE Mathematics grade E/2 fail to make progress over the following two years and around 40% of grade E arrivals in FE go backwards over the following two years, at least according to the measures embedded in the Mathematics Progress measure.
[53] The Association of Colleges records show 294 FE colleges in August 2017, 189 of which were GFECs, and 244 in February 2020, 168 of which were GFECs.

- *vertically* with respect to senior management and curriculum leads at different levels of the organisation, with a shared continuum of strategic/operational responsibilities (see *Figure 3*);
- *horizontally* with vocational/curriculum managers who 'own' the students and have different levels of shared responsibility and accountability, depending on the college approach;
- *horizontally* with respect to managers of other areas of mathematics provision, depending on the structural arrangements in place.

Central management and leadership of mathematics in colleges is typically multi-layered, involving several staff at different levels (e.g. a senior leader, a middle manager, a curriculum lead and course leaders). Together these provide strategic leadership, organisational management, coordination and curriculum expertise. Recognition of this co-dependency and collaboration was not always evident in the MiFEC colleges but where regular collaboration took place, formally and informally, staff felt empowered and motivated.

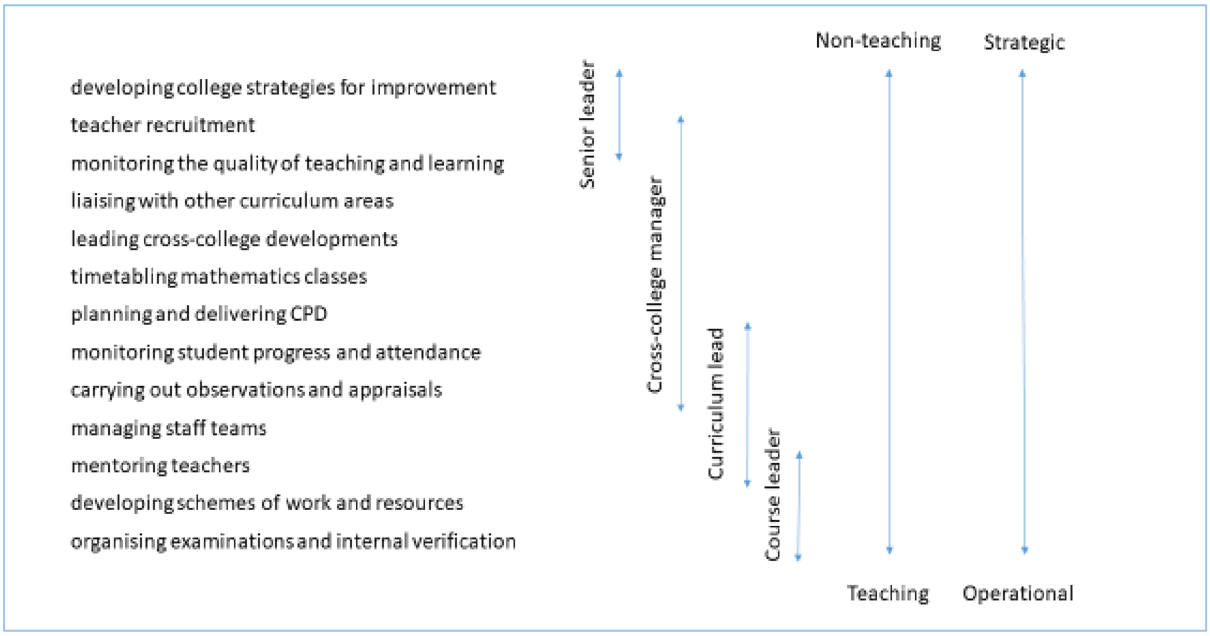

Figure 3: Responsibilities and functions of individuals in management structures for mathematics.

Coordination of mathematics provision involved a substantial amount of collaboration and negotiation with vocational departments, which required high-level skills in systems management and relationship building. Many college managers argue that mathematics needs to be a whole-college responsibility, with mathematics and vocational staff sharing responsibility for students' mathematical progress, actively supported by senior leadership. Such shared responsibility was not always well-defined or consistently implemented in the MiFEC colleges but, where operating well, both mathematics and vocational staff were enthusiastic about the benefits of this collaborative approach.

Responsibility for cross-college strategy and management of mathematics was usually held by one middle/senior manager. This person is critical to the effectiveness of mathematics provision, yet there is little evidence of specific training. These cross-college managers of mathematics need to develop expertise in 1) curriculum leadership, 2) organisational strategy, 3) systems management, and 4) reflective and evaluative change leadership.

Curriculum leadership presents particular challenges. The academic nature of mathematics differs from students' vocational learning activity and the majority are retaking GCSE as a mandatory bolt-on to their study programme. Students' attitudes therefore require careful consideration both in terms of organisational strategy (e.g. timetabling to maximize attendance) and in teaching (e.g. to build confidence).

Effective cross-college mathematics provision in FE is dependent on 1) good understanding of the academic and affective challenges facing GCSE retake students and 2) expertise in developing appropriate organisational and pedagogical approaches. In addition, the cross-college manager often needs to champion the development of embedding mathematics within vocational learning, providing appropriate guidance and training.

Organisational strategies vary between colleges. Contextual differences make some approaches more effective than others in the areas of:

- management and staffing structures for mathematics, including the geographical location of mathematics staff;
- the composition of student groups for mathematics;
- timetabling and classroom organisation.

Cross-college managers need to understand how different approaches combine to impact on provision. MiFEC colleges often adopted an experimental 'try it and see' approach to decision-making without gathering robust data on the effects. Our evidence shows that solutions to complex problems are rarely directly transferable between colleges. Managers need appropriate tools and skills to evaluate the suitability of strategies within their particular context so they can adapt borrowed organisational strategies, predict likely contextual effects and plan mitigations accordingly.

Given the size of mathematics provision and its dispersion across the college, ensuring attendance for GCSE retake students presents significant *systems management* challenges. Systems for timetabling and tracking (e.g. student attendance, student progress) need to be well-designed, consistently enacted and monitored to ensure the college meets policy requirements such as the Condition of Funding.

Change management in the MiFEC project colleges involved frequent, and sometimes radical re-organisation of mathematics provision. This creates considerable turbulence and can be unsettling for staff, adding internal flux to the ongoing churn experienced by the FE sector as a whole. Managers would benefit from knowing how to implement more evolutionary, sustainable, long-term improvement strategies.

Recommendation 3: A new national programme of leadership training should be developed specifically for those in cross-college mathematics leadership positions to include strands on 1) curriculum leadership, 2) organisational strategy, 3) systems management, and 4) reflective and evaluative change leadership.

Management and staffing structures

The MiFEC case studies showed that there was no ideal management and staffing structure for mathematics but there is a need for better understanding of the suitability of different models. Some colleges have a single, co-located team of teachers (*centralised*), whilst others place mathematics teachers in vocational departments (*dispersed*) or, more often, the college adopts a hybrid arrangement with several teams located on different sites, or having responsibility for different programmes (*multi-team*).

The advantages and disadvantages of these models (see R2, *Table 6*) need to be understood by senior leaders, including how to evaluate the suitability of a model for a specific context. For example, the dispersion of vocational students across sites needs to be considered in multi-site provision. For a college with a high proportion of inexperienced teachers, creating a centralised mathematics team might improve opportunities for teacher development and support, even though it risks weakening the links to vocational teams that are a strength of a dispersed arrangement. Managers would benefit from guidance and support to critically review their organisational strategies and develop improvement plans appropriate for their context.

> **Recommendation 4**: A mathematics self-evaluation toolkit and support package should be designed to aid college managers in reviewing their organisational strategies and developing improvement plans appropriate to their local context.

Operational systems and processes

College strategies, systems and operational processes need to address some challenging features of the student cohort. These include the shaping of general aspirations and motivations for mathematics by the local and family contexts of students (see R2) and the prevalence of disaffection, disengagement, anxiety and low levels of confidence amongst GCSE retake students (R3). Examples from the case studies illustrate the potential effects of operational decisions on student learning (R2), some of which are revisited briefly below.

GCSE mathematics was timetabled for 3 hours per week in most of the study colleges, though the time allocated ranged from 2 to 4.5 hours. This was most commonly timetabled as two sessions of 1.5 hours a week for 16-18 year olds. Both teachers and students identified benefits from two sessions rather a single 3 hour session, such as better concentration and more frequent reinforcement. This does however present greater timetabling challenges, especially if vocational learning is largely organised in 3 hour blocks of workshops or practical training. Students and teachers also agreed that sessions late in the day, or disconnected from the rest of their vocational timetable, were likely to reduce attendance and concentration, even for well-motivated students.

Functional Skills mathematics in the case study colleges was generally allocated 1.5-3 hours a week. Some teachers expressed concern that this disadvantaged lower achieving students who has greater challenges with learning mathematics and needed more support, not less, in order to make good progress.

MiFEC colleges took different approaches to locating mathematics lessons. Some had established a centralised suite of rooms and others used classrooms in vocational areas. These decisions were in part pragmatic but also reflected different approaches to curriculum integration and shared responsibility that positioned mathematics as either a stand-alone subject or one more closely connected to the vocational programme. Linked to this, teachers and students presented arguments for placing students from the same vocational area together for mathematics or for arranging them in mixed groups. Teachers and students identified benefits to learning from both arrangements.

There were frequent references to a 'settling' period in September each year, during which changes were made to groups and staffing. This was often considered inevitable by staff but was unpopular with students who explained how their confidence and progress were hampered by changes of teacher or group composition.

MiFEC colleges expend considerable time tracking student attendance in various ways and taking follow-up action. Students identified negative effects on their own learning from inconsistent attendance from their peers but were often unaware of sanctions or considered the actions taken as ineffective ways of changing other students' behaviour.

> **Recommendation 5**: Operational planning (e.g. timetabling, attendance) in some colleges needs to take better account of the GCSE retake students' characteristics in order to provide the best possible environment for learning.

3.3 The teacher workforce

This section draws on analysis of the national survey (R1) and case studies (R2). The FE mathematics teacher workforce includes teachers from a wide range of backgrounds with different subject and teaching qualifications. This diversity has been influenced by the need to expand the workforce since the Condition of Funding in the context of longstanding mathematics teacher shortages. Deregulation of the sector has allowed colleges to make their own judgements about qualifications and training. The MiFEC colleges have developed their own approaches to recruitment but the costs have often been high. Support is needed to boost recruitment and to provide appropriate initial training for those entering teaching from different backgrounds and with different needs.

Building the workforce

Increased demand for (GCSE) mathematics teachers since the Condition of Funding has precipitated significant growth in the size and composition of the mathematics teacher workforce (R1), including an increased number of permanent positions and specialist teachers (e.g. teaching GCSE only). In the absence of a coordinated, national strategy to meet this increased demand for teachers, and amidst sustained national shortages of mathematics teachers, colleges developed innovative and sometimes costly recruitment strategies to achieve this expansion and reshaping, notably:

- Paying higher basic salaries to mathematics teachers or offering enhancements;
- Offering other conditions of service such as career progression pathways or reduced weekly teaching hours;
- Re-training vocational teachers in the college who show an aptitude for mathematics and/or need redeployment;
- Devising 'grow your own' schemes in which business support staff or teaching assistants are retrained;
- Using personal and community contacts to find people interested in training to teach mathematics.

If the FE sector is to make an ever-stronger contribution to improving England's quantitative skills base, a coordinated strategy to expand and develop the mathematics teacher workforce is urgently needed. The present economic challenges resulting from the Covid-19 pandemic offer a time-limited opportunity to retrain teachers leaving business and industry for a second (or third) career in FE teaching.

Workforce composition and entry routes

The composition of the mathematics teacher workforce in FE colleges is different from schools. It is important that decision makers understand this distinctiveness as it has a bearing on recruitment, training and ongoing professional development.

Mathematics teachers in FE have undertaken a wide range of teaching qualifications (R1), some subject-specific and some sector-specific. For the majority of new entrants to teaching, training took place whilst teaching. Most participating colleges expected mathematics teachers to have teaching qualifications or work towards these whilst teaching but made independent decisions about appropriate qualifications.

Mathematics teaching teams typically include people with varied backgrounds and diverse skills and experience and these result in different training needs. The 2018 national workforce survey (R1) identified three main entry routes:

1. changing **career** from business and industry to teach mathematics in FE (24%);
2. changing **curriculum** focus in FE or adding mathematics (19%);
3. changing **context** from teaching elsewhere prior to FE (23%).

Initial training should be contingent upon the entry route into teaching mathematics in FE. Even those who move into FE from other settings (e.g. schools) would benefit from a transition period including targeted training in order to adapt and develop specific skills for teaching a high concentration of low-attaining students.

Very few teachers were in full-time study immediately prior to teaching mathematics in FE (10%). Whether changing *career*, *curriculum* or *context,* teachers from these entry routes bring complementary sets of experience and expertise. It is also important to recognise that their diverse backgrounds provide rich resources for collective professional learning (see Section 3.4) as well as different training needs.

Teachers enter FE mathematics teaching for a variety of reasons, often based on a personal preference or choice. Common motivations include wanting to work with 16-18 year olds or to move away from teaching in school, as well as having a personal enjoyment of the subject. Such motivational diversity is important to consider in recruitment strategies.

> **Recommendation 6:** A national recruitment campaign to attract career-changers from diverse backgrounds should be designed and launched with some urgency.
>
> **Recommendation 7:** Initial training requirements for teaching mathematics in FE should be reviewed and a national training strategy developed that distinguishes between the needs of teachers who are undergoing 1) a significant *career* change, 2) a change of *curriculum* focus, and 3) a change of educational *context*.

Roles and sustainability

The MiFEC survey (R1) showed that the majority of respondents (63%) were employed to teach mathematics only and most of these were on full-time contracts. Around a quarter (26%) were teaching another subject as well as mathematics, with some focusing mainly on mathematics (10%) whilst others were employed as vocational (or other subject) teachers but taught some mathematics as a second subject (16%). A substantial contribution to the workforce is made by these teachers, who have dual priorities. Teacher workload varies between colleges depending on contractual arrangements, roles and expectations but many teachers carry additional responsibilities to ensure college systems operate efficiently and students' needs are met.

The MiFEC survey (R1) identified short-term workforce stability, with the majority of respondents expecting to continue in a similar role for the following year and reasonably good levels of job satisfaction. The medium to long-term prospects were less clear. Looking ahead to the 2020-21 year, 15% of the 2017-18 workforce were expecting to have moved out of FE mathematics teaching and over a fifth were undecided about their future plans, whilst new entrants to the profession only amounted to 18% of the workforce in the three years up to 2018.

The mathematics teacher workforce is under increasing pressure to produce better results. This can be demotivating and some colleges report that current staffing levels are unsustainable in light of these pressures. Staff turnover increases workloads and interrupts strategies for improvement. Establishing a more holistic understanding of the systemic reasons for students' low achievement could help to relieve some of the pressure on teachers, inform professional development and thereby help to produce a more sustainable mathematics teacher workforce.

3.4 Professional development

The professional development (PD) of the FE mathematics teacher workforce is a pressing concern due to mathematics being a priority area and to deregulation in the sector that allows the appointment of teachers without prior training. Few FE mathematics teachers had undertaken full-time pre-service training; they developed professional skills and qualifications whilst employed. Varied backgrounds and entry routes produce diverse PD needs but relying on colleges alone to meet these needs leads to differences in the amount and quality of mathematics-specific PD. Clearer guidance on professional standards for FE mathematics teachers would improve equality of opportunity, particularly if supported by an entitlement to, and ring-fenced funding for, CPD. Colleges would benefit from training needs analysis tools to support professional development planning. Better understanding of CPD models such as the use of college-based professional learning communities and practitioner research for classroom improvement would also be beneficial.

Professional development needs

Professional development activity for FE mathematics teachers can be formal or informal, planned or unplanned. Planned CPD in participating colleges comprised differing blends of generic training (face-to-face and on-line); sessions run by external consultants or organisations (e.g. examination boards); practitioner-led sessions; sharing good practice in teaching teams; mentoring and coaching programmes; and peer observations. Teachers often reported that informal unplanned sharing between colleagues was more valuable than much of the planned CPD.

The MiFEC survey (R1) showed how the amount of mathematics-specific CPD provided varied widely between colleges and was generally low. Formal CPD sessions and on-line CPD provided by colleges for their mathematics teachers often focused on college policies, new procedures or general pedagogy rather than being mathematics-specific. Independent decisions are made by colleges about their CPD offer to mathematics teachers. The financial health and budget priorities of the college act as constraints. In the absence of designated funding to support formal CPD in colleges or any entitlement to mathematics-specific CPD for mathematics teachers, variations between colleges in the quantity and type of CPD accessed by FE mathematics teachers is not surprising.

> **Recommendation 8**: Designated funding should be ring-fenced for the professional development for mathematics teachers in FE colleges.

> **Recommendation 9**: An individual entitlement to high-quality, mathematics-specific continuing professional development should be defined and adopted nationally.

MiFEC analysis (see R2) shows how the teaching of post-16 GCSE retake students, particularly in the vocational learning environment of GFECs, differs in emphasis from teaching in schools. There was agreement amongst respondents that teaching mathematics in FE, especially GCSE retake, presents a particular concentration and balance of challenges and so requires a particular skill set, as shown in *Table 3*.

Context	Skills required
Teaching students who are disaffected with mathematics	Engaging disaffected students. Managing classroom behaviour. Dealing with emotional issues.
Teaching students who have had difficulty learning mathematics	Adaptation and differentiation to meet individual needs. Planning for students with specific educational needs. Identifying why students do not understand, i.e. a diagnostic approach. Different ways of teaching the same topic to suit different student groups.
Teaching an examined retake course	Building on prior knowledge/repairing conceptual foundations. Revision techniques.
Teaching a changing curriculum	Updating subject knowledge and/or adapting to different types of qualification or specifications.

Table 3: Skills required to respond to contextual aspects of teaching mathematics in FE

Mathematics-specific CPD needs to be given higher priority but also needs to be FE sector-relevant, focusing on development of appropriate skills such as those in *Figure 3*. MiFEC teachers report that much of the CPD on teaching and learning focuses on generic approaches that rarely address their more pressing concerns, for example low motivation amongst GCSE retake students. They describe how CPD providers sometimes have little or no experience of the FE sector and rarely offer evidence that their proposed approaches will have a positive impact on post-16 GCSE retake students.

> **Recommendation 10**: Sector agreement on appropriate professional standards for mathematics teachers in the FE sector needs to be established as a framework for professional development.

The provision of CPD and training is subject to local college decisions, which the case studies show is often short-term and reactive. Few colleges in the case studies developed long-term plans for the training and development of individual teachers or for the collective professional development of their mathematics teacher workforce.

It was common practice in the MiFEC colleges for managers to conduct formal and/or informal 'walk through' observations of teaching, from which they obtained a view of weaknesses and strengths in classroom practice. This was typically used to identify improvement priorities for which short-term *remedial* CPD was provided. This could be for the whole team or lead to individual action plans, sometimes with accompanying coaching or mentoring. The emphasis was generally on addressing pedagogic deficits rather than long-term planning for holistic continuous improvement of the workforce.

> **Recommendation 11**: Tools for conducting training needs analysis should be developed to support long-term professional development planning for mathematics teachers and teaching teams.

CPD models

CPD in the MiFEC colleges, especially from external providers, was reported to often be of a transmission style, remote from classroom practice and of variable quality. Research suggests that active teacher participation in knowledge development linked to practice is more likely to have a positive impact[54]. Teachers reported that they often found the informal sharing of practice with colleagues more helpful for their development than formal CPD sessions, due to the situational relevance and close connection to practice. Regular meetings to exchange ideas with colleagues were valued for similar reasons.

The mathematics teacher workforce in large colleges includes diverse knowledge and expertise due to the varied backgrounds and prior experiences of staff. This could be better utilised. Two ways in which practitioner expertise could be used in professional learning were evidenced in the MiFEC colleges (summarised in *Table 4*).

Resource	Model	Purpose	Facilitated by
Maths practitioners from varied backgrounds (from whole college teaching team)	Professional learning community (PLC)	To develop shared understanding and expertise as professionals.	A collaborative, transparent and supportive culture. Appropriate leadership.
Maths practitioners	Practitioner (action) research	To build strong robust evidence of 'what works' in a local college context.	Well-trained experts in research methods and evaluation.

Table 4: Alternative CPD models with potential for developing the FE college mathematics workforce

Some colleges had increased transparency around classroom practice by encouraging peer observation, although such openness was often met with initial resistance. Such cultures were typically associated with a team commitment to collaborative professional learning. These two features are important elements of a professional learning community[55], which itself has been identified as a promising model for teacher development[56].

[54] See for example: Matos, J.F., Powell, A., Sztajn, P., Ejersbø, L., Hovermill, J. & Matos, J.F., Mathematics teachers' professional development: Processes of learning in and from practice. *In* R. Even & D.L. Ball (eds.) (2009). *The professional education and development of teachers of mathematics.* US: Springer, 167-183.
[55] Bolam, R., Mc Mahon, A., Stoll, L., Thomas, S., Wallace, M., Greenwood, A. & Smith, M., (2005). Creating and sustaining effective professional learning communities. Bristol: University of Bristol, DES.
[56] See for example: Vescio, V., Ross, D. & Adams, A. (2008). A review of research on the impact of professional learning communities on teaching practice and student learning. Teaching and teacher education,

Many teachers thought they learnt most from reflection on their own classroom experimentation. Some colleges encouraged their teachers to take risks and try out new teaching and learning approaches but in a rather unsystematic way. Development of rigorous action/practitioner research approaches and evaluation methods would provide more robust contextualised evidence to improve practice. It would also aid the adaptation of approaches borrowed from other contexts.

College managers would benefit from a better understanding of different CPD models, including those in *Table 4*, to aid improvement planning.

> **Recommendation 12**: Guidance on effective CPD models, such as the development of professional learning communities and practitioner research, should be provided in order to build capacity in the workforce for sustainable self-improvement.

Colleges report that a lack of confidence amongst vocational teachers is the greatest barrier to effective cross-college support for mathematics. Vocational staff can identify mathematical processes within their occupational areas but are often uncomfortable dwelling on the mathematics. This hinders the development of embedding mathematical learning and can communicate, implicitly or explicitly, that low levels of mathematical confidence and skill are acceptable.

Many colleges are supporting vocational teachers but this is not always well received and the expectations made of them can be unrealistic[57]. Support can consist of 1) mathematics upskilling courses, sometimes involving a qualification, 2) CPD sessions on embedding mathematics into vocational programmes, or 3) general support via drop-in sessions or from a mathematics teacher linked to the vocational area.

The reliance on colleges to find local solutions has resulted in a rather piecemeal approach to this problem. Evidence from the MiFEC colleges (R2) suggests that this approach to the upskilling of vocational teachers results in unequal opportunities and interventions that are often too late. One approach to addressing this issue would be more emphasis on developing mathematical confidence during initial training or early career development plans for vocational teachers.

> **Recommendation 13**: The initial and ongoing training of vocational teachers should include better opportunities to develop personal confidence with mathematics.

3.5 Teaching and learning

This section considers learning in mathematics classrooms, through independent study and in vocational contexts, including facilities for extra support. Teacher-generated and student-generated data from case study interviews and focus groups reveal teachers' views of 'what works' and students' perceptions of their learning experiences, including what they believe would work better. Teachers and students are in broad agreement about the approaches to teaching and learning that work best and most students view their learning experiences more positively than those in school. Skilled teachers use a rich pedagogical toolkit of strategies and resources so they can adapt to the different needs of

24, 80-91; Stoll, L., Bolam, R., Mcmahon, A., Wallace, M. & Thomas, S. (2006). Professional learning communities: A review of the literature. Journal of educational change, 7, 221-258.

[57] Casey, H. et al (2006). You wouldn't expect a maths teacher to teach plastering…Embedding literacy, language and numeracy in post-16 vocational programmes-the impact on learning and achievement. London: NRDC.

individuals and groups. Further research is needed on approaches that effectively address contextual and affective issues. Variations in the provision and uptake of out-of-class learning opportunities and of embedding mathematics into vocational learning require further exploration to ensure the sector has better evidence of how these may be used to support mathematics learning.

Mathematics teaching in context

The MiFEC cross-case analysis (R2) considered three scales of activity: classroom-level pedagogies, college-level organisational factors, and external factors such as policy constraints. These nested but linked spaces (classroom, organisation and system) are shown in *Figure 4.* Teachers' choices of classroom approaches are contingent upon a range of factors determined by organisational and policy decisions that affect the student cohort, the focus of the course and the learning environment.

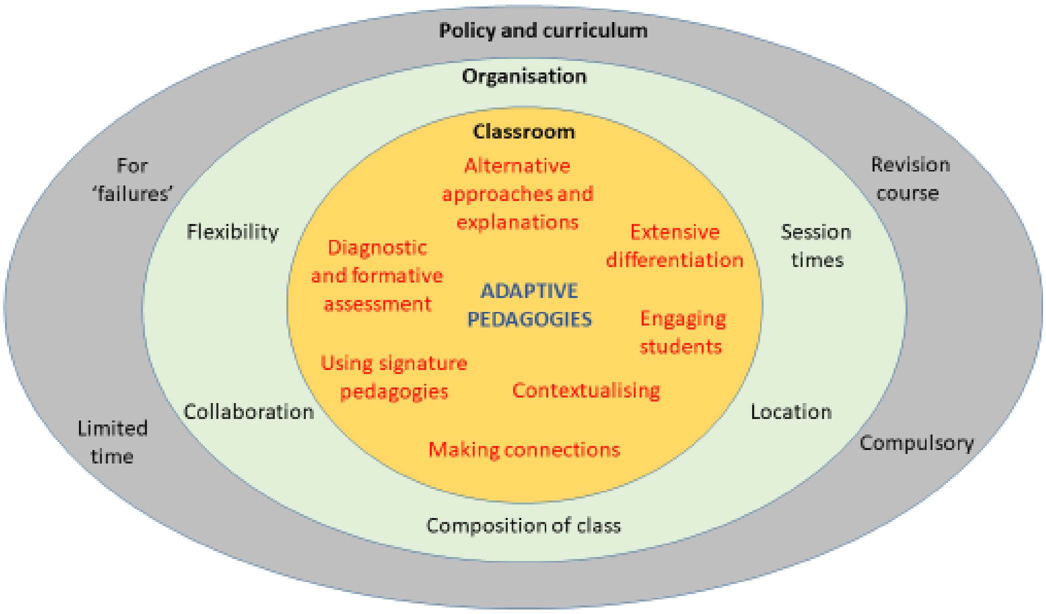

Figure 4: Nested influences on classrooms that lead to adaptations in pedagogy

There were four particular contextual features of GCSE and Functional Skills teaching attributable to current policy that affected the way in which teachers viewed their practice:

- Students are taking a *revision course* leading to a mathematics examination;
- This is a *compulsory subject* for most of the students;
- *Teaching time* is limited given the ground many students need to cover;
- The course is for students who have *previously 'failed'* with mathematics

These combine to create particular tensions. For example, time pressures on high-stakes examination courses leave teachers feeling compelled to 'teach to the test' even though they know this will not allow them to address fundamental weaknesses in students' conceptual understanding. Teachers also find themselves trying to enforce attendance with students exhibiting emotional problems (e.g. anxiety) due to prior experiences of failure.

Contextual factors result in common attitudes and behaviours that require careful consideration when planning teaching:

- Negative emotional responses and attitudes to learning mathematics;
- A lack of motivation to engage and low confidence with learning mathematics;
- Finding mathematics learning challenging, often because foundational concepts are insecure;
- Different mathematics learning backgrounds, varied methods and cognitive challenges.

Local college decisions on the organisation of mathematics provision influence teachers' approaches to teaching and learning, such as the composition of student groups by prior attainment or vocational area, the length and frequency of sessions and the location of mathematics classrooms. Teachers adapt accordingly but work under constraints that may vary between sites and colleges.

Student motivation and engagement

The most commonly reported issue affecting the teaching and learning of mathematics was the low level of motivation and engagement amongst students. Other affective difficulties (e.g. low confidence, anxiety and disinterest) were widely evidenced in the MiFEC colleges (R2). As reported earlier (R3) motivation is linked to students having either a personal reason to gain a better qualification in mathematics or an understanding of its relevance or usefulness in their lives. Teachers found motivation and engagement was also stimulated when:

- students feel that they are making progress;
- teaching is student-centred;
- feedback focuses on strengths of students learning rather than weaknesses;
- teachers build relationships with students;
- contexts are used that are relevant and emphasize the use-value of mathematics;
- links are made between mathematics in vocational or other study programmes and mathematics classrooms;
- mathematics teachers use pedagogies that students value, including the 'signature pedagogies' used in different areas of vocational learning.

These views are largely in agreement with those of students, who emphasised the motivating effects of good relationships with teachers, clear explanations and evidence of progress. Teachers worked hard to incorporate approaches to address poor student motivation and engagement into lessons but identified this as key area for professional development and better evidence of 'what works'.

Recommendation 14: Teaching and learning approaches that address the specific contexts, constraints and affective issues in FE need to be researched, developed and widely disseminated across the sector.

Approaches to teaching and learning

MiFEC teachers addressed the above challenges using a combination of strategies. The most common ones that they considered to be effective were:

- Developing a *contrasting learning experience* from that of school;
- Creating a *classroom culture* in which students feel included and safe;

- Building *positive relationships* with individual students;
- *Pedagogical adaptations* to meet the learning needs of individuals and groups.

Students (R3) expressed similar views that these were important aspects of their learning experiences in college, from which they gained confidence and overcame barriers. Overall students were more positive about their teaching and learning experiences in college than in school but still felt these could be more student-focused, according to the categorisation of statements used in this and other studies[58].

Teachers reported a need for frequent adaptations to meet the needs of different groups and of individuals within groups. These adaptations aimed to address affective issues, motivations, personal interests, knowledge gaps and vocational connections. Many teachers reported that retake classes included students with a wide range of abilities, prior knowledge and skills deficits, even if their attainment level was nominally the same. Initial assessment was often used to ascertain students' levels of working and groups were sometimes streamed but teachers referred to a range of different cognitive and affective needs from students who 1) had recently narrowly 'failed' GCSE in school and are retaking for the first time, 2) were re-sitting GCSE for the second or third time in college, and/or 3) had recently passed Functional Skills mathematics level 1.

To do this kind of contingent teaching effectively, teachers need a rich toolkit of methods, resources and explanations to draw on and the skills to select and use them appropriately for use with groups and individuals. The main pedagogical adaptations evidenced in the MiFEC colleges were:

- alternative approaches and explanations to those encountered previously;
- extensive differentiation of teaching approaches and tasks;
- varied engagement approaches for students with different attitudes, goals and mathematical identities;
- contextualising mathematics to highlight the usefulness and relevance in relation to students' interests;
- making connections to mathematics within vocational programmes;
- aligning to pedagogic strategies used in different vocational areas;
- diagnostic and formative assessment to identify needs and adapt teaching plans accordingly.

Teachers need a sound understanding of both the pedagogical tools and their likely impact on learning (see R2 for more detail on the matter of adaptive pedagogies).

> **Recommendation 15**: Mathematics teachers in FE need ongoing support and high quality CPD to ensure ongoing development of rich pedagogical toolkits that enable them to adapt teaching and learning to meet diverse students' needs.

Independent study and support

Case study teachers and students reported that classroom learning was sometimes supplemented by out-of-class independent study (homework), often involving technology. A range of opportunities for further support (e.g. workshops, one-to-one sessions, revision classes) were available in most colleges that students accessed as required. Expectations

[58] Swan, M. (2006). Collaborative learning in mathematics: a challenge to our beliefs. Leicester: NIACE.

concerning independent study differed between colleges and individual teachers but few embedded this successfully as a regular activity. There were variations between colleges in the extra support provided but this was generally optional and accessed only by a small number of well-motivated students.

Assumptions by some teachers that all students would spend time outside class on mathematics were unrealistic because of poor student motivation to do so. Those with higher levels of motivation identified the benefits of additional independent work, although some did not have the study skills to make significant progress without support. Overall, very few MiFEC colleges had been successful in establishing regular homework as part of their approach to mathematics and only a minority of students completed the work set, whether written or involving e-learning.

Limited availability of computers or portable devices for classroom use sometimes prevented the integration of technology into lessons but most colleges had extensive resources available on-line for out-of-class learning. Students' responses to these were varied (see R3), but reluctance to engage with mathematics outside the classroom, and a preference for face-to-face explanations from some students, explained why these resources were often less widely used than teachers expected.

Students turned most often to their own mathematics teacher for help when they were having difficulty. This was contingent on having a teacher they found approachable and with whom they had a good relationship. Use of workshops and revision sessions was variable. These additional opportunities served a minority of students well but were rarely accessed by the majority due to low motivation and other priorities.

> **Recommendation 16**: More effective strategies for out-of-class mathematics learning for FE students needs to be developed, evaluated and disseminated[59].

Mathematics within vocational learning

Frequent references were made to using embedded approaches within vocational learning but practices varied widely and there was little evidence of any positive effect on student attitudes or progress with mathematics. Constraints such as vocational teacher confidence and the need to develop pedagogical skills have been discussed earlier (see Section 4.3) but there are also contrasting views about what embedding means. Few vocational teachers aimed to develop mathematical understanding and the most common practice was to highlight places where mathematics was being used. Even when highlighted by vocational teachers, students rarely saw the links between mathematics in a vocational context and that taught in mathematics lessons. If embedding is to be used to support mathematics learning in colleges then it needs to be better defined and the impact of different practices evaluated.

> **Recommendation 17**: Research on approaches to the 'embedding' of mathematics into vocational learning and the impact of different practices needs to be commissioned[60].

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[59] Current discussions of the efficacy of online and blended learning as a result of the Covid-19 pandemic might be instructive.

[60] The General Mathematical Competencies framework designed by the RS/ACME and adopted into the T-level framework offer one line of approach that might have wider applicability for vocational programmes.

3.6 Qualifications, opportunities and policy

This section draws on our analysis of mathematics policy over a twenty-year period (WP1) alongside analysis of case study data, in which both staff and students' views of current policy are represented. Repeated cycles of developing 'alternative' qualifications to GCSE mathematics (core, key and functional skills) have failed to produce a qualification with the same credibility that addresses the skills needs of vocational learners. This is an opportune time for a review of post-16 mathematics pathways and policy objectives. Policy implementation may be more effective in future with greater sector involvement in the planning and development phase, realistic timescales, more careful consideration of potential unintended consequences and a long-term commitment to the evolution of trusted qualifications appropriate for vocational students.

Policy goals and qualifications

Recent decades have seen repeated attempts to develop mathematics qualifications for vocational students in FE colleges: core skills, key skills, functional skills and most recently a focus on GCSE[61]. This group of learners, the so called 'the forgotten third'[62], have not been well served by qualifications whose currency has been repeatedly devalued[63].

The emphasis on GCSE resits, and the trend in colleges of re-entering students with prior achievement of grades 1 and 2, has accelerated the 'academic drift' away from mathematics learning that is potentially more vocationally relevant (e.g. Functional Skills mathematics). The GCSE brand is over 30 years old so is widely known and accepted but the question of whether it is the most appropriate qualification, or whether a single qualification for all learners is appropriate, is still very much a live issue in colleges (R2) and amongst other stakeholders[64].

Despite widespread agreement in colleges with the policy goal of improving mathematics skills, almost 80% of MiFEC teachers and managers (see R2) do not support the GCSE resit policy in its current form, considering it to be too prescriptive and unsuited to the learning needs of some students. Furthermore, the outcomes of consistently low pass rates for GCSE resits and progress scores from subgroups of the cohort (See Section 3.1) are arguably not meeting policy aims. Other undesirable effects (e.g. further entrenchment of negative attitudes and diminishing confidence) are not helpful if students are expected to use mathematics efficiently in the workplace and in personal decision making.

Whilst there is general agreement that students who are close to the grade 4 borderline should have the opportunity to retake the GCSE examination, some teachers believe that students should only resit the examination when ready, or that one resit is enough, whilst others advocate a two-year GCSE programme to allow time for developing sound conceptual understanding. Setting a goal of GCSE grade 4 for all students is considered by many MiFEC teachers and managers to be unrealistic. Moreover, if one of the goals of

[61] Dalby, D. & Noyes, A. (2020). Mathematics curriculum waves within vocational education, submitted for review to the Oxford Review of Education

[62] ASCL Independent Commission of Inquiry, available at https://www.ascl.org.uk/Our-view/Campaigns/The-Forgotten-Third

[63] Functional Skills mathematics at level 2 receives less progress measure than a GCSE level 2 pass (at 4)

[64] Labour are committed to scrap the GCSE resit policy and the Nuffield Foundation has recently funded the development of an alternative GCSE qualification.

the skills policy is to address the negative attitudes to mathematics[65], then the current policy is counterproductive for many students.

A suggestion was made by some MiFEC respondents that requiring all students to study mathematics to age 18 may be fairer than just focusing on low-attaining students but they stressed that such a policy would not succeed without a more suitable suite of qualifications designed for vocational students' needs. Given that it is nearly 10 years since the then Secretary of State signalled an aspiration that "within a decade the vast majority of pupils are studying maths right through to the age of 18"[66], it would be timely to clarify aspirations for post-16 mathematics engagement and how suitable mathematics learning opportunities might be developed.

MiFEC colleges emphasised the value of developing mathematical skills with vocational relevance, particularly for students not intending to progress to university. Opinions were divided, however, on what these qualifications should be. Most of the vocational teachers supported the idea of an alternative skills-based mathematics curriculum.

Given the government's recently stated ambition (July 2020) to build a German-style technical/vocational system that 'levels up' skills[67] and values different routes to work, there will need to be clear mathematics qualification pathways that support these routes. Smith's 2004[68] call for "a highly flexible set of interlinking [mathematics] pathways that provide motivation, challenge and worthwhile attainment across the whole spectrum of abilities and motivations" is still far from being realised.

Many A-levels now assess disciplinary-specific applications of mathematics and General Mathematical Competencies[69] are being built into the new T-levels specifications. More systematic understanding and development of mathematics learning across vocational programmes in England's FE sector would be beneficial, particularly if done in a coordinated way and against appropriate common learning frameworks.

> **Recommendation 18:** The long-term policy objectives for post-16 mathematics education need clear articulation. This might include:
>
> - renewed efforts to establish a pathways model for 14-18 mathematics that values different academic, vocational and technical routes[70];
> - identification of recommended qualification pathways for students with particular prior attainment and mathematical learning needs.
> - a mapping of post-16 mathematics learning opportunities both in stand-alone qualifications and embedded within programmes.

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[65] Smith's 2017 recommendation 16 is outstanding: "The Department for Education should commission a study, from pre-school onwards, into the cultural and other root causes of negative attitudes to mathematics, including gender and other sub-group effects."
[66] Gove, M. (2011). "Michael Gove speaks to the Royal Society on maths and science." Retrieved 10.8.20 from https://www.gov.uk/government/speeches/michael-gove-speaks-to-the-royal-society-on-maths-and-science
[67] https://www.tes.com/news/williamson-england-get-german-style-fe-system
[68] https://dera.ioe.ac.uk/4873/1/MathsInquiryFinalReport.pdf
[69] General Mathematical Competencies
[70] For commentary on the metaphor of 'stepping stone' qualifications see Dalby, D. & Noyes, A. (2020). The waxing and waning of Functional Skills mathematics. Journal of Vocational Education and Training. https://doi.org/10.1080/13636820.2020.1772856

Planning and implementing change

Many MiFEC respondents felt that policy-makers need to better understand the FE student cohort to inform more appropriate policies. The general consensus was that future policy should include a more suitable mathematics curriculum and/or qualifications for post-16 vocational pathways and enough flexibility to ensure that the needs of different student groups are met.

The sector is expected to make mathematics engaging and relevant so that students develop mathematical skills for work and life but MiFEC teachers report that making mathematics compulsory and expecting measurable improvement within less than a year does not help teachers achieve this. Indeed, whether the predominance of GCSE resit improves either confidence or competence for the vast majority is a moot point. Clearer identification of the policy challenge might produce different curriculum solutions and policy drivers.

These change agendas and improvement challenges are complex, context-dependent and require collaborative approaches to developing workable and sustainable solutions. They might also require 'slow policy' in the sense that significant change in a historically underfunded and presently deregulated sector, one which serves the majority of England's most disadvantaged 16-19 year olds, will not happen quickly.

Recommendation 19: Future developments in post-16 FE mathematics require:

- a long-term commitment to design, development, piloting and improvement in order to build trusted qualifications and break the pattern of qualification devaluation;
- a realistic timescale and planning process[71] including consideration of staffing, training and CPD; qualification and resource development;
- consideration of potential unintended consequences;
- close liaison with the sector during development and implementation process.

Recommendation 20: A broader set of performance indicators should be considered for post-16 mathematics education, for example confidence and self-efficacy, in order to generate college policy and practice that better addresses the national challenge of improving quantitative skills.

[71] The Royal Society/Advisory Committee on Mathematics Education's ongoing work to develop a Qualifications Assessment Framework could inform such design processes.

4. Conclusions

This Final Report from the MiFEC project has set out the complex amalgam of challenges facing those seeking to improve mathematics learning in England's General Further Education Colleges. The Report aims to enhance key stakeholders' understanding of these issues so as to inform the strategic, holistic design of future policy, sector change processes and local improvement planning.

The Report identifies potential areas for action and makes a series of recommendations for consideration by policymakers, sector bodies and colleges. These are based on a comprehensive programme of empirical research that was completed in 2018/2019.

This Report is published in unprecedented times, with ongoing uncertainty resulting from the Covid-19 pandemic. Following the national lock-down in the spring and summer of 2020, the education sector is now feeling its way into a new academic year. GFECs are doing this is different ways and mathematics education is entangled with these uncertainties. Following the GCSE awarding in the summer, many students who would have been expected to be resitting mathematics in FE this year are not doing so. It will be important to monitor how this impacts the maths progress measures.

Despite the turbulence and uncertainty in society and in education, this Report's findings are still highly relevant because they address underlying systemic and pedagogic issues. For example, students' general lack of motivation and engagement in learning mathematics will not have abated and the fundamental reasons remain the same. Cross-college managers still play a key role in operational strategies that are now even more complex (Recommendations 3-5) and teachers need an even wider toolkit of resources and approaches to cope with changes resulting from Covid-19 (Recommendation 15).

One of the silver linings of the pandemic is the focus on developing blended learning approaches (Recommendation 16), though the reliance on technology has exposed resources gaps for some of the most disadvantaged learners. Moreover, evidence from the MiFEC study suggests that students retaking GCSE mathematics in FE colleges are often disinclined to engage with online resources outside the classroom, so this shift towards virtual learning is likely to create considerable challenges for teachers and students. With classroom contact potentially being limited, it is more important than ever to undertake research into how technology can be used to engage GCSE retake students.

Amidst the pandemic, post-Brexit negotiations continue and it is clear that the strength of the skills base, and the educational system that drives this, is only going to become more important in the coming years if England is to prosper in its new international position. With rapidly rising unemployment and a flooded labour market due to Covid-19, employment opportunities for many of the 'forgotten third' look rather bleak; their education and training are critically important. The need for engaging mathematics learning experiences and relevant qualifications that will equip them for a changing world continues (Recommendation 19).

Although the relative underfunding of the FE sector is well known, now is a particularly challenging time to address this disparity. Yet if the vocational and technical education of the future workforce is to rival some of our European neighbours, further investment is needed. Whilst significant investment would be welcomed, many of the MiFEC project recommendations are relatively low-cost and are more about understanding, coordinating and developing the tools and approaches that can form the foundations of a self-improving FE system.

There is considerable energy, expertise and good will across the FE sector and our recommendations about strategic leadership, self-evaluation and in-house CPD models would have the potential for good returns on modest investment. These recommendations are concerned with harnessing those strengths, trusting the sector, and being optimistic about assets within the system rather than taking a deficit position regarding shortcomings. There needs to be clearer vision for the training, professional standards and ongoing CPD of this important part of the FE workforce (Recommendations 7-12) and a push to attract individuals from diverse backgrounds into FE mathematics teaching (Recommendation 6).

Another set of recommendations are about fitness for purpose of qualifications for students on vocational and technical programmes. Rather than meeting the 2004 vision in Making Mathematics Count[72] for flexible pathways to meet the needs of the full range of learners, the current position prioritises a general GCSE qualification that has its origins in academic pathways and meets the needs of only part of the future workforce. This is not the time for a new round of curriculum and qualification reform, but there is a need for clear, long-term vision for post-16 mathematics education and evolutionary development of mathematics pathways that can meet the needs of all students (Recommendation 18).

The DfE's recent investment in the Centres for Excellence in Mathematics programme is welcomed and these 21 centres and their sector-spanning networks have an important role to play in strengthening post-16 mathematics teaching and learning. We very much hope that this Report, and the recommendations contained herein, can provide direction for the future development of the Centres programme as well as shaping and stimulating future research and support for this important sector.

[72] Smith, A. (2004). Making mathematics count. www.mathsinquiry.org.uk/report/MathsInquiryFinalReport.pdf

Appendices

Summary of strategic and operational functions of cross-college managers

Strategic functions

This varies, depending on how responsibilities are shared with senior managers and curriculum leads in the roles within the vertical dimension to the structure. Strategic responsibilities would typically involve:

- Horizon-scanning and advising senior leaders on changes to mathematics policy or other relevant developments
- Mathematics curriculum leadership
- Developing strategic approaches to policy implementation:
    - Management and staffing structures for mathematics
    - Staffing and teaching roles within the structure
    - Curriculum offer
    - Placement of students on to mathematics qualification courses and progression routes towards GCSE
    - Organisation of classes (e.g. by vocational area or level)
    - Timetabling of classes
    - Evaluation of strategies (existing or proposed) and formulation of plans for improvement
- Leadership of plans for improvement
- Monitoring the quality of mathematics teaching and learning and developing plans for improvement, including personal and collective CPD plans, leadership of a professional learning community and the leadership of action research projects.

Operational functions

These are, again, dependent on the distribution of responsibilities in the structure but would typically involve:

- Development, implementation and maintenance of operational systems to support mathematics policy implementation (e.g. attendance reporting, monitoring student progress)
- Coordination and monitoring of operational processes across the college
- Identifying weaknesses in the design or implementation of operational processes and developing plans to address these
- Liaising and negotiating with others to solve problems or make improvements, on a range of operational issues, depending on the extent of shared responsibility for mathematics provision
- Direct line management of curriculum leads and mathematics teachers, as appropriate to the staffing structure
- Managing teaching staff in dispersed arrangements across sites, including teachers not under direct line management, if appropriate
- Planning approaches to CPD to support improvement plans for mathematics (e.g. for mathematics teachers, for vocational teachers)
- Overseeing a range of activities related to curriculum and teaching (e.g. mentoring of new staff, SoW and resources, exam entries, IV, CPD)

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